

System Planner

ACE3600 RTU

6802979C45-D



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# Table of Contents

<b>TABLE OF CONTENTS</b> .....	<b>I</b>
<b>ACE3600 SYSTEM OVERVIEW</b> .....	<b>1</b>
<b>ACE3600 RTU CONSTRUCTION</b> .....	<b>3</b>
<b>POWER SUPPLY MODULES</b> .....	<b>6</b>
12V BACKUP BATTERY .....	7
<b>CPU MODULES</b> .....	<b>8</b>
<b>I/O MODULES</b> .....	<b>10</b>
<b>DIGITAL INPUT MODULES</b> .....	<b>13</b>
<b>DIGITAL OUTPUT RELAY MODULES</b> .....	<b>22</b>
<b>ANALOG INPUT MODULES</b> .....	<b>31</b>
<b>ANALOG OUTPUT MODULES</b> .....	<b>39</b>
<b>DIGITAL OUTPUT AND DIGITAL INPUT FET MODULES</b> .....	<b>45</b>
<b>MIXED I/O MODULES</b> .....	<b>52</b>
<b>MIXED ANALOG MODULES</b> .....	<b>54</b>
<b>I/O EXPANSION</b> .....	<b>56</b>
<b>EXPANSION POWER SUPPLY MODULE</b> .....	<b>60</b>
<b>EXPANSION MODULE</b> .....	<b>61</b>
MODULE FIRMWARE AND OPERATION MODES.....	62
<b>EXPANSION LAN SWITCH</b> .....	<b>65</b>
<b>RTU I/O EXPANSION - POWER CONSIDERATIONS</b> .....	<b>67</b>
<b>ORDERING INFORMATION</b> .....	<b>70</b>
ACE3600 RTU ORDERING FLOW.....	70
LIST OF ACE3600 MODELS.....	80
LIST OF ACE3600 OPTIONS .....	82
GENERAL ORDERING REQUIREMENTS .....	85
<b>ACE3600 INSTALLATION GUIDELINES</b> .....	<b>86</b>
DIMENSIONS.....	86
GENERAL SAFETY INFORMATION: .....	87
MOUNTING THE ACE3600 FRAME ON A WALL .....	88
INSTALLING THE ACE3600 IN A 19" RACK.....	90
HOUSING INSTALLATION.....	91
<b>COMMUNICATIONS</b> .....	<b>93</b>
MDLC PROTOCOL.....	94
COMMUNICATION LINKS.....	98
RS232 PORTS .....	98
RS485 PORTS .....	99

IP PORTS (MDLC OVER IP).....	101
RADIO COMMUNICATIONS .....	120
COMMUNICATION NETWORK .....	129
MDLC ENCRYPTION .....	135
<b>CLOCK FUNCTIONS AND SYNCHRONIZATION .....</b>	<b>140</b>
RTU CLOCK .....	140
TIME ADJUSTMENT AND SYNCHRONIZATION .....	140
NTP CLOCK SYNCHRONIZATION .....	142
GLOBAL POSITIONING SYSTEM (GPS) .....	144
<b>SCADA SYSTEM COMPONENTS .....</b>	<b>145</b>
CONTROL CENTER – SCADA MANAGER.....	145
M-OPC .....	145
IP GATEWAY .....	147
LEGACY MODBUS FEP .....	147
<b>APPENDIX A - ACE3600 SPECIFICATIONS .....</b>	<b>149</b>
POWER SUPPLY MODULE SPECIFICATIONS .....	152
CPU 3610/CPU 3640 MODULE SPECIFICATIONS.....	155
DI MODULE SPECIFICATIONS.....	156
DO/DI FET MODULE SPECIFICATIONS .....	159
DO RELAY MODULE SPECIFICATIONS.....	161
AI MODULE SPECIFICATIONS.....	163
AO MODULE SPECIFICATIONS .....	164
MIXED I/O MODULE SPECIFICATIONS.....	165
MIXED ANALOG MODULE SPECIFICATIONS.....	167
EXPANSION POWER SUPPLY MODULE SPECIFICATIONS .....	169
EXPANSION MODULE SPECIFICATIONS .....	170
EXPANSION LAN SWITCH SPECIFICATIONS.....	171
<b>APPENDIX B - FCC INFORMATION SPECTRUM AND REGULATORY UPDATE...</b>	<b>172</b>
FCC RULES UPDATE .....	172
LICENSING OF FIXED DATA SYSTEMS.....	175
SPECTRUM AVAILABLE FOR FIXED DATA SYSTEMS.....	175
<b>APPENDIX C: ACE3600 MAXIMUM POWER RATINGS .....</b>	<b>178</b>

## ACE3600 System Overview

The purpose of ACE3600 system is typically to provide some degree of automatic operation to a new or existing customer process. The process may be found in water pump stations, sewage lift stations, communication system monitoring, security, public notification control, electrical substation monitoring, distribution automation, demand-side management, automated meter reading, or other applications. This automation is provided by a combination of hardware.

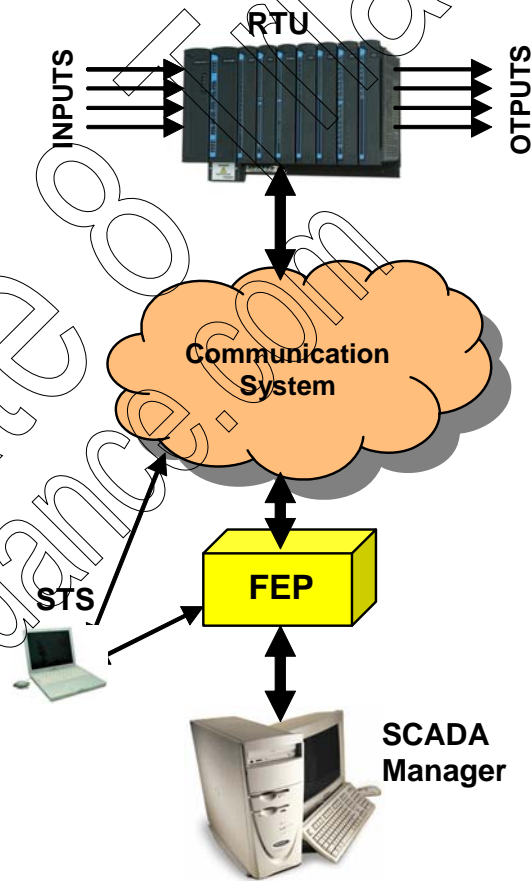
- Remote Terminal Unit (RTU):

The field sites are equipped with ACE3600 RTUs that collect data from on-site sensors, add data from off-site sources, and use this data aggregate to make decisions regarding how the process is operating. Changes to the local process may be made; messages may be initiated that send data elsewhere to influence the operation of off-site equipment or to advise the SCADA Manager of some important change.

- Communications:

The multiple sites in the system may communicate among themselves by utilizing a variety of communication choices: IP networks, two-way conventional, trunked, or data radio or any other communication network. MDLC, the main communication protocol employed by ACE3600, is based on the seven-layer OSI recommendation, and is designed to be totally functional on variety of communication media.

MDLC includes a *store-&-forward* capability that permits different communication media links to be incorporated into the total system, i.e. conventional radio *and* trunked radio *and* microwave radio *and* LAN all interconnected by ACE3600 into a single communication system. Data may be passed from any site to any other site in the system (peer-to-peer) either directly or by multiple hops through intermediate ACE3600 sites. This peer-to-peer communication capability enables system designs that use a distributed-intelligence operating philosophy; central-intelligence-only systems may also be implemented if the load on the communication system permits it.



- The Front End Processor (FEP):

The Front End Processor is used at the central site(s) to provide a two-way path to the communication system and the distant RTUs from the SCADA Manager hardware and software. The FEP converts MDLC protocol data from the RTUs to a protocol used by the SCADA Manager vendor: when the OPC or ModBus protocol is used, the FEP will maintain a local database of all the data from the multiple in-field sites; when TCP/IP gateway is used, the FEP is simply a gateway between the two different protocols. The FEP always acknowledges all RTU-initiated messages. The FEP can also provide a two-way path between the ACE3600 STS and the field RTUs for those functions unique to ACE3600 that are not provided by the SCADA Manager software (over-the-air programming download, diagnostics upload, and more.)

- SCADA Manager:

The SCADA Manager provides the operator with the display and report tools necessary to view and manage the associated process(es). The SCADA Manager obtains data from the FEP according to its needs and typically presents that data on custom-created display formats; control messages may also be initiated from these custom screens. Security is typically implemented via permission levels activated by the operator's sign-on password. Microsoft Windows is becoming the operating system of choice because it easily supports the desired graphic symbols used on the custom screens. The report capability may be provided by the SCADA software or a data export to Microsoft Excel or equivalent may be utilized. The end result is an easy to use pictorially-described representation of the field status of key equipment items plus the means to make changes in how those pieces of equipment operate.

- System Tools Suite (STS):

The ACE3600 STS is a software program that allows the system engineer to set up and maintain the ACE3600 system in accordance with system-specific requirements. The STS computer (PC) may be connected to any RTU/FEP or to the other network points in the system and have connectivity established with any other site through the store-&-forward capability of the MDLC protocol; all the capabilities available during a local connection may then be enjoyed by the remotely-connected system engineer: the communication network topography may be defined; the application(s) for each site may be created and downloaded into the RTUs; run-time and diagnostic data may be uploaded.

## ACE3600 RTU Construction

The ACE3600 RTU is a universal device that may serve as an RTU, a Programmable Logic Controller (PLC), or as the system FEP. It is placed at the system's field sites to collect data from on-site sensors, add data from off-site sources, and use this data aggregate to make decisions regarding how some process is operating. The RTU may make changes to the local process; messages may be initiated that send data elsewhere to influence the operation of off-site equipment or to advise the SCADA Manager of some important change.

The ACE3600 is available in various structures:

- Frame which can accommodate a varied number and type of modules
- Metal chassis which accommodates the frame, and optional radios, backup battery and communication interfaces
- Protective housing which accommodates the frame, and optional radios, backup battery and communication interfaces (suitable for outdoor installation)

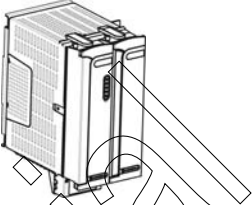
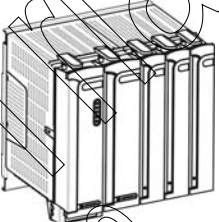
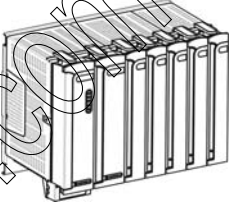
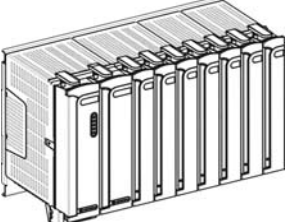
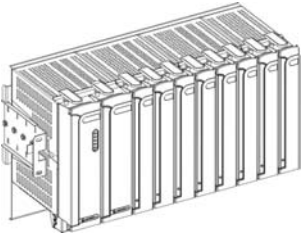
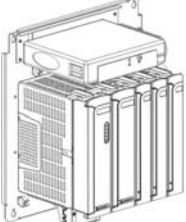


The ACE3600 frame consists of the following elements:

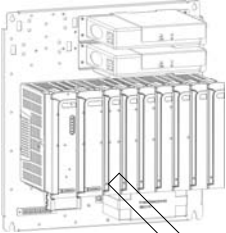
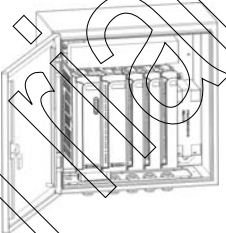
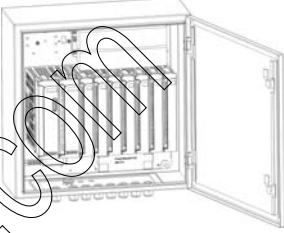
- Plastic slots which accommodate the power supply, CPU and I/O modules, and backplane bus motherboard
- Mounting plate for attaching the plastic slots together and mounting the frame on a wall
- Backplane bus motherboard which connects the modules to each other via the signal buses and connects the modules with operating voltages
- Power junction box for AC or DC power source and ground connections

A frame can be mounted on the wall or installed in a 19" rack or customer enclosure.

Each RTU can include a number of options, including portable and mobile radios, and plastic boxes with interface card for communication, etc.

Housing/Mounting Type	Capacity/Options	Illustration
<p>No I/O slot frame Basic (default) model. Can be installed on a wall.</p>	<p>Power supply and CPU Can be ordered with metal chassis or housing options.</p>	
<p>3 I/O slot frame Can be installed on a wall.</p>	<p>Power supply and CPU, up to 3 I/Os Can be ordered with metal chassis or housing.</p>	
<p>5 I/O slot frame Can be installed on a wall.</p>	<p>Power supply and CPU, up to 5 I/Os Can be ordered with large metal chassis or housing.</p>	
<p>7 I/O slot frame Can be installed on a wall.</p>	<p>Power supply and CPU, up to 7 I/Os Can be ordered with large metal chassis or housing.</p>	
<p>8 I/O slot frame Can be installed on a wall or in 19" rack/enclosure.</p>	<p>Power supply and CPU, up to 8 I/Os  Can be ordered with metal chassis option for accessories: 6.5 or 10 Ah Lead-Acid backup battery up to 2 radios; up to four plastic boxes.</p>	
<p>Small metal chassis Enables installation of radio, backup battery and other accessories. Can be installed on a wall or in housing.</p>	<p>Power supply and CPU, up to 3 I/Os, 1 mobile/portable radio, 1 plastic interface box, 6.5 Ah Lead-Acid backup battery</p>	



Housing/Mounting Type	Capacity/Options	Illustration
<p>Large painted metal chassis Enables installation of radio, backup battery and other accessories. Can be installed on a wall or in housing.</p>	<p>Power supply and CPU, up to 7 I/Os, 1 plastic interface box, up to 2 mobile/portable radios, 6.5 or 10 Ah Lead-Acid backup battery</p>	
<p>Small NEMA 4/IP65 housing Enables installation of radio, backup battery and other accessories. Can be installed on a wall.</p>	<p>Power supply and CPU, up to 3 I/Os, 1 mobile/portable radio, 1 plastic interface box, 6.5 Ah Lead-Acid backup battery</p>	
<p>Large metal NEMA 4/IP65 housing Enables installation of radio, backup battery and other accessories. Can be installed on a wall.</p>	<p>Power supply and CPU, up to 7 I/Os, 1 plastic interface box, up to 2 mobile/portable radios, 6.5 or 10 Ah Lead-Acid backup battery</p>	

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## Power Supply Modules

The ACE3600 power supply module provides the other modules in the RTU with their operating voltages via the motherboard bus.

The following power supply options are available:

- DC power supply low-tier (10.8-16V)
- DC power supply (10.8-16V) – provided as default
- DC power supply (18-72V)
- DC power supply (18-72V) with battery charger
- AC power supply- 100-240V
- AC power supply- 100-240V with battery charger

Common characteristics of all power supply modules: (except the DC power supply low-tier)

- On/Off switch on the front panel
- Controlled auxiliary voltage outputs
- Heat convection cooling (no need for fans)
- Short protection outputs
- Over heating protection
- The module operation is monitored by the CPU module.
- Status LEDs on the front panel
- The PS module is always located in the leftmost slot of the frame.
- Input current protection fuse
- Controlled power line enables centralized disabling of Electrically Energized and Magnetically Latched relay outputs in selectable DO modules.



Note: The DC power supply low-tier does not support radios that require input power other than 10.8-16V. Do not use portable radios which require 7.5V input with this option.

Note: The low limit of the DC power supply (10.8-16V) can be configured to 10.5V. The default is 10.8.

Common characteristics of power supply modules with battery charger:

- Automatic switchover to battery on power fail
- Automatic switchover to main power on power return
- Temperature compensated charging
- Over-charging protection

Characteristics of the DC power supply low-tier:

- Two auxiliary voltage outputs

- Short circuit protection outputs
- PS located on the leftmost slot of the frame
- Overvoltage protection for CPU and I/Os
- Reverse voltage protection

Power supply modules with a battery option support a 6.5 or 10 Ah Lead-Acid battery. The power supply automatically switches to the backup battery as a 12V DC power source for the RTU and communications when the main AC or DC power source fails.

Power supply modules with battery charger option charge the backup battery when not in use, and protect the battery from over-discharge. The charger performs battery tests/diagnostics, including controlled battery discharge, when requested by the user. If the battery is failed, the charger will not charge it and will send a failed status signal to the CPU. If the battery is remotely located, long battery cables can be used.

The charging voltage of the Lead-Acid battery is controlled by the charger as a function of the battery temperature. The charging profile is set to comply with the temperature-compensated float-voltage of the ACE3600 battery.

A battery test can be performed on the Lead-Acid battery, either from the ACE3600 STS Hardware Test utility or from the user application program. The battery test includes disabling the battery charger, discharging the battery and measuring the capacitance.

Note: An additional power supply module for use with I/O expansion frames is described in the Expansion Power Supply Module section below.

### **12V Backup Battery**

The ACE3600 backup 12V Lead-Acid battery provides backup for the main input power. The battery is available in two capacities: 6.5 Ah and 10 Ah. Switching from main input power to the battery and charging of the battery is performed by the ACE3600 power supply module. Sealed Lead-Acid technology batteries can be recharged and discharged at a temperature range of -30° to +60°C. Storage and operating temperatures affect the battery capacity and lifespan. ACE3600 power supply modules include a special charging power supply designed to fit the specific temperature-compensated float-voltage-charging curve of the battery.

## CPU Modules

The main element of the ACE3600 is the CPU module. It controls the I/O modules, processes the gathered data and communicates with the outside world.

The core of the module is Freescale's MPC8270 32-bit microprocessor which has extended communication capabilities, high speed core, DMA and floating point calculation support. The module includes on-board memory, communication ports, I/O bus interface and other circuits.

The firmware is based on Wind River's VxWorks operating system.

**Module Location:** The CPU is a removable module located in a dedicated slot in the RTU rack. The CPU module must be plugged into the wide slot to the right of the Power Supply module.

The CPU module includes several communication ports:

On Board ports:

- Serial 1 (SI1) – RS232/RS485 serial port (configurable)
- Serial 2 (SI2) – RS232 serial port
- Eth1 (E1) - 10/100BaseT Ethernet port (CPU 3640 only)

Plug-in ports bays, where different types of ports can be installed:

- Plug-in 1 (PI1) – fits RS232, RS485, 10 MB Ethernet, 10/100 MB Ethernet, or Radio Modem Plug-in option
- Plug-in 2 (PI2) – fits RS232, RS485, 10 MB Ethernet, or Radio Modem Plug-in port option.

Note: For information on the ACE3600 Ethernet port and Auto-Negotiation, see the Auto-Negotiation Note at the end of the IP Ports (MDLC over IP) section below.

The ACE3600 CPU memory includes FLASH, SDRAM, and optional SRAM Plug-in memory. The FLASH stores the firmware, the user application program, and the user data. The SDRAM memory stores the temporary data. The optional SRAM memory expansion is used for logging user data. The SRAM data is retained using an on-board rechargeable lithium battery.



	Model 3610	Model 3640
<b>Flash memory</b>	16 Mb	16 Mb
<b>SDRAM memory:</b>	32 Mb	32 Mb
<b>User FLASH:</b>	3 Mb	3 Mb
<b>User SDRAM:</b>	10 Mb	10 Mb
<b>SRAM Plug-In</b>	4 Mb	4 Mb

The CPU has a low drift RTC. The date and time are retained using an on-board rechargeable lithium battery. The CPU date and time can be set using the ACE3600 STS. The CPU can also be synchronized with other RTUs in the system, using the system clock.

The CPU's rechargeable lithium battery provides backup power and data retention for the SRAM and RTC. Typically, the battery will preserve the data stored in the SRAM and RTC for 60 continuous days without power. When the SRAM option is not used, the Lithium battery will keep the Real Time Clock (RTC) running for a longer period of time.

The CPU module also includes:

- Buzzer (audio indication), which is used to indicate task completion (such as end of download/upload, restart etc.) and can also be controlled from the user application program.
- Pushbuttons on the front panel, PB1 and PB2. These pushbuttons are used for activating and testing the module LEDs, restarting the unit, erasing the user Flash memory and activating memory test. The pushbuttons can also be monitored by the user application program (when it is running) for the application purposes.
- Status LEDs which indicate the CPU status during startup (boot), run-time or when there is a failure. Communication LEDs are used to indicate the communication port status. User LEDs can be used by the user application program.

The CPU's firmware is a real-time multitasking operating system, based on the Wind River VxWorks OS. The CPU is shipped from the factory with the most recent firmware version, and it can be updated/replaced using a remote or local connection. Downloading firmware updates is performed using the STS. (See Downloading to a Site in the ACE3600 STS User Guide.) If the new firmware download stops or fails, the CPU will restart with the existing firmware.

## I/O Modules

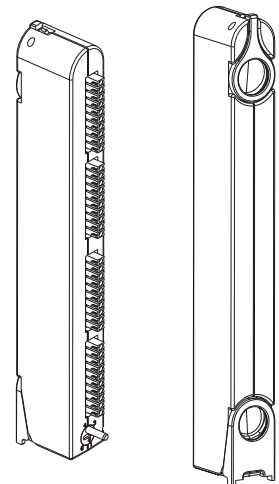
The ACE3600 RTU can include up to eight I/O modules, depending on the frame size. A variety of I/O modules is available. The I/O modules can be positioned in the slots to the right of the CPU. As with all ACE3600 modules, the I/O modules can be replaced while the power is on (hot swap.)

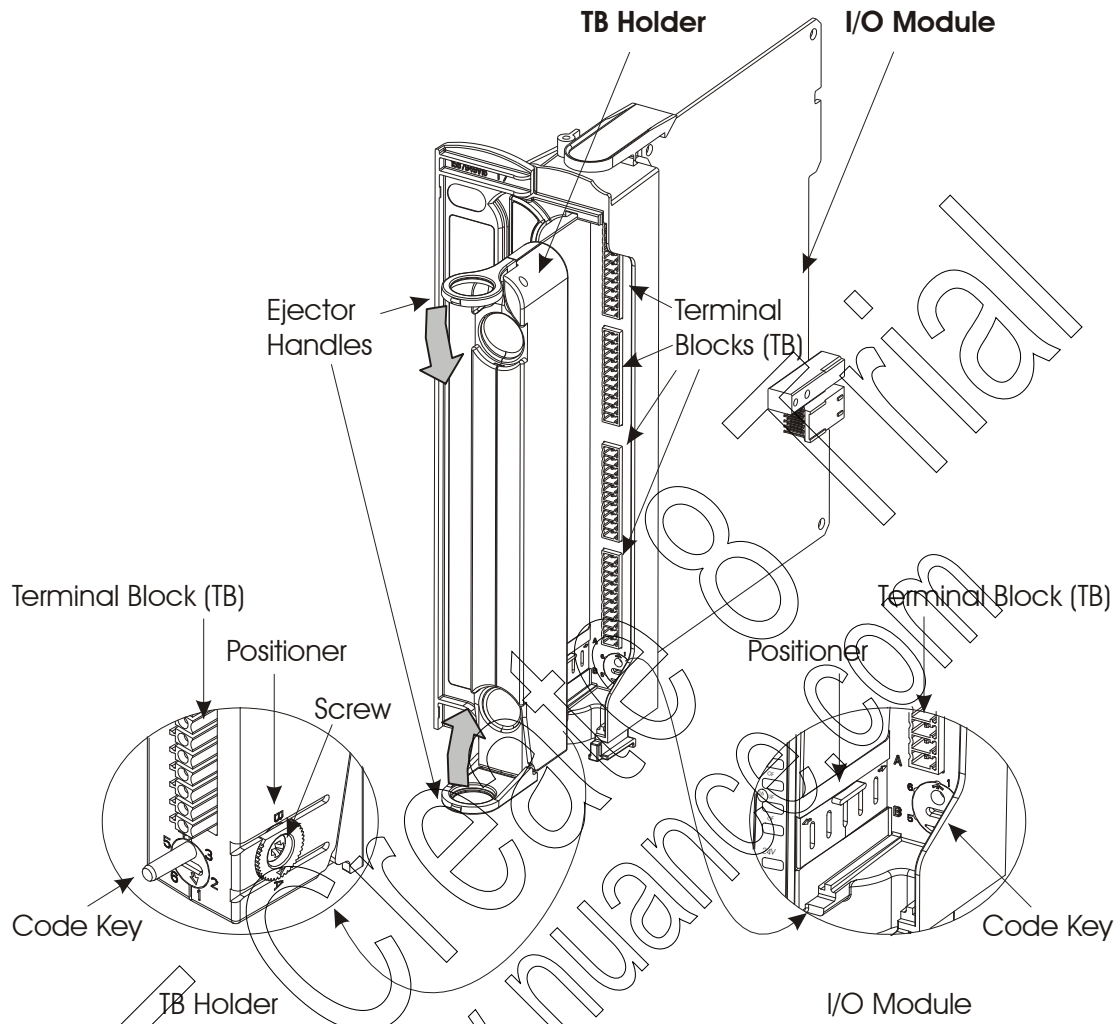
Each I/O module includes an ERR status LED, individual I/O status LEDs, an array of I/O connectors, and a coding mechanism for the terminal cable connector or TB holder option. The ERR LED indicates an I/O module fault and errors. It will remain lit until all the errors have been eliminated. Diagnostic and error messages can be retrieved from the module using the ACE3600 STS Error Logger or SW Diagnostics.

The I/O status LEDs in Digital Input (DI) and Digital Output (DO) modules indicate ON and OFF (LED lit when the I/O is ON.) In Analog Input (AI) modules, each input has two LEDs, indicating Overflow (OF) and Underflow (UF). In Analog Output (AO) modules, each output has three LEDs, indicating voltage output (Vout), current output (Iout), and calibration (Cal).

Each I/O module can be ordered either with a set of two, three or four TB connectors or with a TB holder. TB connectors have a fixed female side on the module and a male plug for the sensor/device wire connection. The TB male side in all modules is screw type for up to 1mm (18 AWG) wire in modules with two/four TBs (3.5 mm pitch) or 1.6 mm (14 AWG) wire in modules with three TBs (5 mm pitch). Two TB extractor tools (EHN7063A) are provided for easy removal of TBs, one for modules with two/four TBs and one for modules with three TBs.

The TB holder secures the male TBs neatly in place and forms a single connector plug per module. The wires connected to the TBs are concealed in the holder. The module and the TB holder provide a coding mechanism to prevent cabling errors. Ejector handles enable easy release of the TB holder connector from the module. An optional three-meter cable braid, completely wired with holder and cable, is available. A TB holder kit is available to enable self-assembly of cables. User assembled cables should use wires of up to 0.4mm (26 AWG) in modules with two/four TBs (3.5 mm pitch) or wires of up to 0.8 mm (20 AWG) in modules with three TBs (5 mm pitch). The TB holder kit does not include a cable.

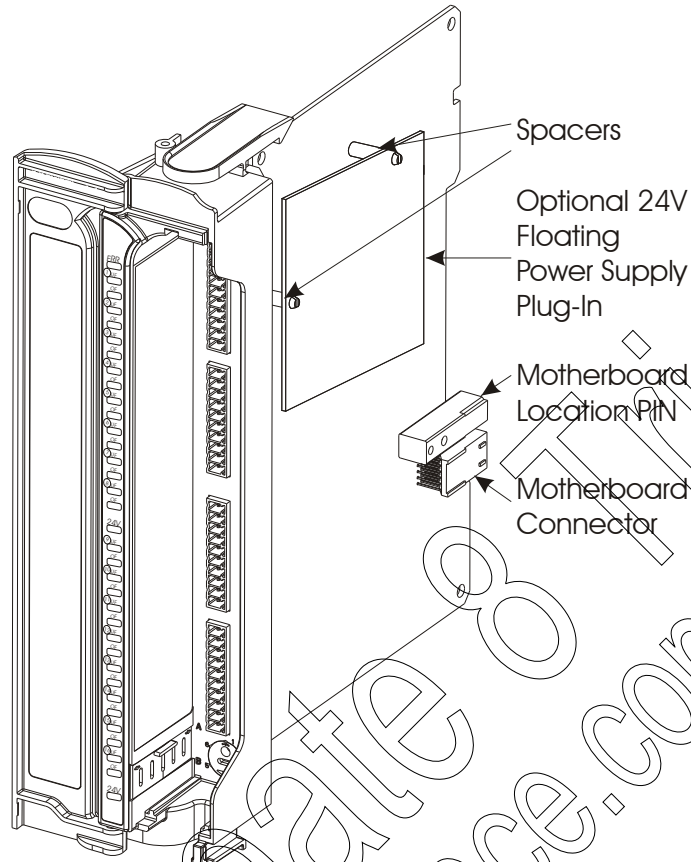




Up to two 24V DC floating plug-in power supplies can be added to certain I/O modules, as detailed in the table below. Up to four 24V DC floating plug-in power supplies can be added per rack.

Module Type	Number of Power Supplies
32 DI	2
16 DI	1
16 AI	1
8 AI	1
Mixed I/O	1
Mixed Analog	1

\* Available as of December 2007.



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## Digital Input Modules

### Low Voltage DI Modules:

The ACE3600 low voltage Digital Input (DI) module can have 16 or 32 inputs. The following DI modules are available:

- 16 DI Fast 24V
- 32 DI Fast 24V
- 16 DI Fast 24V IEC TYPE 2
- 32 DI Fast 24V IEC TYPE 2

Two types of low voltage (“wet”) inputs are supported, IEC 61131-2 Type II compliant inputs and 24V “MOSCAD compatible” inputs.

In the 32 DI modules, the first 20 inputs can function as fast counters. In the 16 DI modules, all inputs can function as fast counters. A counter’s maximum rate is dependent on the module type (see the specifications below.)

All the inputs are optically isolated. The DI modules support optional 24V DC floating plug-in power supplies (for contact “wetting” or other purposes).

The 16 DI Fast 24V and 32 DI Fast 24V modules can handle AC and DC input signals. The user can select DC or AC operation per module. When AC configuration is selected, the Fast Capture, Counter Function and Input Filters (see below) are disabled.

### 120/230V (HV) DI module:

The ACE3600 high voltage Digital Input (DI) module has 16 inputs. All the inputs are IEC 61131-2 Type2 compliant and all are optically isolated.

This module supports high voltage AC or DC signals in the inputs. The Counter function is not supported in this module.

### Common Characteristics to all DI modules:

Each DI can be an event trigger (interrupt-driven) to a high priority fast process. The high priority fast process enables very fast activation of an output in response to an input trigger and logical conditions. This high priority fast process is not dependent on the I/O scan.

When the DI module is in DC mode, each DI can be configured as a Fast Capture DI. Fast capture causes the SCAN ladder output operation to get the first change that occurred since the previous scan. When fast capture is disabled, the scan gets the current value of the DI (in this case, any DI changes between scans are missed.)

When the DI module is in DC mode, each input has a HW input filter to make sure that the input reading is stable. The range of the HW DI filter is 0 to 50.8 millisecond (in 0.2 mS steps). The Fast Counter DI filter range is 0 to 12.75 millisecond (in 0.05 mS steps).

The DI module features which can be configured are listed in the table below. Some parameters are per module and some are per input.

Feature	Parameter Settings	Default Setting	Per Module/ Input	Parameter Setup Location
DC or AC operation*	AC/DC	DC	Module	STS site configuration
Fast Capture	Disabled /Enabled	Disabled	Input	STS site configuration
DI Filter (DC)	0-254 (x 0.2 mS)	50 (10 mS)	Module	STS site configuration; 'C' User Program
Counter Filter (DC)	0-255 (x 0.05 mS)	20 (1 ms)	Module	STS site configuration 'C' User Program
Event Time Tagging	Disabled/ Enabled	Disabled	Input	User Program I/O link table
Keep Last Value and Predefined Value	KLV/PDV PDV=0/1	KLV	Input	User Program I/O link table
Mask	No /Yes	No	Input	User Program I/O link table

Note: In the 120/230V DI module, the minimum effective DI Filter parameter value is 7.0 mSec.

Each DI can be set in the user application program's I/O link table to trigger recording of time tagged events upon any input change of state. The time tagged events are recorded in the CPU memory and can be retrieved for various purposes.

Each input can be configured to "Keep Last Value" (KLV) or to "Predefined Value" (PDV 0 or 1). This value is shown to the user application program in the event of DI module failure. The PDV can also be used during normal operation to force a value that masks the actual input value. In this case the user program will get the PDV instead of the actual input value.

---

\* in Fast 24V IEC TYPE II modules –only DC

Each DI module can be switched by the user application program to Sleep Mode. In Sleep Mode, the module does not function and the power consumption is minimized. During Sleep mode, the user application program will get the predefined values (PDV) for each I/O.

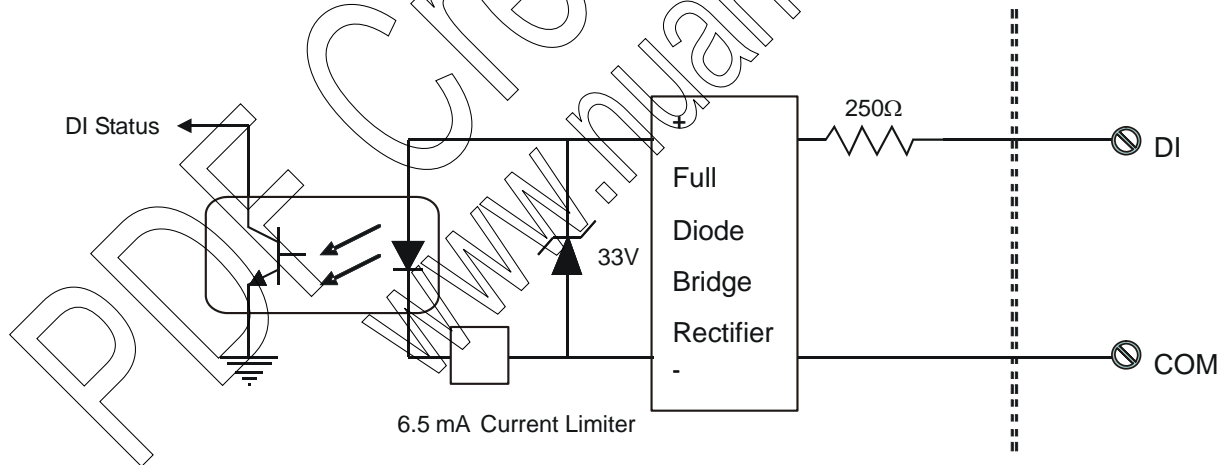
The DI module can be diagnosed and monitored using the STS Hardware Test utility. This test verifies that the module is operational, presents the module configuration and shows the actual value of each input. It is also possible to change the input filter setup temporarily for the duration of the Hardware Test.

In the STS Hardware Test utility, it is possible to set the DI module to Freeze Mode. In this mode the user application program will get the predefined value of each input in the module, instead of the actual input value. Freeze mode enables testing the inputs while the user application program is running.

Connection of a dry contact sensor to the low voltage DI module requires “wetting” the contact with a voltage. This can be done using the 24V DC floating plug-in power supplies that can be added to the module. The 24V can be also used to power “wet” sensors. \*\* The 24V can be also used to power “wet” sensors. (Low voltage only)

**Low Voltage DI I/O Circuit Diagram:**

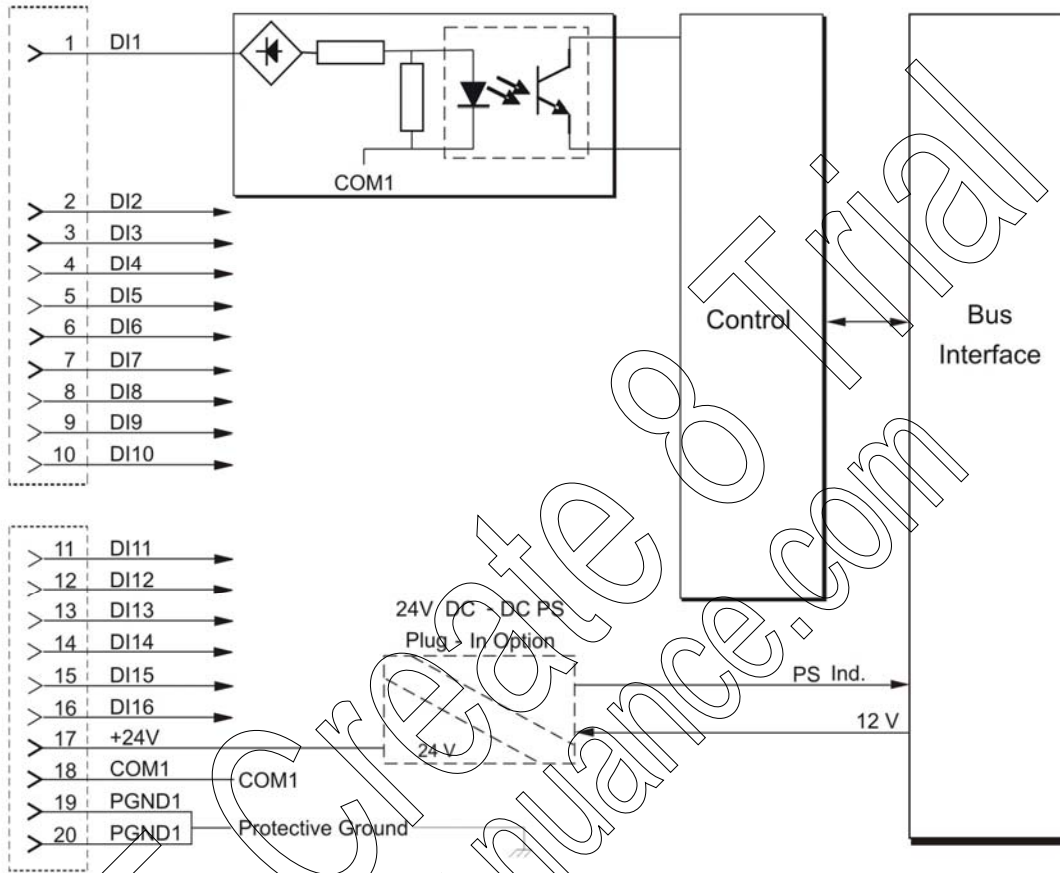
**DI - Typical Input Circuit**



\*\* Available as of December 2007.

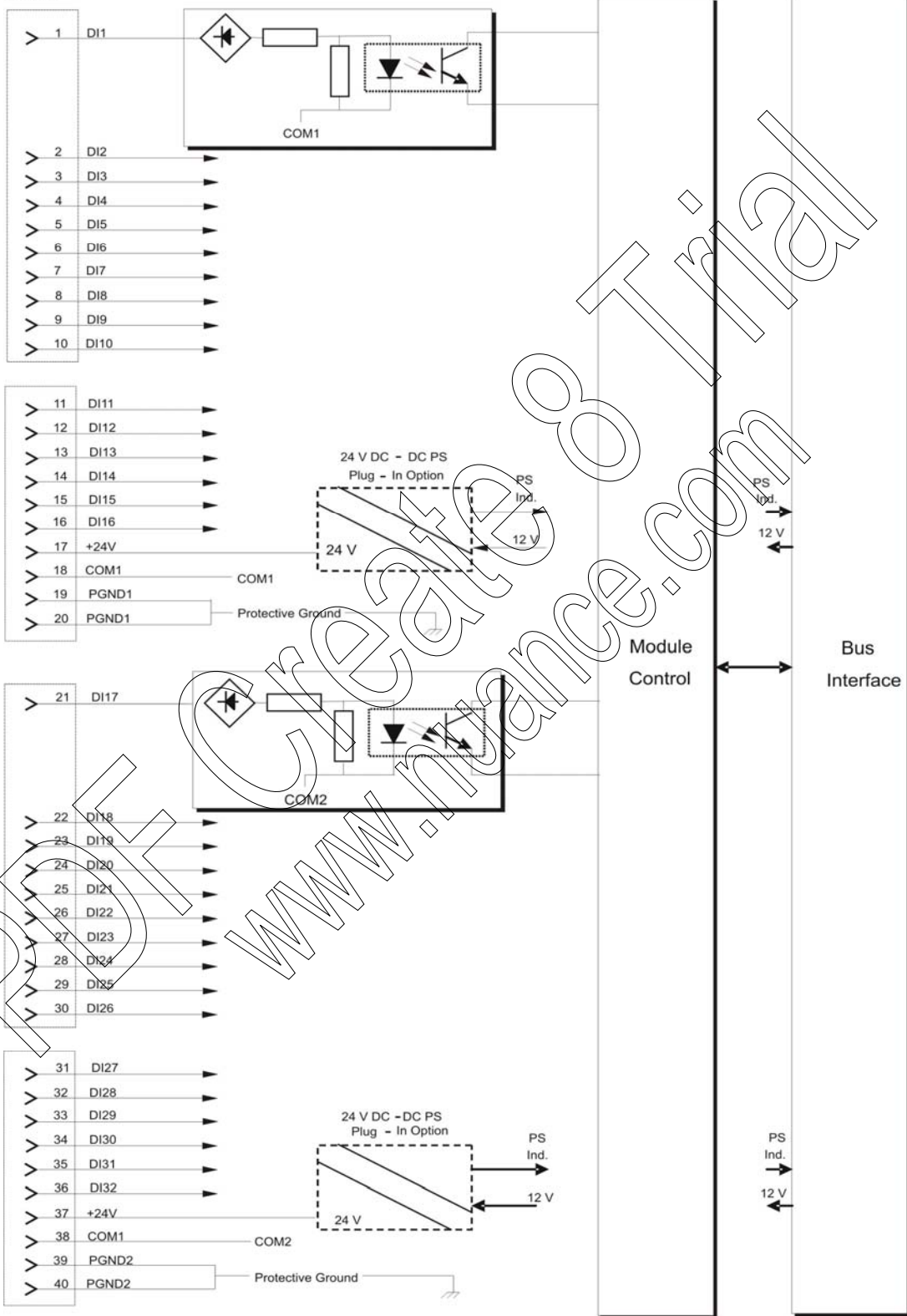
16 DI Module Block Diagram:

16 DI

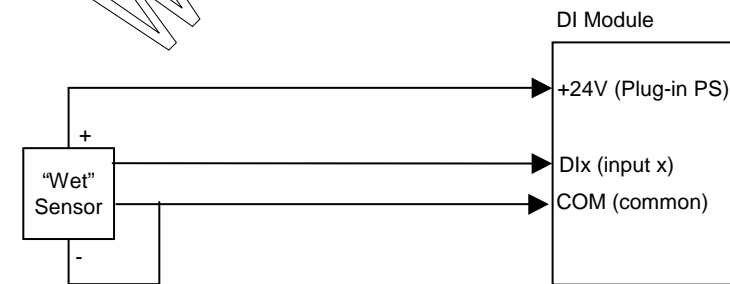
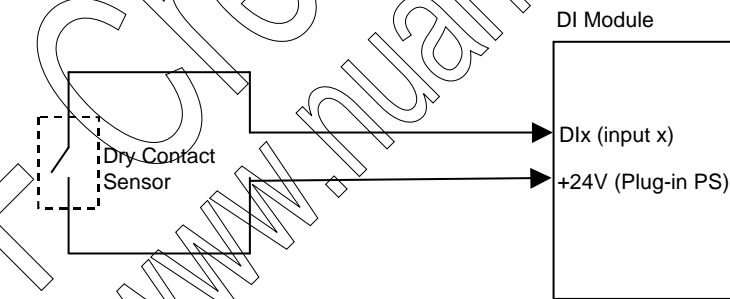
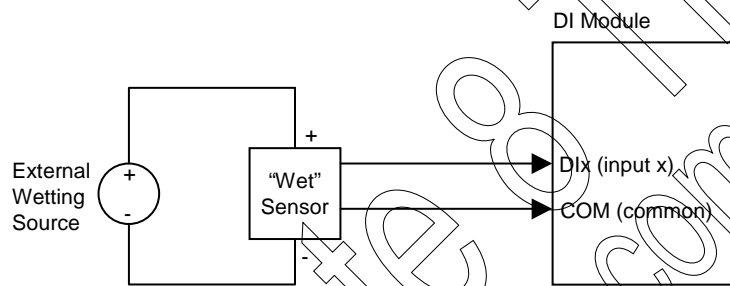
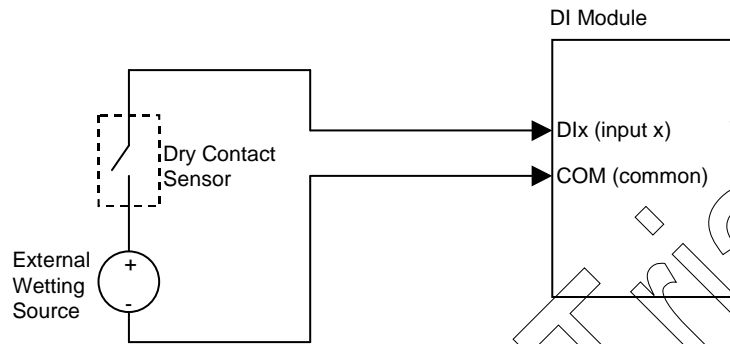


32 DI Module Block Diagram:

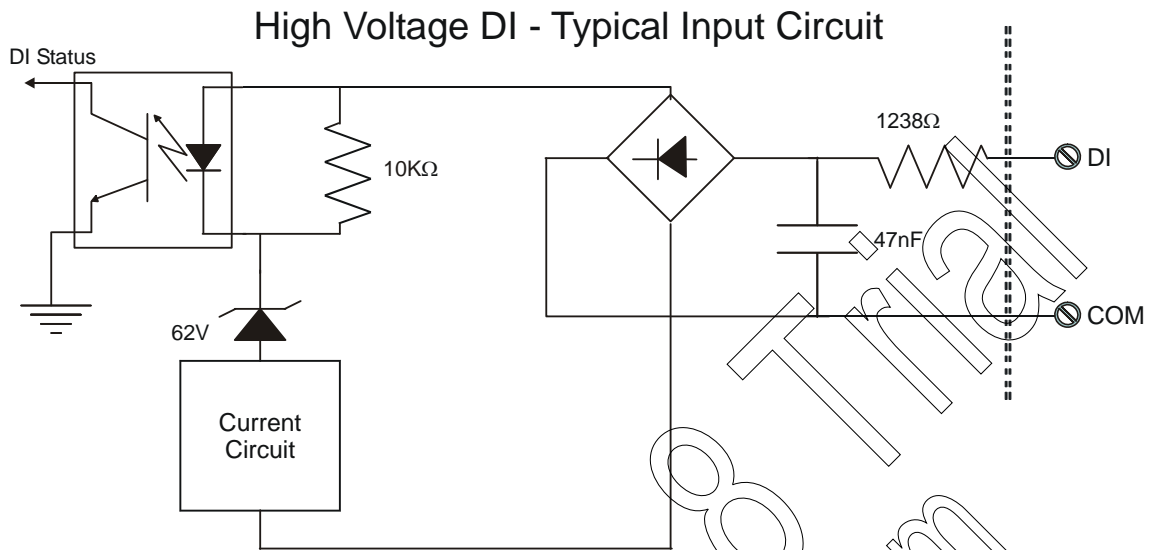
32 D1



Low Voltage DI I/O Connection Diagram:



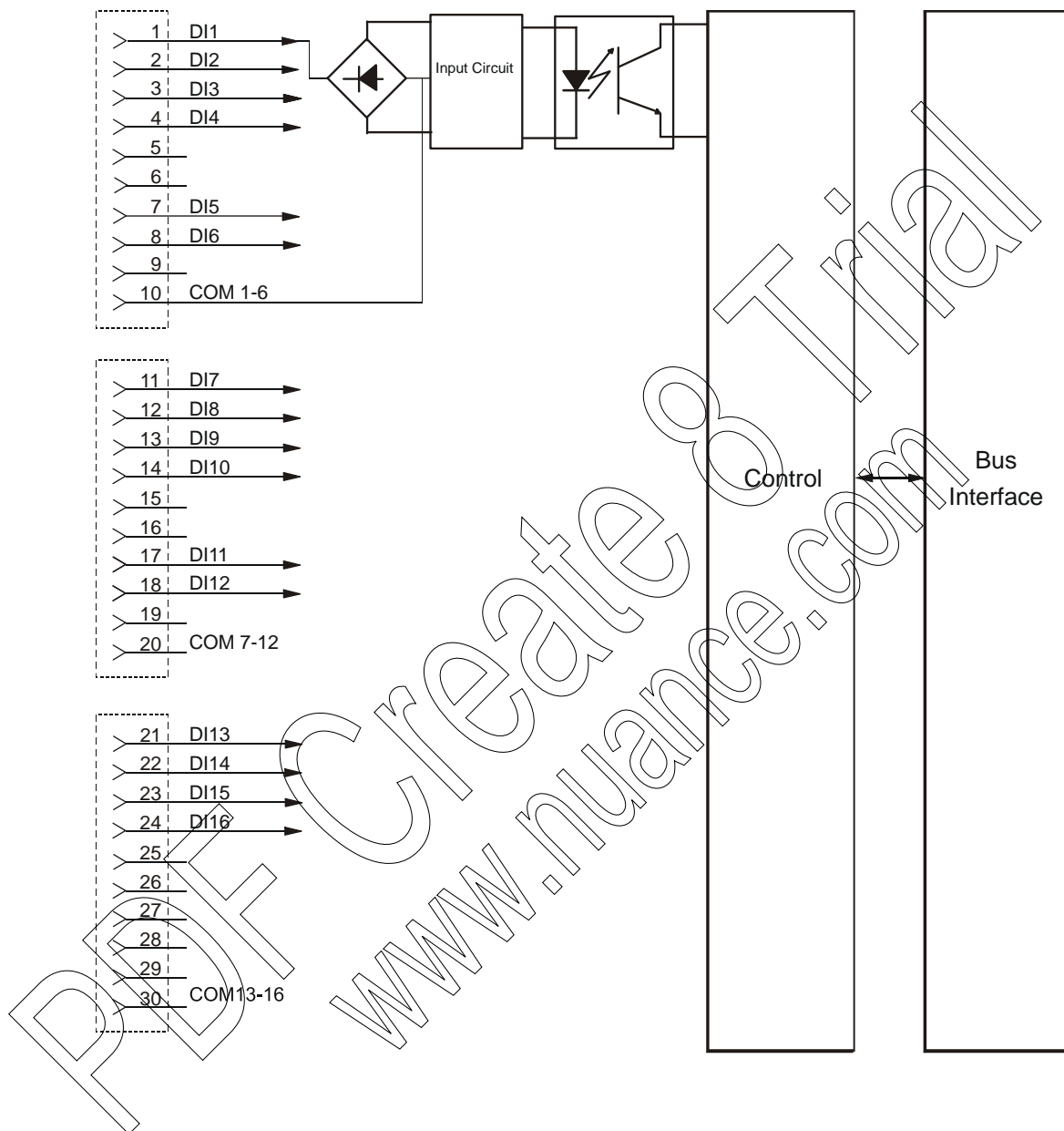
High Voltage DI I/O Circuit Diagram:



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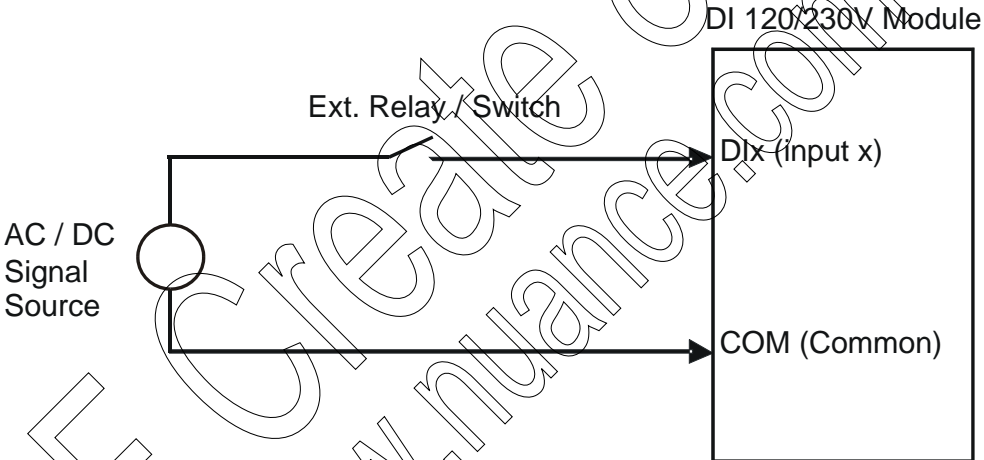
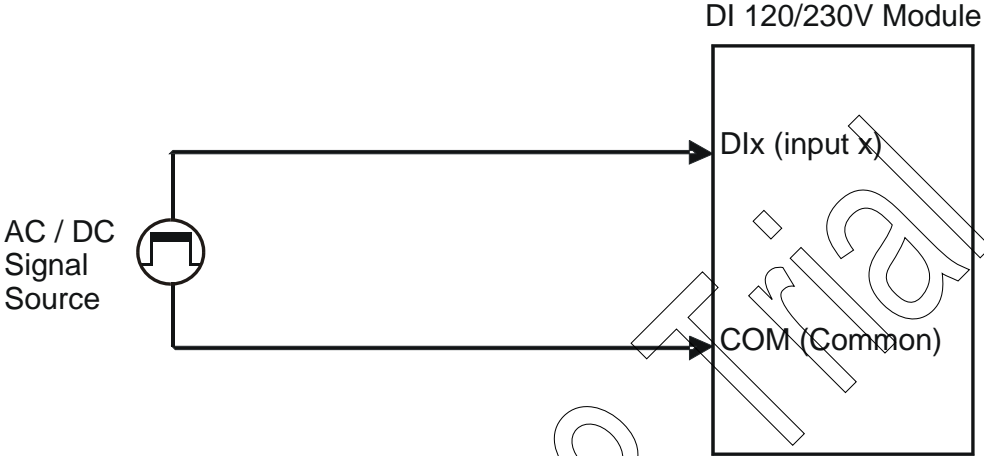
16 DI 120/230V Module Block Diagram:

16 DI High Voltage





16 DI 120/230V I/O Connection Diagram:



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## Digital Output Relay Modules

### Low Voltage DO Relay Modules:

The DO Relay modules have 8 or 16 outputs. There are two types of DO relays:

- Electrically Energized (EE) - the outputs return to the non-energized state in case of power off or module failure.
- Magnetic Latch (ML) - Relay outputs are magnetically latched, the outputs maintain their state in case of power off or module failure.

The following DO relays modules are available:

- 8 DO EE Relay 2A
- 16 DO EE Relay 2A
- 8 DO ML Relay 2A
- 16 DO ML Relay 2A

In the 8 DO modules, the relays of outputs 1 through 5 are Single Pole Single Throw (SPST) normally open (NO) and are referred to as the “Form A” relays. The relays of outputs 6 through 8 are Single Pole Double Throw (SPDT) and are referred to as the “Form C” relays.

In the 16 DO modules, the relays of outputs 1 through 5 and 9 through 13 are Single Pole Single Throw (SPST) normally open (NO) “Form A” relays. The relays of outputs 6 through 8 and 14 through 16 are Single Pole Double Throw (SPDT) “Form C” relays.

### 120/230V DO Relay Modules:

The ACE3600 DO Relay 120/230V (High Voltage DO) modules have 12 outputs. Each output is switched by a relay.

There are two types of DO relays:

- Electrically Energized (EE) - the outputs return to the non-energized state in case of power off or module failure.
- Magnetically Latched (ML) - Relay outputs are magnetically latched, the outputs maintain their state in case of power off or module failure.

The following DO relays modules are available:

- 12 DO EE Relay 120/230V 3A
- 12 DO ML Relay 120/230V 3A

### DO Modules Common Characteristics:

The physical position of each relay is monitored by the module logic, using a back indication signal which is connected to the relay’s second contact set. Any contradiction

between the required position and the back indication signal is reported to the CPU and is available to the user program.

In some applications it is necessary to inhibit relay output operation when attending the site for safety reasons. In all DO relay modules, it is possible to inhibit all relays per DO module.

When a module is configured to enable relay inhibiting, the power to the relays is provided from the power supply via a dedicated power line (12V DO), controlled from the “12V DO” input (TB located on the power supply module front panel). When the input’s terminals are shorted, the relays are operational. When the input’s terminals are open, the relays are inhibited (EE relays in 0 position and ML relays do not change state.) The user program can monitor the relay inhibiting status and act accordingly. Also, when the module’s relays are inhibited, any mismatch between the relay position and the output logical state is ignored.

Each output can be configured to “Keep Last Value” (KLV) or to a “Predefined Value” (PDV 0 or 1). This value is executed when the user program stops or when the module has no communication with the CPU module. Also, the PDV can be used during normal operation to force a value on the output by ignoring the user program value (mask).

In the ML relay modules, it is possible to configure the module to reset all the ML relays positions on startup. This is set in the STS site configuration.

Parameter	Selection	Default Setup	Per Module/ Input	Parameter Setup Location
DO Keep Last Value & Pre-Defined Value	KLV/PDV PDV = 0/1	KLV	Output	Application Programmer I/O link table
DO Mask	No /Yes	No	Output	Application Programmer I/O link table
Reset DO at Startup	Disable/Enable	Disable	Module	Site configuration
Relay Inhibiting (SW selectable)	Disable/Enable	Disable	Module	Site configuration

Each DO module can be switched by the user program to Sleep Mode. In Sleep Mode, the module does not function and the power consumption is minimized.

The DO module can be diagnosed and monitored using the STS Hardware Test utility. This test verifies that the module is operational, presents the module configuration and shows the actual value of each output. It is also possible to change the DO’s value. In the Hardware Test utility, it is possible to set the module to Freeze Mode. In this mode, the

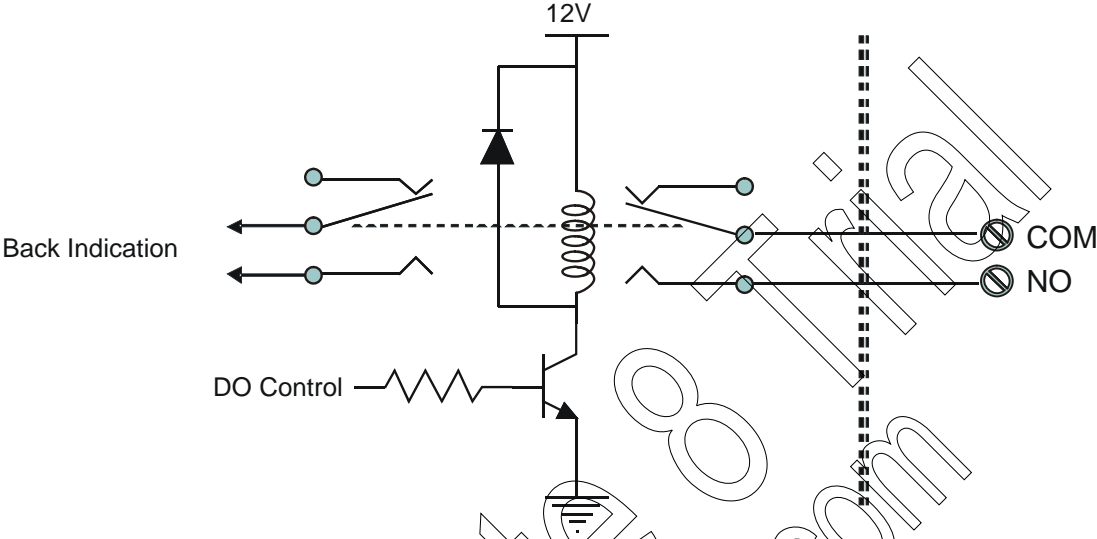
DOs will keep the last value they had at the time they were frozen. Freeze mode enables testing the inputs and outputs while the user program is running.

Note: In systems with I/O expansion, the power supplies on I/O expansion frames can be attached via DC cable to the power supply on the previous I/O expansion frame in a daisy-chain manner, or directly to the main power supply. In this case, the 12V DO control on the main power supply can control all DO EE relays in the entire RTU that were configured by dip switch for 12V DO. This enables the user to inhibit all DO EE relays in the entire RTU simply by removing the plug from the 12V DO control in the main power supply.

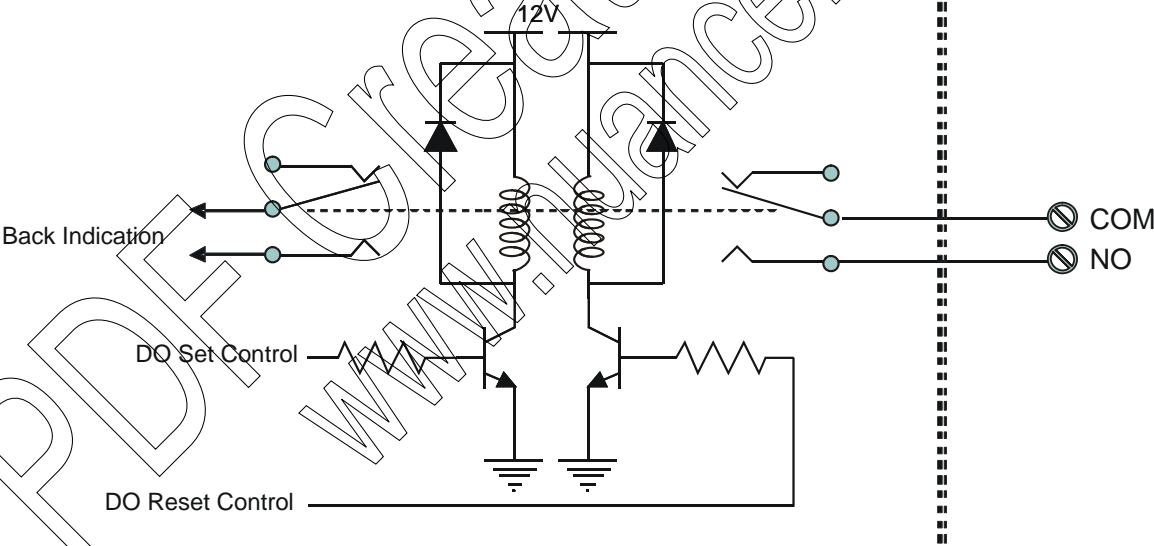
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Low Voltage I/O Circuit Diagrams:

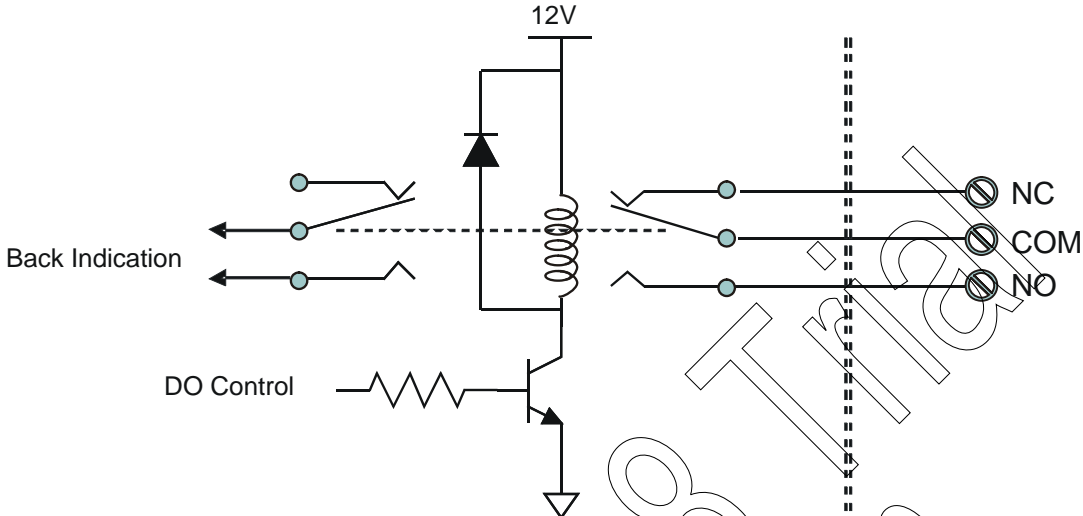
DO EE Relay (SPST) - Typical Output Circuit



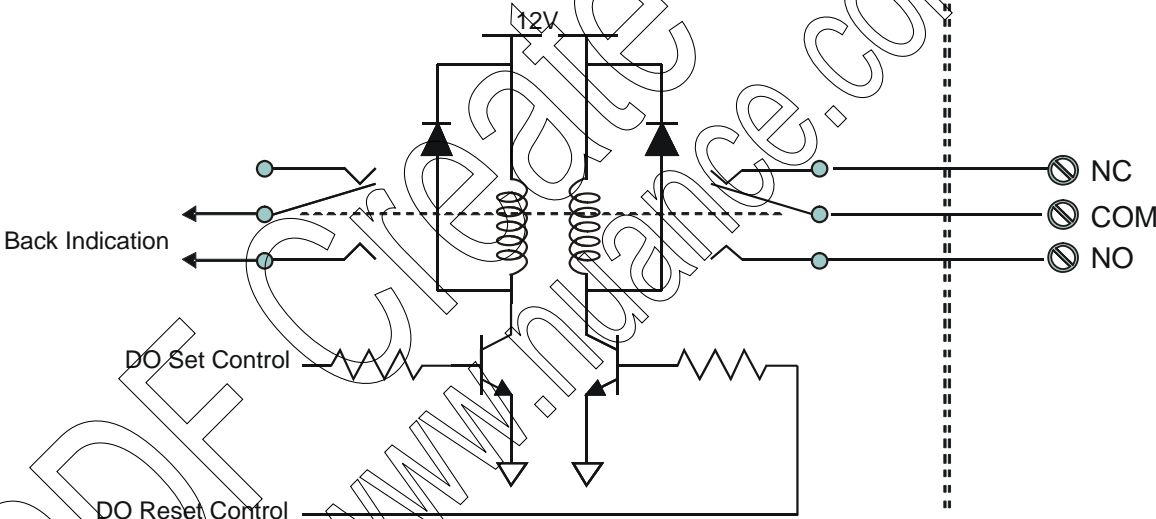
DO ML Relay (SPST) - Typical Output Circuit



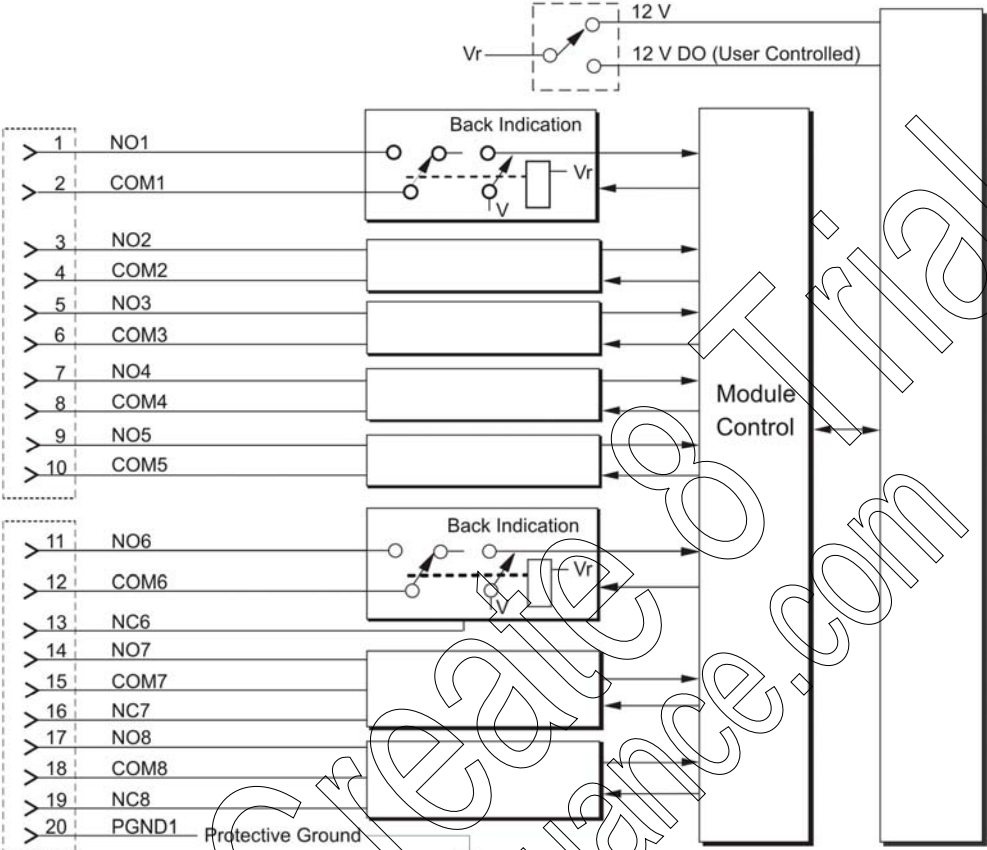
### DO EE Relay (SPDT) - Typical Output Circuit



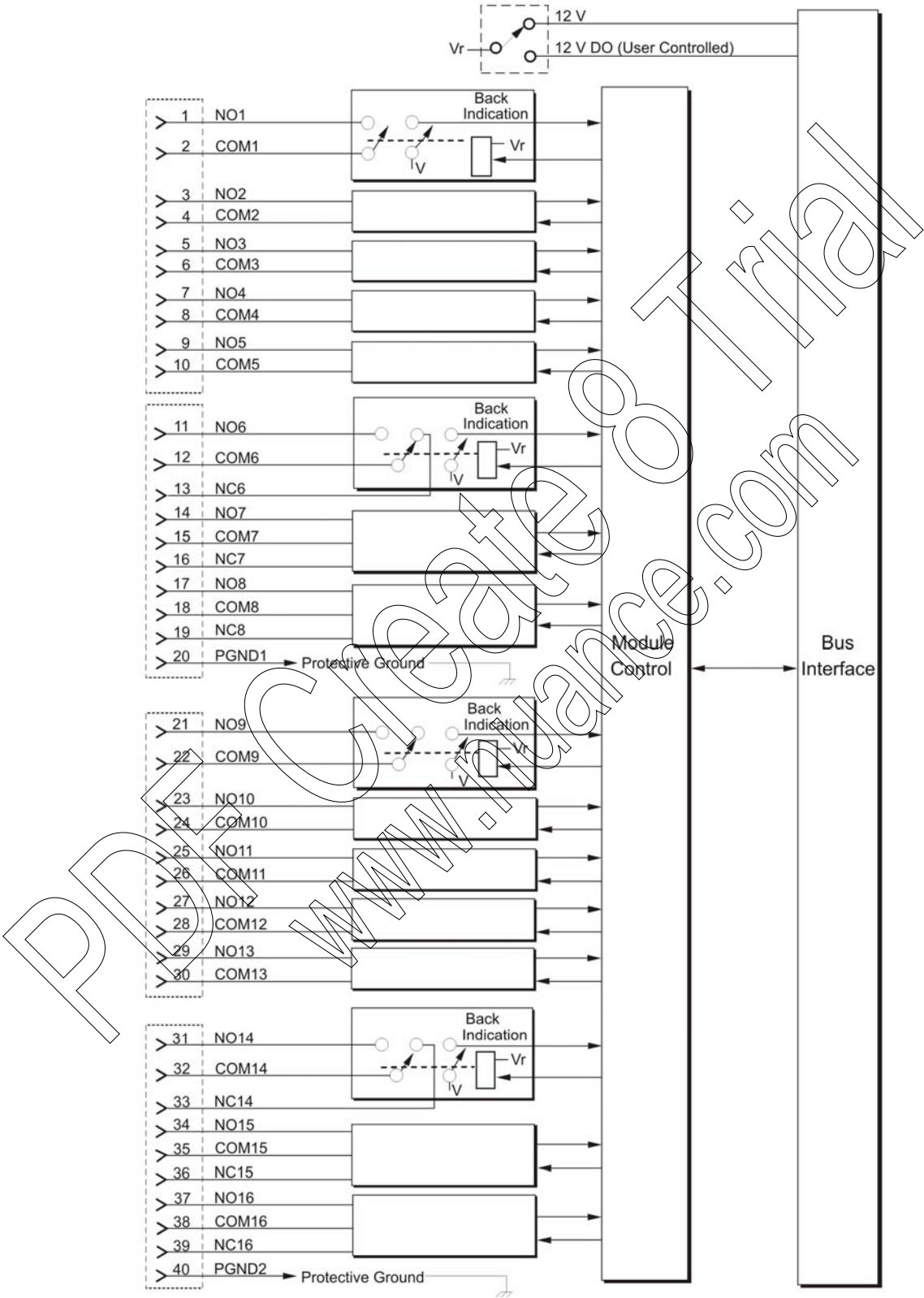
### DO ML Relay (SPDT) - Typical Output Circuit



8 DO Module Block Diagram



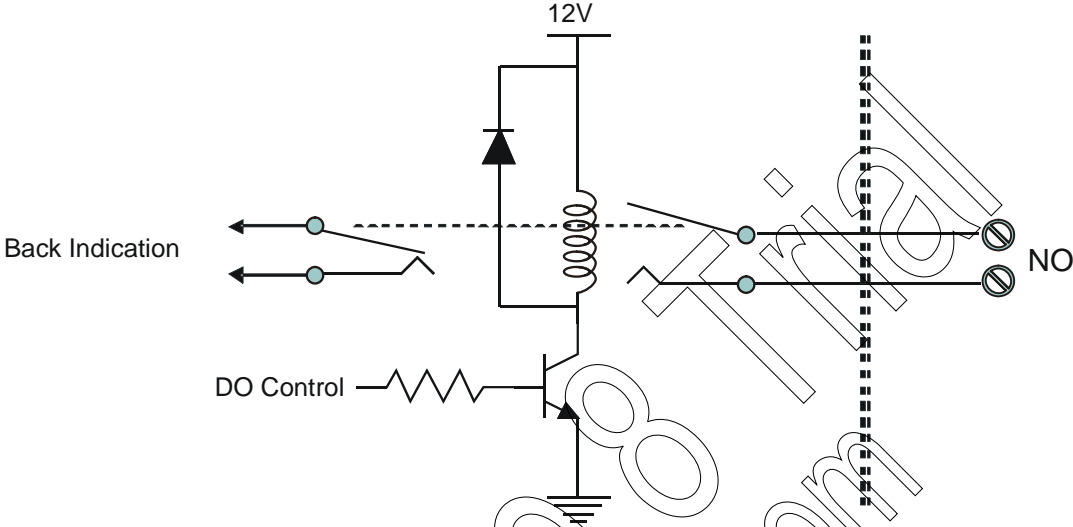
16 DO Module Block Diagram:



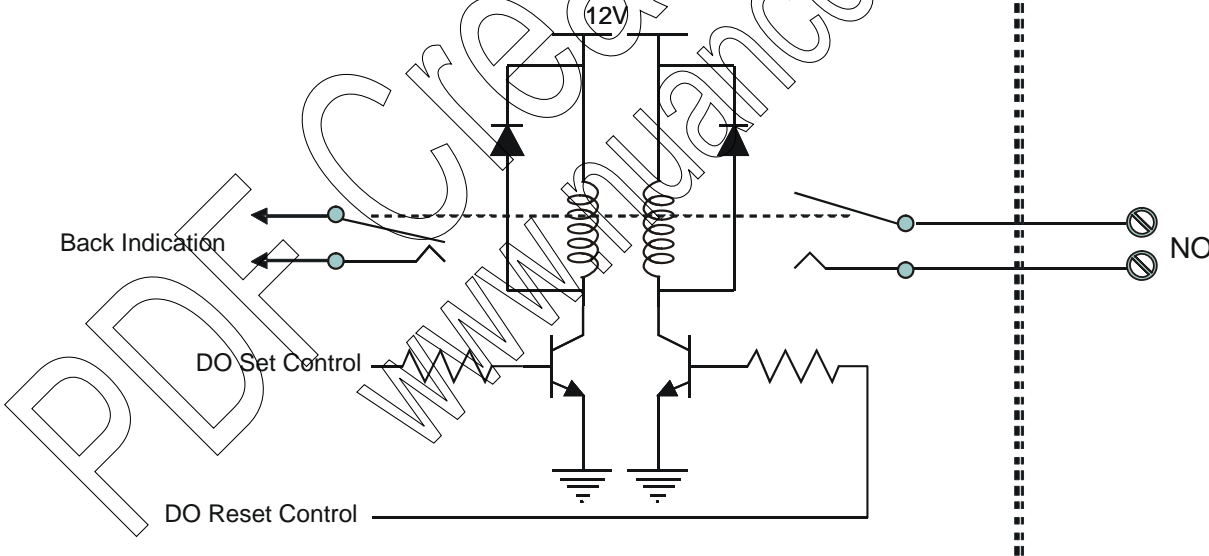


120/230V DO I/O Circuit Diagram:

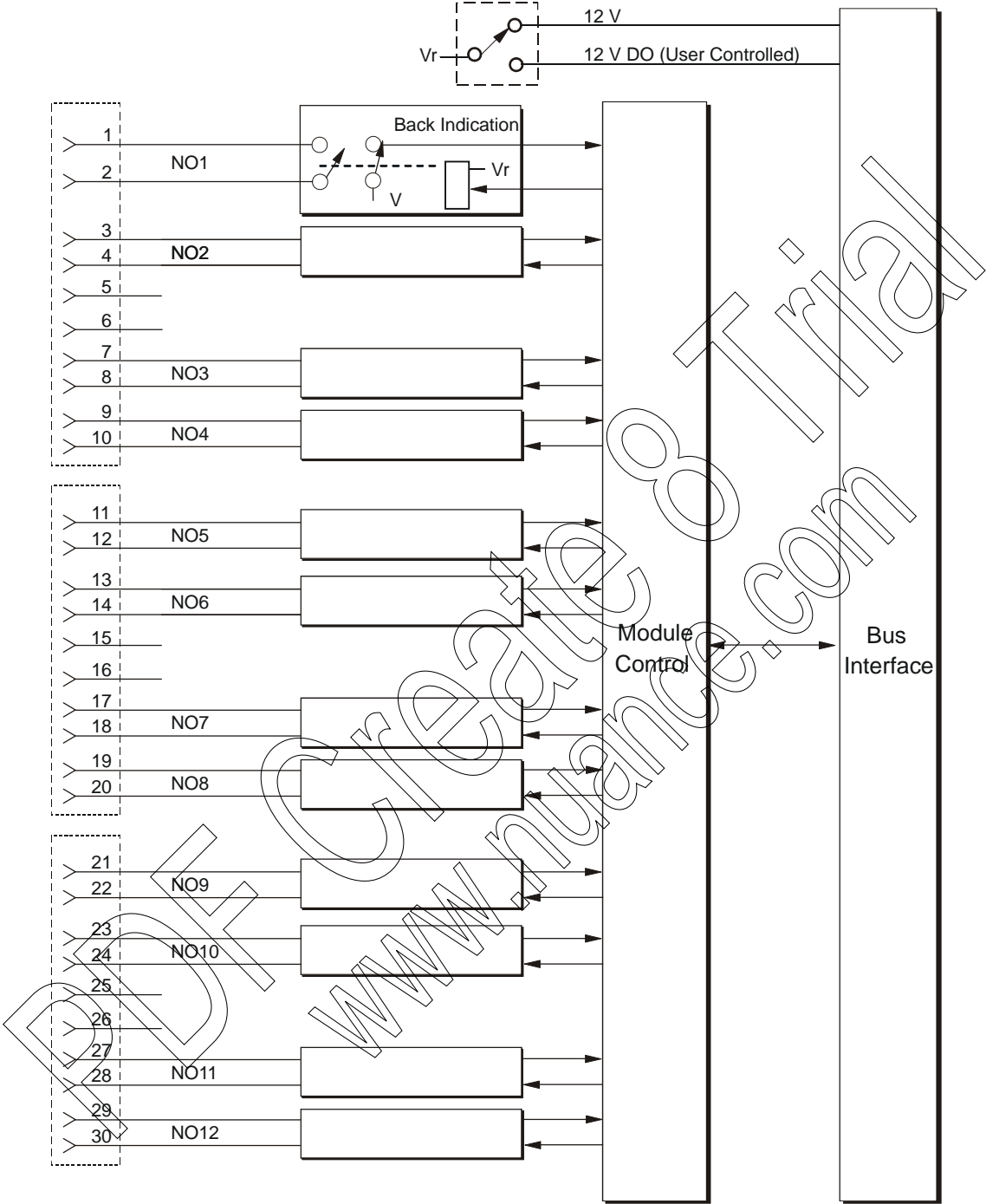
HV DO EE Relay (SPST) - Typical Output Circuit



HV DO ML Relay (SPST) - Typical Output Circuit



120/230V DO Module Block Diagram:



## Analog Input Modules

The Analog Input (AI) modules have 8 or 16 inputs. The modules sample and convert analog data into digital format and transfer the digital data to the CPU module.

The following modules are available:

- 8 AI,  $\pm 20$  mA (supports 4-20 mA)
- 16 AI,  $\pm 20$  mA (supports 4-20 mA)
- 8 AI,  $\pm 5$  V (supports 0-5 V and 1-5 V)
- 16 AI,  $\pm 5$  V (supports 0-5 V and 1-5 V)

The module's analog-to-digital conversion resolution is 16 bit (including sign). Each input is fully isolated from the other inputs on the module and also optically isolated from the module internal circuits. The modules are fully calibrated and can be tested and recalibrated in the field.

The measured values are digitally filtered to reduce 50 or 60 Hz noise. The user can select the filtering frequency per module. The measured values can be smoothed by digital filtering.

Smoothing is accomplished by calculating the running average values of a defined number of converted analog values (samples). The user can select the level of smoothing per module. The higher the smoothing level chosen, the more stable the smoothed analog value and the longer it takes until the smoothed analog signal is applied after a step response.

The user can select how the analog values are represented to the user application program, as unit-less numeric values or as scaled values that represent certain Engineering Units (EGU).

Each AI module can include an optional plug-in floating 24V DC power supply to power external devices.

Each analog input has two status LEDs:

- UF - indicates Underflow when lit
- OF - indicates Overflow when lit

The AI Module Configuration includes:

- 50/60 Hz Filtering - This parameter enables the user to configure the module to use 50 or 60 Hz filter on all inputs.
- AI Filter (Smoothing) - This parameter enables the user to configure the level smoothing (averaging) on all inputs. It can be set to 1, 2, 4, 8, 16, 32, 64, 128 samples.
- Change Of State (COS) Delta - This parameter sets a delta value for each input. This enables the user application program to get an indication when the input value change is more than  $\pm$  delta value.
- Input Range - This parameter sets the input overflow and underflow LEDs limits (refer to AI Module value representation below). In the current input modules, the ranges that can be selected are:  $\pm 20$  mA (default) and 4-20 mA. In voltage input modules, the ranges that can be selected are  $\pm 5$  V (default), 0-5 V and 1-5 V.
- “Keep Last Value” (KLV) and “Predefined Value” (PDV) - Each input can be configured to KLV or to a PDV. This value is shown to the user application program in the event of AI module failure. The predefined value can also be used during normal operation to force a value that masks the actual input value. In this case the user program will get the PDV instead of the actual input value.
- I/O Legacy Resolution Parameter - In systems with both ACE3600 RTUs and legacy (MOSCAD/MOSCAD-L) RTUs, some MOSCAD/MOSCAD-L applications can be upgraded to ACE3600 without modifying the references to analog values in the applications (‘C’ or ladder). The I/O Legacy Resolution STS advanced parameter sets the Analog I/O bit resolution to either Actual (ACE3600) or Legacy (MOSCAD/MOSCAD-L).

Parameter	Selection	Default setup	Per Module/ Input	Parameter Setup location
50/60 Hz Filtering	50/60	50 Hz	Module	STS Site configuration
AI Filter (Smoothing)	1/2/4/8/16/32/64/128 (x10 mS)	32	Module	STS Site configuration
Input Range	Current: $\pm 20$ mA/ 4-20 mA Voltage: $\pm 5$ V/0-5V/ 1-5V	Current: $\pm 20$ mA Voltage: $\pm 5$ V	Module	STS Site configuration
COS Delta	value	0 (disabled)	Input	Application Programmer I/O link table
KLV & PDV	KLV/PDV PDV=value	KLV	Input	Application Programmer I/O link table
Mask	No /Yes	No	Input	Application Programmer I/O link table

In the event of AI Module failure, the I/O module ERR LED will be lit. The event is registered by the CPU in the Error Logger. AI Module failure status is also visible to the user application program.

In addition to the ERR LED, the module includes an Underflow (UDF) and Overflow (OVF) LED for each input.

- When the UDF LED is lit, it indicates that the signal level in the corresponding input is below the nominal range.
- When the OVF LED is lit, this indicates that the signal level in the corresponding input is above the nominal range.
- If both the UDF and OVF LEDs of the same channel are lit, the channel is uncalibrated.

The AI module can be diagnosed and monitored using the STS Hardware Test utility. The Hardware Test verifies that the module is operational, presents the module configuration and shows the actual value of each input, including overflow and underflow. It is also possible to change the input filter setup for the duration of the Hardware Test.

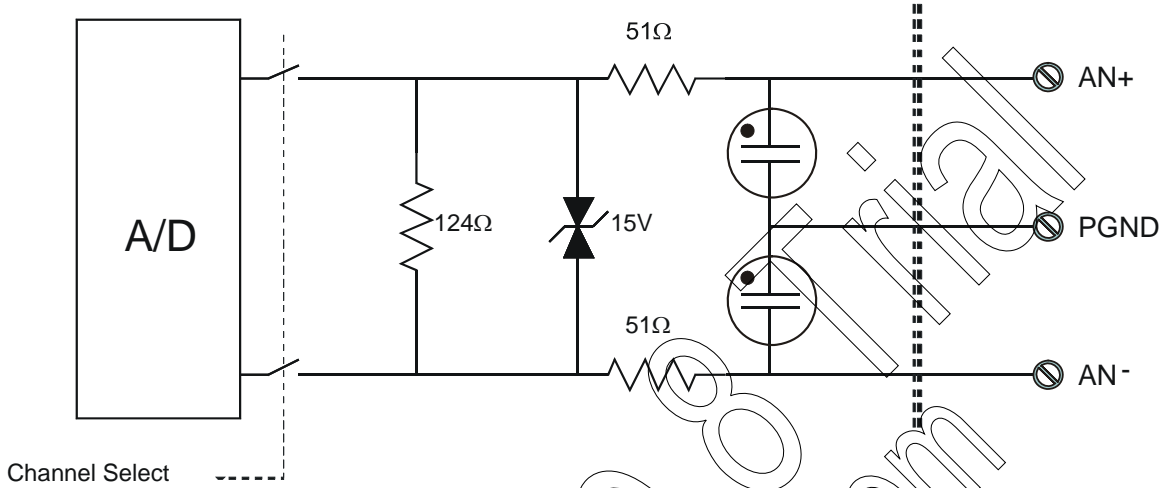
In the Hardware Test utility, it is possible to set the AI module to Freeze Mode. In this mode, the program user will get the KLV or PDV of each input in the module instead of the actual input value. Freeze mode enables testing the inputs while the user application program is running.

## AI Module Value Representation:

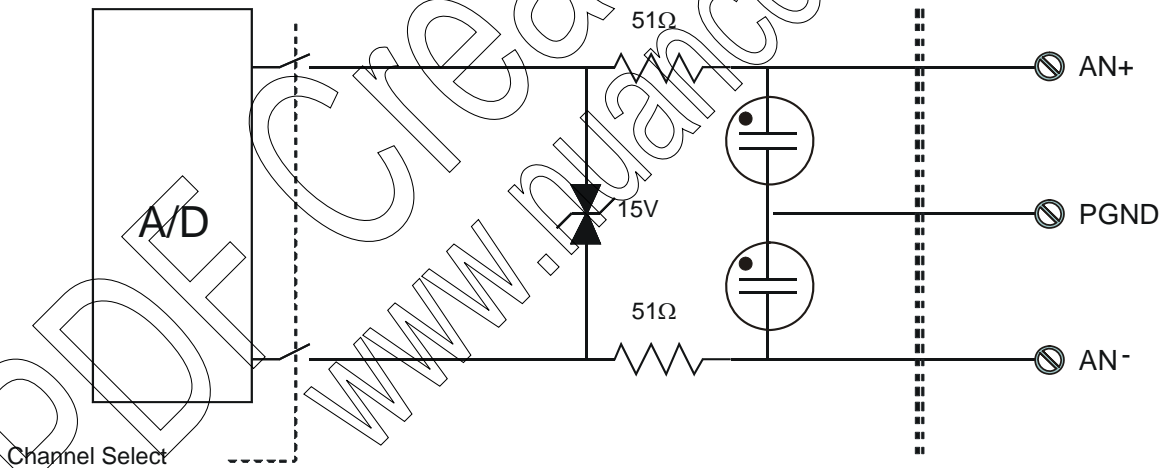
In $\pm$ 20 mA current inputs	Decimal Value	Input Current	Indication
	< -32256	< -20.16 mA	Underflow LED ON
	-32000	-20 mA	Rated range (no LED active)
	0	0 mA	
	32000	+20 mA	
	> 32256	> +20.16 mA	Overflow LED ON
In 4 - 20 mA current inputs	Decimal Value	Input Current	Indication
	< 6144	< 3.84 mA	Underflow LED ON
	6400	+4 mA	Rated range (no LED active)
	0	0 mA	
	32000	+20 mA	
	> 32256	> +20.16 mA	Overflow LED ON
In $\pm$ 5 V current inputs	Decimal Value	Input Voltage	Indication
	< -32256	< -5.04 V	Underflow LED ON
	-32000	-5 V	Rated range (no LED active)
	0	0 V	
	32000	+5 V	
	> 32256	> +5.04 V	Overflow LED ON
In 0 - 5 V current inputs	Decimal Value	Input Voltage	Indication
	< -256	< -0.04 V	Underflow LED ON
	0	0 V	Rated range (no LED active)
	32000	+5 V	
	> 32256	> +5.04 V	Overflow LED ON
In 1 - 5 V current inputs	Decimal Value	Input Voltage	Indication
	< 6144	< 0.96 V	Underflow LED ON
	6400	1 V	Rated range (no LED active)
	32000	+5 V	
	> 32256	> 5.04 V	Overflow LED ON

I/O Circuit Diagram:

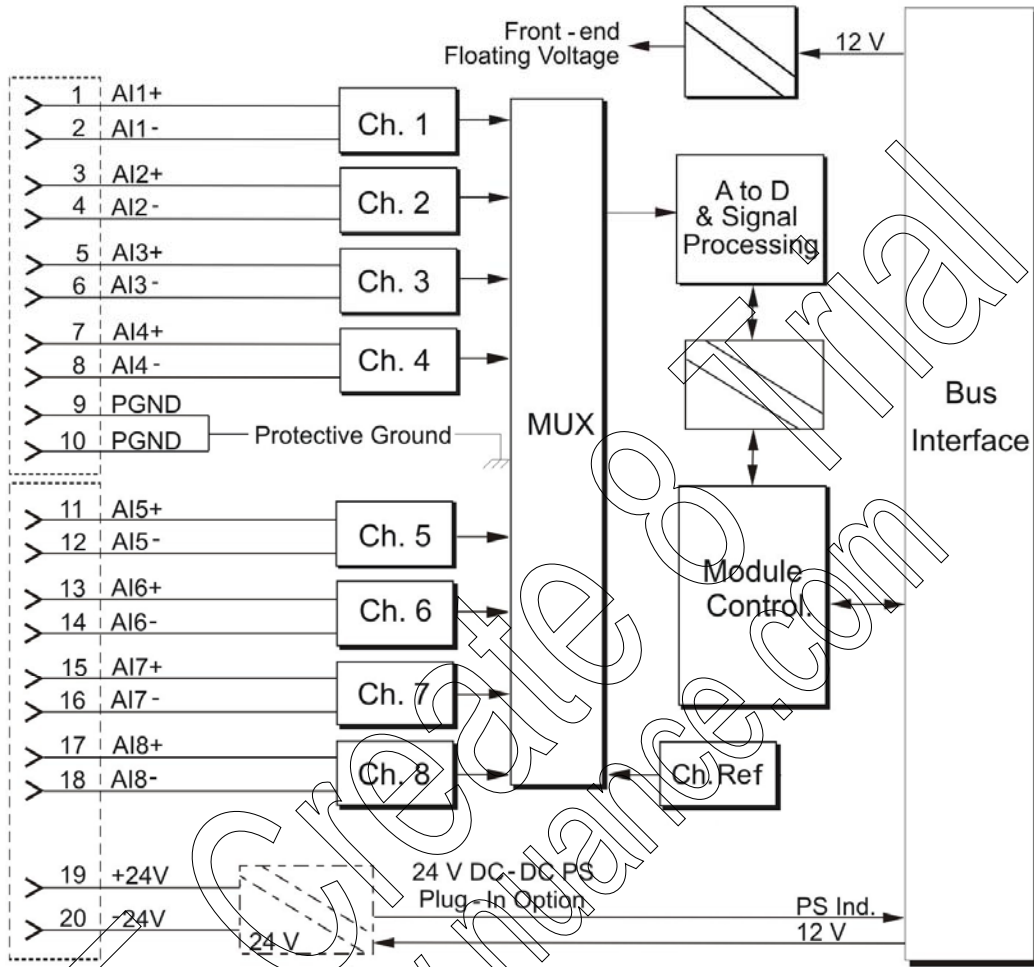
AI  $\pm 20$  mA - Typical Input Circuit



AI  $\pm 10$  V - Typical Input Circuit



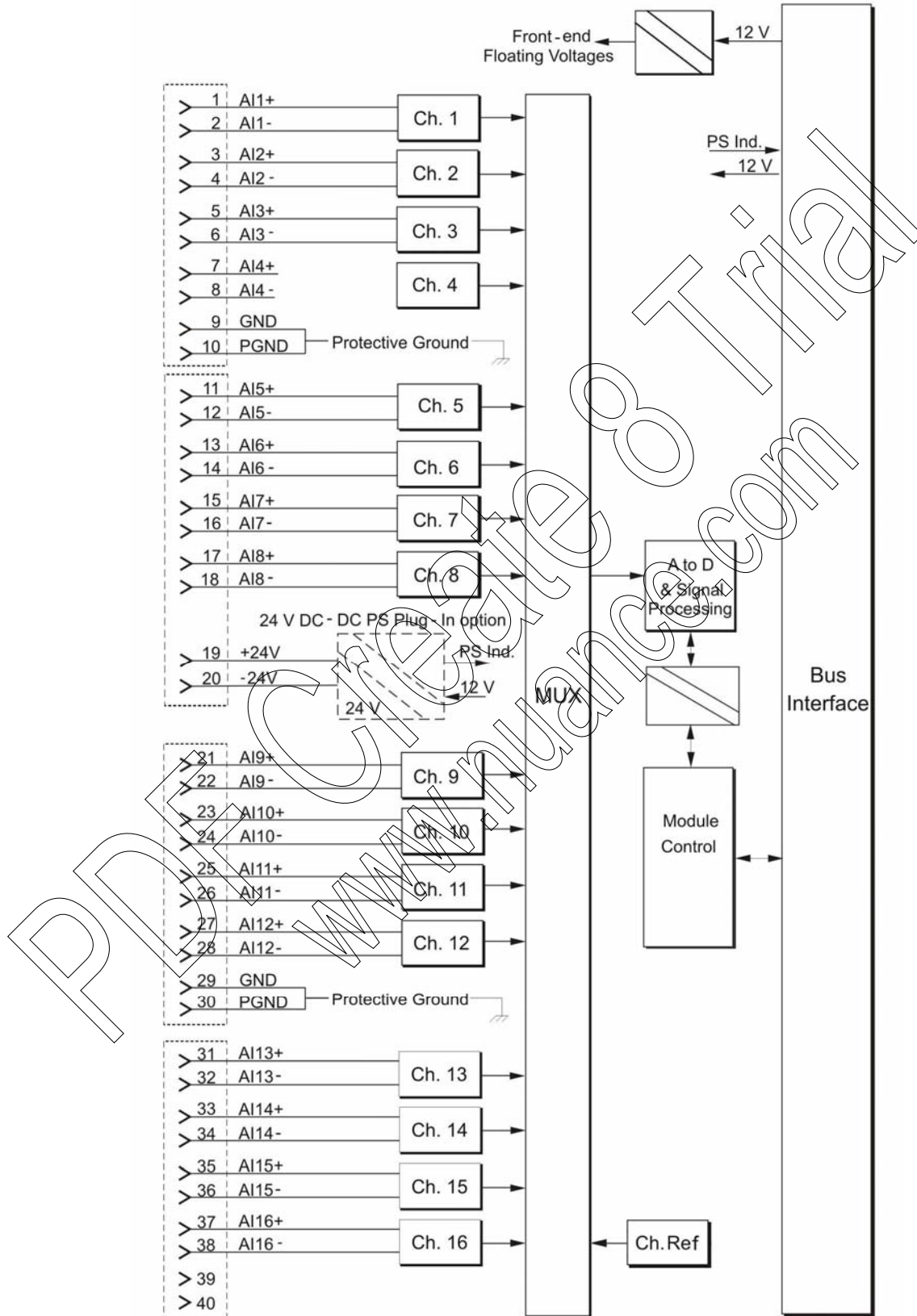
8 AI Module Block Diagram:



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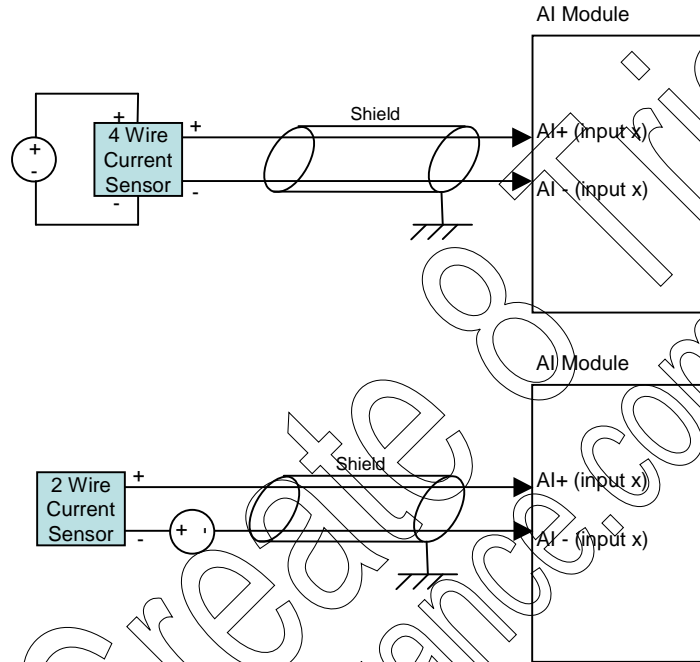


16 AI Module Block Diagram:

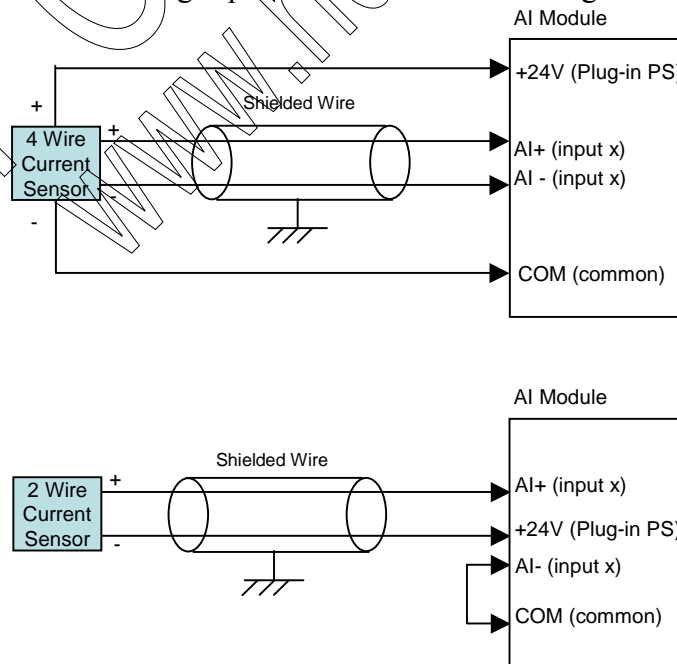


**I/O Connection Diagrams:**

There are two types of current sensors/transmitters, namely 2-wire and 4-wire. The 2-wire transmitters require a serial power feed for the current loop, whereas 4-wire transmitters have a separate power supply connection. As a result, with 4-wire transmitters a single power supply may be used to provide power to several sensors; the diagram below describes the connection of the two types of current sensors to the analog input module.



The diagram below describes the connection of 2-wire and 4-wire current sensors using the 24V PS plug-in on the Analog Input module. Note: 24V Plug-in is a future option.



## Analog Output Modules

The Analog Output (AO) modules have four optically-isolated analog output channels for controlling user devices (see Figure 1). Each channel has two possible outputs: 0-20 mA Interface industry standard current output and 0-5 V Interface industry standard voltage output. Only one of the outputs can be enabled in a particular channel - either current or voltage.

The module's digital to analog converter resolution is 14 bit. The Analog Output channels are optically isolated from the module internal logic circuits. The modules are fully calibrated and can be tested and recalibrated in the field.

Each analog output has three status LEDs, Vout, Iout, and CAL which represent the calibration status of each output for voltage/current.

The AO Module Configuration includes:

- AO Type - The analog outputs can be set to voltage, current, or raw data.
- AO Value - The analog outputs can be set to a numeric value (in the range of 0 to 16000) or either in voltage or current according to the output type. The values for voltage are 0 to 10 V and the values for current are 0 to 20 mA.
- AO Calibration - The upper and lower limits of analog outputs can be calibrated - either as current (20mA upper limit and 4mA lower limit) or voltage (10V upper limit and 2V lower limit). Default upper and lower calibration limits are provided from the factory.
- "Keep Last Value" (KLV) and "Predefined Value" (PDV) - Each output can be configured to KLV or to a PDV. This value is maintained in the event of AO module failure or communication failure with the CPU. The predefined value can also be used during normal operation to force a value that masks the actual output value.
- Sleep Mode - Each AO module can be switched by the user application program to Sleep Mode. In Sleep Mode, the module does not function and the power consumption is minimized. During Sleep mode the user application program will get the predefined values for each output.
- I/O Legacy Resolution Parameter - In systems with both ACE3600 RTUs and legacy (MOSCAD/MOSCAD-L) RTUs, some MOSCAD/MOSCAD-L applications can be upgraded to ACE3600 without modifying the references to analog values in the applications ('C' or ladder). The I/O Legacy Resolution STS advanced parameter sets the Analog I/O bit resolution to either Actual (ACE3600) or Legacy (MOSCAD/MOSCAD-L).

Parameter	Selection	Default setup	Per Module / Output	Parameter Setup location
AO Type	Voltage/Current	User Defined	Output	STS HW Test/User application program
AO Value	Voltage - 0 to 10 V Current - 0 to 20 mA	User Defined	Output	STS HW Test/User application program
AO Calibration	Voltage - 2 to 10 V Current - 4 to 20 mA	Voltage - 2 to 10 V Current - 4 to 20 mA	Output	STS HW Test
KLV & PDV	KLV/PDV PDV=value	KLV	Output	Application Programmer I/O link table
Mask	No /Yes	No	Output	Application Programmer I/O link table

In the event of AO Module failure, the I/O module ERR LED will be lit. The event is registered by the CPU in the Error Logger. AO Module failure status is also visible to the user application program.

In addition to the ERR LED, the module includes a voltage output (Vout), current output (Iout), and calibration (CAL) LED for each output.

CAL	Vout	Iout	Indication
On	On	On	Neither output is calibrated.
On	Off	On	Iout is uncalibrated.
On	On	Off	Vout is uncalibrated.
Off	On	On	Both outputs are defined by the user, either using HW test or user application program to send raw data.
Off	On	Off	Vout is defined by the user, either using HW test or user application program.
Off	Off	On	Iout is defined by the user, either using HW test or user application program.

The AO module can be diagnosed and monitored using the STS Hardware Test utility. The Hardware Test verifies that the module is operational, shows the type and actual value of each output, enables calibration, and presents the ROM data calibration factors. The AO type can be set either in the user application program or in the Hardware Test.

To set the output value in the Hardware test, the user application program must be stopped or the AO module frozen. To calibrate the output in the Hardware test, the user application program must be stopped or the AO module frozen.

In the Hardware Test utility, it is possible to set the AO module to Freeze Mode. In this mode, the AOs will keep the last value they had at the time they were frozen. Freeze mode enables testing the inputs and outputs while the user program is running.

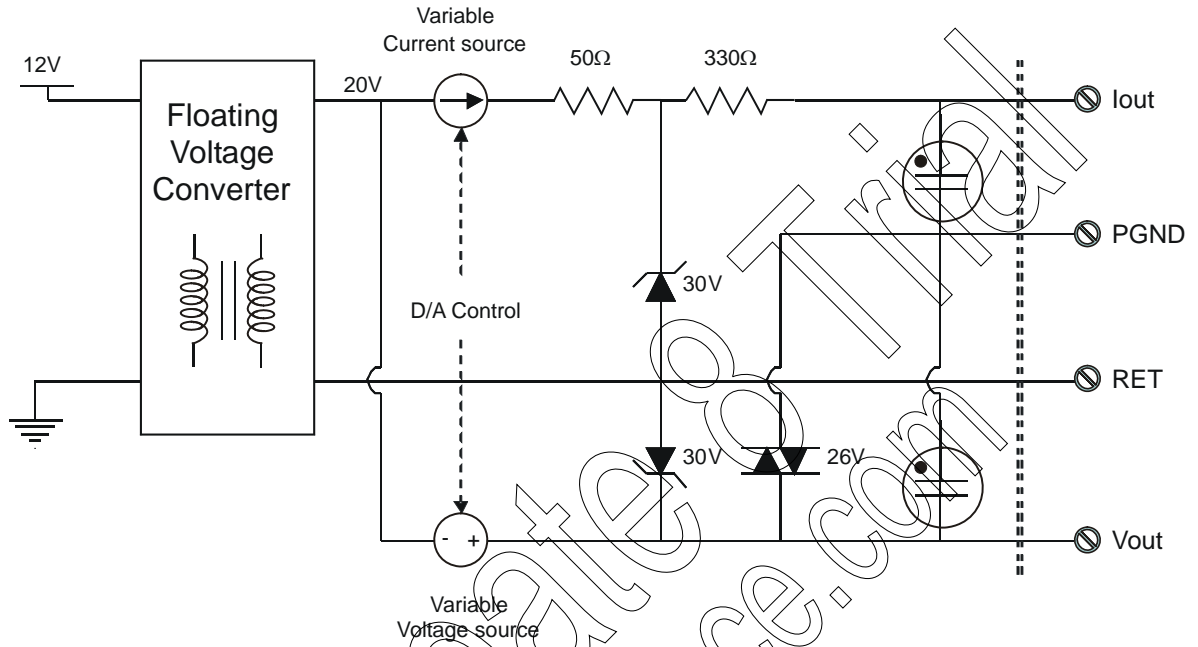
**AO Module Value Representation:**

In 0-20 mA current outputs	Decimal Value	Output Current
	0	0
	4000	5 mA
	8000	10 mA
	16000	20 mA
In 0- 10 V voltage outputs	Decimal Value	Output Voltage
	0	0 V
	4000	2.5 V
	8000	5 V
	16000	10 V

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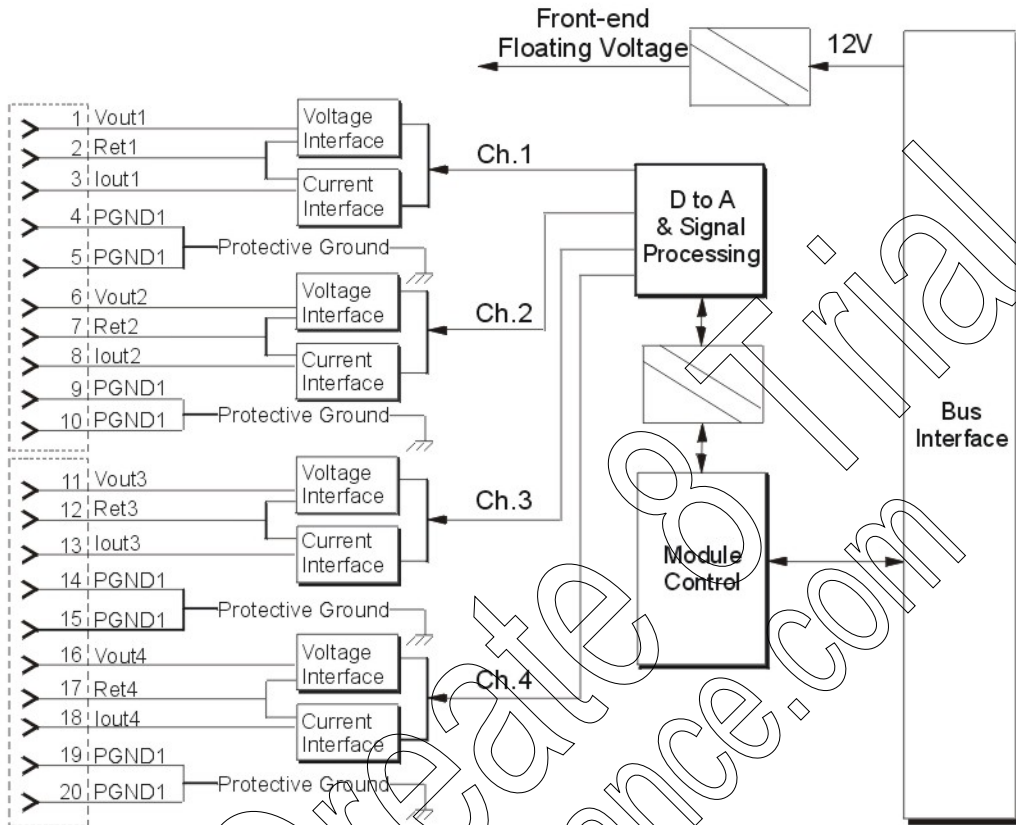
I/O Circuit Diagram:

AO - Typical Output Circuit



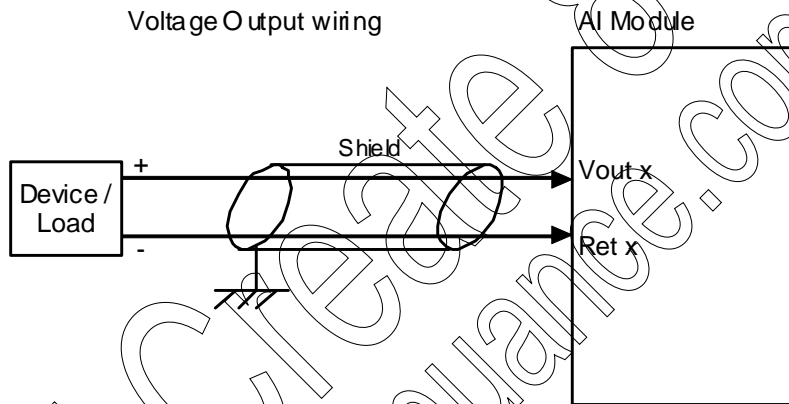
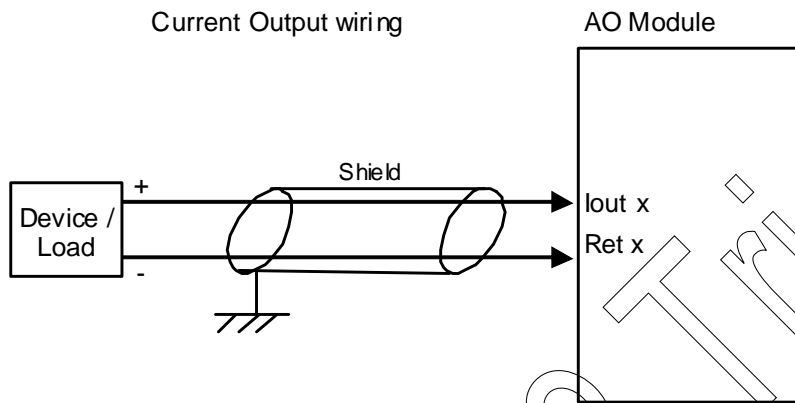
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4 AO Module Block Diagram:



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I/O Connection Diagram:





## Digital Output and Digital Input FET Modules

The Digital Output/Digital Input (DO/DI) FET modules have 16 or 32 configurable user connections, organized in groups. Each group can be configured as an 8 DO group or as an 8 DI group.

The outputs are optically isolated current sink FET type with back indication. The inputs are optically isolated Dry Contact type with internal “wetting” voltage.

In the 32 DO/DI module, the following I/O combinations can be configured in the ACE3600 STS site configuration:

I/O combination	DI location	DO location
32 DO	-	1-32
8 DI + 24 DO	1-8	9-32
16DI + 16 DO	1-16	17-32
24 DI + 8 DO	1-24	25-32
32 DI	1-32	-

In the 16 DO/DI module, the following I/O combinations can be configured in the ACE3600 STS site configuration:

I/O combination	DI location	DO location
16 DO	-	1-16
8 DI + 8 DO	1-8	9-16
16 DI	1-16	-

The appropriate combination is selected as the I/O module type, when configuring the I/Os in the ACE3600 STS site configuration.

Each DI can be configured as Fast Capture DI in the STS advanced I/O configuration. Fast capture causes the SCAN ladder output operation to get the first change that occurred since the previous scan. When fast capture is disabled (default), the scan gets the current value of the DI (in this case DI changes between scans are missed).

Each input has a hardware input filter to make sure that the input reading is stable. The hardware DI filter range is 0 to 50.8 mS (in 0.2 mS steps). Counter DI filter range is 0 to 12.75 mS (in 0.05 mS steps). The DI filter can be set in the STS advanced I/O configuration.

Note: In this module, the minimum effective filter value is 1 mS.

Each DI can be set in the Application Programmer I/O link table to trigger recording of time tagged events upon any input change of state. The time tagged events are recorded in the CPU memory and can be retrieved for various purposes.

Each input can be configured to KLV or to a PDV (0, 1) in the Application Programmer I/O link table. This value is shown to the user application program in the event of DI module failure. Also, the predefined value can be used during normal operation to force a value that masks the actual input value. In this case the user application program will get the PDV instead of the actual input value.

Each output can be configured to “Keep Last Value” KLV or to a “Predefined Value” PDV (0, 1). This value is executed when the user application program stops or when the module has no communication with the CPU module.

Also, the predefined value can be used during normal operation to force a value on the output by ignoring the user application program value.

The DO/DI FET module features which can be configured are listed in the table below. Some parameters are per module and some are per input.

Parameter	Selection	Default Setup	Per Module/ Input	Parameter Setup Location
DI Fast Capture	Disabled /Enabled	Disabled	Input	RTU configuration
DI Filter*	0-254 (x 0.2 mS)	50 (10 mS)	Module	RTU configuration; 'C' Program
DI Counter Filter*	0-255 (x 0.05 mS)	20 (1 ms)	Module	RTU configuration; 'C' Program
DI Event Time Tagging	Disabled /Enabled	Disabled	Input	Application Programmer I/O link table
DI Keep Last Value & Predefined Value	KLV/PDV PDV = 0/1	KLV	Input	Application Programmer I/O link table
DI Mask	No /Yes	No	Input	Application Programmer I/O link table
DO Keep Last Value & Predefined Value	KLV/PDV PDV = 0/1	KLV	Output	Application Programmer I/O link table

---

\* The counters are limited to 1Khz; therefore filtering is relevant from 1mS and above. In this module the minimum relevant value for DI Filter is 5 and the minimum value for DI Counter Filter is 20.

Parameter Selection		Default Setup	Per Module/ Input	Parameter Setup Location
DO Mask	No /Yes	No	Output	Application Programmer I/O link table

Each DO/DI module can be switched by the user application program to Sleep Mode. In Sleep Mode, the module does not function and the power consumption is minimized. During Sleep mode, the user application program will get the KLV or PDV per each DI.

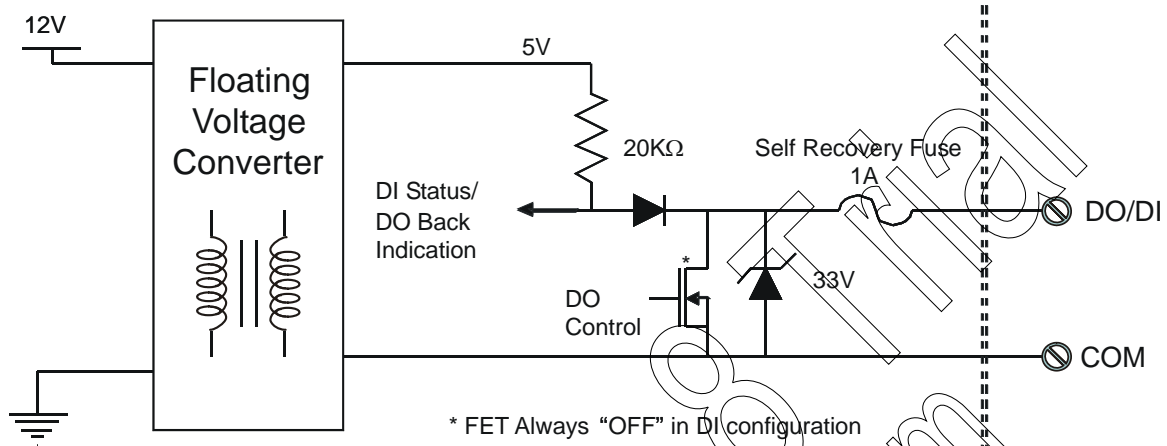
In the event of a DO/DI module failure, the ERR LED on the module will be lit. This event is registered by the CPU in the Error Logger. DO/DI module failure status is also visible to the user application program.

The DO/DI module can be diagnosed and monitored using the STS Hardware Test utility. The Hardware Test verifies that the module is operational, presents the module configuration and shows the actual value of each input and output. It is also possible to change the input filter setup for the duration of the Hardware test and change the value of the DOs.

In the Hardware Test utility, it is possible to set the module to Freeze Mode. In this mode the user application program will get the KLV/PDV of each input in the module instead of the actual input value. The DO values will keep the last value they had when the module was switched to Freeze Mode. Freeze mode enables testing the inputs and outputs while the user application program is running.

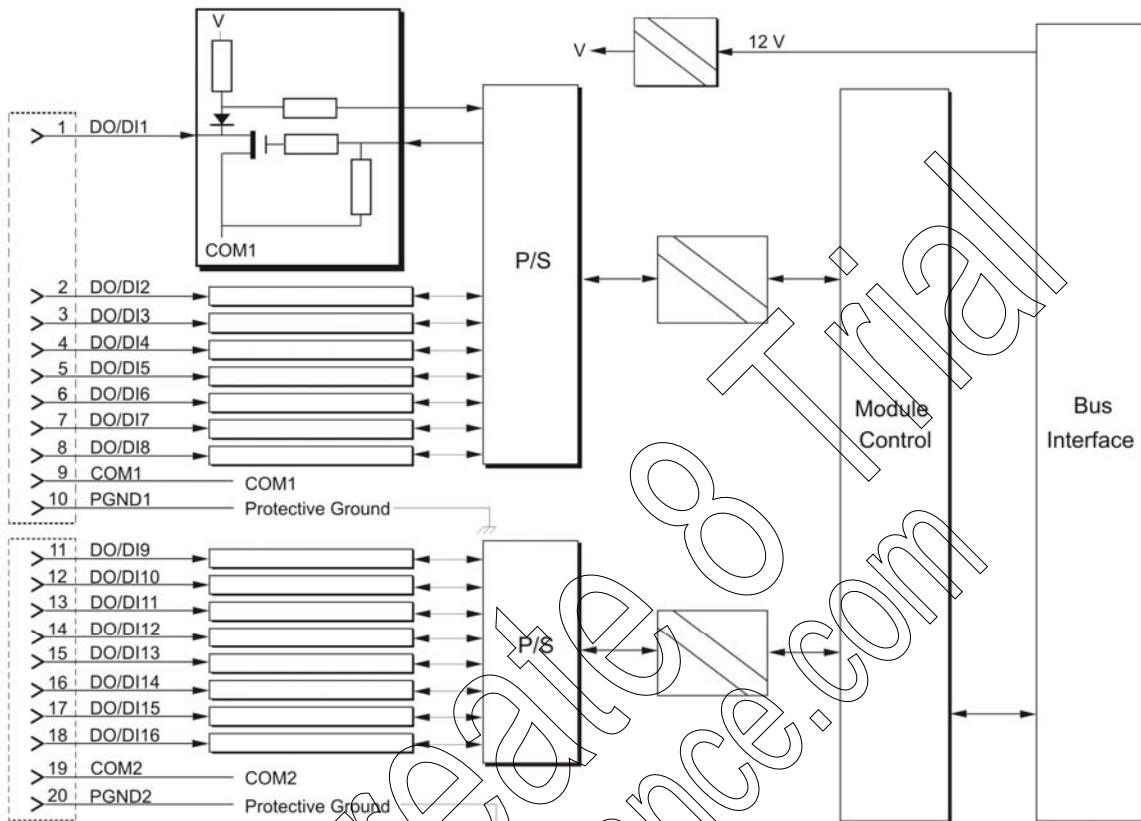
I/O Circuit Diagram:

DO/DI - Typical I/O Circuit



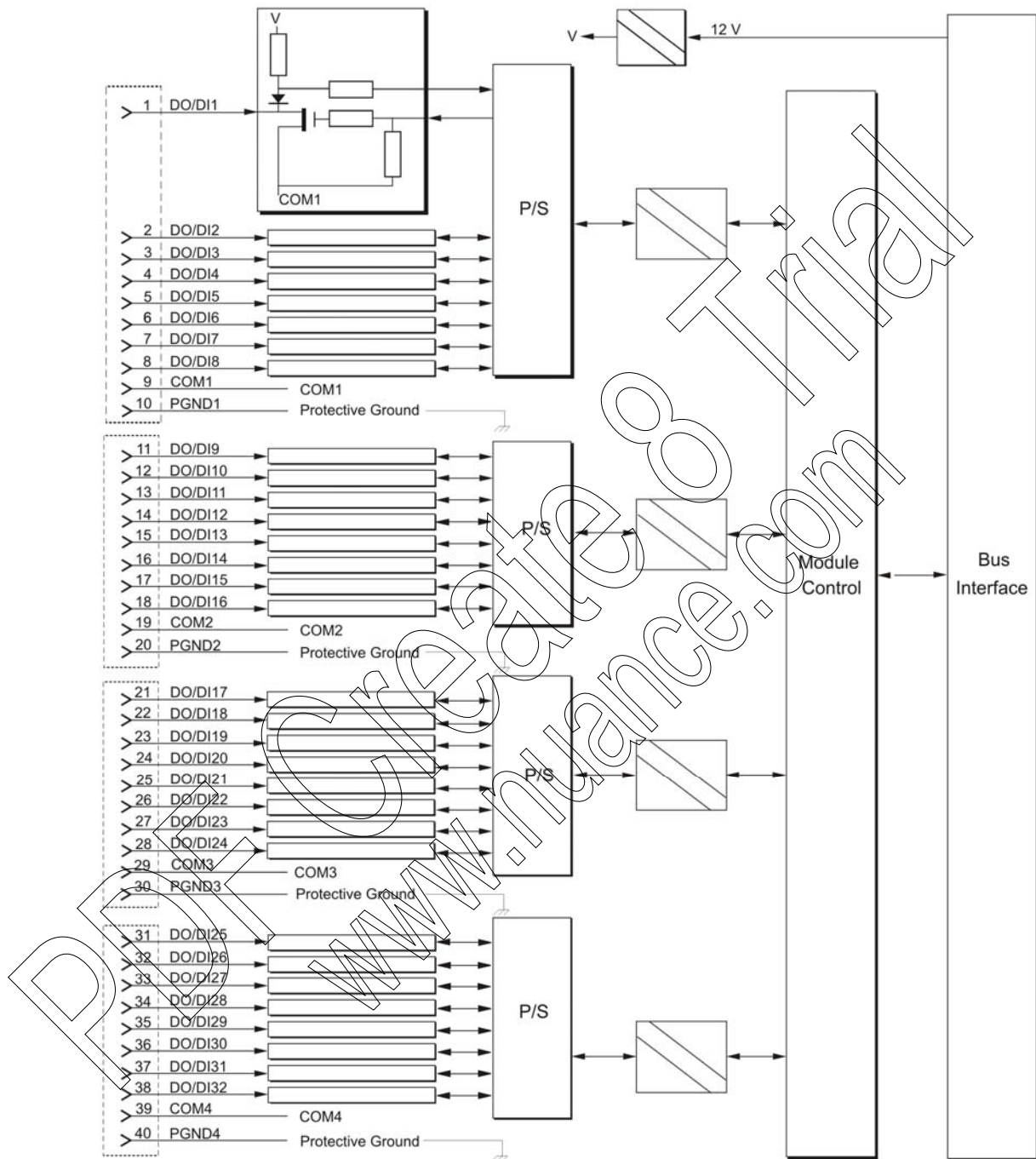
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16 DO/DI Module Block Diagram:



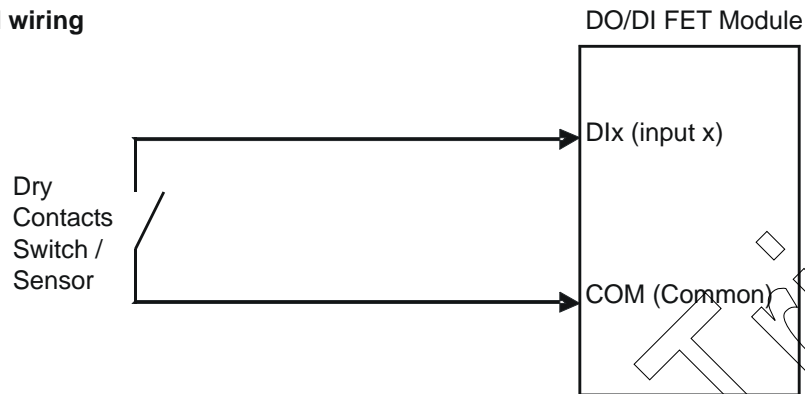
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32 DO/DI Module Block Diagram:

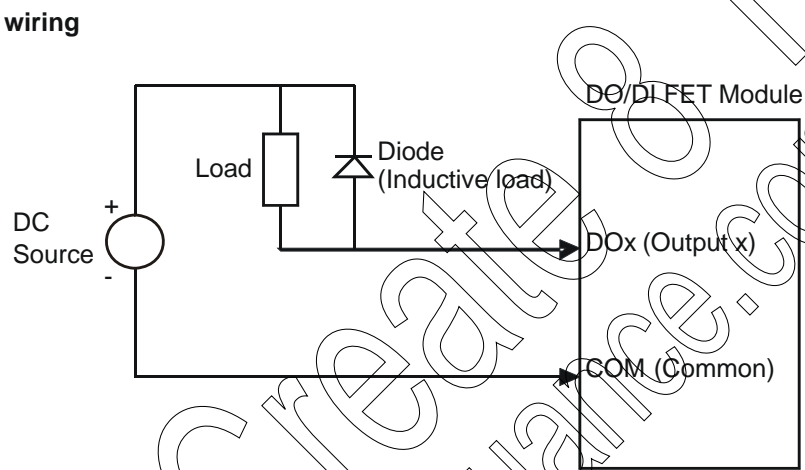


I/O Connection Diagram:

DI wiring



DO wiring



## Mixed I/O Modules

The ACE3600 Mixed I/O modules include a mixture of Digital Inputs, Relay Outputs and Analog Inputs on the same module.

The available Mixed I/O modules are:

- 16 Digital Inputs + 4 EE DO Relay Outputs + 4 Analog Inputs ( $\pm 20$  mA)
- 16 Digital Inputs + 4 ML DO Relay Outputs + 4 Analog Inputs ( $\pm 20$  mA)

For operation, description, and configuration of the DIs, refer to the Digital Input Modules chapter.

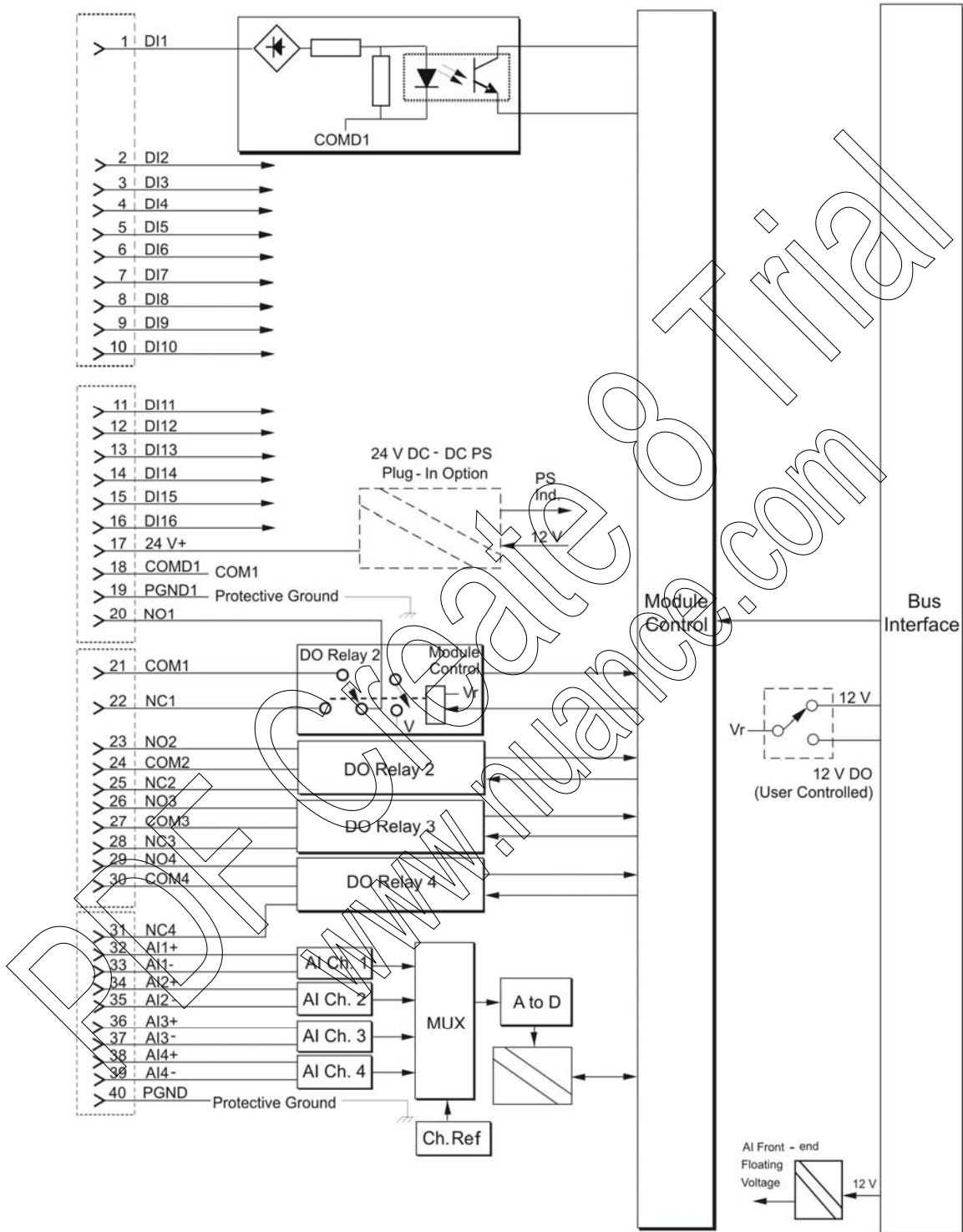
For operation, description, and configuration of the DOs, refer to the Digital Output Relay Modules chapter.

For operation, description, and configuration of the AIs, refer to the Analog Input Modules chapter.

For operation, description, and configuration of the AOs, refer to the Analog Output Modules chapter.



Mixed I/O Module Block Diagram:



## Mixed Analog Modules

The ACE3600 Mixed Analog modules include a mixture of Analog Inputs and Analog Outputs on the same module.

The available Mixed Analog modules are:

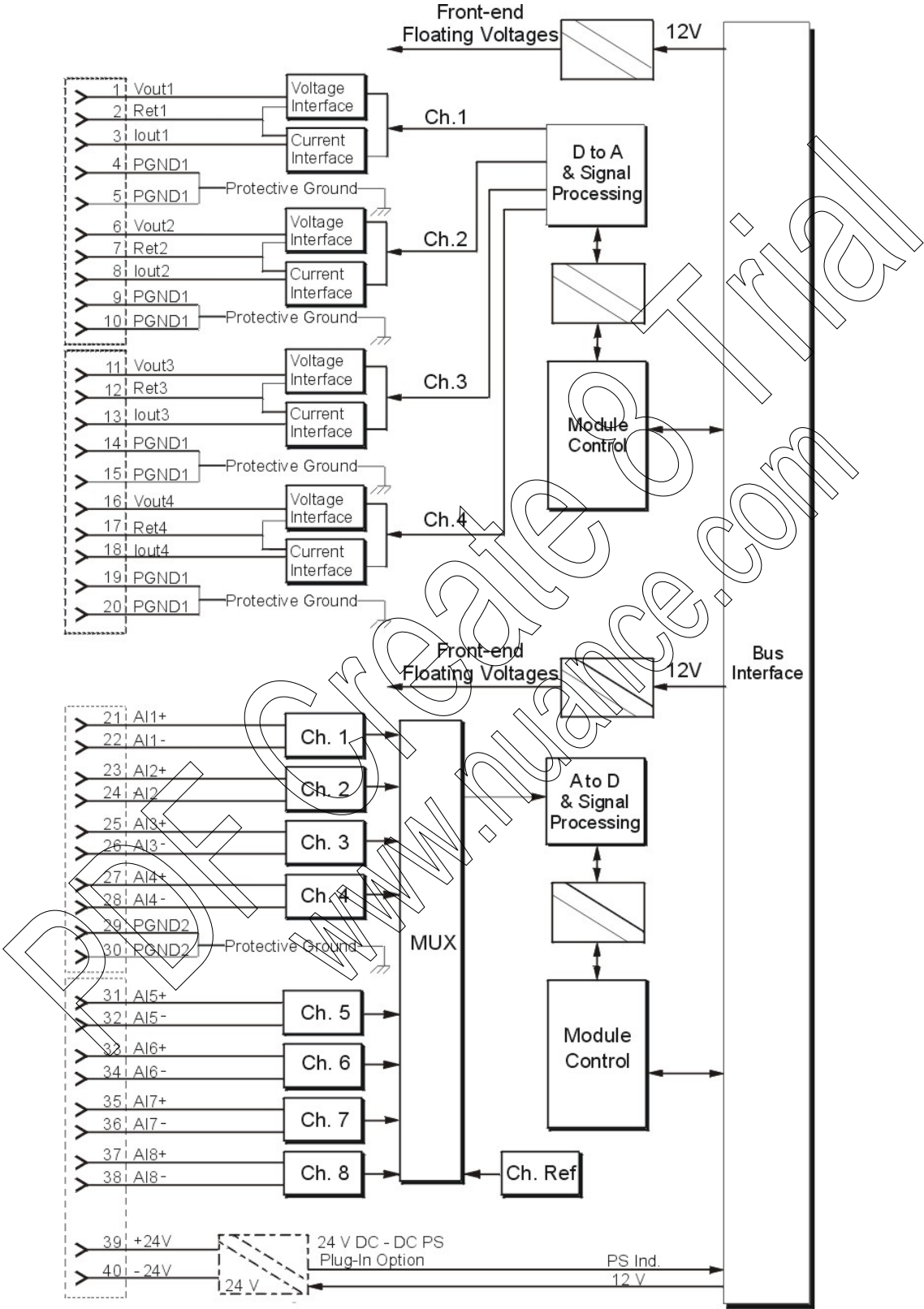
- 4 Analog Outputs + 8 Analog Inputs (0-20 mA)
- 4 Analog Outputs + 8 Analog Inputs (0-10V)

For a description of the AIs in the Mixed Analog modules, see the Analog Input Modules chapter. For a description of the AOs in the Mixed Analog modules, see the Analog Output Modules chapter.

The Mixed Analog modules support an optional 24V DC floating plug-in power supply to power external devices.

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Mixed Analog Module Block Diagram:



## I/O Expansion

The ACE3600 RTU includes the option of expanding the number of I/O modules controlled by a single CPU module on the main frame. The I/O expansion frames can be co-located with RTU on the main frame (installed in the same 19" rack or cabinet) or distributed in the same site (up to 50 meters from the main frame.)

I/O expansion is based on a 100 Base-T full duplex Ethernet connection between the CPU module and the expansion modules. This type of connection enables the user program application to control and monitor the I/O modules on the expansion frames transparently as if they are located on the main frame.

The user can diagnose all the modules on the expansion frames using the STS connected to the CPU on the main frame (locally or remotely.) The STS can also be connected locally to the expansion module's RS232 (STS1) port.

I/O expansion is based on three modules:

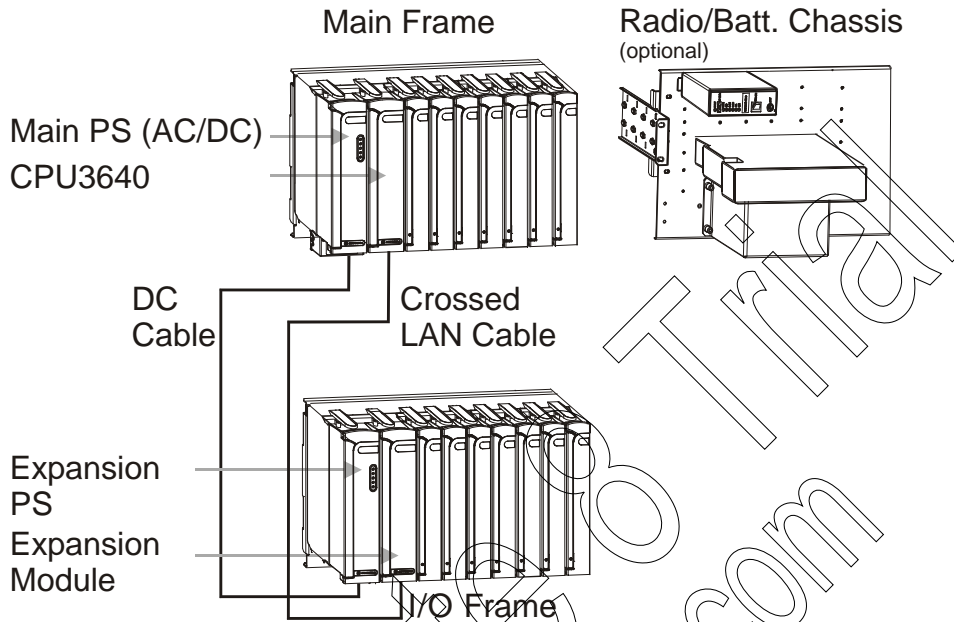
- **Expansion LAN Switch:** This module is part of the expansion frame. It is installed in the main frame in an I/O module slot. Up to seven expansion frames can be connected through a single expansion LAN switch. (For one expansion frame, the switch is not required.) Eight to thirteen expansion frames can be connected using a combination of two expansion LAN switches.
- **Expansion Power Supply:** This module is installed in the I/O expansion frame. It extends power (and 12V DC control) from the power supply on the RTU's main frame to the I/O expansion frame, or from one I/O expansion frame to another. This module can be replaced by another ACE3600 power supply option per power requirements or when the expansion frame is not co-located with the main frame.
- **Expansion Module:** This module is part of the expansion frame. It is installed in the I/O expansion frame next to the power supply. It is connected via LAN to the RTU's main frame, either to the CPU module or to the expansion LAN switch, depending on the configuration. For more information, see Expansion Module below.

Note: Only a dedicated LAN with ACE3600 components should be used by the main CPU and expansion modules to communicate with each other. Connecting other elements such as routers and other devices to the LAN may disrupt the I/O expansion system operation.

Note: The main CPU must include an Eth1 Ethernet port. Therefore, only the CPU 3640 can be used for I/O expansion on the main frame.

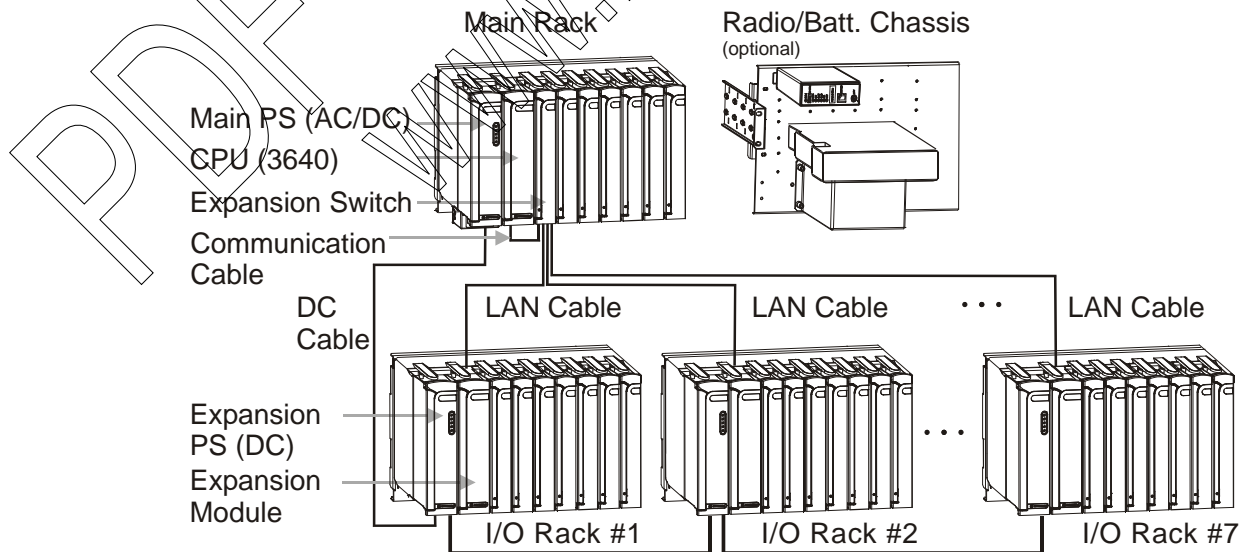
The figure below provides a general view of an ACE3600 CPU with a single I/O expansion frame. The expansion module on the I/O expansion frame is connected using a crossed LAN cable to the CPU3640 on the main frame (Port Eth1.) The expansion power supply on the I/O expansion frame is attached via DC cable to the power supply on

the main frame. Accessories such as a mobile radio, battery, etc. are attached to a separate optional 19" chassis.



**ACE3600 I/O Expansion – Single Frame Example**

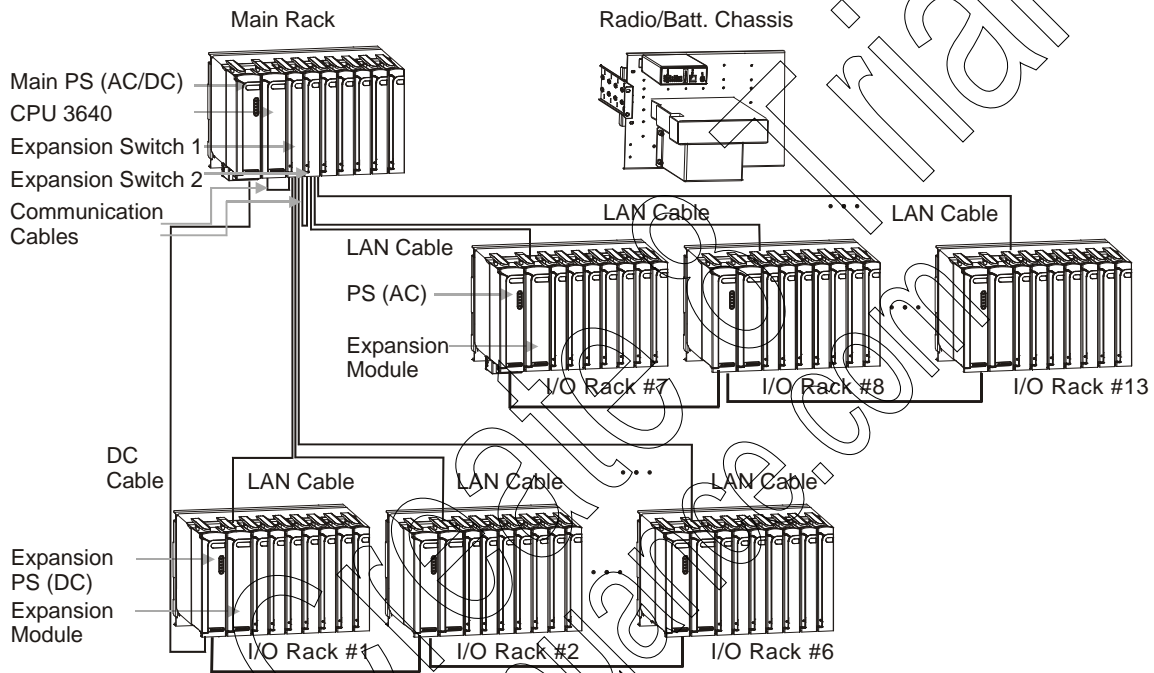
The figure below provides a general view of an ACE3600 CPU with a single I/O expansion frame. The expansion module on the I/O expansion frame is connected using a crossed LAN cable to the CPU3640 on the main frame (Port Eth1.) The expansion power supply on the I/O expansion frame is attached via DC cable to the power supply on the main frame. Accessories such as a mobile radio, battery, etc. are attached to a separate optional 19" chassis.



**ACE3600 I/O Expansion – Multi-Frame Example**

Note: The number of expansion power supplies that can be cascaded to the power supply on the main frame is limited. When required, optional DC or AC power supplies should be installed on the expansion frames to meet the accumulated power consumption and voltage level requirements.

In the maximal configuration, up to 110 I/Os can be connected to the ACE3600, by using two expansion Ethernet switches on the main frame and thirteen I/O expansion frames. See the figure below.



**ACE3600 I/O Expansion – Maximal I/O Configuration**

The following table shows the various configurations per required number of I/O slots:

Number of I/O Slots	0-8	9-16	17-23	24-31	32-39	40-47	48-55	56-63	64-70	71-78	79-86	87-94	95-102	103-110
Main Frame F75xx	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LAN Switch option	0	0	1	1	1	1	1	1	2	2	2	2	2	2
Exp. Frame F7510	0	1	2	3	4	5	6	7	8	9	10	11	12	13
LAN Cable	0	0	2	3	4	5	6	7	8	9	10	11	12	13
LAN Crossed Cable	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Note: This table assumes the main frame and expansion frames have 8 I/O slots (use option V108).

### ***I/O Expansion Frame***

An I/O expansion frame always includes an expansion module to enable the CPU in the main frame to communicate with and control the expansion frame and its I/O modules. The expansion module is provided with each expansion frame (model F7510). Like the ACE3600 main frame, the I/O expansion frame can contain 3, 5, 7 or 8 I/O slots. The expansion frame is compatible with the chassis and housing options.

### ***I/O Expansion Power***

The choice of power supplies for a system with I/O expansion is determined by the specific configuration and the power requirements of the system. In a co-located system where the power supply on the main frame feeds the I/O expansion frame, a low-tier power supply cannot serve as the main power supply. In a distributed system where the power supply on the I/O expansion frame is not connected to the main frame, any power supply modules can be used which suit the power requirements of the system. When applicable, it is recommended to have an external single power on/off switch to control all the power supplies simultaneously. Similarly, it is very important to have a single on/off switch for all 12V DO controls.

### ***Power-up/Restart/Power-down***

In a system where the power supply on the main frame feeds the I/O expansion frame, powering up/restarting the main power supply will power-up/restart the expansion frames as well. Power down of the main power supply will power-down the expansion frames as well. In a system where the power supply on the I/O expansion frame is not connected to the main frame, powering down or restarting the main power supply will not impact the I/Os on the expansion frame I/Os. However, these expansion I/Os may be reset after a period of time as a result of this action. If the expansion frame loses communication with the main frame for more than a certain number of seconds (configurable), it will restart. For information on configurable timeouts which may cause the expansion module to restart, see the ACE3600 STS User Guide - Appendix A: Site Configuration Parameters.

### ***Status and Diagnostics***

Status and diagnostics information can be retrieved from the expansion module, LAN switch, and power supply using the STS Hardware Test utility and SW Diagnostics and Loggers, via the CPU on the main frame. In a system where the expansion frames are not co-located with the main frame, status and diagnostics information on the expansion components can be retrieved by connecting a PC running STS directly to any expansion module RS232 port.

## Expansion Power Supply Module

The expansion power supply module (10.8-16V DC) extends power from the power supply on the RTU's main frame to the I/O expansion frame, or from one I/O expansion frame to another.

Note that this module is provided as default power supply in each I/O expansion frame unless replaced with the other power supply options.

Characteristics of the expansion power supply module:

- Located on the leftmost slot of the expansion frame
- Provides overvoltage protection for the I/O expansion frame

The expansion power supply can only be connected to the power supply on the ACE3600 RTU main frame and to other expansion power supply modules. If all the power supplies on I/O expansion frames are attached via DC cable to the power supply on the previous I/O expansion frame in a daisy-chain manner, the main power supply controls the entire RTU. This enables the user to turn off the entire RTU simply by turning off the main power supply.

If the main power supply does not control all other power supplies in the RTU (e.g. when the total power consumption required does not allow all frames to be daisy chained), it is recommended that the main power provided to the power supplies be connected to a single external on/off power switch.

**Important:** When adding expansion power supplies, make sure that you do not exceed the total power limit of the main power supply, as all connected expansion power supplies drain energy from it. Also make sure that the voltage provided to each power supply (when connected in a daisy-chain manner) does not fall below the minimum operating voltage (see RTU I/O Expansion - Power Considerations below).

The power supply on each expansion frame must be connected to the grounding strip of its frame.

The expansion power supply includes two slow blow fuses, one 4A fuse for overcurrent protection for the I/O expansion frame and one 8A fuse for maximum current via the Power in/out circuit.

The expansion power supply module is connected to another ACE3600 power supply using a DC power cable (FKN8559A/3002360C26).





## Expansion Module

The expansion module provides an interface from the CPU module (either directly or via the expansion LAN switch) on the ACE3600 main frame to the I/O modules on the expansion frame. This enables the CPU on the main frame to control the I/O modules on the expansion frame and process the gathered data.

This module is installed in the I/O expansion frame in the CPU slot, second slot from the left and is connected via dedicated LAN to the RTU's main frame.

The expansion module includes two on board communication ports:

- Exp Eth1 (E1) - 10/100BaseT Ethernet port, used to connect to the expansion Ethernet switch or to the main CPU
- STS 1 (STS1) – RS232 port, used to connect a PC running the ACE3600 STS to perform diagnostics and other STS operations (for distributed I/O), as if it is connected directly to the main CPU.

The expansion module includes a (rotary) selector switch which enables the user to determine the frame number in the expanded RTU. The frame number is used during communication with the main CPU, with the STS, etc. The expansion frame number range is 1 to 13. On the selector switch, A, B, C and D refer to 10, 11, 12 and 13.

Note: Changing the selector position when the expansion frame is running, takes effect only after the next restart.

The expansion module shipped from the factory is set by default to 1. In a multi-expansion frame configuration, the settings of additional I/O expansion frames must be changed accordingly to provide each frame with a unique number.

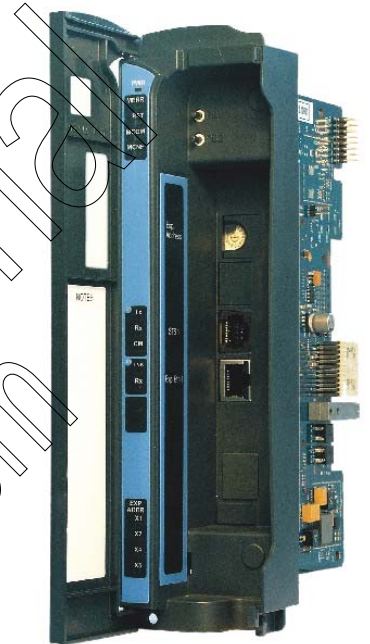
The expansion module can be connected to the main frame in two ways:

### Single expansion frame - Direct connection:

In a system with a single expansion frame, connect the Eth1 port on the expansion module directly to the Eth1 port on the main CPU, using a crossed LAN cable (V665/FKN8525A).

### Switch connection:

- In an RTU with more than one expansion frame, the Eth1 port on the expansion module is connected to one of the Ethernet ports Eth2-Eth8 on the expansion Ethernet switch (situated on the main frame). Note: The Eth1 port in the expansion Ethernet switch is reserved for connection to the main CPU.
- If two switches are used, the Eth1 port on the expansion module is connected to one of the Ethernet ports (Eth3-Eth8) on the first expansion Ethernet switch or to one of



the Ethernet ports (Eth2-Eth8) on the second switch. (The Eth2 port on the first switch is connected to the Eth1 (M) port on the second switch Ethernet LAN.)

Expansion frames are provided without cables. For connection, use one of the cables listed below or use any other standard Category 5E shielded (FTP) LAN cable (up to 50 meter length).

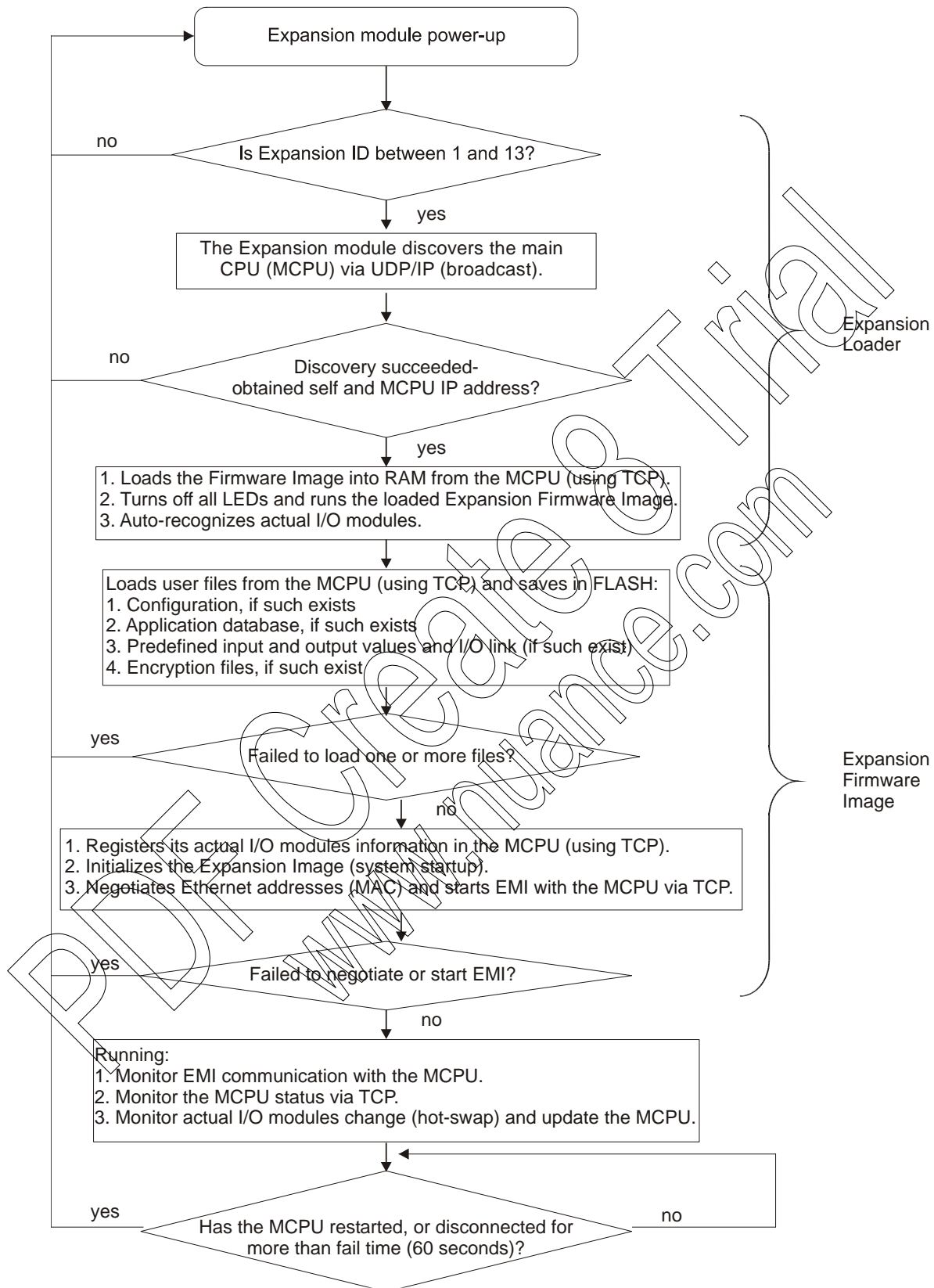
Three different Ethernet cables are available for this purpose. Choose the cable length based on the distance from the main frame to the expansion frame.

- 60 cm (Motorola p/n V529 / FKN8561A) - This cable is used for local connection of the main CPU to the expansion switch, or connection of the first LAN switch to the second, if such exists.
- 2 meter (Motorola p/n V648 / FKN8562A)
- 3 meter (Motorola p/n V666 / FKN8563A)

### ***Module Firmware and Operation Modes***

The expansion module firmware extends the main CPU control to the I/O modules located in the expansion frame. The expansion module (expansion CPU) is shipped from the factory with a dedicated firmware called Expansion Loader. After connecting to the main CPU (MCPU), the expansion module loads the Expansion Firmware Image from the main CPU to ensure that all modules use the same firmware version.

The following diagram describes the initiation process of an expansion module after power-up/restart and during run-time.



## Expansion Module Power-up and Restart

The MCOM LED on the expansion module indicates the connection status between the expansion module and the main CPU and expansion frame initialization progress.

The main CPU expects the expansion frames to complete the initialization within a configurable period of time (60 seconds default). After this period of time elapses, the main CPU will operate normally with the connected frames and their I/O modules. Any expansion frame that has not completed initialization within that time (e.g. because it was connected later to the RTU) will be ignored until the next main CPU restart.

Note that after the main CPU starts up, it waits for the expansion modules to complete the initialization process. The wait time is derived from the number of expansion frames configured in the RTU. After all the expansion frames have completed the initialization, the main CPU will continue its system startup. The main CPU will wait 60 seconds (default) for all expansion frames to connect.

## Expansion Module during Run-Time

The expansion module constantly exchanges I/O data and status data with the main CPU, using the Ethernet Micro-code Interface (EMI). The EMI enables the main CPU to be updated by all the expansion modules every very short period of time via the expansion Ethernet LAN. The main CPU constantly synchronizes the expansion module date and time, and periodically polls the errors, pushbuttons and time tagged data from all the connected expansion modules.

If the connection between the expansion module and the main CPU is lost (e.g. due to main CPU restart, cable disconnection, etc.) for a configurable period of time (1 minute default), the expansion module will restart and the initialization process will begin again.

After the expansion frames have initialized, it is possible to download to the RTU a user program or other user defined files. After successful download, the main CPU automatically updates each expansion module. Note that if the main CPU tries to download a user program or other files to an expansion module during initialization, the expansion module is restarted.

## Expansion LAN Switch

The expansion Ethernet switch provides an interface from the ACE3600 CPU (on the master RTU frame) to up to seven expansion frames, or up to 13 expansion frames when two switches are used. This enables up to 110 I/O modules in a single RTU.

The expansion modules can be co-located with the switch (installed in the same 19" frame or cabinet) or distributed in other locations.

The switch is installed only in the RTU's main frame, in either of the first two I/O module slots.

The ACE3600 expansion LAN switch is configured to prioritize different Ethernet data frame types. A special protocol, used for communication between the expansion LAN switch and the main CPU, quickly collects I/O information from the expansion frames to the main CPU and adds the highest priority and special tags to these Ethernet frames. The switch recognizes these frames and gives them the highest priority in the buffer queue, higher than the frames of the standard protocols (MDLC, TCP/IP) used for communication in the ACE3600 system. For this reason, only the ACE3600 expansion LAN switch can be used in an I/O expansion system.

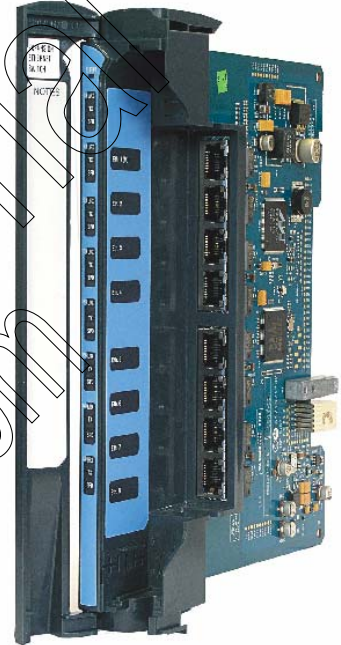
**IMPORTANT:** When an expansion LAN switch is used on an I/O expansion LAN, only the main CPU and the expansion frames (expansion modules) can be connected to the expansion switch(es). Any attempt to connect other devices to the expansion switch(es) may result in unpredictable communication delays between the main CPU and the expansion frames and malfunction of the expanded RTU.

The expansion LAN switch includes eight 100BaseT Ethernet communication ports:

The expansion LAN switch can be inserted and extracted while the system is powered up.

LAN switch status and diagnostics information can be retrieved via the main CPU using the STS Hardware Test utility. LAN switch warnings and errors are logged in the main frame CPU memory. The RTU error logger information can be retrieved using the STS Error Logger utility.

The expansion LAN switch option includes a 60 cm Ethernet cable (Motorola p/n V529/FKN8561A). Use this cable to connect from the Eth1 port on the main CPU to the Eth1 (M) port on the expansion switch. For the second switch in a system (if such exists), use this cable to connect from the Eth2 port on first switch to the Eth1 (M) port on the second switch.



One of three Ethernet cables can be used to connect an Ethernet port on the expansion LAN switch to an expansion module in an expansion frame. If the system includes one switch (for up to seven frames), ports Eth2-Eth8 are available. If the system includes two switches (for up to thirteen frames), ports Eth3-Eth8 are available on the first switch and ports Eth2-Eth8 are available on the second switch. Note: The Eth.1 (M) port on the expansion LAN switch is reserved for connection to the main CPU. For details on the Ethernet cables, see Expansion Module above.

In systems with several expansion frames, the ACE3600 STS can be used to provide automatic switch connection configuration. The following physical connections are assumed:

- A system with one expansion frame is connected directly to the main CPU.
- A system with 1-7 frames (frame IDs 1-7) is connected via one switch (to expansion LAN switch ports Eth2-Eth8 respectively.)
- A system with 1-13 frames is connected via two switches (frame IDs 1-6 connected to expansion LAN switch 1 ports Eth3-Eth8 respectively and frame IDs 7-13 connected to expansion LAN switch 2 ports Eth2-Eth8 respectively.)

If the expansion frames are not physically connected as described above, the switch connection must be manually configured in the STS Switch Connections dialog. For more information, see the ACE3600 STS User Guide.

## RTU I/O Expansion - Power Considerations

When planning a co-located multi-I/O expansion frame configuration (where all frames are located in the same enclosure or 19" rack), it is possible to cascade the power supplies of the expansion frames to the power supply in the main frame. In the system design stage (before ordering), it is critical to calculate the maximal accumulated power consumption from the main frame power supply (or from a power supply located on an expansion frame which is not an expansion power supply) to make sure it is not overloaded. It is also critical to consider the voltage drop due to the cascading of power supplies.

### Power Consumption

The first step in the design is to calculate the number of expansion frames that can be cascaded per the power supply specifications.

The following power consumption information should be accumulated for the RTU:

- Maximal accumulated power consumption of the main frame (CPU, I/O modules, 24 V floating power supplies on modules, radio, etc.)
- Maximal accumulated power consumption of the each expansion frame (expansion module, I/O modules, floating power supplies on modules)

Note: The power consumption information is described in the ACE3600 Owner's Manual and in this document in Appendix C: ACE3600 Maximum Power Ratings.

The accumulated power consumption from the main power supply (located in the main frame) should not exceed its maximum current output specifications. Consider the following example:

- An expanded RTU requires five expansion frames.
- The accumulated power consumption of all frames exceeds the main power supply specifications.
- The accumulated power consumption of the main frame and the four first frames exceeds the main power supply specifications.
- The accumulated power consumption of the main frame and the three first frames does not exceed the main power supply specifications.
- This means that from the power consumption perspective the first three expansion frames can be cascaded to the power supply in the main frame, the expansion power supply on the fourth expansion frame should be replaced with AC or DC power supply option and the fifth expansion power supply can be cascaded to this added power supply.

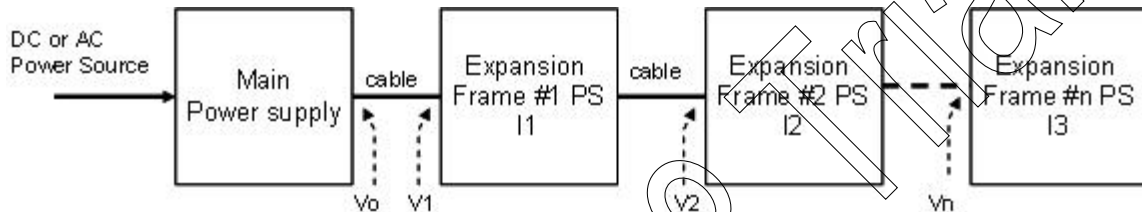
### Voltage Drop

The second step is to calculate the number of expansion power supplies that can be cascaded per the allowable input voltage to the expansion power supply.

Each cascaded expansion power supply gets a lower input voltage from the preceding power supply. The voltage drop is a function of the expansion power cable resistance and the current flowing through the cable (which is the accumulated current of the expansion frame and all the following expansion frames cascaded to it.)

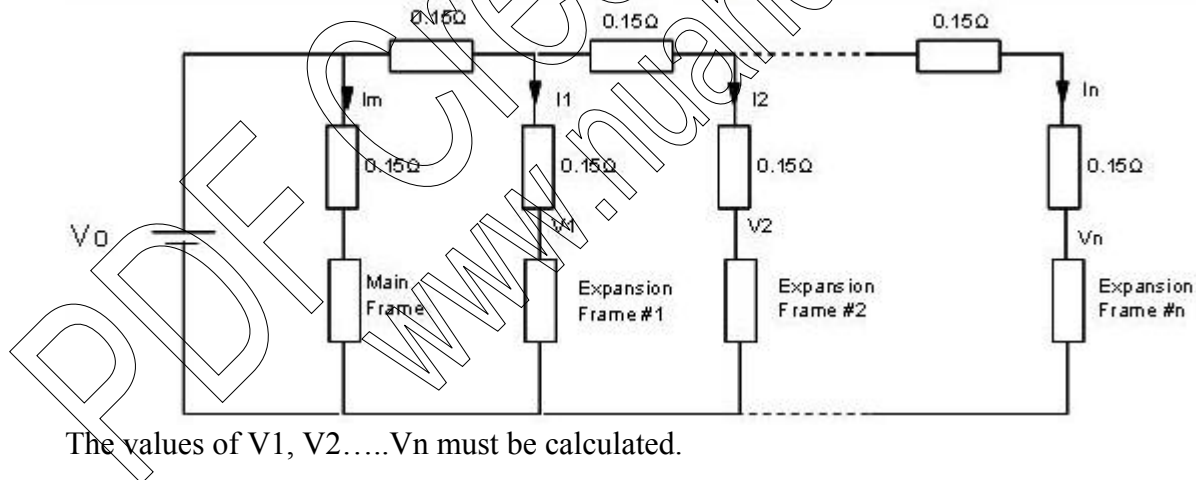
The paragraph below shows how the input voltage of a cascaded expansion frame can be calculated.

Below is a block diagram of cascaded power supplies.



- n the number of expansion frames
- $V_o$  the output voltage of the main power supply
- $I_x$  the maximal power consumption of expansion frame #x ( $x = 1,2,3..n$ )
- $V_x$  the voltage in the input of expansion power supply #x ( $x = 1,2,3..n$ )

The equivalent electrical circuit diagram of such system is:



The values of  $V_1, V_2, \dots, V_n$  must be calculated.

For example:  
Assume  $n=4$

$$V_1 = V_o - 0.15(I_1+I_2+I_3+I_4) - 0.15(I_1)$$

$$V_2 = V_o - 0.15(I_1+I_2+I_3+I_4) - 0.15(I_2+I_3+I_4) - 0.15(I_2)$$

$$V_3 = V_o - 0.15(I_1+I_2+I_3+I_4) - 0.15(I_2+I_3+I_4) - 0.15(I_3+I_4) - 0.15(I_3)$$

$$V_4 = V_o - 0.15(I_1+I_2+I_3+I_4) - 0.15(I_2+I_3+I_4) - 0.15(I_3+I_4) - 0.15I_4 - 0.15(I_4)$$



The general equation for  $V_x$  is:

$$V_x = V_o - 0.15 \left( I_x + \sum_{j=1}^x \sum_{i=j}^N I_i \right)$$

$V_o$  depends on the power supply configuration.  $V_o$  should be 13 V DC when the backup battery option is not used. If the battery option is used with the main power supply, during power fail  $V_o$  depends on the battery voltage (which may be below 13 V DC). It is highly recommended to use at least 11 V DC for input voltage  $V_x$ .

Consider the following example:

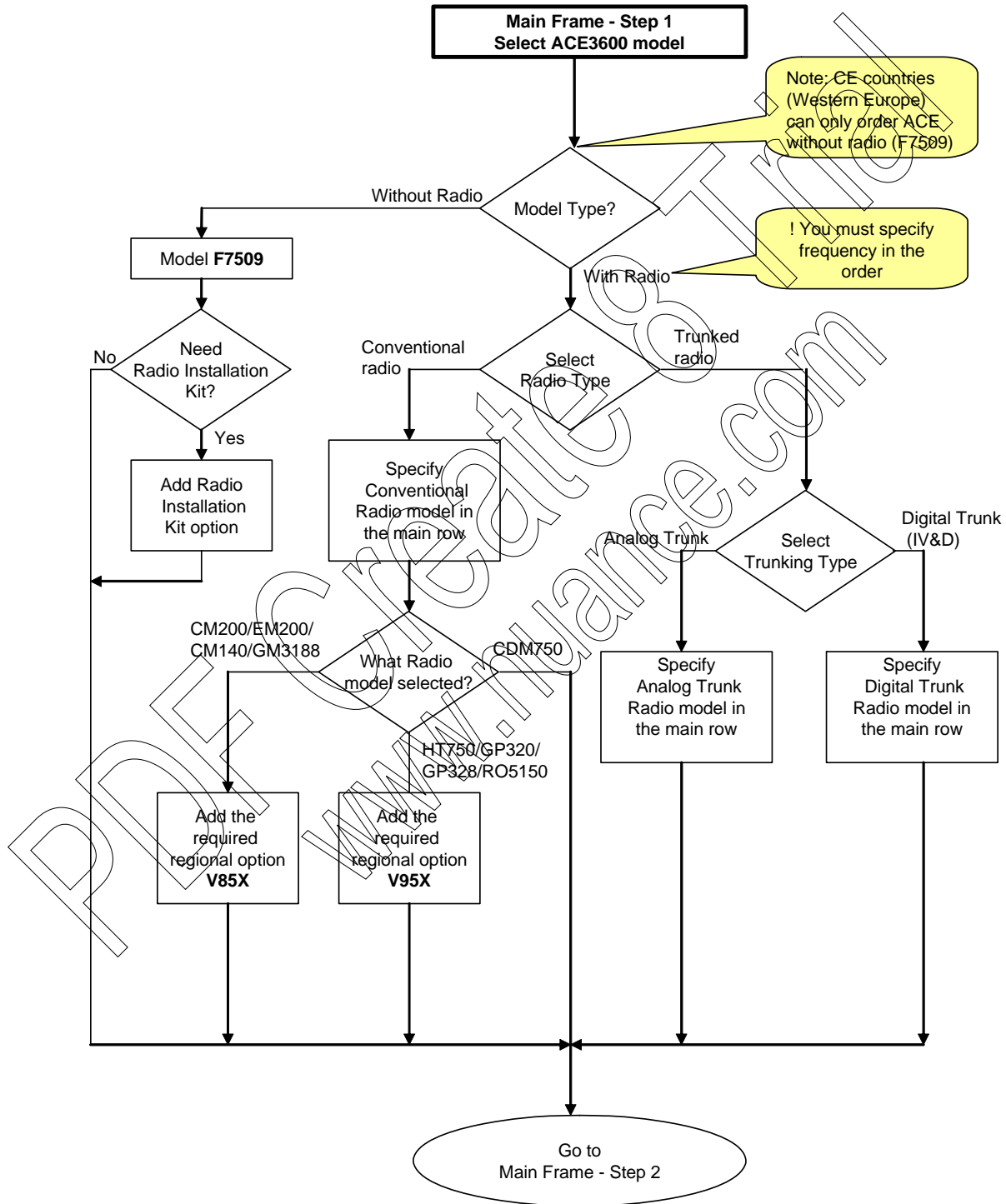
- An expanded RTU includes five expansion frames.
- The maximal accumulated current consumption of each expansion frame (expansion module, I/O modules, floating power supply on modules, etc.) is calculated.
- The input voltage  $V_x$  of each expansion power supply (V1-V5) is calculated as described above.
- The input voltage at the first three expansion power supplies (V1, V2, V3) is above 11 V DC.
- The input voltage at the last two expansion power supplies (V4, V5) is below 11 V DC.
- This means that from the voltage drop perspective, the first three expansion frames can be cascaded to the power supply in the main frame, the expansion power supply on the fourth expansion frame should be replaced with an AC or DC power supply option and the fifth expansion power supply can be cascaded from the fourth frame power supply.

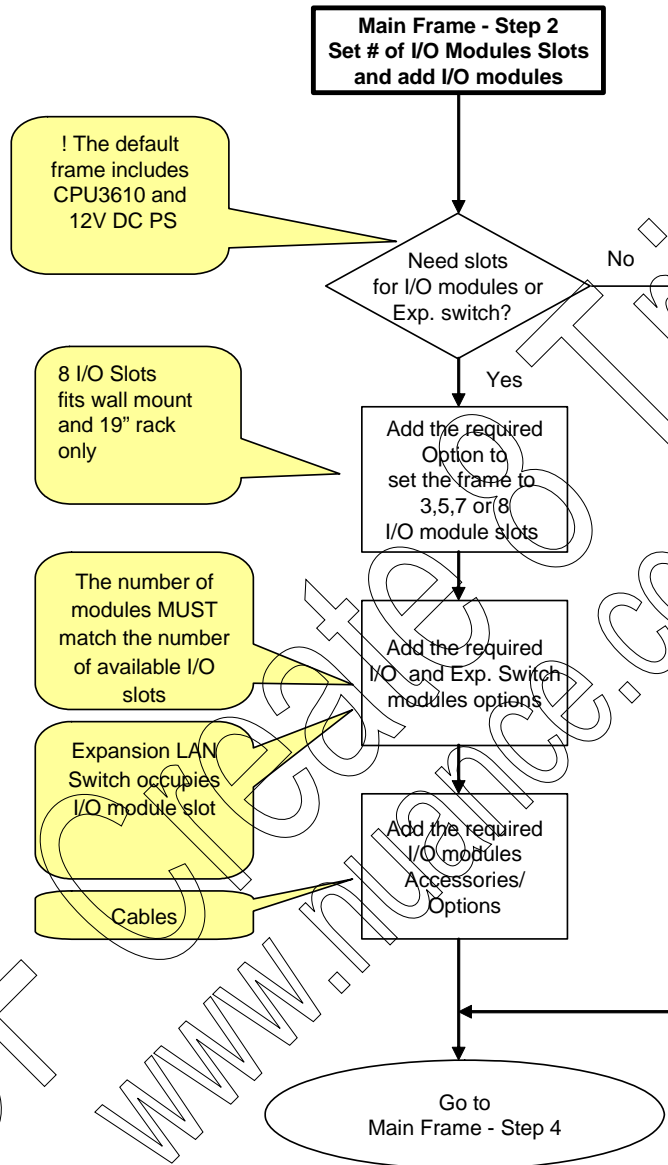
**IMPORTANT:** Design note: The design must take into account the worst case result of both the power consumption calculation and voltage drop calculations.

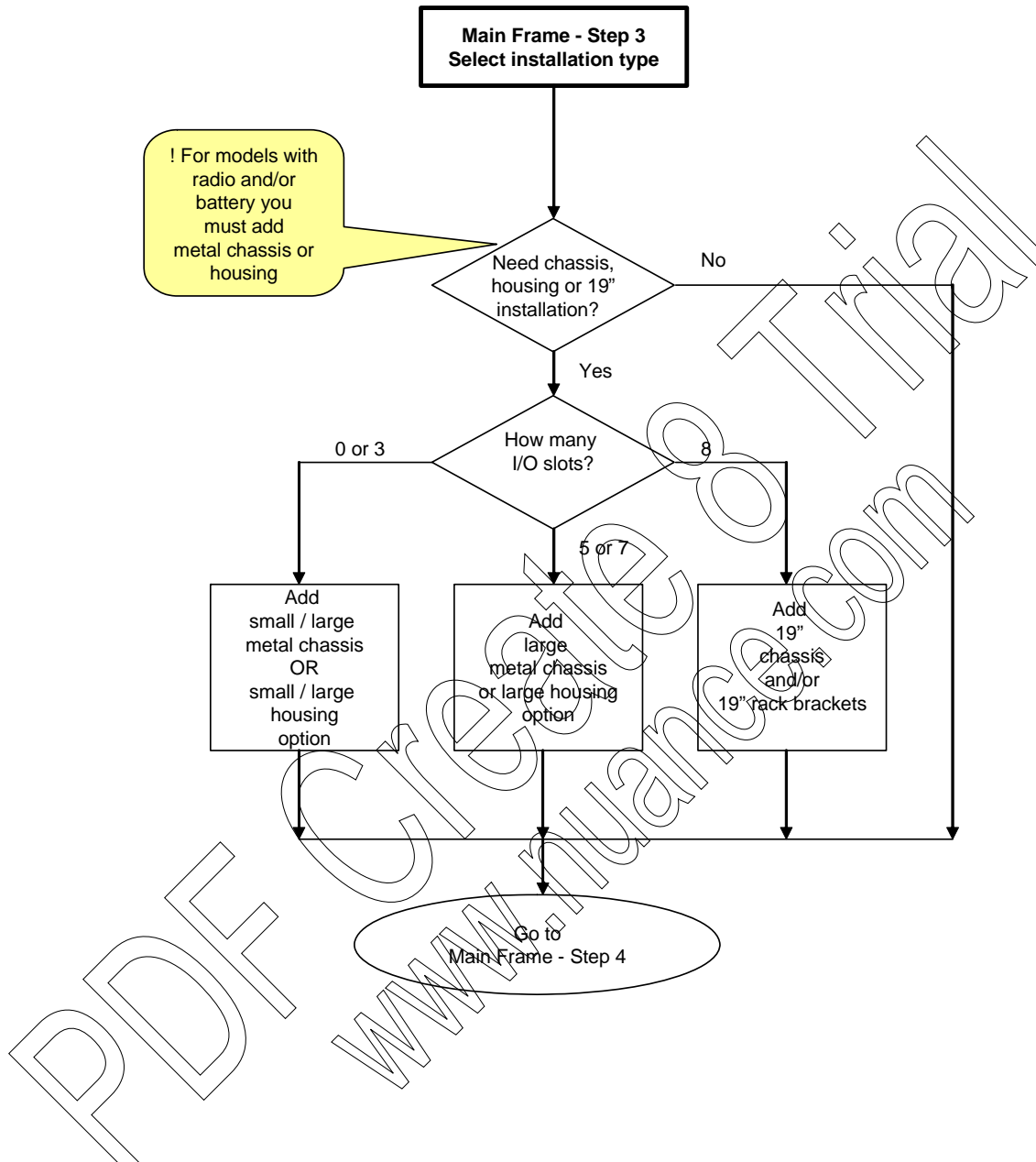
# Ordering Information

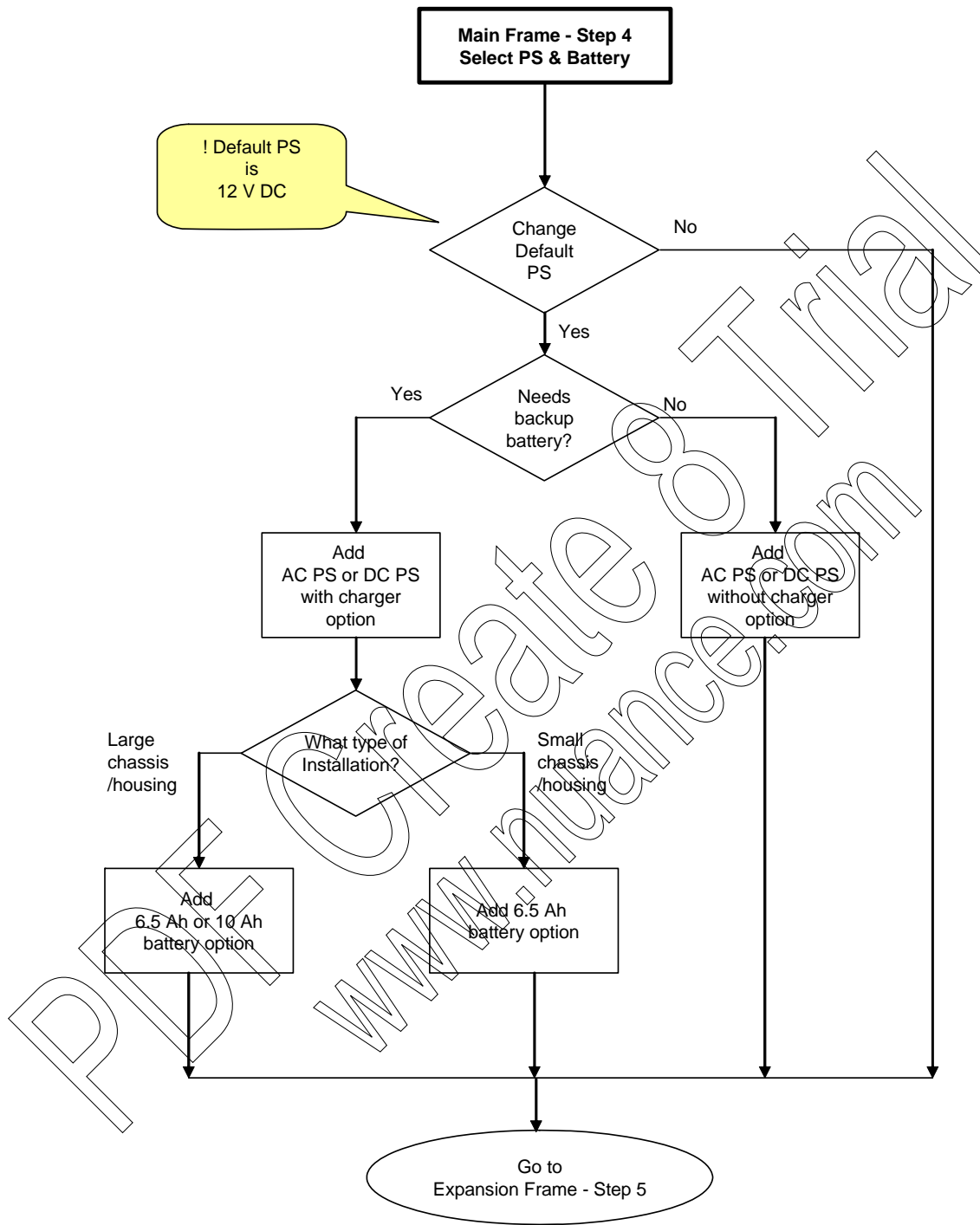
## ACE3600 RTU Ordering Flow:

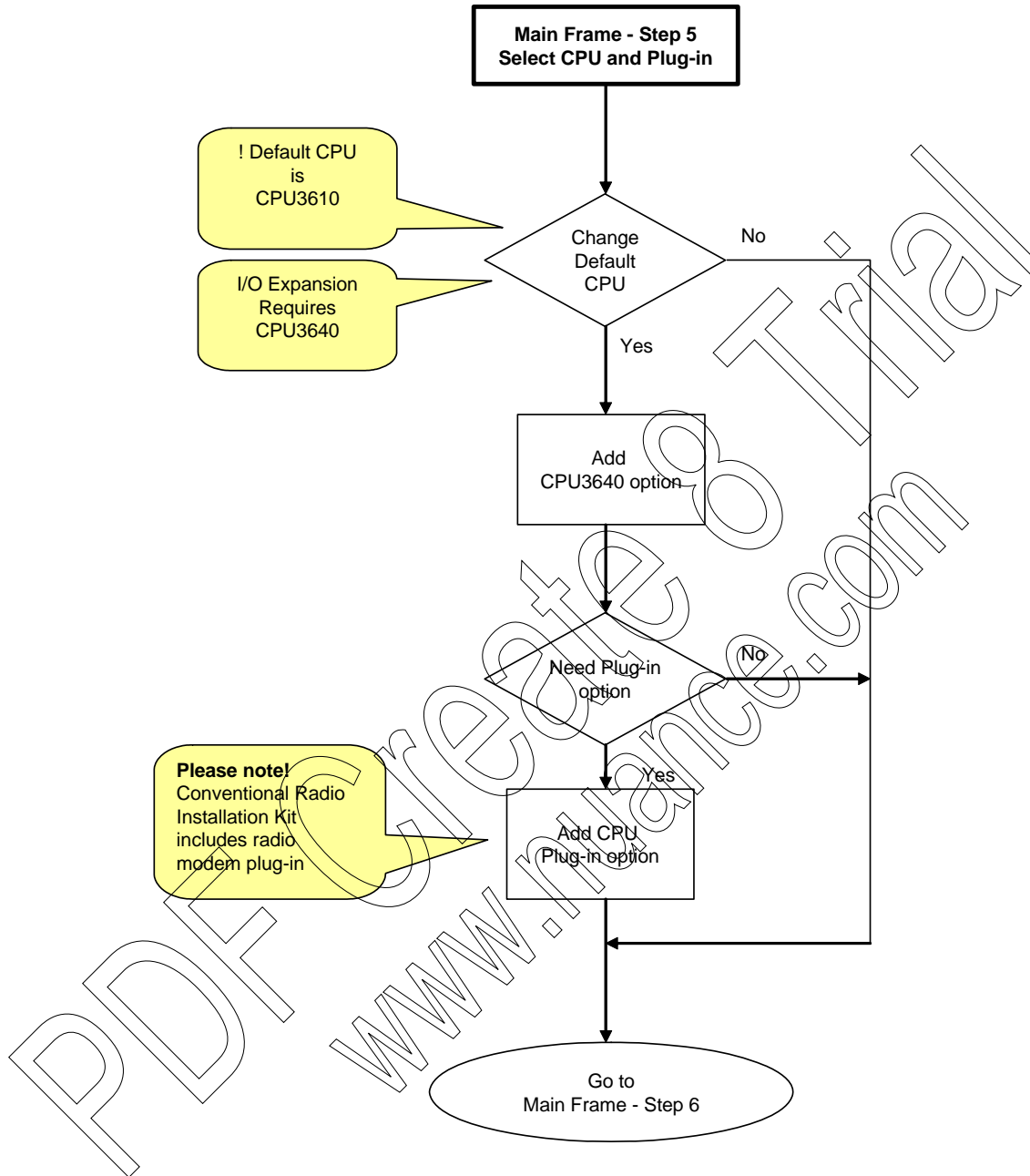
For RTUs without I/O expansions, follow only the ordering steps for Main Frame below.

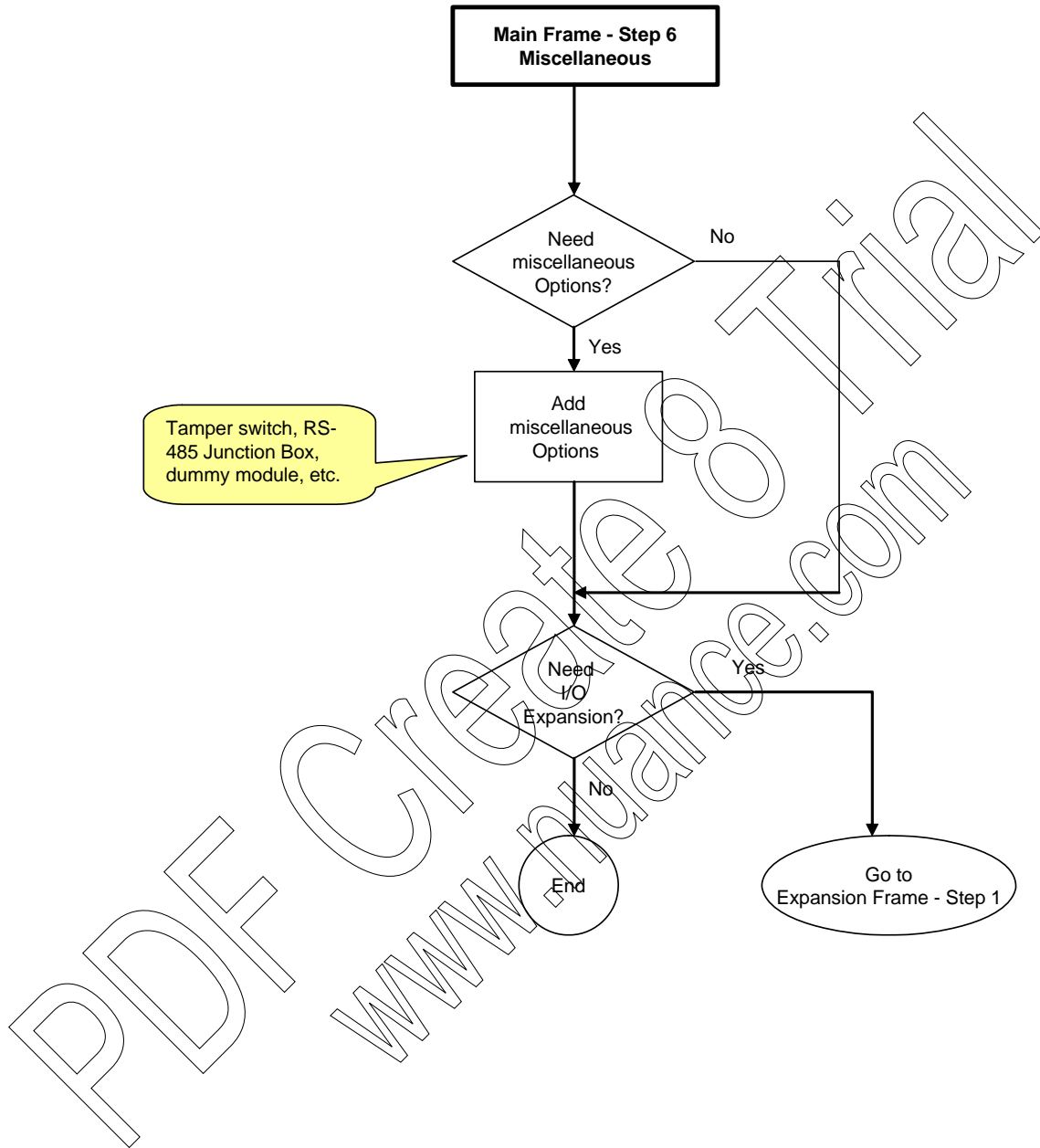


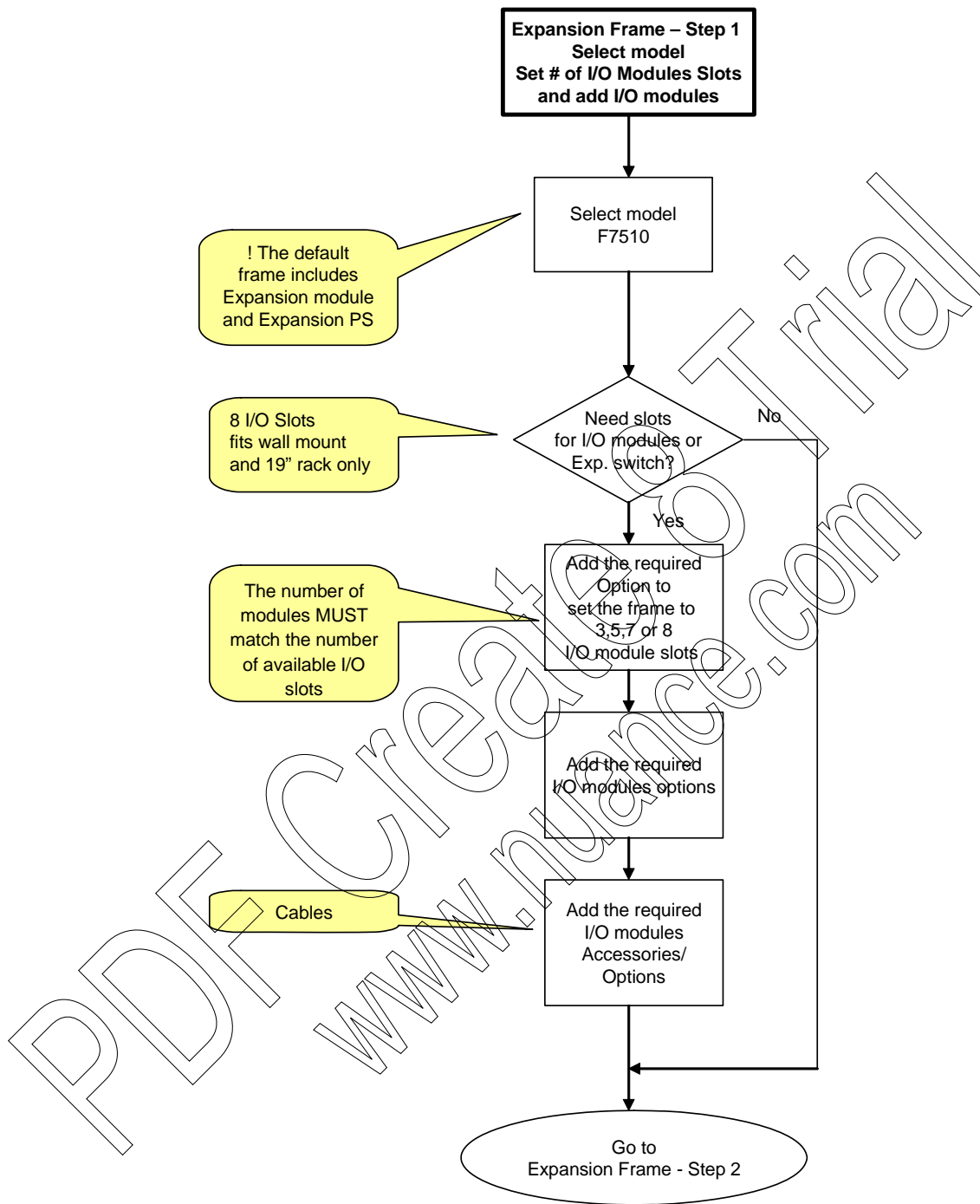




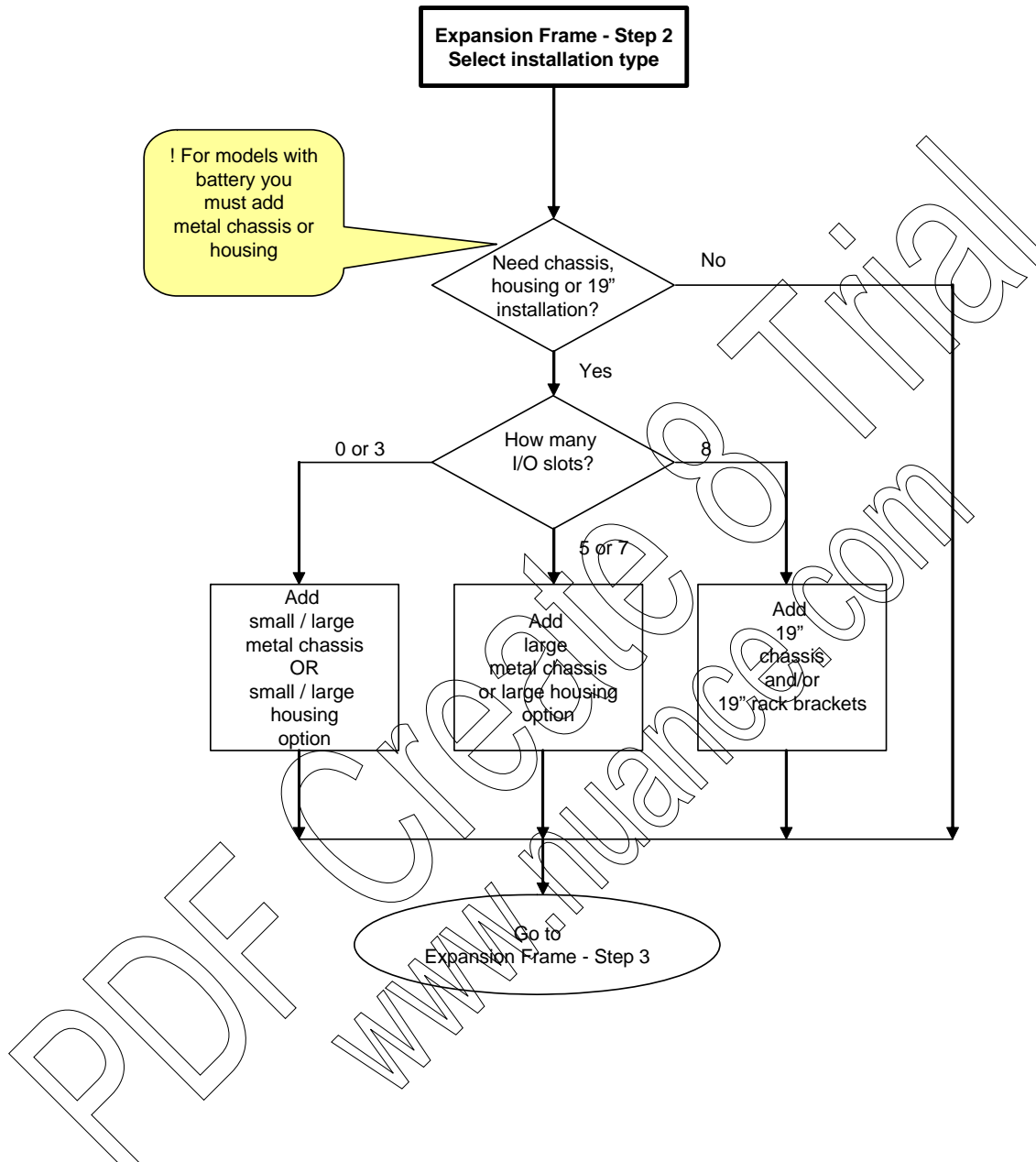


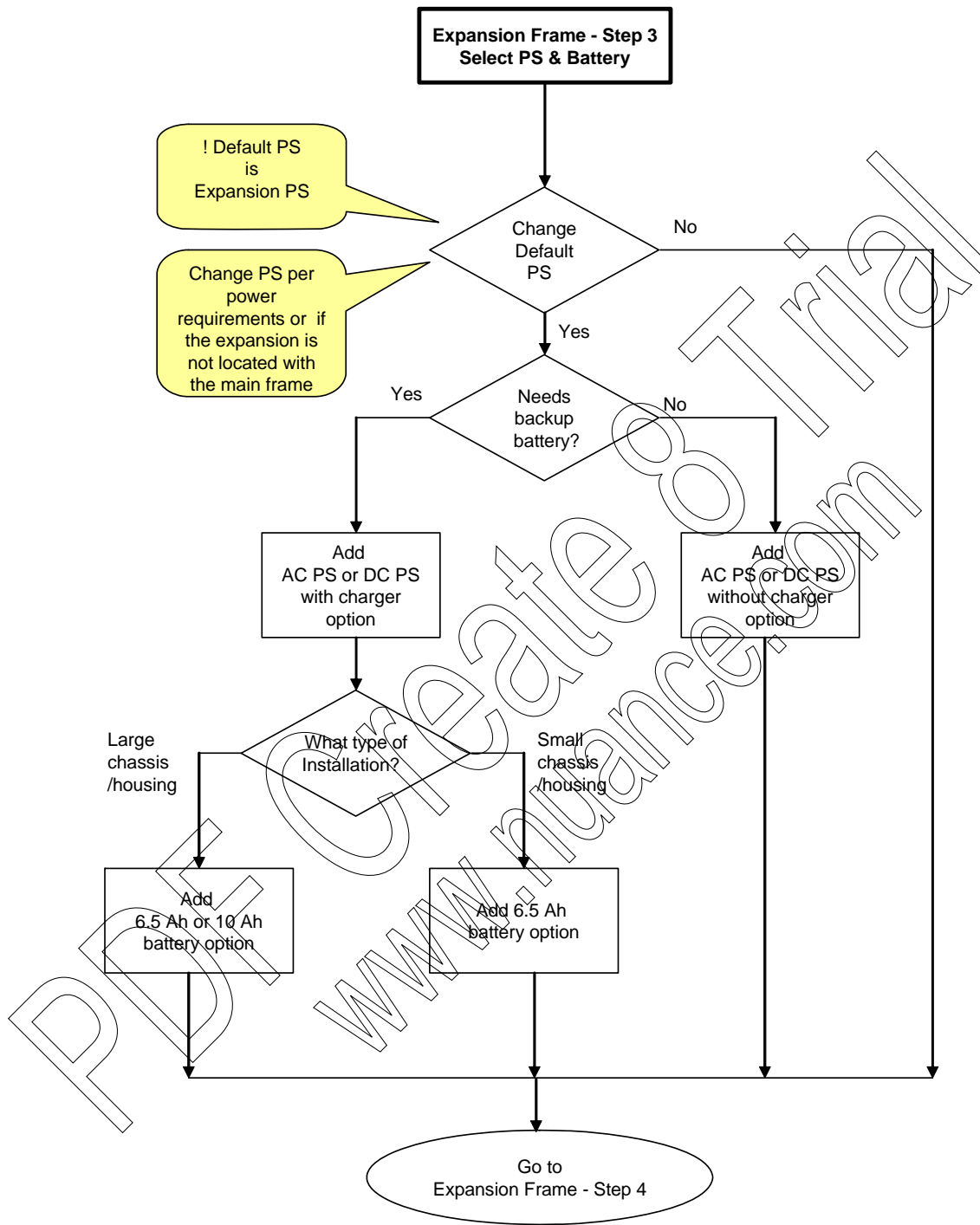


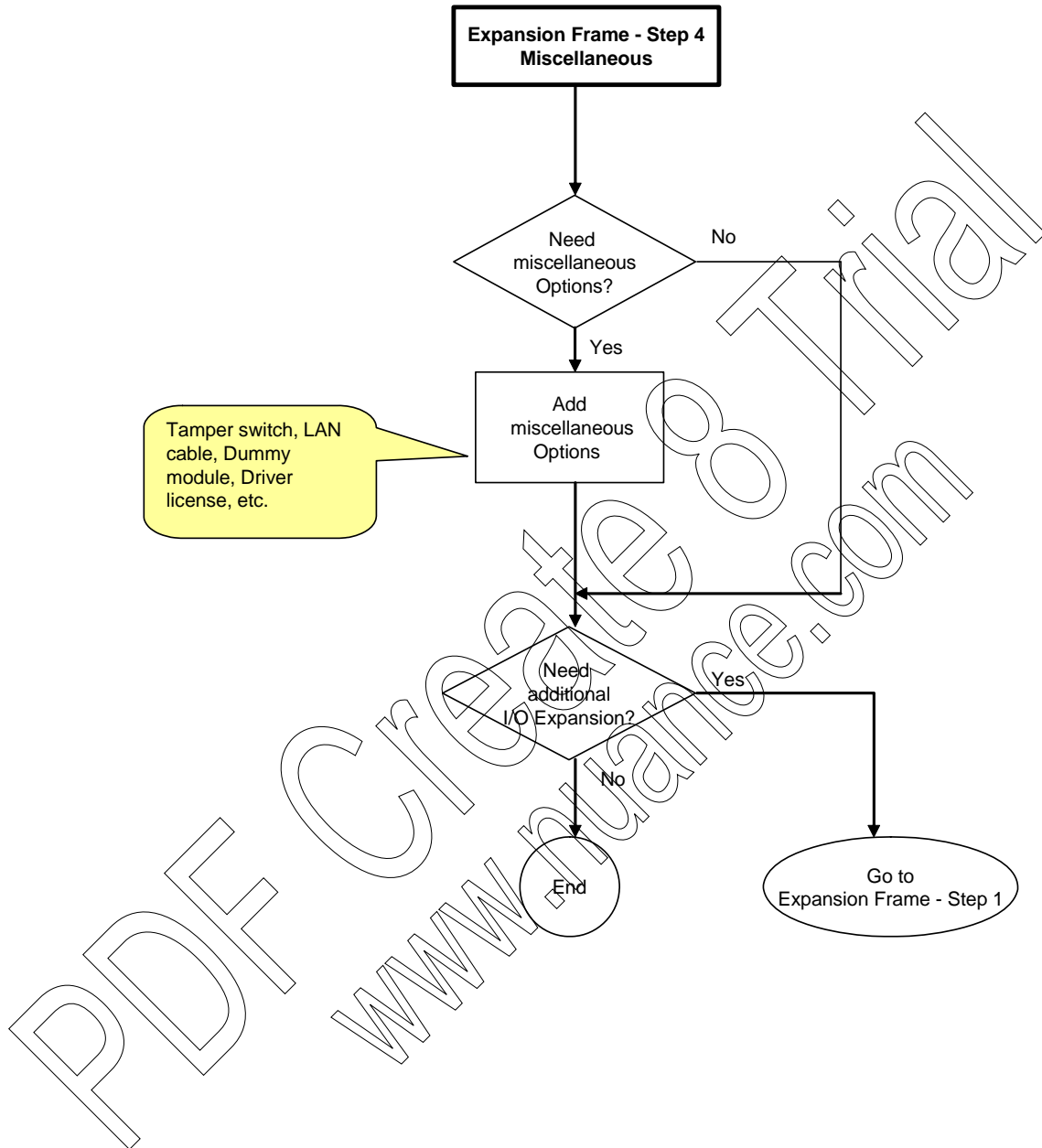












## List of ACE3600 Models

Note All RTU models include no I/O slots frame,  
10.8-16 V DC PS and CPU3610.

### No Radio Model

- ACE3600 Basic Model No Radio F7509

### I/O Expansion Model

- Expansion Frame F7510

### Conventional VHF Radio Models

- ACE3600 with CM200/CM140/EM200/GM3188 VHF F7573
- ACE3600 with CDM750 136-174 MHz F7563
- ACE3600 with HT750/GP320/GP328 /PRO5150 VHF F7553

### Conventional UHF Radio Models

- ACE3600 with CM200/CM140/EM200/GM3188 UHF F7574
- ACE3600 with CDM750 403-512 MHz F7564
- ACE3600 with HT750/GP320/GP328 /PRO5150 UHF F7554

### Analog Trunked VHF Radio Models

- ACE3600 with XTL2500 136-174 MHz Analog F7533
- ACE3600 with XTL2500 136-174 MHz Digital F7593
- ACE3600 with XTS2500 136-174 MHz Digital F7543

### Trunked UHF Radio Models

- ACE3600 with XTL2500 380-520 MHz Analog F7534
- ACE3600 with XTL2500 380-520 MHz Digital F7594
- ACE3600 with XTS2500 380-520 MHz Digital F7544

### Trunked 800MHz Radio Models

- ACE3600 with XTL2500 800MHz Analog F7538
- ACE3600 with XTL2500 800MHz Digital F7598
- ACE3600 with XTS2500 800MHz Digital F7548

### Software

- ACE3600 System Tool Suite (STS) F7500
- ACE3600 C Toolkit (CTK) F7600
- ACE3600 Enhanced PID FVN5680

Note: All radio models require Metal Chassis or Housing option.

IMPORTANT: Only model F7509A and all its options, including radio installation kits, may be shipped to European Union (EU) countries. The installer must confirm that there are no emissions or harmful interference to the spectrum due integrating the radio into this model.

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**List of ACE3600 Options**

**Regional radio options**

**CM200/CM140/EM200/CM3188**

One of the following options must be ordered for models

F7573 and F7574:

- CM 200
- CM140
- GM3188
- EM200

V851

V852

V853

V854

**HT750/GP320/GP328/PRO5150**

One of the following options must be ordered for models

F7553 and F7554.

- HT750
- GP320
- GP328
- PRO5150

V951

V952

V953

V954

**Frames**

- 3 I/O slots frame
- 5 I/O slots frame
- 7 I/O slot frame
- 8 I/O slots frame
- 19" rack brackets for 8 I/O slots frame

V103

V105

V107

V108

V051

**Metal Chassis**

- 48 x 48 cm Metal Chassis (up to 7 I/O slots)
- 38 x 38 cm Metal Chassis (up to 3 I/O slots)
- 8 I/O (19") Metal Chassis

V056

V214

V269

**Housing**

- 50x50 cm Metal Housing (up to 7 I/O slots)
- 50x50 cm Metal Housing with padlock accessory
- 40x40 cm Metal Housing (up to 3 I/O slots)
- 40x40 cm Metal Housing with padlock accessory
- Housing Tamper Switch

V228

VA00405

V276

VA00406

V224

**Power Supply, Battery Charger & Backup Battery**

(Default PS is 10.8-16 V DC input)

- DC Power Supply Low-Tier 10.8-16V
- AC Power Supply 100-240 V
- DC Power Supply 18-72V
- AC PS 100-240 V with Battery charger
- DC PS 18-72V with Battery charger
- 6.5 Ah Backup Battery

V149

V346

V251

V261

V367

V114

- 10 Ah Backup Battery V328

**CPU Upgrade**

(Default CPU is CPU3610)

- ACE CPU3640 V446
- Plug-in SRAM V447

**CPU Plug-in Ports**

- Plug-in RS232 Port V184
- Plug-in RS 485 PORT V440
- Plug-in Ethernet 10M Port V204
- Plug-in Ethernet 10/100 M Port V212
- Plug-in Radio Port VA00362

**Digital Input Modules**

- 16 DI FAST 24V DC V265
- 32 DI FAST 24V DC V379
- 16 DI FAST 24V IEC TP2 V117
- 32 DI FAST 24V IEC TP2 V959
- 16 DI 120/230V VA00331AA

**Relay Output Modules**

- 8 DO EE relay 2A V508
- 16 DO EE relay 2A V616
- 8 DO ML relay 2A V314
- 16 DO ML relay 2A V516
- 12 DO EE relay 120/230V VA00348
- 12 DO ML relay 120/230V VA00332

**Analog Input Modules**

- 8 AI,  $\pm 20$  mA V318
- 16AI,  $\pm 20$  mA V463
- 8 AI,  $\pm 5$  V V741
- 16AI,  $\pm 5$  V V742

**Analog Output Modules**

- 4 AO,  $\pm 20$  mA V118

**Mixed Input/Output Modules**

- 16 DI/DO FET V480
- 32 DI/DO FET V481
- 16 DI 4 DO EE 4 AI,  $\pm 20$ mA V245
- 16 DI 4 DO ML 4 AI,  $\pm 20$ mA V453

**Mixed Analog Modules**

- 4AO/8AI  $\pm 20$  mA V562
- 4AO/8AI  $\pm 5$  V V460

**Blank Module**

- Blank I/O module V20

**I/O Module Cables**

- 20-wire cable braid with TB holder 3 m V253
- 30-wire cable with TB holder 3 m V202
- 40-wire cable braid with TB holder 3 m V358
- 20-pin TB Holder kit V158
- 30-pin TB Holder kit V203
- 40-pin TB Holder kit V153

**I/O Expansion**

- ACE3600 Expansion LAN Switch V400226
- LAN Cable 60cm length V529
- LAN Cable 2 Meter length V648
- LAN Cable 3 Meter length V666
- LAN Cross Cable V665

**Communications Interface**

- RS485 Connection Box V186

**Third Party Protocol**

- Third party protocol license V377

**Accessories**

- ACT module V155
- 24V Plug-in Floating Power Supply FPN1653A

**Software License (RTU Options)**

- AGA 7+8 License V284
- DNP3+ License V283
- IEC 60870-5-101 License V242



## General Ordering Requirements

1. All orders must list the Model (F75XX) as a main line item.
2. Models F7573 and F7574, (CM200 / CM140 / EM200 / GM3188 conventional radio models) require ordering option V85x (radio type by region).
3. Models F7553 and F7554 (HT750/GP320/GP328 /PRO5150 conventional radio models) require ordering option V95x (radio type by region).
4. Entering a frequency is mandatory for all models with radio.
5. The default frame for all models is No I/O Slots Frame (CPU and PS slots only). To change to 3, 5, 7 or 8 I/O slots, add the required Frame option to the order (V103, V104, V105, V107 or V108).
6. 8 I/O Slots Frame is provided with wall-mount bracket. Installation on 19" rack requires ordering 19" rack brackets option (V051). If V269 is used, two V051 units are required.
7. The Default Power Supply in all models excluding F7510 (expansion frame) is DC 10.8-15.5 V (12 V DC PS). To change the power supply type, add the required PS option.
8. The default CPU module for all models (except F7510) is CPU 3610. To change to CPU3640 type, add V446. For I/O expansion, V446 on the main frame is mandatory.
9. Model with conventional radio or analog trunked radio are provided with plug-in radio modem installed in the CPU module.
10. Models with radio and orders that include battery option or accessories option (such as RS-485 Junction Box) must be ordered with metal chassis or housing options (mandatory).
11. Model F7510 (I/O Expansion Frame) includes an expansion module (CPU), expansion power supply and expansion power cable. To change the power supply type, add the required PS option to the order.
12. The expansion LAN switch occupies an I/O module slot. It is provided with a 60 cm LAN cable.
13. To connect a single expansion frame (for an RTU with up to 16 I/O module slots), use a crossed LAN cable (3 meter length).

## ACE3600 Installation Guidelines

The ACE3600 RTU is shipped from the factory with the modules and plug-in ports assembled. The RTU frame is ready for mounting directly on a wall or in a customer's enclosure. The 8 I/O frame can be installed on a 19" rack.

**Note:** For specific installation instructions, please refer to the ACE3600 Owner's manual.

### Dimensions

#### Frame Dimensions:

- No I/O slots - PS and CPU modules only, wall mount  
117 W x 209 H x 198 D\* mm (4.61" x 5.30" x 7.80"), 0.95 Kg (2.1 lb)
- 3 I/O slots - PS, CPU and up to 3 I/O modules, wall mount  
234 W x 244 H x 198 D\* mm (9.21" x 9.61" x 7.80"), Approx. 1.9 Kg (4.19 lb)
- 5 I/O slots - PS, CPU and up to 5 I/O modules, wall mount  
314 W x 244 H x 198 D\* mm (12.36" x 9.61" x 7.80"), Approx. 2.4 Kg (5.3 lb)
- 7 I/O slots - PS, CPU and up to 7 I/O modules  
391 W x 244 H x 198 D\* mm (15.39" x 9.61" x 7.80"), 3. Kg (6.6 lb)
- 8 I/O slots - PS, CPU and up to 8 I/O modules, wall mount or 19" rack  
435 W x 244 H x 198 D\* mm (17" x 9.61" x 7.80"), Approx. 3.3 Kg (7.3 lb)

#### Metal Chassis Dimensions:

- Large - for PS, CPU and up to 7 I/O slot frame, two radios and 6.5 or 10 Ah backup battery, wall mount, 448 x 468 mm x 200 D\*\* mm (17.64" x 18.43" x 7.88")
- Small - for PS, CPU and up to 3 I/O slot frame, one radio and 6.5 Ah backup battery, wall mount, 335 W x 355 H x 198 D\*\* mm (17.64" x 18.43" x 7.80")

#### Housing Dimensions:

- Large NEMA 4/IP66 painted metal - up to 7 I/O slot frame, two radios and 6.5 or 10 Ah, backup battery, 500 W x 500 H x 210 D mm (19.7" x 19.7" x 8.26")
- Small NEMA 4/IP66 painted metal - up to 3 I/O slot frame one radio and 6.5 Ah backup, Battery, 380 W x 380 H x 210 D mm (15" x 15" x 8.26")

---

\* Depth Including Module panel

\*\* Depth Including Frame and Module

## **GENERAL SAFETY INFORMATION:**

### **WARNING:**

Installation of the ACE3600 should be done only by authorized and qualified service personnel in accordance with the US National Electrical Code. Only UL Listed parts and components will be used for installation.

Use UL Listed devices having an environmental rating equal to or better than the enclosure rating to close all unfilled openings. If the installation involves high-voltage connections, technicians must be specifically qualified to handle high voltage. If the I/O connections are powered by a hazardous voltage ( $>60\text{VDC}$  or  $>42\text{Vpeak}$ ), all inputs should be defined as hazardous and the unit must be installed in a restricted access area for service personnel only.

If the I/O connections are powered by a safety extra low voltage (SELV) ( $<60\text{VDC}$  or  $<42\text{Vpeak}$ ), all inputs should be defined SELV.

### **INSTALLATION CODES**

This device must be installed according to the latest version of the country's national electrical codes. For North America, equipment must be installed in accordance to the applicable requirements in the US National Electrical Code and the Canadian Electrical Code.

### **INTERCONNECTION OF UNITS**

Cables for connecting RS232 and Ethernet Interfaces to the unit must be UL-certified type DP-1 or DP-2. (Note- when residing in a non LPS circuit.)

### **OVERCURRENT PROTECTION**

A readily accessible Listed branch circuit over current protective device rated 20 A must be incorporated in the building wiring.

## Mounting the ACE3600 Frame on a Wall

### WARNING:

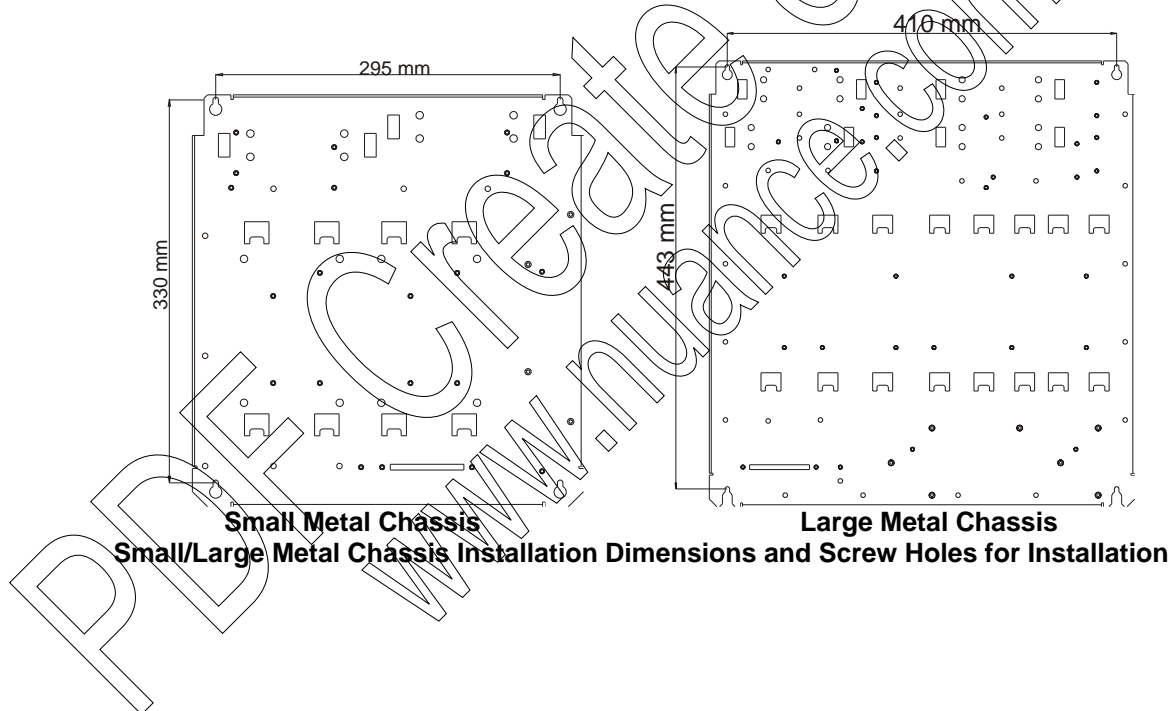
Before drilling holes for mounting the frame, make sure there are no electrical wires installed inside the wall at the holes' location.

### CAUTION:

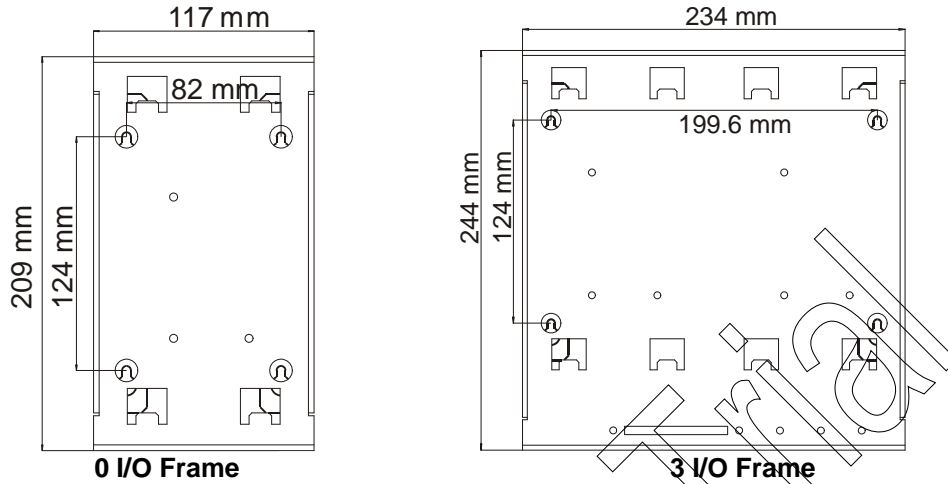
If the ACE3600 is subject to high levels of shock or vibration, you must take suitable measures to reduce the acceleration or amplitude. We recommend that you install the ACE3600 on vibration-damping materials (for example, rubber-metal anti-vibration mountings).

## Wall Mount Installation

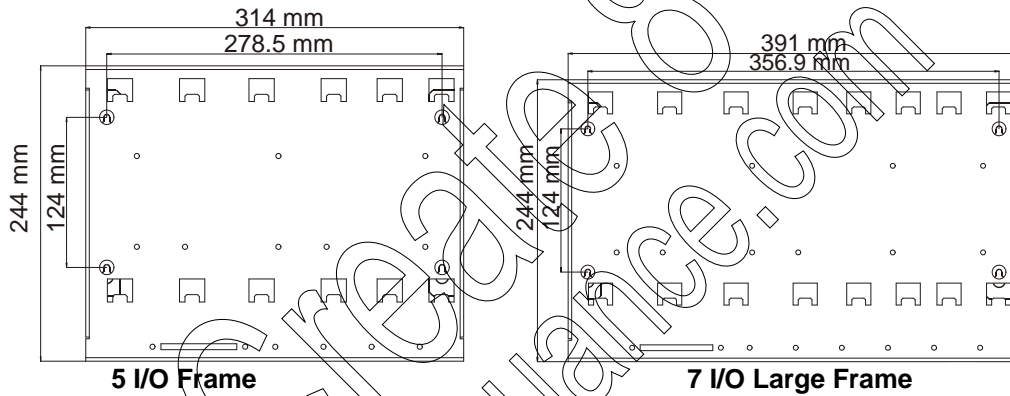
For convenient installation of the ACE3600 RTU on a wall, allow an additional 6 cm (2.4") (in W, H) and 7 cm (2.75") (in D) around the plate. Four holes are provided, one in each corner of the RTU metal chassis, for wall mounting the RTU. The figures below show the dimensions (in mm) of the various frames/metal chassis and the distances between the holes.



Small Metal Chassis  
Large Metal Chassis  
Small/Large Metal Chassis Installation Dimensions and Screw Holes for Installation

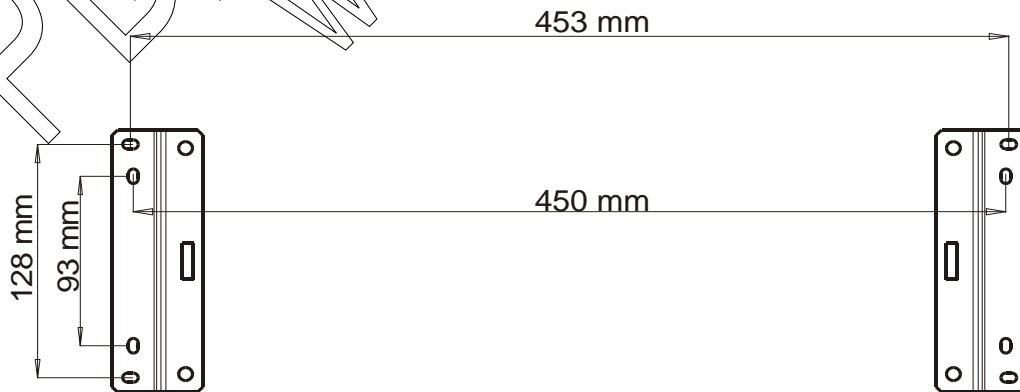


No I/O and 3 I/O Frame Installation Dimensions and Screw Holes for Installation



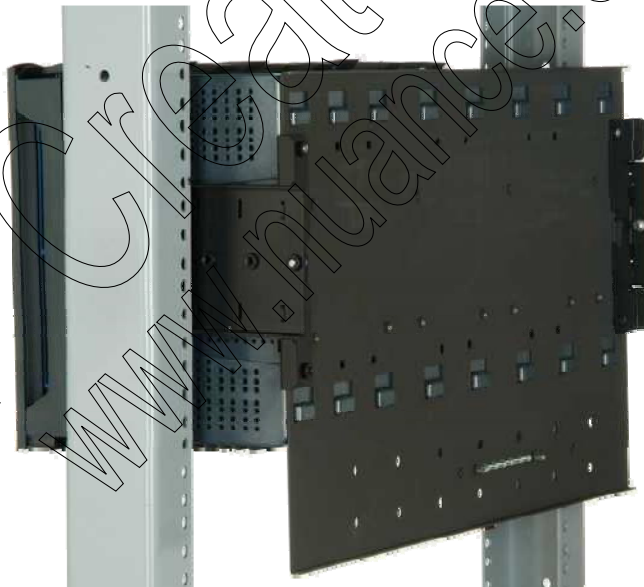
5 I/O and 7 I/O Frame Installation Dimensions and Screw Holes for Installation

The 8 I/O slots frame and the 8 I/O (19") Metal Chassis (V269) can be installed on a wall using two bracket that are shipped with the RTU. The figure below shows the required dimensions (in mm) for installation.



### ***Installing the ACE3600 in a 19" Rack***

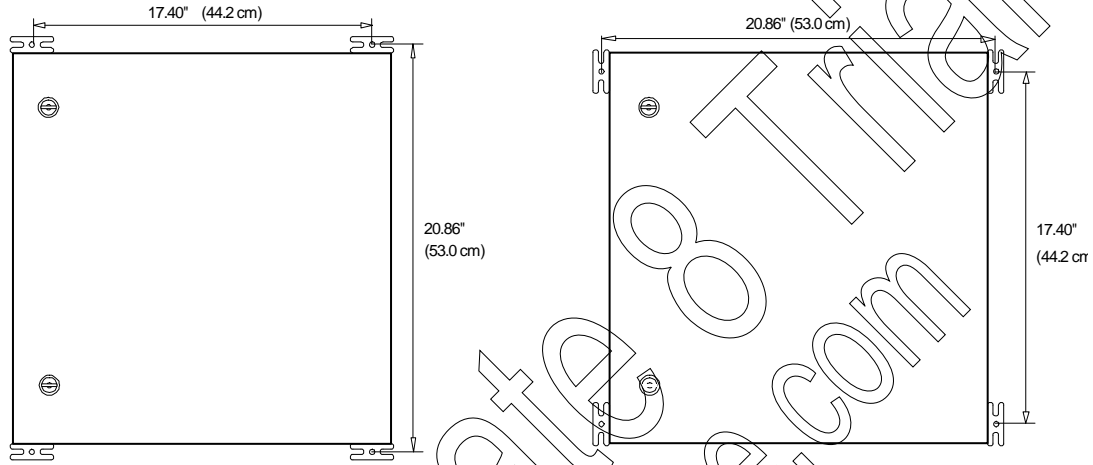
The 8 I/O slot frame and the 8 I/O (19") Metal Chassis (V269) can be installed on 19" racks using the 19" rack brackets for 8 I/O slots frame (V051) as depicted in the pictures below.



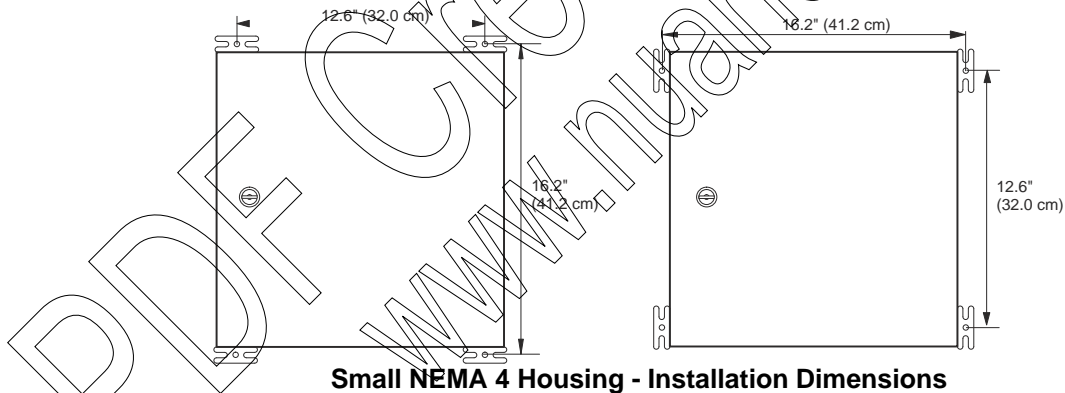
### Housing Installation

For convenient installation of the ACE3600 RTU with the NEMA 4 housing, allow an additional 6 cm (2.4") (in W, H) and 7 cm (2.75") (in D) around the housing.

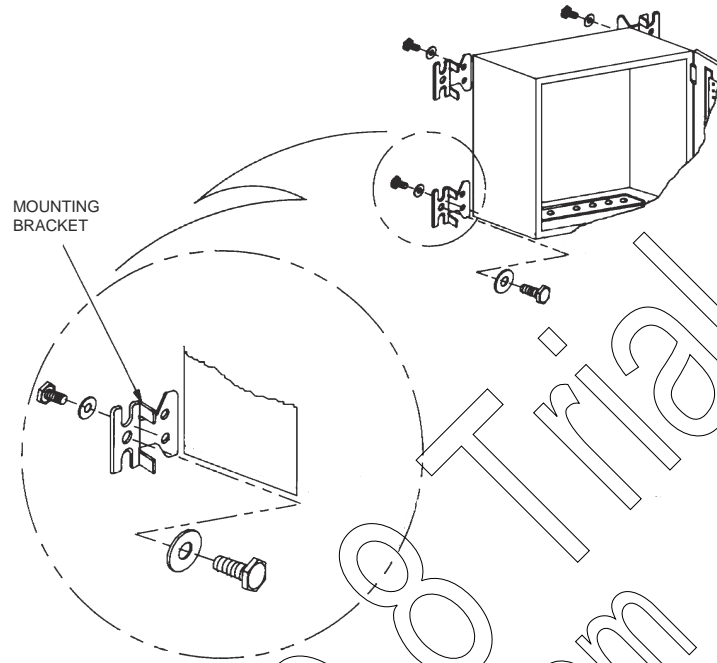
Four mounting brackets are provided, one in each corner of the RTU, for wall mounting the RTU housing (see the figures below). The figures below show the distances between the bracket holes.



**Horizontal Bracket Installation      Vertical Bracket Installation**  
**Large NEMA 4 Housing - Installation Dimensions**



**Small NEMA 4 Housing - Installation Dimensions**



Mounting the NEMA 4 Housing

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## Communications

The ACE3600 (as well as MOSCAD family RTUs) facilitates the establishment of a highly sophisticated hybrid data communication network for SCADA that utilizes a variety of radio and/or line communication links. Radio links may include conventional (VHF, UHF, 800 & 900 MHz), analog trunked, digital trunked, and both analog and digital microwave radio technologies. Line links may include point-to-point, multi-drop, Public Service Telephone Network (PSTN) voice/data via dial-up modems, cellular packet data modems and Local Area Networks (LAN).

Multiple data bit rates are available to accommodate the particular need of these links. Lower data speeds are used when the bandwidth of the link is reduced either by their design or by laws in the user's country, or when data speed is sacrificed to achieve greater communication range. The higher data speeds typically usable, combined with the optimized-for-radio MDLC data protocol, ensure high network throughput even if the network is spread over a large geographical area.

The ACE3600 system network consists of RTUs communicating with one or more computerized control centers and/or with other RTUs. Each control center is connected to the communication network.

The system can be relatively simple, comprising several RTUs and one control center. It can be modularly expanded to a more hierarchical system, where several sub-systems (comprising intelligent RTUs and/or sub-centrals controlling their peripheral RTUs) communicate with a central computer.

The communication network is flexible, enabling each RTU to communicate with hierarchies above it (RTU-to-central), parallel to it (RTU-to-RTU), under it (another RTU), and also relaying messages through it (when the RTU serves as a communication node).

While the communication protocol allows for a complex hierarchical system structure, it does not make it complicated. This is because most of the communication interactions are transparent to the user, except in those cases where the communication is to be defined by the user program ladder application. In such cases, you should perform simple programming operations to configure the required application.

Each RTU may be configured to serve as a far-end terminal or as a regional center. The RTU may function as a regional center either by definition or only after loss of communication with the central. It also can act as a communication node (an interconnection point between two or more different links) while performing its other tasks.

The RTU network uses the MDLC protocol, which incorporates all seven layers of the OSI model adapted for SCADA. It supports multiple logical channels per physical port, enabling simultaneous central-to-RTU and RTU-to-RTU sessions. It also enables each

RTU to simultaneously run several kinds of communication applications, such as reporting alarms by contention, on-line monitoring, performing diagnostics checks, etc. The MDLC protocol is discussed below.

### **MDLC Protocol**

The MDLC protocol is a Motorola SCADA protocol that is based on the Open System Interconnection (OSI) model recommended by the International Organization for Standardization. MDLC utilizes all seven layers of the OSI model. This protocol is designed for optimum operation in SCADA systems which operate with diverse communication media such as two-way radio, line, LAN, etc. Each RTU, FEP, or ToolBox has all seven layers of the MDLC protocol available to them. The functions of the seven layers are summarized below.

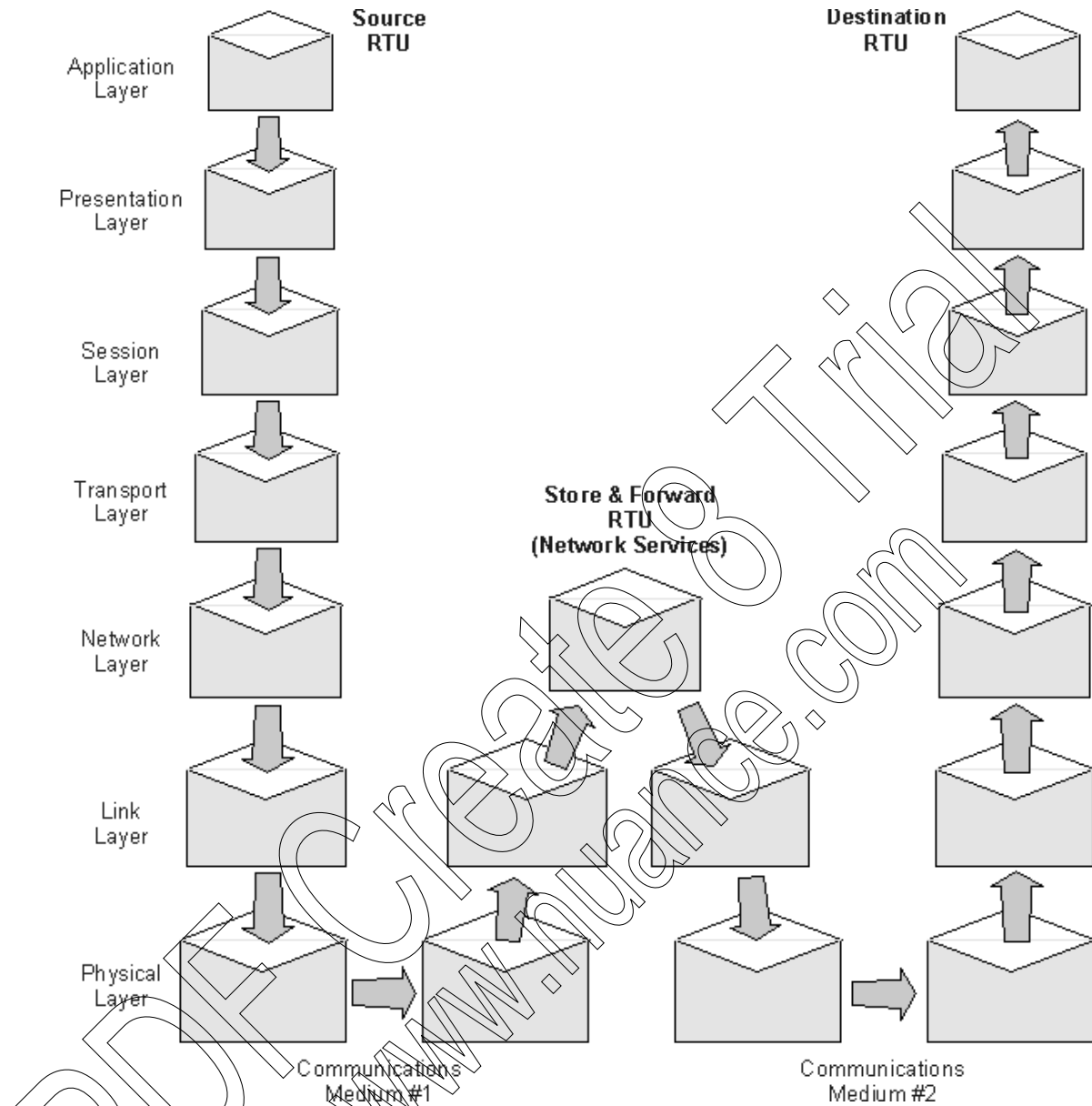
<b>Layer</b>	<b>Function</b>
<b>Layer 1: Physical</b>	This layer caters to communications over conventional radio, trunked radio, data radio, serial data channels, modems, Ethernet or telephone lines. The layer is also responsible for channel access and collision control on shared media.
<b>Layer 2: Link</b>	This layer ensures proper communications over a physical link. The layer arranges the data in variable-length frames and attaches addresses, frame sequence numbers, and Cyclic Redundancy Code (CRC) to the frames.
<b>Layer 3. Network</b>	This layer is responsible for the establishment of end-to-end communication paths in a network. This is necessary since communications may take place on more than one link and a message may travel through several nodes before reaching the final destination.
<b>Layer 4. Transport</b>	This layer ensures end-to-end integrity of the information flow between two nodes in the network. This is achieved by remote-end acknowledgement that data has been received completely and passed in the correct order to the next layer.
<b>Layer 5. Session</b>	This layer allows the definition of any number of entities capable of conducting simultaneous sessions with an equivalent entity in some remote unit. This enables transparent communications among multiprocessing machines without interference in their applications.
<b>Layer 6. Presentation</b>	This layer structures the information to/from various applications. This layer may also perform format conversion, data authentication, etc. if implemented.
<b>Layer 7. Application</b>	This layer interfaces to the various applications such as data transfer, configuration downloading, application software monitoring, remote diagnostics, etc.

The MDLC protocol is intended for operation in point-to-multipoint links, such as two-way radio or multidrop wireline, as well as in point-to-point communication networks. The protocol facilitates communications among all sites in the system, including extensive diagnostic messaging. MDLC is transparent and liberates the system engineer

from the technical constraints and complexities of network operations thus allowing the intended application to be the item of focus.

MDLC uses a semi-synchronous data format on two-way radio and an asynchronous format on wirelines. It is not correct to refer to message size in byte notation because of the 16-bit architecture; the data may not be sent in asynchronous format—no start and stop bits—but it is not true synchronous either because there is no single network-provided clock signal. Instead, each CPU has a clock that is entirely adequate to provide the synchronize signal for data transfer. It is therefore better to refer to MDLC in terms of data words where each word may be variable in length, consist of both header and body components, and contain up to 80 16-bit variables within the body. A physical message may consist of a single word or may consist of a concatenated series of words (packets), each word addressed to one or more destination sites with some or all words requiring subsequent store-&-forward operation by the recipient site(s). The concatenated data words may be any combination of the supported functions, i.e. data upload to the SCADA Manager, error logger data to the STS/ToolBox, etc.

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The lower three layers of the MDLC protocol stack are commonly known as Network Services. These layers only are used when communicating with intermediary sites which make it possible to pass any data through the system and not require the total system to know the details of the data. Each layer adds (removes) data to what was received and thereby communicates with equivalent layers in the destination (source) site—see figure above.

RTU-to-RTU communications suppress the Presentation, Session, and Transport layers; all layers are present for SCADA Manager-to-RTU communication and for communications with the STS.

## MDLC Data Transfer Methods

Three messaging methods are commonly used by the Motorola RTU: Contention (transmission upon change-of-state; also called burst), Polling (interrogation), and Report-by-Exception. The Contention method has the RTU report upon a change-of-state (COS) of conditions/values without waiting for a poll from the SCADA Manager. The RTU recognizes a COS and reports relevant data to the SCADA Manager or to another site as soon as the shared communication medium becomes available. The RTU will repeat the data message until confirmation of reception is received. The RTU listens to the shared communication medium before sending a message and then uses a slotted channel acquisition method to avoid synchronized message collisions. This is the messaging method most often used by Motorola RTUs because it uses the shared communication medium properly.

The Polling (interrogation) method is a periodic activity used to confirm the proper operation of the normally silent RTUs and/or to update the SCADA Manager database at specified intervals or when manually instructed by the operator. The Report-by-Exception method has the RTU report only the conditions/values that have changed since the last poll. The SCADA Manager retains all data conditions and values in a local database for instant use.

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## Communication Links

The system may support a network comprised of a nearly unlimited number of links. The RTU supports a variety of communication media, protocols and data speeds, as detailed below:

- Serial RS232 ports, up to 115.2 kbps, supports:
  - Local PC using MDLC (MDLC or User Protocol)
  - RTU to RTU (MDLC)
  - External Data (MAS) radio (MDLC, ModBus RTU, DF1 or user protocol)
  - External Wire-line modem (MDLC, ModBus RTU, DF1 or user protocol)
  - External Dial up modem PSTN or Cellular (MDLC)
  - External Cellular packet data modem (MDLC/PPP)
  - Astro Digital Trunk Radio (IV&D) XTL5000/XTS2500 (MDLC/PPP)
  - TETRA MTM700/MTM 800 Radio (MDLC/PPP)
  - Third party PLC/Device (ModBus RTU, DF1 or user protocol)
  - GPS receiver interface

The ACE3600 supports RS232 links to standard modem over PPP on the built-in serial ports and on the plug-in ports. These ports may be connected to an external modem supporting AT commands.

- RS-485 ports, multi-drop 2-Wire up to 460.8 kb/s, supports:
  - RTU to RTU on multi-drop connection (MDLC).
  - Third party PLC/Device on multi-drop connection (ModBus RTU or User protocol).
- Ethernet port, up to 100 Mbps, supports:
  - Local PC using MDLC (MDLC over IP or User Protocol on TCP/IP)
  - RTU to RTU (MDLC over IP)
  - Third party Device (User Protocol on TCP/IP)
- Radio modem port, supports:
  - Conventional radio – DPSK 1.2 kbps, FSK 2.4 kbps, DFM 2.4/3.6/4.8 kbps, Duobinary 9.6 kbps (MDLC)
  - Analog Trunked radio - DPSK 1.2 kbps (MDLC) - See the list below.

## RS232 Ports

On ACE3600 CPU modules, Serial Port 1 and Serial Port 2 (SI1 and SI2) are RS232 ports. Additionally up to two RS232 Plug-in ports can be installed on the CPU module (on PI1 and PI2 plug-in ports). The RS232 ports can be configured to Async or Sync operation mode and they enable local connection of a PC with the ACE3600 STS to the RTU, direct connection of another RTU, connection of modems, digital radios, data radios, third party PLCs and other devices. In addition, the ACE3600 supports RS232 links to standard modem over PPP on the built-in serial ports and on the plug-in ports. These ports may be connected to an external modem supporting AT commands (refer to

IP Ports). The RS232 ports may operate at data speeds up to 115.2 kbps (depending on the total wire length).

### **RS485 Ports**

On ACE CPU modules, Serial Port 1 (SI1) can be configured as RS485 port. Additionally up to two RS485 Plug-in ports can be installed on the CPU module (on PI1 and PI2 plug-in ports).

The RS485 ports permits up to 32 2-wire RS485 devices to be parallel-connected (multi-drop) onto one pair of wires for the exchange of data. A typical ACE3600 use for RS485 is the interconnection among multiple RTUs in the same site. RS485 is also used to connect various devices in the site to the RTU using the ModBus protocol or a user defined protocol. The RS485 Connection Box is available to make this interconnection; or the installer may make the cables by using the small handset-size connectors commonly found on modular telephones. The RS485 port may operate at data speeds up to 460 kbps (depending on the total wire length).

The RS485 specification calls for the circuitry to be capable of communicating at 10 Mbit/s for 40 feet (12 meters). At 4000 feet (1200 meters), maximum cable length, the data rate is reduced to 100 Kbit/s. There are other factors involved including the network configuration; wire characteristics, the device used, biasing resistors and termination resistors (see later) that can influence the data rate. One of the most frequently asked questions and one of the most difficult to answer is the speed/distance/number of drops tradeoff.

Different studies in the industry have given some of the following (often conflicting) results, however the table below provides a conservative estimate based on the assumption of a daisy chain topology with no stubs.

<b>Data Rate (Kbps)</b>	<b>Distance (feet)</b>	<b>Distance (meters)</b>
<100	4000	1200
200	2000	600
300	1000	300
400	800	240
500*	700	210

The following factors affect how far one can reliably transmit at a given data rate:

- Cable length: At a given frequency, the signal is attenuated by the cable as a function of length.
- Cable construction: Cat 5 24AWG twisted pair is a very common cable type used for RS485 systems. Adding shielding to the cable enhances noise immunity, and thereby increases the data rate for a given distance.

- Cable characteristic impedance: Distributed capacitance and inductance slows edges, reducing noise margin and compromising the 'eye pattern'. Distributed resistance attenuates the signal level directly.
- Termination: A long cable can act like a transmission line. Terminating the cable with its characteristic impedance reduces reflections and increases the achievable data rate.

Although normally required at higher transmission frequencies, it is good practice to terminate the cable runs with a resistor equal to the characteristic impedance of the cable. This reduces the reflection of a signal when it reaches the end of the cable. Avoid adding a termination resistor at other locations as this can overload the driver and reduce the reliability of the data transfer. The distance can be increased by the use of repeaters.

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## ***IP Ports (MDLC over IP)***

ACE3600 RTUs can use IP (Internet Protocol) technology to interface to advanced radio infrastructure (e.g. TETRA or GPRS) and to standard private IP networks. Most benefits of the MDLC protocol are preserved. MDLC and IP networks can be integrated in the same system, as networking properties are preserved. MDLC applications need not be modified as the lower layers of the protocol support IP.

MDLC packets to be transmitted are enveloped inside UDP/IP datagrams and sent between remote RTUs or between an IP Gateway and an RTU over UDP port 2002. The UDP Port number is configurable for each port.

The ACE3600 RTU can have several MDLC over IP ports, each identified by its own link ID: MDLC over RS232 PPP ports, and MDLC over LAN/Ethernet ports that can have static or DHCP addressing modes. In some cases it is required that an MDLC over IP port have more than one link ID.

Each MDLC over IP port has its own unique link ID. An IP address identifies each port, and is set by the user in a static LAN port (fixed IP address). For DHCP and PPP this address is learned automatically (dynamic IP address), and the user does not need to define it.

A PC running STS can be connected to one of the RTU ports, to one of the serial ports of the IP Gateway, FEP or to the Ethernet.

An MDLC over IP port can be used in one of four ways:

1. ACE3600 RTU port connected to a packet data radio/modem over PPP (Point to Point Protocol). The RTU can act as a remote unit or as a front end serving a SCADA control center (over PLC or user port).
2. ACE3600 RTU port connected to a LAN through one of its on-board or plug-in Ethernet port. A direct LAN connection exists between the Ethernet port and the radio infrastructure. The RTU can act as a remote unit or as a front-end, serving a SCADA center. This port can be configured as static LAN or as DHCP LAN.
3. ACE3600 FEP connected to LAN. An FEP serves as a front-end for a TCP/IP based SCADA central and enables it to communicate with remote RTUs. The FEP can use MODBUS over RS232 or any other proprietary protocol over RS232 or LAN to communicate with the SCADA. If a LAN is used, the 'C' Toolkit socket (user protocol over IP) functions provide that functionality. The ACE3600 RTU can use a direct LAN port connection with other RTUs over the radio infrastructure. It can also be connected with a packet data modem/radio over PPP. For information on the 'C' Toolkit socket functions, see the ACE3600 RTU 'C' Toolkit User Guide.

4. IP Gateway connected to LAN. An IP Gateway (IPGW) serves as a front-end for a TCP/IP-based SCADA central and enables it to communicate with remote RTUs. The IPGW uses a direct LAN connection to the radio infrastructure. It cannot be connected with a packet IP Ports (IP LAN/WAN ports) data modem/radio over PPP. For this purpose an RTU (with packet data radio/modem) is needed with RS232/RS485 to connect them.

Note: Although the ACE3600 RTU has Ethernet ports, it does not have the IP Gateway functionality.

Auto-Negotiation Note: The ACE3600 Ethernet port performs one Auto-Negotiation procedure upon startup. It is recommended to configure the Ethernet port of the device connected to the ACE3600 Ethernet port (e.g. switch, etc.) to Auto-Negotiation mode. If the Auto-Negotiation fails, the ACE3600 Ethernet port default is 10 Mbps half-duplex.

## Broadcast and Setcalls

Most wireless packet data networks do not support broadcast IP. When transmitting a group call (Site 0), a separate frame is transmitted to each site specified in the IP Conversion Table over UDP/IP. If broadcast IP exists, then this IP can be specified in the IP Conversion Table under Site 0 with the proper link ID (port). Sending to Site 0 with that link ID will transmit a single message, through that port, to all RTUs over UDP/IP using that address. Note that in ASTRO IV&D, GPRS, TETRA and most wireless media, this is not supported, so a separate message is transmitted to each site. It is preferable to transmit to each site separately, rather than send this setcall, with a delay around 100-300 milliseconds between one transmission and another.

## New Features for MDLC over IP in ACE3600

The following features are available in ACE3600 that are not available in legacy MOSCAD RTUs and IP Gateway. These features apply to Ethernet static IP address, Ethernet DHCP, and RS232 PPP port types.

### *Multiple IP Ports*

The user can specify more than one MDLC over IP port in ACE3600. The IP Conversion Table includes a link ID column which enables the same ACE3600 site ID to appear several times, with a different link ID and the same IP address.

In some cases, it is necessary to have more than one link ID per MDLC over IP port. For example, if RTU 1 has a single Ethernet MDLC over IP port, and it communicates with another RTU that has two (or more) MDLC over IP ports LINE1 and LINE2. In this case RTU 1 must have its MDLC over IP port assigned with two link IDs: LINE1 and LINE2. This will enable direct communication to RTU 2 LINE1 port or to RTU 2 LINE2 port.

### ***IP Conversion Table Enhancements***

An IP conversion table can be assigned to each RTU/FEP. It maps each site ID+link ID (port) to an IP address. The link ID column supports multiple MDLC over IP ports per RTU. Each link ID uniquely identifies the port/IP connection of that RTU. The table enables the MDLC over IP port to transmit MDLC packet to its destination based upon its site ID and link ID (port).

The enhanced IP conversion table also supports the user of a host name instead of a numeric IPv4 address (IP address). In order to use host names, the operator must support this in the network DNS Server, and the user must specify them in the appropriate port configuration. The IP conversion table is dynamic, which means its numeric addresses are automatically learned/updated in runtime, for example when a new RTU is added, or an existing one changes its addresses. In some cases, such as dynamic addresses of RTUs, there is no need to download that table to FEP, simply because RTUs addresses are updated when they transmit to the FEP. In this case, it is recommended that the user application perform these transmissions periodically. Note: The IP conversion table learns only numeric IP addresses. Host names of other RTUs are not learned.

#### ***Using Host Names***

Sometime it is necessary to refer to an RTU or FEP using a host name rather than a numeric IP addresses. Any MDLC over IP port (Ethernet or RS232/PPP) has that option, however it is the responsibility of the user and network to make sure this is supported.

In the IP conversion table, it is possible to set a host name instead of a numeric IP address for a specific site + link ID. The link ID, for example LINE5, identifies the port/IP connection of that site.

To enable this, the port needs the list of DNS servers for that MDLC over IP port. DNS list can be automatically learned. The list must be set only for an Ethernet port configured as Static IP address mode. An Ethernet port configured as DHCP or an RS232 port configured as PPP automatically learns this list from the network, and the user does not need to set them.

Note: Some PPP connected radios such as TETRA and ASTRO IV&D radios do not provide DNS information. These systems usually do not use host names either, but if necessary, the user can set the list of DNS Servers in the port configuration.

The FQDN option for an Ethernet port configured as DHCP updates the DNS servers when a new IP address is allocated to it by DHCP. The user need only set the full host name of that port. A warning is logged if the router/DHCP server does not support this option.

### ***Configuring NTP Servers***

An Ethernet or RS232 PPP port can be configured for NTP protocol (NTP is UDP port number 123.) In this case, the RTU will retrieve its time from a set of NTP servers specified by the user. The clock offset between the RTU and these servers depends on network delays, and may be up to 100 milliseconds in some wireless media. The clock offset on LAN in the same Ethernet network is approximately 1 millisecond.

Note: It is possible to define an NTP server with a full host name (e.g. www.mysite.com). To do so, the user must set DNS servers for this port, either statically, or from a DHCP server or PPP modem.

### ***User Protocol over IP***

Both Ethernet and PPP ports provide an interface for a user application written in the ‘C’ Toolkit using MOSCAD\_socket() functions, also known as “User protocol over IP”. An MDLC over IP port can serve a user application at the same time as it serves MDLC which is built in the socket API. MDLC takes one logical UDP port number (2002 by default); other applications can use other TCP or UDP port numbers. For more information on the ‘C’ Toolkit socket functions, see the ACE3600 RTU ‘C’ Toolkit User Guide.

### ***Dynamic IP Address***

Many wireless networks do not allocate a fixed IP address to a PPP modem (such as the GPRS network). For the FEP to communicate with the RTU it must know its address or host name. Since these networks do not provide a name for each modem, there is no option of setting them in the FEP beforehand. In this case, the FEP should not be assigned an IP conversion table with that link ID (port). The RTUs should be associated with a table which has the FEP’s IP address. If the network operator assigns a host name to the FEP instead of a numeric address, this can be set in the IP conversion table. When the RTU detects that its modem is connected, it will notify this address, the FEP, of its new IP address, thus updating its table in runtime.

Since this process does not guarantee that the FEP will be updated, it is highly recommended that user application periodically send a message to the FEP. For example, if the user application expects an interrogation every two minutes from the FEP, and it has not received that, it will send a message to the FEP. This will update the RTU address in the FEP.

### ***MDLC over IP Port Routing***

In the example mentioned in Dynamic IP Address above, for RTU-to-RTU (modem to modem) communication, set ‘Enable routing of MDLC over IP port’ parameter in the FEP. Then assign to the RTUs an IP conversion table which list the RTUs’ site IDs as having the FEP IP address.

When one RTU transmits to another, the transmission will go through the FEP which will route it to its destination, without the need of a network configuration.

Note: This feature can also be used in an FEP connected to the CEN of ASTRO IV&D, where it is required for one RTU connected to a radio to communicate with another RTU.

## MDLC over IP PPP Connections

The ACE3600 RTU can include up to four RS232/PPP ports - two on-board (SI1 and SI2) and two plug-in RS232 ports (PI1 and PI2.) Each port may be PPP connected to a packet data radio/modem over PPP and have its own link ID.

Several RS232 over PPP connections are supported:

- MDLC via IDEN modem (e.g. iM1000, iM1500)
- MDLC via Astro IV&D digital radio (e.g. XTL5000)
- MDLC via Standard modem, (e.g. GPRS data modem.) See MDLC over Standard Modem Setup for configuration details. A modem configuration file must be attached to the site and downloaded to the RTU when using this connection.
- MDLC via Tetra radio. This is similar to Standard modem. See MDLC over Tetra Setup for configuration details. When using a Motorola radio (e.g. MTM800), no modem configuration file needs to be downloaded.
- MDLC via Null modem. This is suitable for direct cable connections over PPP with devices such as Terminal Servers, wireless modem, etc. Depending on the modem used you may or may not need to download a modem configuration file.
- MDLC over ASTRO IV&D. See MDLC over ASTRO IV&D for configuration details. When using the ASTRO IV&D (Integrated Voice & Data) connection, no modem configuration file needs to be downloaded.

In order for a variety of modems to be used, a modem configuration file is downloaded to a specific port configured for MDLC over IP. The modem/radio can also be diagnosed using AT commands specified in that file. For MDLC over IP this feature is applicable to all connections: Standard Modem, Null Modem, Tetra, iDEN, and ASTRO IV&D.

Note: The same modem configuration file can be used when configuring a port for MDLC over IP or when configuring the port for dialup. For details, see Modem Configuration File below. Note that for iDEN, Tetra and ASTRO IV&D the modem configuration is not required, since the firmware already has these commands built in.

## MDLC over IP/LAN Connections

The ACE3600 RTU can include one on-board 10/100 Ethernet BaseT port (ETH1) (not in ACE3610) and up to two plug-in 10/100 BaseT ports (PI1 and PI2.) Each Ethernet port has its own link ID and can be connected to the same or to a different network mask.

An Ethernet (LAN) port can be configured in one of several modes:

- Static IP address mode
- Dynamic (DHCP)

With static IP address mode, the user is required to set the link ID, IP address, subnet mask and default gateway. If DNS or NTP servers are required, these must be defined as well. DNS servers are only required if this port is to be accessed via a host name rather than a numeric IP address. In this case the operator assigns a host domain name to the FEP or RTU. The IP conversion table must include the domain name well. If an NTP server is to be used to obtain the time, the numeric IP address or domain name of the NTP server must be defined.

In DHCP address mode, the user is only required to set the link ID for this port. If DNS servers are required there is no need to set them, since they are learned from the network. If NTP servers are required, the user must set them since they are not learned from the network.

As an option, user can set a full host domain name for an Ethernet port that is configured as a dynamic DHCP client. Each port should be set with a different name. This option allows the network DNS servers to be updated when the DHCP server changes its IP address, keeping its name up to date. This is called FQDN and is not always supported by the DHCP server (in this case a warning is logged.)

### **MDLC over IP Site Paging**

A paging mechanism is available in each site (peer) to make MDLC over IP more reliable. (This feature is the same as in Toolbox V9.54 and MOSCAD V9.25.) Paging a site before transmitting MDLC data to it over IP, guarantees that the site is reachable. This is necessary because MDLC over IP does not have a confirmed type of link in which the peer acknowledges received packets (as opposed to other types of MDLC ports). It relies on the radio to have a link layer that will guarantee a 'best effort' delivery, and thus avoids overloading the channel with excessive traffic.

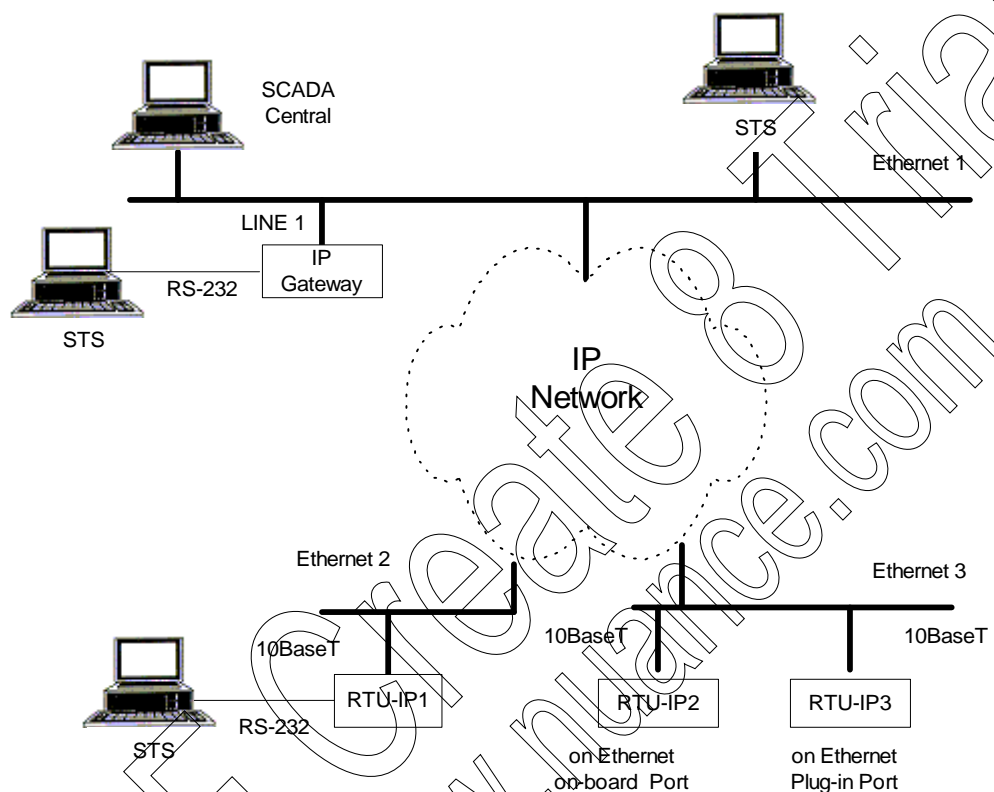
A site is paged by sending it a poll request and awaiting a poll reply. During this time, the RTU can continue to transmit to other sites (and receive transmission from other sites). If the site responds with a poll reply, or any other MDLC data, it is considered as reachable and all pending transmissions are sent to it immediately. Further transmissions will be sent to it as well without paging until the site is declared as failed.

If an 'ICMP Destination Unreachable' message is received or if the site does not respond to paging for a configurable poll interval, it will be polled again for a maximum number of polls. If there is still no response, the site is considered to be failed, and the network layer is notified so any pending transmissions can be redirected to an alternative route. If subsequent transmissions are to be sent to the site through an MDLC over IP port, paging will be performed again before actual transmission takes place. The Site Paging mechanism can be enabled or disabled.

## MDLC over LAN/Ethernet

The ACE3600 RTU can communicate over Ethernet media, via the onboard Ethernet port or 10/100BT plug-in ports.

The figure below illustrates an example of a SCADA system with IP Gateway and ACE3600 RTUs connected to Ethernet LAN:



With SCADA systems the ACE3600 RTU can be connected to Ethernet/LAN as an FEP (FIU) for a SCADA, and an RTU. It communicates with MDLC over IP between FEP/IP Gateway and RTU. The IP Gateway unique functionality provides an API over TCP/IP API, for the SCADA PC. It provides the SCADA with the current values of the RTU tables and with the events (Bursts) that are associated with each entity. The ACE3600 does not have that functionality built-in and requires an IP Gateway.

Unlike IP Gateway, ACE3600 can be connected to several Ethernet connections. They can reside on the same or on different network subnet masks, and are distinguished from one another by a link name.

A number of connection methods are available when configuring an Ethernet-based RTU:

1. Static IP address – The user sets the IP address within the configuration of the device in the STS. To use this method, follow the instructions for configuring an RTU in the Operation chapter in the ACE3600 STS User Guide. All DHCP parameters will remain at default values.
2. DHCP-supplied reserved IP address – For every ACE3600 RTU, an IP address will be reserved within the DHCP server. The link between the RTU and the reservation will be based on unique ID. In the DHCP Server, set the unique ID. The default unique is the MAC address. In the DHCP server, define a reservation for a specific RTU based on its MAC address.
3. DHCP-supplied dynamic IP address – A dynamic IP address is distributed from the DHCP server to the ACE3600 RTUs. The IP address of each ACE device is unpredictable. In this case you will need a DNS server that will resolve the link between the IP address and the RTU. You will have to supply a name for each RTU. This name will be updated within the DNS server along with IP address of the RTU. Within IP conversion table of ACE3600 RTU you will use this DNS name instead of IP address.

In order to comply with IP networks standards, all configuration methods described in this chapter are based on standard procedures used in IP networks.

### **MDLC over ASTRO IV&D**

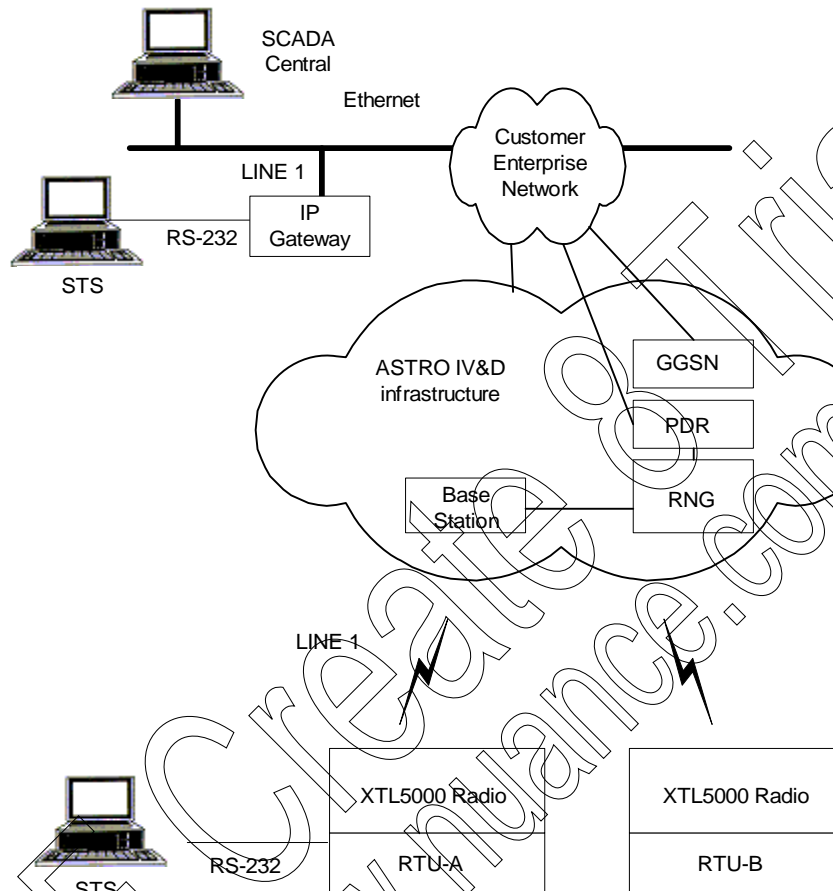
With SCADA systems, ACE3600 RTUs can be connected to an ASTRO IV&D radio. The ASTRO infrastructure (R6.4 or higher) and radio must support integrated voice and data (named IV&D). This is relevant to Motorola subscriber data radios such as the XTL5000 mobile and XTS2500 portable.

The connection to ASTRO IV&D can be made via LAN or via radio. The LAN is called a CEN (Customer Enterprise Network). An IP Gateway or RTU with an Ethernet port can be connected to the CEN. On the other end, an RTU can be connected to an ASTRO IV&D radio via an RS232 data cable. Note that a specific codeplug which supports the data option must be used when programming them.

In the figure below, the SCADA central and IP Gateway are connected via LAN to a Customer Enterprise Network (CEN). The CEN is connected via a border router gateway to the ASTRO IV&D infrastructure. An RTU, running MDLC over IP protocol over PPP, is connected via XTL5000 radio using an RS232 data cable. A unique IP address is assigned by the GPRS Gateway Support Node (GGSN) to each RTU according to its radio individual unit ID (UID), such that when a frame is transmitted from the CEN to that IP address, the Packet Data Router (PDR) and Radio Network Gateway (RNG) transmit it to the appropriate radio.



Unlike other infrastructures (such as iDEN and TETRA), this IP address and radio unit ID cannot be retrieved for diagnostics from the radio. Instead a dummy IP Address is provided by the radio as it is configured using the CPS (Codeplug Programming Software).



A PC running STS can be connected directly to an RTU, directly to a radio, or it can operate remotely over the CEN.

For an RTU or PC to communicate over the air using an ASTRO IV&D radio, the radio must be context activated, or registered for data, in addition to the PPP connection over RS232 interface.

The RTU uses SNMP protocol and sets a value in a MIB variable defined for this radio. When this succeeds, the radio configuration is completed, and the radio (using the IP address provided periodically by the GGSN in the infrastructure) is able to receive and transmit data. If the context activation fails or is deactivated, the RTU causes the radio to restart (power itself off and on.) Once the radio has been context activated, an RTU (or PC) can transmit IP frames over the air to the PDR which routes them to the GGSN and CEN.

Certain configuration steps are performed on the radio itself using the CPS and in the infrastructure using the UCM tool. See the relevant radio documentation for more information.

There are two types of hardware interface between the RTU and the radio: For a mobile radio such as the XTL5000, the interface is comprised of a radio data cable over RS232.

Note: A PC needs a tool called Data Link Manager (DLM) in order to communicate over the air

**NOTE:**

ASTRO IV&D does not support group calls (RTU-to-RTU broadcasts). To send a frame to a group of sites, the application should send to each site individually, leaving a short wait time between each transmission (300-1000 milliseconds depending upon the communication used.)

Sending frames from one RTU to another when both are connected to radios may not be reliable, because of the ASTRO IV&D's limited resources. It is recommended to have an RTU connected to LAN (CEN) that will route the information between them.

**MDLC over iDEN**

ACE3600 RTUs can be connected to iDEN iM1000/iM1500 modems (OEM version  $\geq 35.01.00$ ) to communicate using RS232/PPP port on iDEN infrastructure to the IP network. Since iDEN infrastructure connects to Local Area Networks (LAN) as well, a LAN-connected IP Gateway or FEP can communicate directly with these RTUs over iDEN infrastructure.

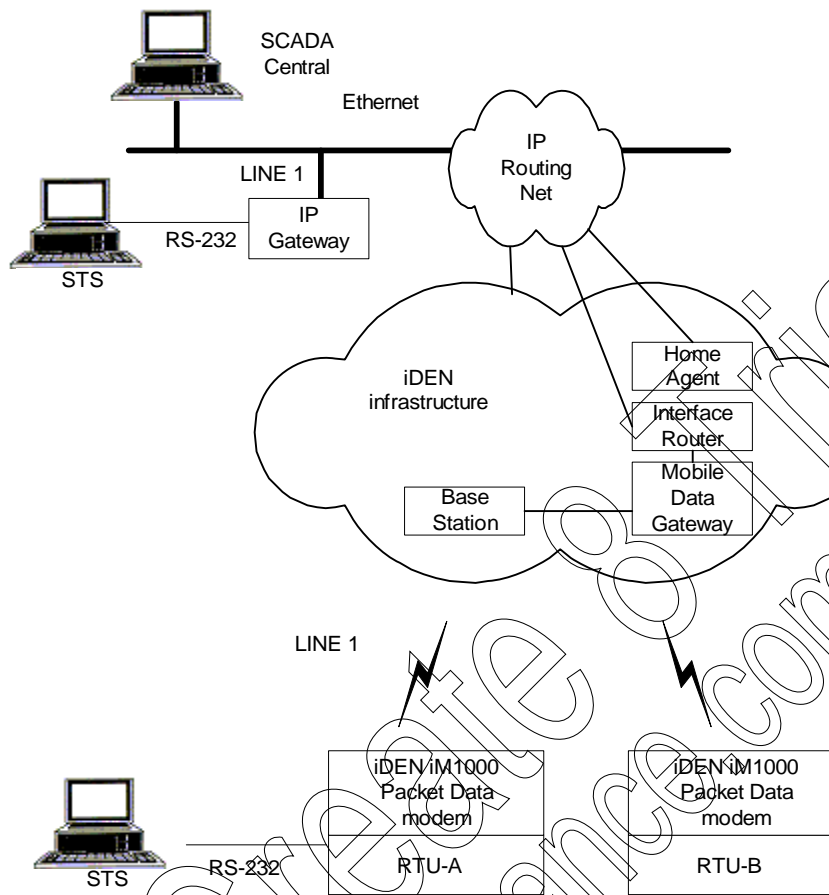
The iM1000/iM1500 is configured to operate works in various modes, including:

- Packet Data (PD)
- Circuit Data (CD)
- Packet Data over Circuit Data (PD over CD)

MDLC over iDEN, which uses IP technology, deals only with the first mode (PD). The other two modes can only be used with an external dialup port in the RTU, and do not support direct communication with another RTU/IP Gateway having an MDLC over IP port. Therefore they are not relevant to MDLC over IP topic.

In the figure below, the SCADA central and IP Gateway are connected via LAN to iDEN infrastructure. Each RTU has an iM1000 or iM1500 modem connected to RS232/PPP Port.

A unique IP address is assigned to each RTU according to its modem's identifier. All communication between RTUs and the IP Gateway involves sending datagrams in packets over the network (IP). A PC running ACE3600 STS can be connected directly to an RTU or operate remotely over IP.

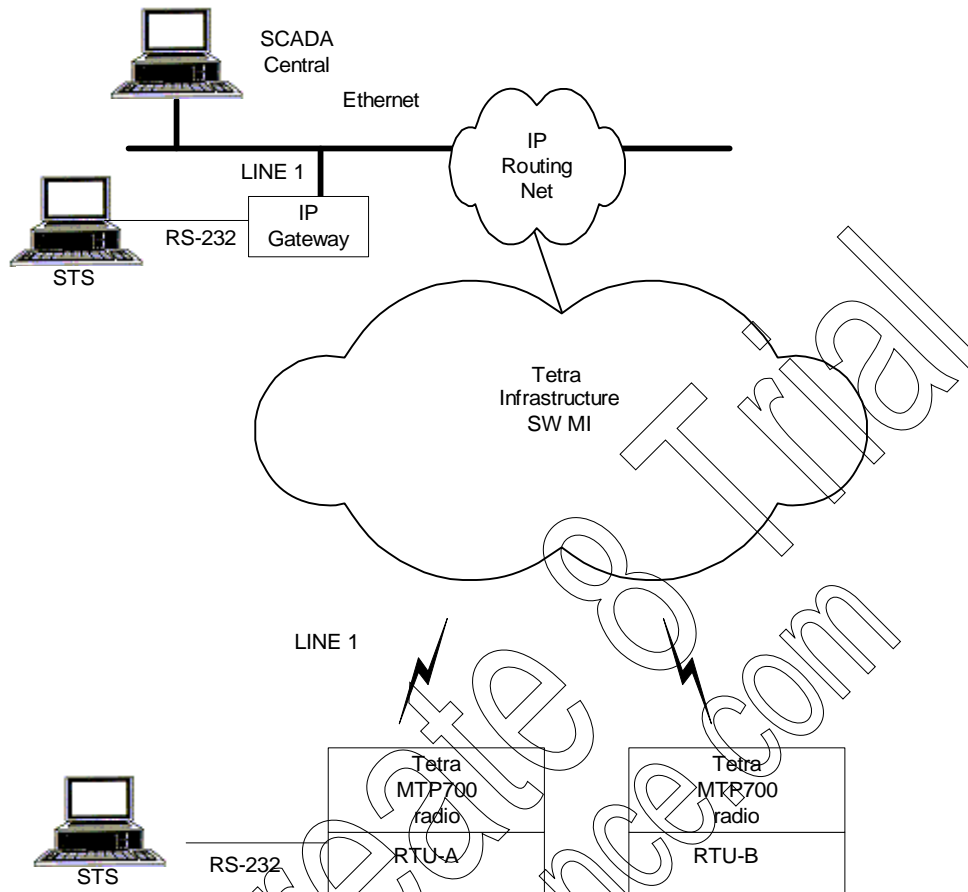


### MDLC over Tetra

ACE3600 RTUs can be connected to a Tetra radio. Tetra infrastructure and radio should support packet data.

The connection to Tetra can be made via LAN or via radio. An IP Gateway or an RTU with an Ethernet plug-in or on-board port can be connected to a LAN. In Tetra terms, an RTU that is connected through LAN is called a LAN RTU. An RTU that is connected to a radio is called a PEI (Peripheral Interface) RTU. A PEI RTU is connected to a radio through RS232 using standard PPP (Point to Point Protocol).

In the figure below, the SCADA central and IP Gateway are connected via LAN to Tetra infrastructure. Each RTU has an MTM700 or MTM800 radio connected to its MDLC over IP Port using PPP. A unique IP address is assigned to each RTU according to its radio's identifier (SSI). All communication between RTUs and the IP Gateway involves sending datagrams in packets over the Internet (IP). A PC running ACE3600 STS can be connected directly to an RTU or operate remotely over IP.



The STS can communicate with remote RTUs over IP using the Tetra infrastructure. The PC running the STS is connected to the Tetra radio (e.g. MTH500 radio) or to the RTU. For this purpose, the PC should have a Tetra PD installation (as specified in the CPS user manual).

After setting up the connection, the user should run the STS Communication Setup utility, select Ethernet port and specify in a focal point RTU/IP Gateway IP Address under 'Local Site IP Address'.

It is important to note that RTU to RTU communication is routed through the infrastructure LAN system and not directly.

Note that a paging mechanism to each site (peer) in IP conversion table makes MDLC over IP more reliable. For details, see MDLC over IP Site Paging.

Tetra does not support group calls (RTU-to-RTU broadcasts). To send a frame to a group of sites, the application should send to each site individually, leaving a short wait time between each transmission (about 300 milliseconds).

## MDLC over IP - Standard Modem

To avoid system setup for each modem/radio which supports packet data, a general concept has been introduced for, whereby IP can connect to any modem or radio supporting packet data.

A standard modem supporting packet data is a modem which requires an AT command set to configure and PPP to initiate. It can connect to a PC using Microsoft Standard Modem and RAS setup. A modem configuration file can be downloaded into the RTU specifying the exact command set needed by the modem/radio. A default AT command set is used in case this file is not downloaded. The same concept is used for circuit data modem over dial port.

For information of downloading modem configuration files, refer to ACE3600 STS Advanced Features Manual.

Connection to Standard modem is made using RS232 PPP over the operator infrastructure. Since the operator infrastructure connects to LAN as well, a LAN-connected RTU can communicate directly with these RTUs over that infrastructure, if enabled by the operator.

Some modems have an internal fixed IP address for PPP connection. If so, only one modem of the same vendor can be connected to RTU, since they all have the same IP address. Other modems such as Motorola g18 do not have an internal IP address; in this case several MDLC over IP ports can be configured to connect with them.

To verify if more than one modem can be used, try to connect two modems and see if you get an error message: "IP Address in use by other ports".

## MDLC over Null Modem

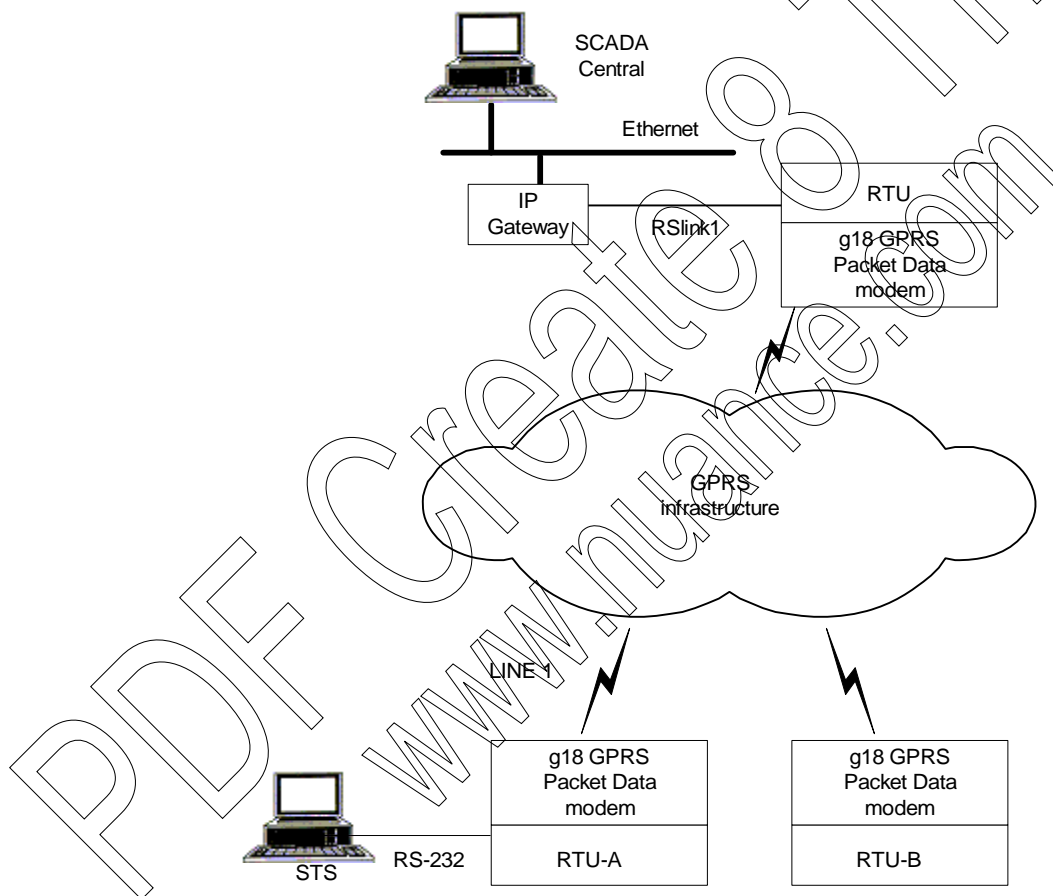
The RTU can connect to any device using PPP.

This connection is made using PPP and is basically the same as MDLC over Standard modem. When the RTU is powered up, it sends a client string and expects a client-server response. Only when it gets that response will it initiate PPP and poll for CD signal (carrier detect). CD is constantly being polled, and if it drops, PPP is disconnected. The user can opt to ignore CD using Advanced Link Layer parameters in the site configuration. In this case, PPP is initiated upon power up. When connected, CD is polled in order to stay connected. If it drops, then PPP is reconnected. By default, the RTU acts as a Windows Null modem connection. It sends a client string and expects a client-server response before initiating PPP. The user can override this behavior by downloading a modem configuration file.

## MDLC over GPRS Network

An RTU can be connected to GPRS (GSM) network through a LAN or through a radio. An IP Gateway or an RTU with an Ethernet port can be connected to the LAN.

In the figure below, the SCADA central and IP Gateway are connected via LAN to the GPRS infrastructure. Each RTU has a G18 GPRS/GSM modem connected to its MDLC over IP Port using PPP. A unique IP address is assigned to each RTU according to its modem identifier (IMSI). All communication between the RTUs and the IP Gateway involves sending datagrams in packets. The GPRS infrastructure routes those packets directly between two RTUs, or between IP Gateway and an RTU. A PC running STS can be connected directly to an RTU or operate remotely over IP.



A single GPRS modem can be connected to an RTU. Other ports can be connected to other GSM modems using dialup ports.

It is recommended that the operator provides an APN (Access Point Name) for a fixed IP address and enable one modem to communicate with another over UDP port 2002. However it is not always possible, so the following steps can be made:

1. Assign FEP need to have a fixed IP or host name. Make sure operator support UDP port 2002 from modem to FEP and vice versa.
2. Assign an IP conversion Table for RTUs having that FEP IP address or host name.
3. In application of RTUs transmit periodically to FEP, so it learns the recent address. Recommended time every 2 minutes. A better example is to wait for a timeout and if not getting anything from FEP send it a message.

Since there is no fixed IP addresses one modem cannot communicate with another. If this is required, the FEP can be used to route information between modems as follows:

1. Assign an IP conversion Table for RTUs that has the FEP Site ID + Link ID and IP address, along with all other relevant sites it needs to communicate over that GPRS Link ID.
2. In FEP enable the 'Enable routing of MDLC over IP port' parameter for that Link ID.

GPRS does not support group calls (RTU-to-RTU broadcasts). To send a frame to a group of sites, the application should send to each site individually, leaving a short wait time between each transmission (about 300 milliseconds).

Configuring an RTU to operate over GPRS is the same as configuring MDLC over IP for the Standard modem connection. If a modem configuration file is used (e.g. G18.stm), this too must be downloaded to the appropriate RTU port.

Note that before downloading the modem configuration file for GPRS, you need to change its APN according to your operator instructions. The APN (Access Point Name) is an address such as intranet.motorola.com. The APN defines the security and capabilities set by your provider for your SIM cards.

Note: Each SIM Card has unique identifiers for a GPRS/GSM modem. Placing a given SIM card on different modems causes the same settings to be retrieved from infrastructure (phone number, IP Address etc.) regardless of the modem.

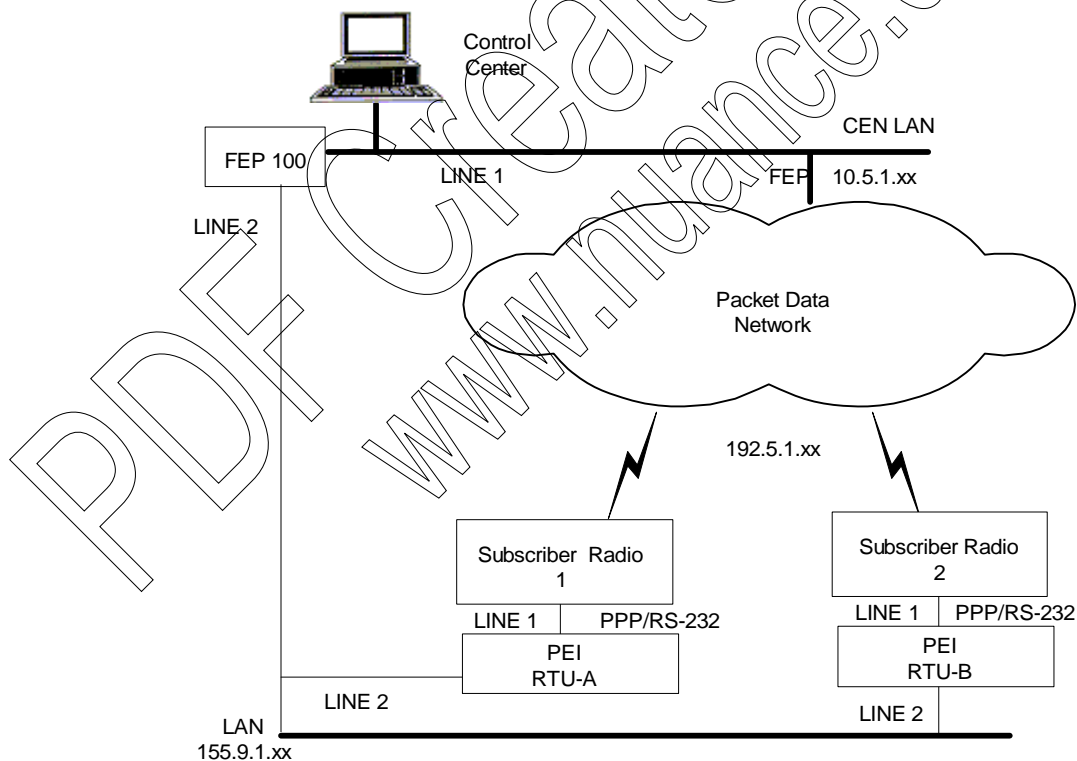
Use the STS Add-Ons Manager and Downloader to select the modem configuration file for the specified port and download the G18.stm file.

## IP Conversion Tables

The IP conversion table is created in the ACE3600 STS using the IP Conversion Table Manager. Note that unlike the network configuration, there is no default, and any IP conversion tables must be created manually. The IP conversion table maps sites in the system (site ID+link ID) to IP addresses or host names. Each site ID/link ID pair can have one unique entry in the table, though an IP address can appear in more than one row. A site ID of 0 is reserved for a group call.

In RS232/PPP and Ethernet DHCP, the IP address is read from the network once it is connected to the RTU. In Astro IV&D, this is not the real IP address set by the infrastructure; rather, it is a dummy address configured in the radio via the CPS Mobile Computer IP address which is (by default 192.168.128.2). In the IP conversion table do not specify this address, but the actual IP address assigned by the infrastructure operator.

The ACE3600 IP conversion table format includes a link ID column which allows more than one port in the same site to be connected to LAN or to PPP. Any legacy MOSCAD RTU or IP Gateway in the network must be defined using its own Toolbox IP Conversion Table utility.





In the example above, two sets of IP conversion tables should be created and the FEP's Table should be assigned to the RTUs:

The following IP Conversion Table should be loaded to the RTUs:

Site ID	Link ID	IP Address or Host name
100	LINE1	10.5.1.160
100	LINE2	155.9.1.17

The following IP Conversion Table should be loaded to the FEP:

Site ID	Link ID	IP Address or Host name
1	LINE1	192.5.1.161
1	LINE2	155.9.1.18
2	LINE1	192.5.1.162
2	LINE2	155.9.1.19

As another example the IP conversion table can be set with names rather than numeric IPv4 addresses. In this case make sure these names are the full host names set by your network administrator. Make sure the DNS Servers are either learned (DHCP or PPP) or set them manually in port configuration (Static LAN).

In this example assume the operator has assigned two names for the FEP:

- FEP1.moto.com for port LINE1
- FEP2.moto.com for port LINE2.

The following IP Conversion Table should be loaded to the RTUs:

Site ID	Link ID	IP Address or Host name
100	LINE1	FEP1.moto.com
100	LINE2	FEP2.moto.com

In this example, LINE2 is Static LAN so the user needs to set the DNS servers of LINE2 network in the LINE2 port configuration of RTU #1 and RTU #2. LINE1 is PPP, so there is no need to set these servers – they are learned from the network automatically.

In principle it is recommended to create two sets of IP conversion tables – one that will be assigned to an FEP/IP Gateway on the LAN, and one to all other RTUs which are connected with the ASTRO IV&D radios. The first will include the above information concerning each RTU, and the second will have only the FEP/IP Gateway.

For MDLC over iDEN, MDLC over Tetra, and MDLC over Standard or Null Modem, consult the system provider for the infrastructure relating to the IP addresses.

## Firewall

The ACE3600 Firewall enables the user to define a variety of firewall protections.

The firewall is configured and activated in the ACE3600 STS site configuration per site, for all IP ports in the site. The user can specify the list of IP addresses to accept, i.e. the list of IP addresses allowed to pass through this firewall. If no IP addresses are defined, then all addresses are allowed.

When the firewall is active, all UDP/ TCP ports will be blocked (e.g. telnet, http) except the following:

- DHCP port
- DNS port
- MDLC port (UDP 2002)
- NTP port
- MODBUS port (TCP 502)
- Expansion TCP connectivity and data ports (configurable, by default 57001, and 57002)
- Expansion UDP discovery port (57001, not user configurable)
- Timer event (UDP 57003)

The firewall also enables the user to define the maximum length of ICMP Echo (ping) allowed. A ping packet with a bigger size will be ignored, no response will be sent back.

In a system with I/O expansion, an enabled firewall could potentially block communication from expansion frames to the main frame. To enable communication from expansion frames to a main frame with enabled firewall, either:

- Manually enter the IP addresses of the expansion frames and main frame OR
- Make sure that no address ranges are defined in the firewall Address List (default) and the firewall will allow all IP communication.

## ***MDLC over Dialup Modem Configuration***

The ACE3600 can be connected to dial-up modem. The user can configure the modem from the RTU using the MDLC over Dialup port. A configuration modem string can be defined in the Physical Layer to configure the modem. The modem configuration file enables the user includes the configuration modem string and other AT commands. If no modem configuration file exists, the configuration modem string will be used. If both exist, the modem configuration file will be used.

MDLC over Dialup is different than MDLC over IP in the way it configures modem and connects it. It is important to note that in many cases the same modem can work in both modes, but the user must decide when configuring the port, what method to use. With MDLC over Dialup, the modem is placed in circuit data mode, meaning it establishes phone call conversations with remote sites upon transmitting to them. It accepts calls when another site transmits an MDLC frame to it. Most of the time the modem is idle, meaning it is in command mode. It only moves into data mode, when it needs to transmit or is called from another site. After a predetermined idle time, the modem disconnects the call. With MDLC over IP, the modem is ALWAYS in a "call". The "call" is actually PPP mode. This enables it to receive MDLC over IP frames from remote sites, as well as sending them. This "call" does not consume any air resources since it begins with the RTU and ends in the modem itself.

To make it more reliable when using wireless modems in dial mode, the modem can be monitored periodically to check if it is registered in the wireless network. This is done periodically every few seconds.

## Radio Communications

The ACE3600 RTU is designed to operate with various Motorola conventional and trunked radio transceivers (see table below). Other Third Party conventional radios can be interfaced to the ACE3600 using the radio modem ports using DPSK 1.2 kbps modulation (for more information consult Motorola support).

Radio	Bands	Modulation
HT750 - North America GP320 - Europe, Middle East, Africa GP328 - Asia & Pacific Pro5150 - South America	VHF 136-174 MHz UHF 403-470 MHz UHF 450-512 MHz	DPSK 1200 bps
CDM750 – North America	VHF 136-174 MHz UHF 403-470 MHz UHF 450-512 MHz	DPSK 1200 bps FSK 2400 bps DFM 4800 bps
CM200 - North America CM140 - Europe, Middle East, Africa GM3188 - Asia & Pacific EM200 - South America	VHF 146-174 MHz UHF 438-470 MHz	DPSK 1200 bps FSK 2400 bps DFM 4800 bps
XTL5000/XTL2500 Analog Trunk XTL5000/XTL2500 Digital Trunk (IV&D)	VHF 136-174 MHz UHF 450-520 MHz UHF 380-470 MHz 764 - 806 MHz 806 - 869 MHz	DPSK 1200 bps (analog operation)
XTS2500 Digital Trunk (IV&D)	VHF 136-174 MHz UHF 380-470 MHz UHF 450-520 MHz 764 - 806 MHz 806 - 869 MHz	N/A

**Radio FCC information**

Radio	Band	Power Output*	Transmitter Type Acceptance	Emissions	Applicable Rules
HT750	VHF 136-174 MHz	1-5W	AZ489FT3794	16K0F3E, 11K0F3E	90
	UHF 403-470 MHz	1-4W	AZ489FT4826		
	UHF 450-512 MHz	1-4W	AZ489FT4834		
CDM750	VHF 136-174 MHz	1-25W	AZ492FT3796	16K0F3E	22
	UHF 403-470 MHz	1-25W	AZ492FT4835	11K0F3E	74
	UHF 450-512 MHz	1-25W	AZ492FT4829	11K0F2D 5K60F2D	90 90.210
CM200	VHF 146-174 MHz	1-25W	AZ492FT3805	11K0F3E	90
	UHF 438-470 MHz	1-25W	AZ492FT4856	16K0F3E 16K0F2D 11K0F2D	90.210
XTL5000	VHF 136-174 MHz	10-50W	AZ492FT3806	8K10F1D 8K10F1E	22 74
	UHF 450-520 MHz	10-45W	AZ492FT4867	11K0F3E	90
	UHF 380-470 MHz	10-40W	AZ492FT4862	16K0F3E 20K0F1E	20K0F1D
	764 - 806 MHz 806 - 869 MHz	10-35W	AZ492FT5823	20K0F1E	
XTL2500	VHF 136-174 MHz	10-50W	AZ492FT3806	8K10F1D 8K10F1E	22 74
	UHF 450-520 MHz	10-35W	AZ492FT5823	11K0F3E	90
	UHF 380-470 MHz	10-40W	AZ492FT4862	16K0F3E 20K0F1E	20K0F1D
	764 - 806 MHz 806 - 869 MHz	10-35W	AZ492FT5823	20K0F1E	
XTS2500	VHF 136-174 MHz	1-5W	AZ489FT3807	11K0F3E 16K0F3E	22 74
	UHF 380-470 MHz	1-5W	AZ489FT4865	20K0F1E	90
	UHF 450-520 MHz	1-5W	AZ489FT4866	8K10F1E 8K10F1D	
	764 - 806 MHz 806 - 869 MHz	1-3W	AZ489FT5804		

**Conventional and Analog Trunked Radio Modulation Types**

The physical interface to the conventional or analog trunked radio is through a plug-in radio modem board on the CPU module; the characteristics programmed into the plug-in modem determine the emission characteristics of the radio. The data may directly modulate the FM transceiver’s oscillator to most effectively use the radio bandwidth. Motorola refers to this modulation technique as DFM; in the U.S. this is also described by the FCC as an F1 emission. The figure below shows the modulation sideband created by DFM. FCC licenses specifically state when F1 emission may be used and only radios having an F1 emission designator may be used in those licensed systems. No F1 emission is suitable when intermediate amplifiers (voice/RT repeaters) are present and should not be used with PL/DPL, but F1 emissions are fully compatible with the ACE3600 store-&-forward operation.

The data may instead modulate a tone oscillator to produce a variable tone or variable phase output; this signal output then modulates the FM transceiver’s oscillator. Motorola refers to this modulation technique as FSK (variable tone) or DPSK (variable phase). The figures below show the modulation sidebands created by FSK and DPSK. The FCC has revised the rules governing the use of these emissions, so please read carefully the Refarming section below. FSK or DPSK must be used whenever any intermediate amplifier (voice/RT repeater: conventional or trunked) is present; DPSK must be used when any degraded bandwidth condition (notch filters, etc.) exists, and DPSK is the only emission allowable in the U.S. VHF splinter channels. FSK and DPSK are also fully compatible with store-&-forward operation.

Modulation Technique	Data Speeds in bps (* = recommended)
COS	9600
DFM	4800(*), 3600, 2400
FSK	2400(*), 1800
DPSK	1200

Note: Intrac modulation is not supported in ACE3600.

**PL & DPL**

Private Line (PL) and Digital Private Line (DPL), also known as Continuous Tone-Coded Squelch System (CTCSS), was created for voice users of two-way radio to suppress activity from other co-channel users from being heard; it offered the illusion of a private channel. PL/DPL adds a decoder to the receiver that keeps the receiver muted until a signal having a specific low-frequency tone (PL) or slow data code (DPL) is received. All transmitters must encode the proper tone/code to open the protected receiver. Some repeaters, notably those in the UHF band, use PL or DPL to prevent unwanted access to the repeater system by co-channel users.

In the U.S. the FCC's rules for Fixed Secondary Signaling and for Telemetry operations require data not to interfere with voice operations—the data message must wait until the voice message is finished. This is a practical matter also—if a data message were attempted simultaneously with any co-channel message, there is a high probability that the data would be corrupted and throughput would be zero. So why create the interference for no gain. Therefore the data equipment must listen to all on-channel activity; PL/DPL protection on the receiver is unwanted.

PL/DPL may be used in ACE3600 or MOSCAD systems when it operates through some existing voice repeater system that requires PL or DPL for repeater access, but the PL/DPL is added to the transmitter and not the receiver. Note that PL/DPL should never be used on VHF splinter channels: the FCC limits the occupied channel bandwidth by severely limiting deviation; PL or DPL would consume too much of the authorized deviation to produce an effective system. Never use PL/DPL with DFM modulation.

### ***FCC Reframing (USA only)***

In the U.S., the FCC has revised the rules that govern the frequencies between 150.8 and 512 MHz; the rules for the frequencies above 806 MHz have not changed. Two issues addressed by the new rules are channel bandwidth and data efficiency on those channels.

The VHF and UHF channel bandwidth have been split. The former 25 kHz channels have been split into two 12.5 kHz channels and will be split further into four 6.25 kHz channels in the future. Manufacturers are required to design all new products to comply with the new channel bandwidth requirements, but there are no requirements that force licensees to migrate to 12.5 kHz channel operation. The MT-2000 and MCS-2000 radios used within MOSCAD may operate on either 25 kHz or 12.5 kHz bandwidth channels; Radio Service Software is used to define the mode of operation.

Radios used for data must meet a minimum efficiency requirement. In a separate action, the FCC clarified key definitions.

- Data is any signal that bypasses the microphone input's filters (i.e., the splatter filter).
- Voice is any signal that passes through the microphone input's filter.

The FSK and DPSK modulating signals are indeed data superimposed onto tone carriers and these signals always pass through the radio's splatter filter. Therefore, these modulating signals are voice, require an emission designator with the F3E characteristic, and are not required to satisfy a data efficiency requirement.

### ***VHF Splinter Channels (USA only)***

In the U.S. the FCC has defined certain frequencies in the 154 MHz and 173 MHz bands for data operation—the splinters. The frequencies are few in number, some have a 12.5 kHz bandwidth, all have a FCC-imposed deviation restriction, and are very commonly used. In an attempt to insure that the transmitted emission stays within the assigned channel bandwidth, the FCC has stipulated that an F2 emission must be used and that the

Sum of the Highest Modulating Frequency plus Deviation shall not exceed a stated maximum. For most channels, that maximum is 2800 Hz but on two frequencies (173.2100 and 173.3900 MHz) the maximum is 1700 Hz. The splinters were exempt from all Refarming actions and still require a 5K60F2D emission designator.

ACE3600, when using DPSK modulation, uses a 1200 Hz modulating tone; the legal allowable deviation on the “2800” channels is therefore 1.6 kHz whereas on the “1700” channels the legal deviation is an unusable 500 Hz. FSK is theoretically usable but at an impractical small deviation (300 Hz); DFM may not be used because it is not an F2 emission. PL/DPL must never be used because their deviation (750 Hz) must be subtracted from the data deviation which worsens an already marginal situation.

Therefore, DPSK modulation at 1.6 kHz is the only legal emission available for “2800” splinter frequency use; never use the “1700” frequencies and never use PL/DPL on a splinter frequency. Refer to the FCC rules or other applicable regulations to understand additional constraints on maximum Effective Radiated Power, antenna height, and antenna directivity.

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## Analog Trunked Radio Systems

In an analog trunked radio system, any unit that needs to send a message, requests, and is assigned to, a channel by the trunking system controller. The ACE3600 RTUs are typically clustered into a single trunked data group and are managed by the trunking system controller as a single entity. Therefore, any RTU that requests a channel causes all RTUs to switch to the assigned channel so that all units hear, decode, and may appropriately respond to the data transmitted. Two way data transfer among many RTUs may occur following a single channel request/assignment. Also, trunked systems provide an infrastructure that is inherently redundant—if one base station should fail, the trunked system automatically assigns communications to a remaining station. SCADA system data and trunked radio systems are very compatible!

Most analog trunked radio systems are set up to optimize the performance of the many mobile and portable voice radios in the system. This setup may not be optimal for data users. ACE3600 operates best in the Message Trunking mode whereas many systems are setup to use the PTT-ID Trunking mode. ACE3600 may be made compatible by lengthening the delay-before-transmit time to allow the PTT-ID activity to be completed before the ACE3600 data is transmitted.

Many trunked radio systems are designed with multiple transmit and receive sites. This is advantageous for the mobile and portable users that roam over a large territory but detrimental to ACE3600 data use. Receiver voting is present so the best quality received audio will be used; a quality analysis will occur at regular intervals, typically 350 msec, and a switch to the better quality signal may occur. That switch (revote) may introduce a small hole and/or a signal phase change into the audio message. Voice users are minimally affected by the hole/phase-change, but those artifacts may compromise the data message so that no throughput occurs (complete destruction). When ACE3600 is used in a multi-site system, the antenna choice and placement must be carefully selected so that only one site will receive a strong signal — this will prevent the site switch associated with a revote.

System engineers are encouraged to contact the ACE3600 Product Support Group during the design phase of any trunked radio system so that these and other issues may be discussed.

## Digital Trunked Radio Systems

In digital trunked radio systems such as ASTRO IV&D and TETRA (Dimetra), the ACE3600 uses the packet data capability of the system. The digital trunked radio system behaves as an IP network. The ACE3600 interfaces to the digital radio using an RS232 port configured to PPP protocol. For more information refer to the MDLC over ASTRO IV&D chapter in the ACE3600 STS Advanced Features Manual.

## Conventional Radio Interoperability

### *Introduction*

Since the first MOSCAD RTU was introduced to the market, various models of Motorola conventional radios had been used with Motorola RTUs. In cases where new RTUs are added to existing systems with newer radio models, or when legacy radios are replaced with newer models, it is important to make sure the radios can interoperate in the same system.

The purpose of this technical note is to provide important information on Motorola radio interoperability in control systems that use MOSCAD, MOSCAD-L, MOSCAD-M, ACE3600, and Front End Processors (FEPs) such as MCP-M and IP Gateway. The radios discussed in this document are Motorola conventional radios.

### *Channel Monitor Resolution Parameter (MDLC Slot Time)*

The MDLC protocol uses a slotted time channel access algorithm for radio communications. The Channel Monitor Resolution parameter sets the time slot period (in milliseconds) in the RTU/FEP. The types of radios used in the system determine the value of this parameter (typically 100 to 300 ms).

**Please note that the Channel Monitor Resolution parameter should be the same in all the RTUs/FEPs in the system. When different radios are used in the system, the parameter is determined by the radio that requires the longest slot time.**

For example, in a system which uses both 200 ms and 300 ms radios, the Channel Monitor Resolution parameter should be set to 300 ms in all the RTUs/FEPs in the system. To determine how to set up the Channel Monitor Resolution parameter in RTUs in your system, see the table on the following page.

### *First Warm-up Delay Parameter*

When the radio's PTT is activated, the radio starts transmitting a carrier wave. The other radios on the same frequency channel that receive the carrier wave activate the Channel Monitor and signal the RTU that the channel is busy. For each type of radio, there is a specific delay between the activation of the PTT in the transmitting radio and the activation of the channel monitor signal in the receiving radios. The types of radios that are used in the system determine the value of this parameter (typically 200 to 350 ms in Motorola conventional radios).

**Please note that this parameter should be the same in all the RTUs that reside on the same frequency channel and communicate with each other. When different radios reside on the same frequency channel, the parameter is determined by the radio that requires the longest Warm-up.**

For example, in a system which uses both 200 ms and 300 ms radios on the same channel, the First Warm-up parameter should be set to 300 ms in all the RTUs. To determine how to set up the First Warm-up Delay parameter in RTUs in your system, see the table on the following page.

***F1-F2 Repeater Considerations***

When the system uses an F1-F2 repeater, the First Warm-up Delay Parameter should be longer from the values in the table below. Also the Channel Monitor Resolution Parameter might be longer. In this case, the parameter setting in the system is determined by the RTUs/FEP radios and the repeater’s performance.

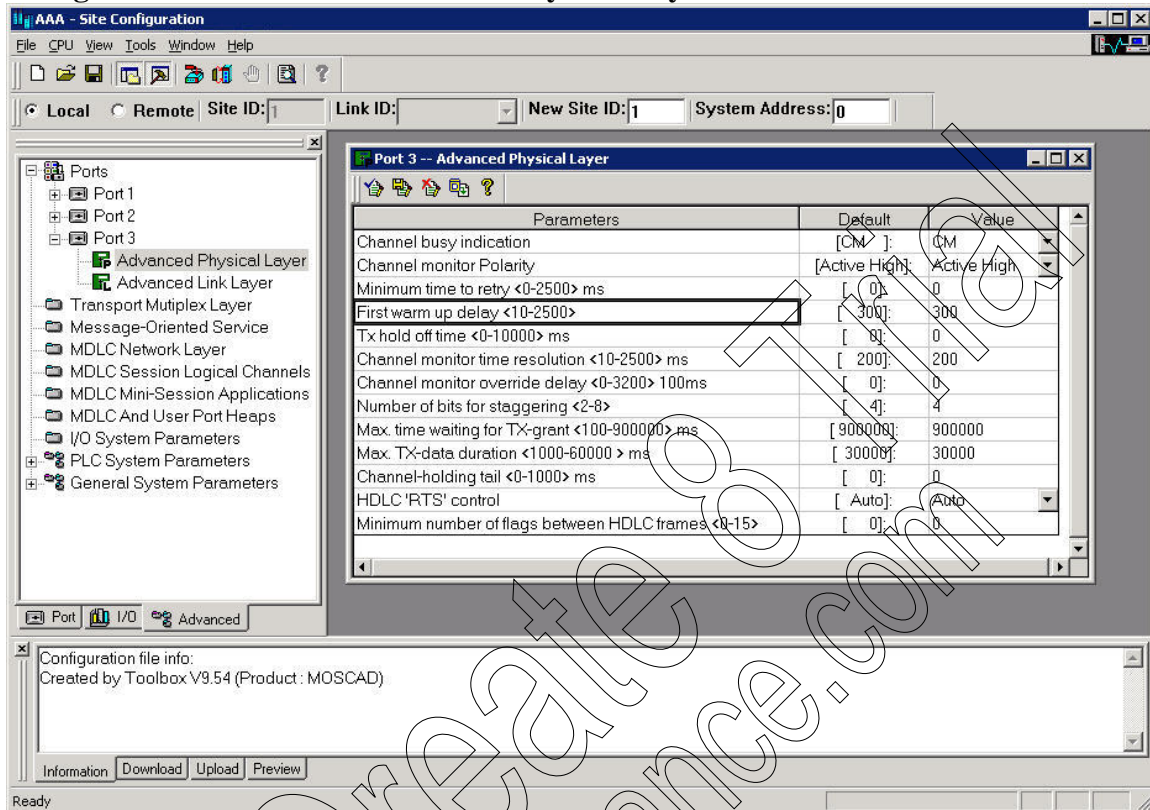
For technical support concerning setting parameters in system with F1-F2 repeaters, please contact Motorola technical support.

***Parameter Setting for Motorola Conventional Radios in MOSCAD / ACE3600 Systems***

Radio	Modulation	First Warm-Up Delay [ms]	Channel Monitor Resolution [ms]
XTL2500/5000 analog conventional operation	DPSK only	300	200
CDM750	FSK & DPSK @ 12.5 KHz channel spacing	200	100
	DFM @ 25KHz channel spacing	200	100
CM140;CM200;EM200;GM3188;GM338;GM339;GM340;GM350	FSK & DPSK @ 12.5 KHz channel spacing	300	200
	DFM @ 25KHz channel spacing	300	200
MCS2000; Maxtrac	FSK & DPSK @ 12.5 KHz channel spacing	200	100
	DFM @ 25KHz channel spacing	200	100
MTS2000	FSK & DPSK @ 12.5 KHz channel spacing	300	200
HT1000	DPSK only	300	200

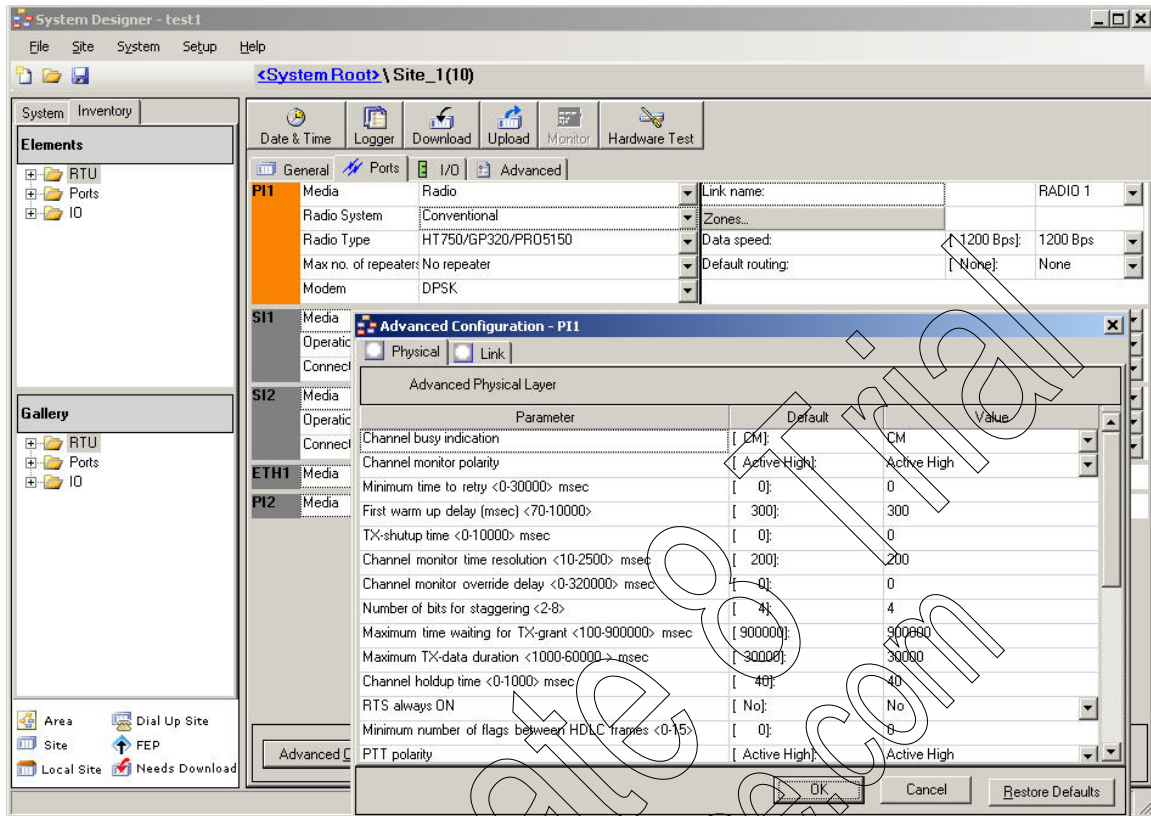
### Setting the Parameters in the MOSCAD/MOSCAD-L ToolBox

The Channel Monitor Resolution and First Warm-up Delay parameters are set in the **Site configuration -> Port 3 -> Advanced Physical Layer** screen.



### Setting the Parameters in the ACE3600 STS

The Channel Monitor Resolution and First Warm-up Delay parameters are set in the **Site -> Port Tab -> Port X -> Advanced Configuration -> Physical Tab** screen.



## Communication Network

The ACE3600 system network consists of RTUs communicating with one or more computerized control centers and/or with other RTUs. Each control center is connected to the communication network.

The system can be relatively simple, comprising several RTUs and one control center. It can be modularly expanded to a more hierarchical system, where several sub-systems (comprising intelligent RTUs and/or sub-centrals controlling their peripheral RTUs) communicate with a central computer.

The communication network is flexible, enabling each RTU to communicate with hierarchies above it (RTU-to-central), parallel to it (RTU-to-RTU), under it (another RTU), and also relaying messages through it (when the RTU serves as a communication node).

While the communication protocol allows for a complex hierarchical system structure, it does not make it complicated. This is because most of the communication interactions are transparent to the user, except in those cases where the communication is to be defined by the ladder application. In such cases, you should perform simple programming operations to configure the required application.

Each RTU may be configured to serve as a far-end terminal or as a regional center. The RTU may function as a regional center either by definition or only after loss of

communication with the central. It also can act as a communication node (an interconnection point between two or more different links) while performing its other tasks.

The RTU network uses the MDLC protocol, which incorporates all seven layers of the OSI model adapted for SCADA. It supports multiple logical channels per physical port, enabling simultaneous central-to-RTU and RTU-to-RTU sessions. It also enables each RTU to simultaneously run several kinds of communication applications, such as reporting alarms by contention, on-line monitoring, performing diagnostics checks, etc. The MDLC protocol is discussed later in this manual.

The ACE3600 System Tools Suite (STS) may perform monitoring, modification, diagnostics, error logging, etc., on any RTU in the system from any RS232 port in the system, configured as either RS232 Local Computer port, RTU-to-RTU RS232 (RS-link1) or from any IP port in the system (not necessarily RTU port).

### Communication Types

The RTUs in the system are linked to a radio or line network as defined by the system engineer, according to user requirements. Each RTU executes its application and, simultaneously, supports the communications link (or links) defined for it, and serves as a network node, if so defined.

The ACE3600 system supports up to 29 line links (LINE 1 to LINE 29), up to nine radio links (RADIO 1 to RADIO 9), up to 19 local RTU-to-RTU links (RS-link 1 to RS-link 19) that use RS232, up to 29 IP links (LINE 1 to LINE 29), and one dial link. Any of the radios may be either conventional or analog trunked. Computers may be connected to the ports configured as RS232 Local Computer, as local RTU-to-RTU link, or via Ethernet.

For conventional radios, up to nine zones can be defined on every frequency (of the nine supported frequencies). A radio link for conventional radios is divided into zones when not all sites can communicate with each other and F1/F2 repeaters (using two frequencies) are not to be used. In this case, some RTUs will serve as Store & Forward repeaters and the link is divided into zones.

A zone is defined as a group of one or more sites that can directly communicate with each other without a Store & Forward repeater. The name of a zone is composed of the link name and the zone number. For example, for RADIO 3 zone number 1 is named RADIO 3/1, zone number 2 - RADIO 3/2 and so on.

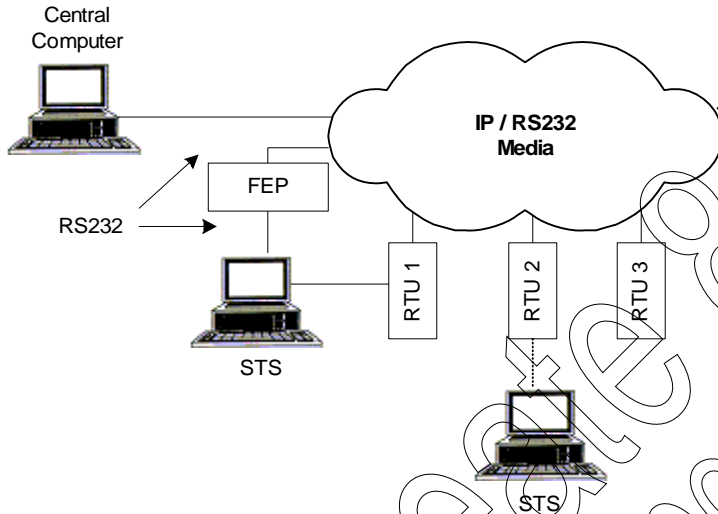
After defining the communications network, the user must define the various links used in the system as well as the RTUs that serve as nodes between the links. A network node is an RTU that functions as an interconnection point between two or more different links. A Store & Forward node, on the other hand, is a network node, which relays messages using the same physical port.

## Network Configurations

The ACE3600 system supports both simple and complex communication networks. The following sections describe various configurations from different aspects.

### *Simple System*

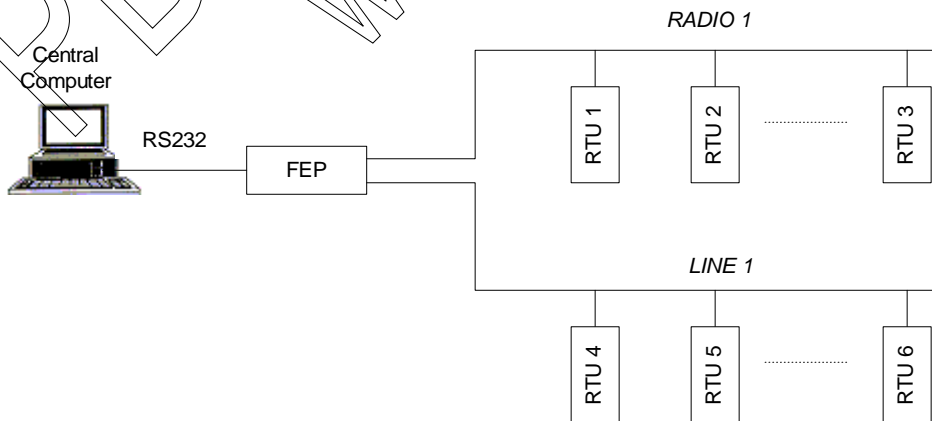
A simple system, comprised of a central computer and RTUs connected over one communication link, is shown in the following figure:



The STS may be connected to any port of the RTU. The ports of the RTUs should be defined via Site Configuration. The logical name (e.g. LINE1, etc.) of the communication link is also defined.

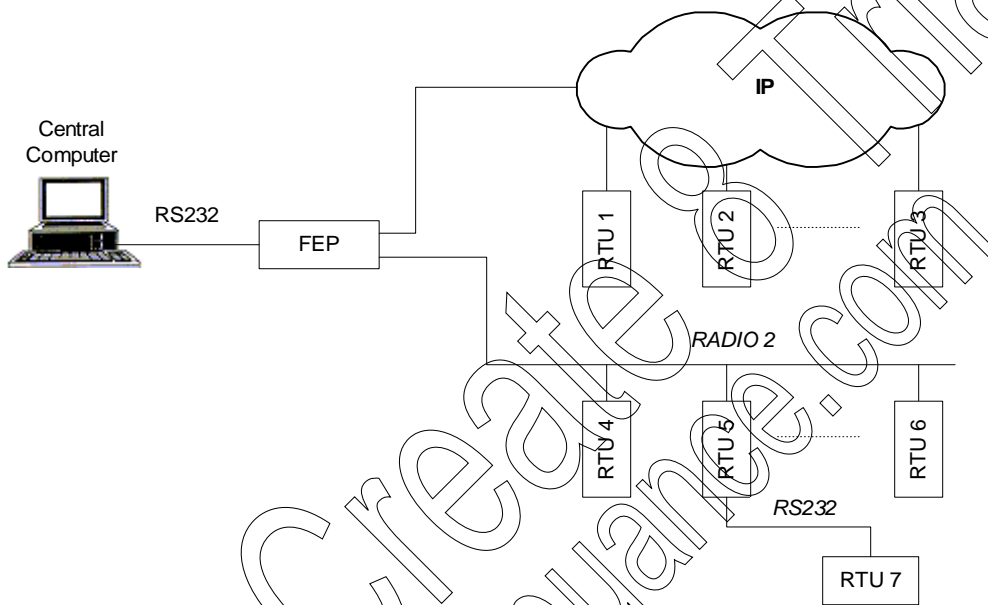
### *Two-Link and Multiple Link Systems*

A two-link system utilizing a communications network, comprised of two communication links, is described in the following figure:



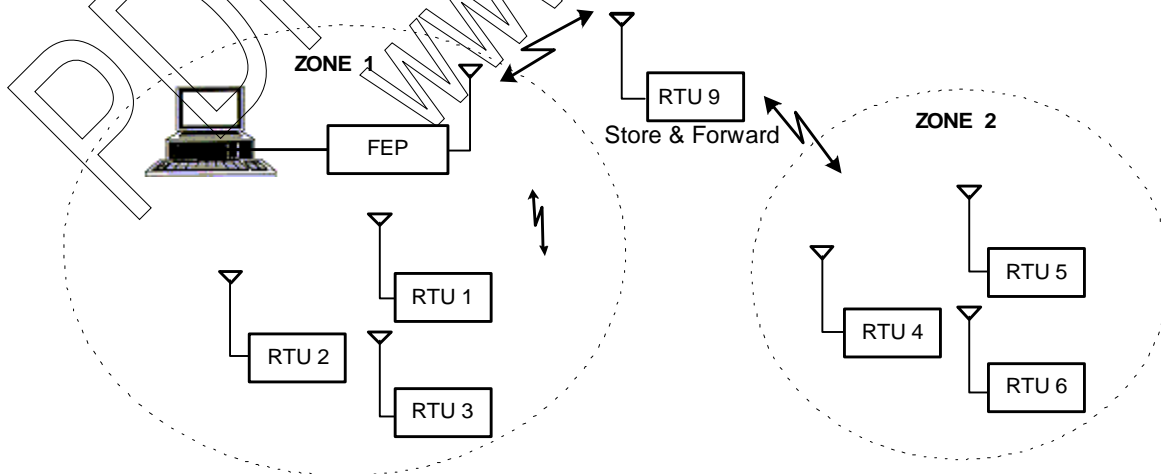
The FEP in the system illustrated above serves as a network node between link RADIO 1 and link LINE 1. Configuring the FEP to have access to two different links enables it to serve as a node between these links. The MDLC protocol permits RTU-to-RTU communications without the intervention of the central computer. RTUs that are not on the same link communicate with each other via the network node (in this case, the FEP).

A multi-link system is a network that uses several link types. The following figure illustrates a system where a third link type, RS232, connects an RTU to another terminal that communicates over RADIO 2. RTUs connected to the IP link can reach RTU 7 via IP network and then RADIO 2.



**Two-Zone System**

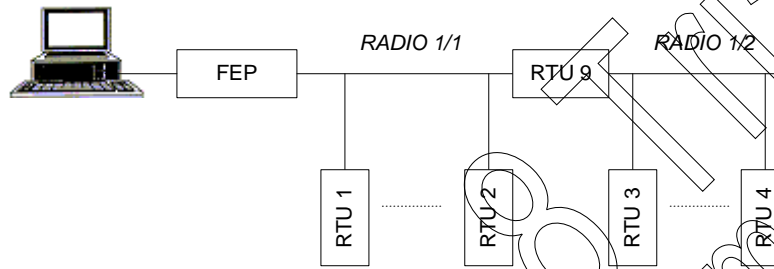
A two-zone system that uses conventional radio over a single frequency is described in the following figure:





RTU 9 (Site ID = 9) is configured as a Store & Forward repeater. It performs data exchange between units that operate on the same frequency but are unable to communicate directly for reasons of path and propagation. Any RTU in zone 1 may communicate with any RTU in zone 2 via this repeater.

The figure below illustrates this system schematically. In this case, RTU 9 is a network node between the RADIO 1/1 and RADIO 1/2 links. The network software treats the Store & Forward node as it treats the node between line and radio: logically the links appear as two different links, but physically they share the same port.

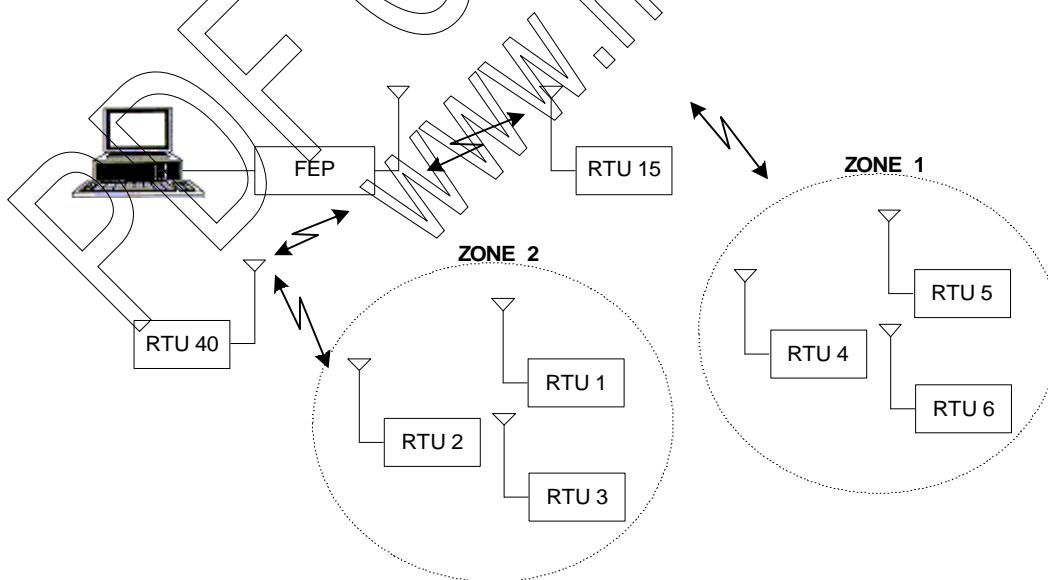


Using Site Configuration, the FEP and the RTUs in zone 1 are configured to have access to the RADIO 1/1 link. The RTUs in zone 2 are configured to have access to the RADIO 1/2 link, and RTU 9, the network node, is configured to have access to both RADIO 1/1 and RADIO 1/2 links.

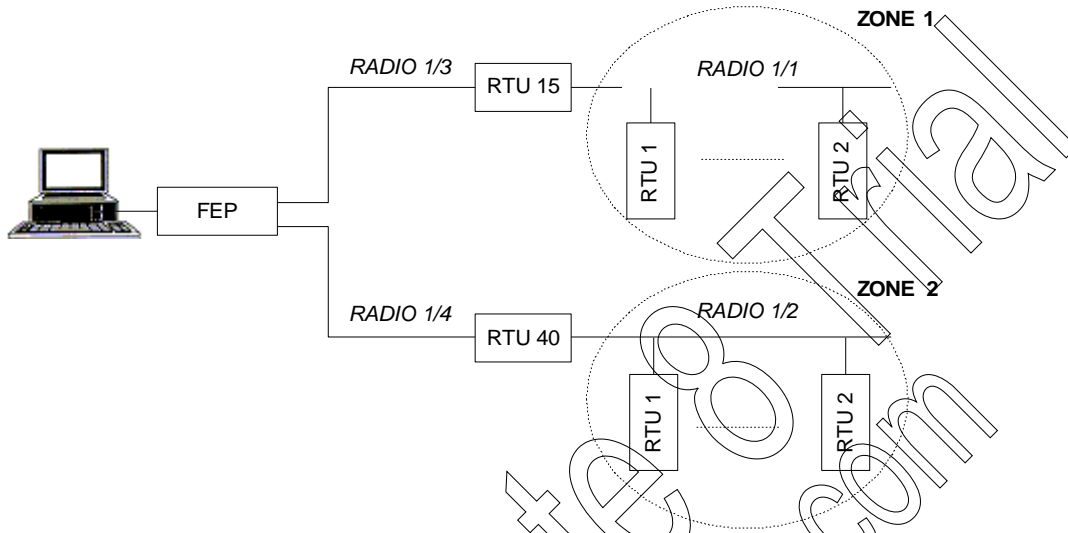
Using Network Configuration, RTU 9 is configured as the only node in the network. This terminal is configured to have two links, RADIO 1/1 and RADIO 1/2.

**Multiple Zone System**

The following figure illustrates an ACE3600 system spanning multiple zones.

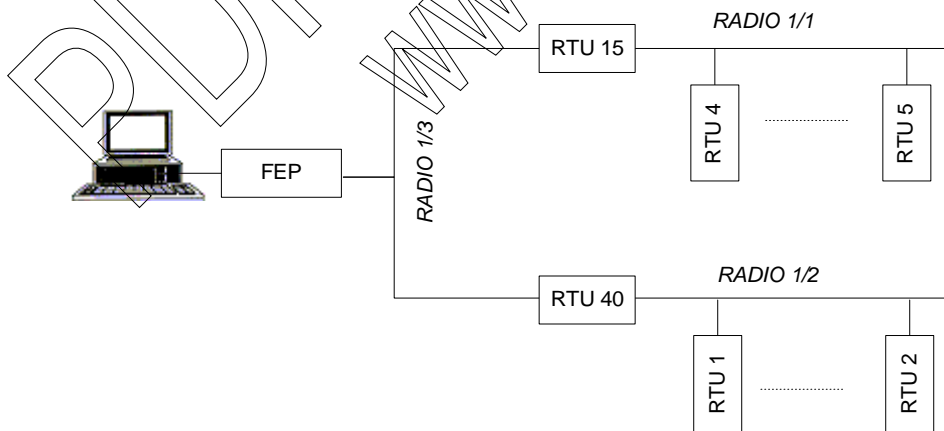


The schematic representation of this system is shown below. The system assumes that the two nodes, RTU 15 and RTU 40, cannot “hear” each other. They communicate via the FEP, which is also a Store & Forward node. This system, therefore, consists of four zones and three nodes (RTU 15, RTU 40, and FIU). Any communication between RTUs in different zones passes through these three nodes.



In the above situation, three nodes with their accessible (logical) links should be defined. Using the STS site configuration, the RTUs in zone 1 should be configured to have access to the RADIO 1/1 link, and the RTUs in zone 2 to the RADIO 1/2 link. RTU 15 should be configured to have access to both RADIO 1/1 and RADIO 1/3 links, while RTU 40 should be configured to have access to both RADIO 1/2 and RADIO 1/4 links.

The FEP is configured to have access to both RADIO 1/3 and RADIO 1/4 links. Assuming that the two nodes (RTU 15 and RTU 40) can “hear” each other, the result is a system consisting of three zones and two nodes, as shown in the following figure:



In this case, the two nodes do not communicate through the FEP. Therefore, the FEP does not serve as a node in the system. Note that the communication between RTUs in different zones passes only through two nodes.

## MDLC Encryption

### Overview

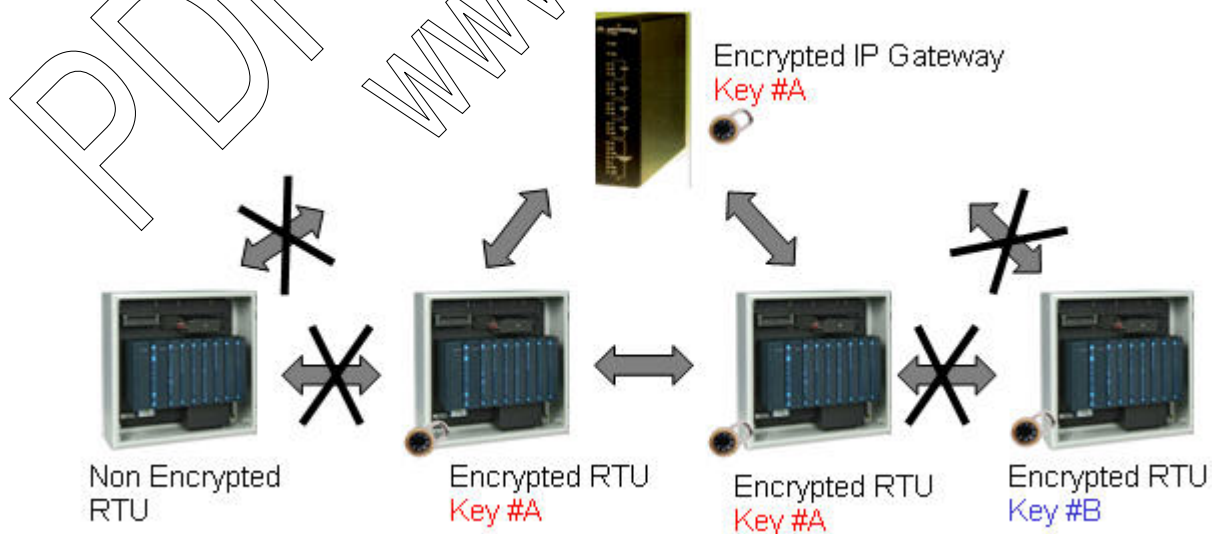
Encryption prevents any non-authorized party to communicate on MDLC network. The level of protection provided by encryption is determined by an encryption algorithm. The encryption strength is measured by the number of possible encryption keys and the key size.

ACE3600 and legacy MOSCAD and MOSCAD-L RTUs can communicate using encrypted MDLC protocol. The Encryption is based on Tiny Encryption Algorithm (TEA). The information being sent within the MDLC packets is encrypted using a 128 bit encryption key. To enhance security, each RTU can store 9 replaceable encryption keys. The encryption keys can be replaced in all the RTUs in a system at the same time. Encryption is possible on all the types of communication links that use MDLC protocol.

MDLC data encryption is supported by:

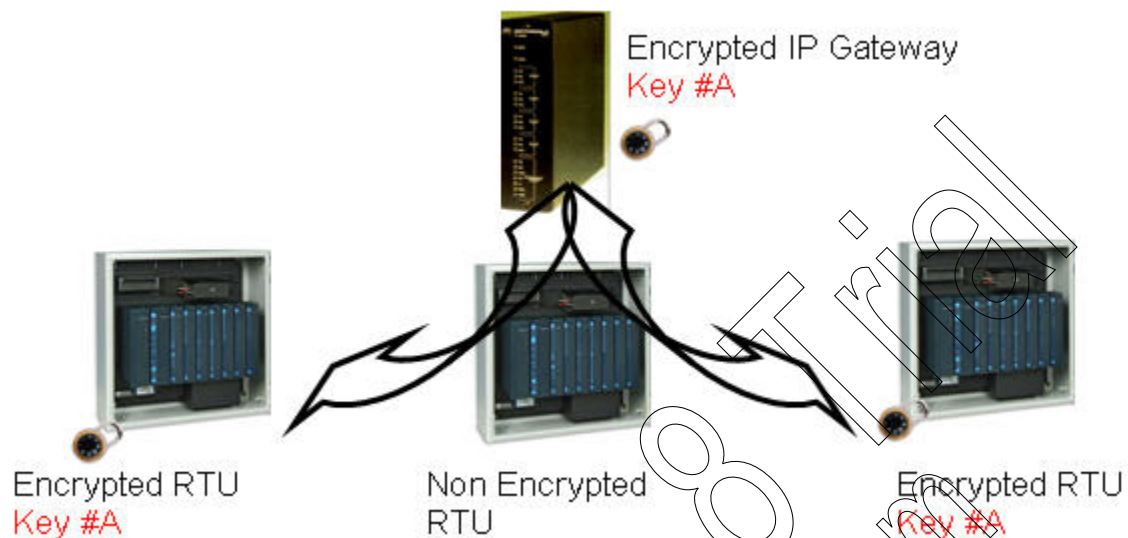
- ACE3600
- MOSCAD IP Gateway
- MOSCAD (CPU420)
- MOSCAD-L (CPU020)

Only encrypted RTUs / IP Gateways that are using the same Encryption Key are able to exchange data and commands. An RTU that receives data or a command from another encrypted RTU that uses a different key (or from a non-encrypted RTU) will reject the received data or command.



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Both a non-encrypted RTU and an encrypted RTU can serve as an MDLC network node for encrypted or non-encrypted RTUs.



## Encryption Keys

A set of Encryption Keys is defined for the system using the MDLC Encryption Tool. The Keys File (KF) is saved and then downloaded to the IP Gateway and to the RTUs using the MDLC Encryption Tool. The KF can be loaded to a local or a remote RTU. Each KF contains nine keys, indexed '1' to '9'. The same KF is used by the IP Gateway, the RTUs and the ToolBox MDLC driver. The KF is encrypted and cannot be obtained from without password

The KF is stored encrypted in the RTU and in the IP Gateway.

Only one KF is in use in a system at any given time. Only one Encryption Key from the KF should be active at any given time, and it is identified by its 'index' (1-9). If the active key index is set to '0', the MDLC Encryption is disabled (the RTU / IP Gateway / ToolBox becomes non-encrypted).

The MDLC Encryption Tool enables setting and managing the encryption in a system. It has the following major features:

- Building a system site map
- Defining KF with 9 encryption keys
- Downloading the encryption KF to the RTUs and IP Gateway
- Setting Active Key index in RTUs, IP Gateway and in the ToolBox MDLC driver.

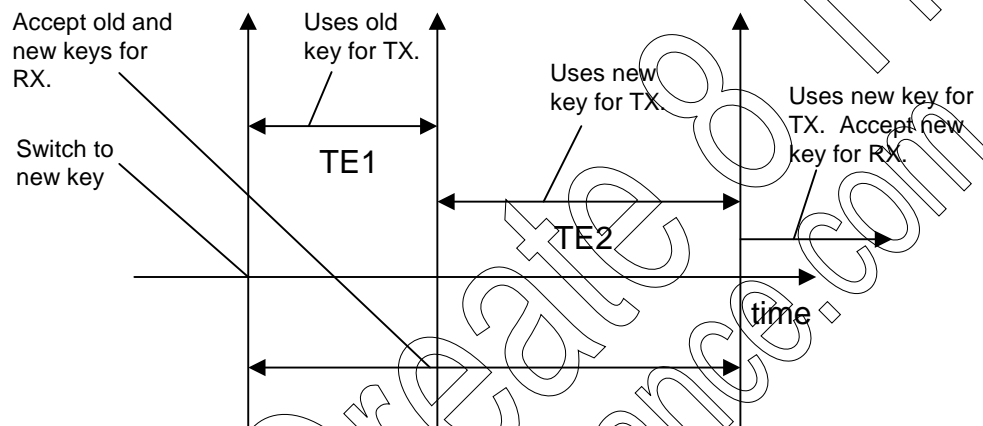
The encryption keys are stored in the RTU / IP GW FLASH memory.

When an RTU is first configured and starts up (cold start in MOSCAD and MOSCAD-L RTUs), the key index is set to '0' (non-encrypted mode). Encryption is then activated by changing the Active Key index to a number other than '0' (1-9). This is done using the MDLC Encryption Tool.

The replacement of the encryption key is initiated by the MDLC Encryption tool.

Successful replacement of the active key requires that all RTUs in the system be time-synchronized by the IP Gateway.

To compensate for possible time drifts during a transition from one encryption key to another, there is a configurable time interval where both the old and new keys are valid.



TE1 is the interval, in seconds, which represents the possible time drift.

Note: It is recommended that at least one non-encrypted IP Gateway (FIU) will be connected to the system to enable communication with non-encrypted RTUs when necessary

### Encryption in the STS/ToolBox MDLC Driver

Once KF is defined in the MDLC Encryption Tool, it can be set as the Active File in the STS/ToolBox MDLC driver. The Active Key Index is then set to the same index (1-9) of the Active Key of the system. This enables the STS or ToolBox to exchange data with encrypted RTUs.

In the event that the STS/ToolBox must send a non-encrypted message, (to an RTU that performed a cold restart), the encryption should be deactivated by setting the MDLC driver Key Index to 0.

## Security Administration Tool

The Security Administrator Tool, provided with the MDLC Encryption Option is used to control access to the MDLC Encryption Tool and files.

Using this tool, the administrator can define users and groups, and grant permissions to authorized personnel as necessary.

## MDLC Encryption Implementation Considerations

- Encryption Interoperability:  
Encrypted system requires using the following versions of firmware and tools in the same system.

The following versions should be used in the same system:

1. MOSCAD firmware V9.29 or higher
  2. IP Gateway firmware V5.40 or higher
  3. ACE3600 firmware V11.05 or higher
  4. MOSCAD/MOSCADL ToolBox V9.54 with Service Pack 2 (SP2)
  5. IP Gateway Toolbox V5.52 or higher
  6. ACE3600 STS V11.70 or higher
  7. Encryption Tool 1.00 or higher
- The Encryption Tool, STS and IP Gateway ToolBox require that MOSCAD/MOSCAD-L ToolBox V9.54 with Service Pack 2 (SP2) will be installed on the same PC to be able to work in encryption mode. (This requirement is valid to STS and Encryption Tool V1.00 only. STS will not require ToolBox V9.54 when higher Encryption Tool versions will be used).

# **Clock Functions and Synchronization**

## ***RTU Clock***

The ACE3600 RTU has one time source, an internal system clock which is in microsecond resolution. This time source is updated using a backup source of the RTC hardware component - Real Time Clock (seconds accuracy).

In addition, external clocks, such as GPS and NTP servers can be used as a time source. See NTP Clock Synchronization and Global Positioning System (GPS) below.

The time resolution of the system clock is hour, minute, second, millisecond, microsecond. The date resolution is day, month, year. Leap year support is automatic.

When the RTU first starts up, the system clock is set according to the RTC, which always retains its time in seconds (even when the RTU is powered down.) The RTU time can then be set using a number of mechanisms.

The RTU clock controls the date and time of the ACE3600 unit. Date and time information is used for timestamps on events such as time tagging changes to time tagged discrete inputs, etc.

The ACE3600 includes configurable time zone support, where RTUs in one time zone can adjust messages received from another time zone. The time zone is commonly used in conjunction with NTP servers and GPS receiver. These servers operate in UTC (Universal Time Clock) which is in the (Greenwich Mean Time) GMT time zone. Setting time zone in a unit will adjust it to the local time.

The ACE3600 also supports daylight savings time. Daylight savings time is used only in conjunction with a time zone. The start and end dates for daylight savings time (month, day, our) can be defined in the Daylight Saving Dates table. (The current year is assumed.) The RTU will check these dates and adjust the time by one hour when appropriate. The time zone is set in the STS site configuration and the daylight savings time is set in the application system table.

## ***Time Adjustment and Synchronization***

MDLC time synchronization of the RTU clock can be performed locally or remotely, using MDLC protocol over a variety of communication media, including conventional radio, RS485, and RS232. Synchronization is accurate to 1 millisecond+0.5 (very low delay). With IP media, this feature can be enabled, but because its accuracy/delay is unpredictable it is not recommended. NTP, the recommended method of obtaining the time over IP media (PPP or Ethernet), allows accuracy of 1 to 100 milliseconds depending on the media.



In ACE3600 RTUs, a new MLDC extended time synchronization can be enabled which includes the synchronizing RTU's password. In this case, all RTUs in the system must use the same password. This extended time synchronization also enables synchronizing two RTUs in different time zones, and better accuracy than the MOSCAD MDLC legacy synchronization. Note that by default, the ACE3600 uses MOSCAD MDLC legacy synchronization (to support IP Gateway and MOSCAD RTUs) which does not include the time zone and password features.

Note: An extended time synchronization of two RTUs, where only one is configured for time zone, will proceed as if both RTUs are in the same time zone.

The RTU clock can be synchronized during runtime using a number of methods. Before synchronizing the clock, make sure that the appropriate parameters have been configured properly. (See Time Parameter Configuration below.)

### User Time Control Actions

- STS Date & Time utility – From the STS, the user sets the RTU date/time to the PC's date/time (which is limited to second accuracy.) For information on using the Date & Time utility, see the Operation chapter of the ACE3600 STS User Guide.
- STS Sync utility – From the STS, the user instructs the local RTU to synchronize (in milliseconds accuracy) the date/time of other RTUs attached to one or all links. It is recommended to synchronize all links, so that the entire system has the same date/time. For information on using the Sync utility, see the Operation chapter of the ACE3600 STS User Guide. Note that MDLC dialup links do not support synchronization.
- User Application – The user application (ladder or 'C') can synchronize RTUs on one or all links using the Sync function. It is recommended that an RTU with a reliable clock source synchronize all RTUs in the system once per day to correct clock drift.

The requirement for legacy MOSCAD RTUs to synchronize RTUs at least once every 48 days is not relevant to ACE3600 RTUs. However, ACE3600 has a drift of 30 ppm which is 2.6 seconds per day if not connected to an NTP server and/or GPS receiver. The worst case is a drift of 1.8 milliseconds per minute, or 18 milliseconds per 10 minutes. Typical tests shows better results at 1 millisecond per 2 minutes, or 5 millisecond per 10 minutes. The interval of sending a time sync, is proportional to that clock offset/accuracy – sending a sync every 2 minutes assures a 1 millisecond offset typically.)

For information on the Sync function, see Appendix B: Ladder Diagram Language in the ACE3600 STS User Guide and 'C' Toolkit for ACE3600 RTUs User Guide.

When the user application (ladder or 'C') updates the Time & Date database

system table, it also changes the RTU time and date. For more information on the Time & Date database system table, see Appendix C: Database Tables and Data Types in the ACE3600 STS User Guide.

The user can update the same Time & Date database system table (HH:MM:SS) using the Application Programmer database monitor function. In this case, synchronization is direct (no time zone aspect.) For information on monitoring a database table, see the Application Programmer chapter of the ACE3600 STS User Guide.

### System Time Control Actions

- **GPS Connection** – An RTU which is connected to a GPS receiver continuously polls the GPS time and synchronizes itself. Because the clock source is reliable, this RTU can be used to synchronize the rest of the system. See the Global Positioning System (GPS) section below.
- **NTP Connection** – An RTU which is connected to an NTP server continuously polls the NTP server(s). Because the clock source is reliable, this RTU can be used to synchronize the rest of the system. The accuracy of NTP time depends on the link to the NTP server. It can be 1 millisecond in a LAN where the NTP server resides on the same network, and up to 100 milliseconds if using wireless media such as GPRS or TETRA. See the NTP Clock Synchronization section below.

If the synchronizing RTU is in a different time zone than the RTU being synchronized, the system will adjust the time accordingly; the receiving RTU will add the time zone of the sender to the global time (GMT) and use this. If only one of the two RTUs involved is configured for time zone support, the synchronization will proceed as if both sites are in the same time zone.

Note: A legacy MOSCAD RTU is treated as an RTU which is not configured for time zone support.

Note: In systems with I/O expansion, clock synchronization of the expansion modules is controlled by the main CPU. In addition, a sequencing mechanism ensures that time tags and timer events are sequenced properly in chronological order.

### NTP Clock Synchronization

The Network Time Protocol (NTP) can be used as an external clock source to synchronize the ACE3600 RTU over IP with one or more NTP servers.

In the MOSCAD system, the NTP works in client/server mode, in which a client RTU polls another server and gets a reply. The server can be another RTU operating NTP, or a host (PC, Unix, Linux). NTP poll the server RTU every 2 seconds, every 4 seconds, 8 and so on, up to a poll every 17 minutes. NTP provides client accuracies typically within a millisecond on LANs and up to 100 milliseconds on WANs (Internet, GPRS). Any

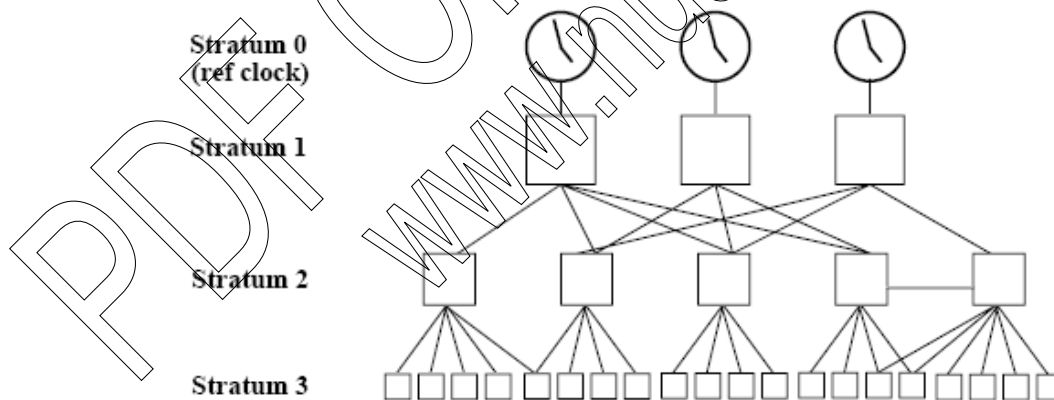
RTU (usually FEP) can act as a server. This enable setting its time via MDLC time sync, for example, and having other RTUs specify it as an NTP server and obtain their time from it.

NTP synchronizes clock both in time and frequency. In time means it make its clock offset as close as possible to the server. In frequency means it learns the server drift (time between “ticks”) in order to avoid polling it every few seconds. An example, not related to NTP, is ACE3600 send MDLC Sync over radio to another ACE3600. The clock offset guaranteed to be less than 1 millisecond. However a 30ppm clock drift after 1 minute offset will be 1.8 milliseconds. NTP prevents that by learning the drift frequency of the server.

User can set a single NTP server, or several ones. NTP operates under the assumption that each server's time should be viewed with a certain amount of distrust. NTP really prefers to have access to several sources of lower stratum time (at least three) since it can then apply an agreement algorithm to detect insanity on the part of any one of these. Normally, when all servers are in agreement, NTP will choose the best of these, where "best" is defined in terms of lowest stratum, closest (in terms of network delay) and claimed precision, along with several other considerations.

As the below figure shows, at the top of any NTP hierarchy are one or more stratum 0 reference clocks. These are electronic clocks such as GPS signals, radio signals, or extremely accurate frequency control. Reference clocks are assumed to be accurate. In ACE3600 a GPS port can be configured, it will serve as a reference clock for that RTU. In this case RTU will operate on stratum 1 with an accuracy of 200 microseconds.

FIGURE 1 NTP Strata



### NTP Architecture

As the above figure shows, time is distributed from an NTP subnet of servers. Each server comprises a *stratum*, which designate its location in terms of hops to the *UTC source*. The *stratum 1* is the most accurate server of which all servers should be synchronized to. Up to 15 *stratum* levels may exist. *Stratum 16* means server unreachable.

The accuracy of other clocks is judged according to how “close” a clock is to a reference clock (the *stratum* of the clock, the network latency to the clock, and the claimed accuracy of the clock. The accuracy of NTP thus depends on the network environment. Because NTP uses UDP packets, traffic congestion could temporarily prevent synchronization, but the client can still self-adjust, based on its historic drift. Under good conditions on a LAN without too many routers or other sources of network delay, synchronization to within a few milliseconds is normal. Anything that adds latency, such as hubs, switches, routers, or network traffic, will reduce this accuracy. The synchronization accuracy on a WAN is typically within the range of 10-100 ms. For the Internet/GPRS synchronization accuracy is unpredictable, so special attention is needed when configuring a client to use public NTP servers. Testing with the ACE3600 connected with the Internet gains accuracy of 20-30ms, but theoretically it may be even 100ms.

NTP uses UTC time base (Coordinated Universal Time). UTC evolved from Greenwich Mean Time (GMT). GMT is based on the earth’s rotation, which is not constant enough to be used for detailed time measurements. UTC is based on a standard second length determined by the quantum phenomena. There is a difference of a few seconds between the two (14seconds in 2006), so every several years add one more second (called leap second) to UTC. This is built in NTP protocol.

To translate the UTC time into local time, user can configure Time zones and Daylight Savings in RTU. Note however, that if setting NTP server to another stand alone ACE3600, which has no time zone, both will operate with the same local time if no time zone set. If that ACE3600 is connected to a GPS or to another NTP server then there is a need to set a time zone.

### **Global Positioning System (GPS)**

The ACE3600 system can use a GPS receiver precise time measurement application for synchronization purposes, to synchronize the RTU with other SCADA systems.

The ACE3600 RTUs use GPS timing receivers equipped with a 1 Pulse per Second (PPS) output. The receivers are connected to an RTU port. In case of a satellite failure, the time is manufactured internally and the receiver indicates its inability to trace the satellite.

The recommended GPS receiver is the Synergy Systems SynPaQ/E GPS Sensor with M12+ Timing Receiver which must be purchased from a Synergy vendor. Along with the timing receiver, a data/power cable and antenna should be purchased. For details on connecting to the GPS receiver, see Appendix A: RS232/RS485 Adaptor Cables in the ACE3600 STS Advanced Features manual.

# SCADA System Components

## **Control Center – SCADA Manager**

Supervisory Control And Data Acquisition (SCADA) originally described a monitor and control process wherein all intelligence resided in a central computer (the SCADA Manager). The human operators would manage the system by observing the data as presented on the computer's terminal(s).

### **FEP**

The SCADA Manager in most cases consists of a personal computer(s), the software package on that computer, the configuration files/screens created for the system and an interface assembly between the computer system and the communication system—this interface is the Front End Processor (FEP). Commonly, the FEP is isolated and the term SCADA Manager is used instead to describe the computer, software, etc.; that convention will be used hereafter.

The SCADA Manager typically does not support the MDLC protocol, the SCADA Manager might not support conventional, trunked, or data radio; it might not support LAN or dial-up. The FEP provides this support and passes data to the SCADA Manager. The SCADA Manager “assumes” it is communicating with the field units but is truly communicating only with (or through) the FEP. The technology used within the FEP is necessarily different according to the connectivity available in the SCADA Manager.

### **M-OPC**

OPC defines an open industry-standard interface based on OLE and ActiveX technology that provides interoperability between different field devices, automation/control and business systems. The OPC specification defines a set of interfaces for easy to use objects including methods and properties to manipulate these objects. The basic transport layer for OPC is DCOM and therefore, a Man-Machine Interface (MMI) or supervisory control and data acquisition (SCADA) software package can process and collect data from OPC servers that are running on different computers in the network. The specification also defines a standard mechanism to access named data items contained in an OPC server.

Motorola used the OPC specification to build the M-OPC server. This server enables exchange of information over the communication system between SCADA managers (or any other application) and Motorola RTUs.

The M-OPC software package comprises:

- M-OPC server
- M-OPC client interface
- MDLC communications driver
- M-OPC Monitoring and Setup Tool
- Security Administration Tool

All the M-OPC components run on a standard PC hardware platform that supports both MS Windows 2000 Pro and MS Windows XP Pro.

The M-OPC solution uses a standard client/server architecture. The Control center components include Client(s) (SCADA software or other applications), M OPC server, MDLC driver and Field Interface Unit –FIU (ACE3600, MOSCAD or MOSCAD-L CPU). The FIU provides MDLC networking and various media connectivity to the RTUs.

The M-OPC offers the following functionality:

- Standard interface between ACE3600 and MOSCAD family RTUs and many control center SCADA managers.
- Support of special features unique to Motorola RTUs.
- Support of the MDLC protocol and all Motorola RTU types, i.e., ACE3600, MOSCAD, MOSCAD-L and MOSCAD-M.

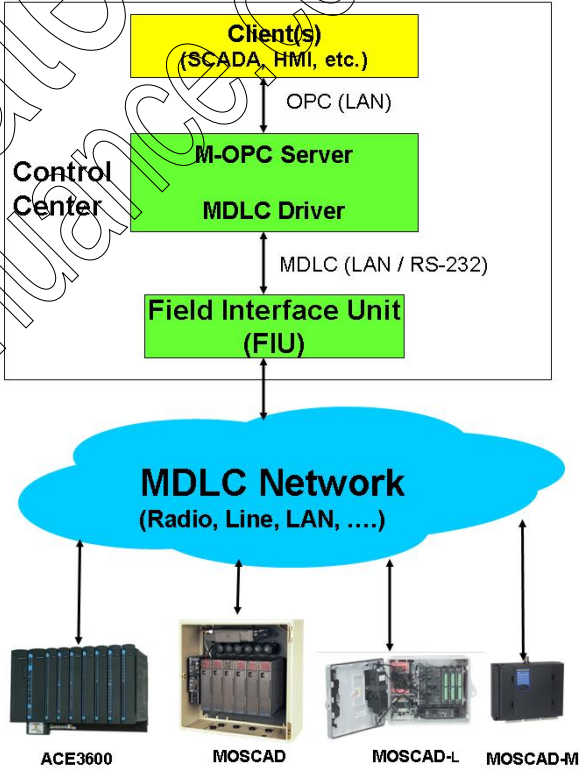
The M-OPC server uses OPC Data Access (DA) V2.05. The server enables the clients to organize the field data according to the OPC logical object model and read/write data either synchronously or asynchronously. It automatically updates clients when new groups are created and also enables SCADA clients to retrieve new groups without having to restart the server.

The server uses the MDLC driver to:

- Poll the RTU databases
- Send commands to the RTUs
- Receive data bursts from the RTUs

The server scheduler is responsible for scheduling the polling of RTU data. Data polling can be performed in periodic intervals or upon specific requests from clients. Schedules are set using the M-OPC Monitoring and Setup Tool. The scheduler optimizes the communications with the RTUs to minimize the MDLC network communication load. This feature is extremely important in radio networks.

The server holds the information received from the RTUs in a cache database. The cache reflects the latest value of the data as well as its quality and the server time-stamp.



During the M-OPC Server operation, various operational data are collected and logged for user diagnostics purposes.

### ***IP Gateway***

TCP/IP is a protocol in common use on Ethernet data highways such as the World Wide Web and others. The MOSCAD IP Gateway (was MCP-T) supports this connectivity.

The MOSCAD IP Gateway is packaged in the small NEMA 4 enclosure, contains an 8Amp power supply/charger, battery, and communication device (radio or wireline modem) according to the needs of the system. The IP Gateway module has communication ports but it does not support any I/O modules. Both 10BaseT and AIX connectors are available to connect the IP Gateway to the 10 Mbps Ethernet LAN.

The IP Gateway is a gateway—a real-time protocol converter—that connects MDLC on its communication medium to TCP/IP. It does not contain a database. It is configured by simply assigning an MDLC and an IP address for their respective systems' use; a configuration software program is provided with the IP Gateway to ease this task. An API is also provided which the system engineer must use to develop a driver between the programs in the server that require data from the IP Gateway and the IP Gateway itself. Contact your Motorola Data Specialists to determine if a driver is already available for the host hardware/software being used.

### ***Legacy ModBus FEP***

ModBus is a wireline protocol in common use in SCADA markets (now also available on TCP/IP networks). It is supported by many SCADA Manager vendors and it is traditionally used in MOSCAD systems at the central. ModBus drivers typically expect prompt communications between the computer and the field units; they do not tolerate well the random delays encountered when a shared communication medium is used. The legacy MOSCAD Communications Processor for ModBus (MCP-M) was designed to interface ModBus to both MDLC and the shared media. MCP-M exists in many existing MOSCAD system where additional ACE3600 RTUs can be installed.

The MCP-M contains a Series 400 CPU module with a RAM expansion board and a special FEP program. The MCP-M is packaged in the small NEMA 4 enclosure, contains the 8Amp power supply/charger, battery, and communications device (radio or wireline modem) according to the needs of the system. The FEP program retains the communication ports but does not support any I/O modules. A serial data cable connects between either Port 1B or Port 2 (or both—the MCP-M supports two simultaneous ModBus sessions) on the CPU module and the appropriate COM port on the PC computer; ModBus data typically at 19.2 kbps exists on this connection.

The MCP-M maintains an internal database of all the reportable data from all of the MOSCAD RTUs in the system. A System Builder software program is provided with the MCP-M to ease this task: it reads the export file created by the MOSCAD Programming ToolBox for each of the many RTUs' applications and prompts the system engineer to identify which data items are to be collected and which are not. Each identified data item

has an equivalent ModBus address according to some very simple yet rigorous rules; therefore, the database in the MCP-M may easily be read, or written to, by the SCADA Manager. The MCP-M's database is kept accurate by any combination of the communication modes discussed in the Communication chapter. If the SCADA Manager should change the contents of any database items defined as outbound (a control), that change will automatically be sent to the associated RTU.

The MCP-M may be configured to periodically interrogate (poll) one or more RTUs to collect some or all of the reportable data in those RTUs and to update the MCP-M database accordingly. Multiple interrogation schedules may be defined: short time intervals for the sites with more interesting data and less often for the other sites.

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## Appendix A - ACE3600 Specifications

### General

Frames	<u>No I/O slots</u> - PS and CPU modules only, wall mount, Dimensions (WxHxD*): 117 x 244 x 198 mm (4.61" x 8.23" x 7.80"), Weight: 0.95 Kg (2.1 lb)
	<u>3 I/O slots</u> - PS, CPU and 3 I/O modules, wall mount, Dimensions (WxHxD*): 234 x 244 x 198 mm (9.21" x 9.61" x 7.80"), Weight: approx. 1.9 Kg (4.19 lb)
	<u>5 I/O slots</u> - PS, CPU and 5 I/O modules, wall mount, Dimensions (WxHxD*): 314 x 244 x 198 mm (12.36" x 9.61" x 7.80"), Weight: approx. 2.4 Kg (5.3 lb)
	<u>7 I/O slots</u> - PS, CPU and 7 I/O modules; wall mount, Dimensions (WxHxD*): 391 x 244 x 198 mm (15.39" x 9.61" x 7.80"), Weight: 3.0 Kg (6.6 lb)
	<u>8 I/O slots</u> - PS, CPU and 8 I/O modules, wall mount or 19" rack, Dimensions (WxHxD*): 435 x 244 x 198 mm (17" x 9.61" x 7.80"), Weight: approx. 3.3 Kg (7.3 lb)
Expansion Frame	<u>Number of I/O slots</u> - 3, 5, 7, or 8
	<u>Default power supply</u> - Expansion power supply
	<u>Compatible power supplies</u> - All except: 10.8-16V DC low-tier power supply
Metal Chassis	<u>Large</u> - for PS, CPU and up to 7 I/O slot frame, two radios and 6.5 or 10 Ah backup battery, wall mount, Dimensions (WxHxD**): 448 x 468 x 200 mm (17.64"x 18.43" x 7.88")
	<u>Small</u> - for PS, CPU and up to 3 I/O slot frame, one radio and 6.5 Ah backup battery, wall mount, Dimensions (WxHxD**): 335 x 355 x 198 mm (13.19" x 13.98" x 7.80")

\* Depth including Module panel

\*\* Depth including Frame and Module

## Appendix A – ACE3600 Specifications

Housing	<u>Large NEMA 4/IP65 painted metal</u> - up to 7 I/O slot frame, two radios and 6.5 or 10 Ah, backup battery, Dimensions (WxHxD): 500 x 500 x 210 mm (19.7" x19.7" x 8.26" )
	<u>Small NEMA 4/IP65 painted metal</u> - up to 3 I/O slot frame one radio and 6.5 Ah backup battery, Dimensions (WxHxD): 380 x380 x 210 mm (15" x 15" x 8.26")
Power Supply	10.8-16 V DC low-tier 10.8-16 V DC (default) 18-72 V DC 18-72 V DC with 12V smart battery charger 100-240 V AC, 50-60 Hz 100-240 V AC, 50-60 Hz, with 12V smart battery charger
Backup Battery	6.5 Ah - Sealed Lead-Acid 10 Ah - Sealed Lead-Acid
Operating Temperature	-40 °C to +70 °C (-40 °F to 158 °F) Notes: 1) When using a metal housing option, the maximum operating temperature outside the housing is +60 °C (140 °F). 2) ACT module and Motorola radios operating temperature range is: -30 °C to +60 °C (-22 °F to 140 °F).
Storage Temperature	-55 °C to +85 °C (-67 °F to 185 °F)
Operating Humidity	5% to 95% RH @ 50 °C without condensation
Mechanical Vibrations	Per EIA/TIA 603 Base-station, Sinusoidal 0.07mm @ 10 to 30 Hz, 0.0035 mm @ 30-60 Hz
Operating Altitude	-400m to +4000 meter (-1312 ft to + 13120 ft) above sea level Note: When using 18-72V DC or 100-240 VAC power supply, the operating altitude is -400 to +3000m.
<b>Regulatory Standards</b>	
Safety	UL 60950-1 (UL listed), CSA 22.2-950-1, EN60950-1, IEC 60950-1, AS/NZS 60950 FM/cFM certified as Nonincendive Class I, Division 2 - standard FM 3611 (Note: FM approval refers to model F7509 only and most of the ACE3600 options)
Emission	Emission standards for industrial environments CFR 47 FCC part 15, subpart B (class A); CE EMC: EN50081-2/EN61000-6-4 (CISPER 11/EN55011 class A)
Immunity	Immunity standards for industrial environments Per EN50082-2 /IEC 61000-6-2

<b>Communications</b>	
Communication Ports	Up to 5 Ports per CPU Serial - up to 4 x RS232 ports Multi-drop – up to 3 x RS485 port Ethernet - up to 2 x 10/100 MB ports and 1 x 10 MB Two-way radio/analog trunked radio - up to 2 x modem ports
Motorola Radio Support	<u>Mobile conventional two-way radios</u> – CM 200, CM 340, GM 3188, EM 200, CDM750 <u>Portable two-way radios</u> – HT750, GP320, GP328, PRO5150 <u>Analog trunked radios</u> – XTL5000, XTL2500, XTS2500 <u>Digital trunked radios</u> – XTL5000, XTL2500, XTS2500, MTM800 (TETRA)
Third Party Radio Support	Two-way radios, Data radios, TETRA radios (PD)
Modem Support	Dial-up modems, Cellular modems (dial mode and PD)
Protocols	MDLC, TCP, UDP, IP, PPP, NTP, DHCP
Third Party Protocols	MODBUS RTU: master and slave on RS232/RS485/Ethernet DF1 (Allen Bradley): master on RS232 DNP 3.0: master/slave on RS232/RS485/Ethernet IEC 60870-5-101: slave on RS232
User Protocol (user program)	Possible on RS232, RS485 and Ethernet ports

Specifications subject to change without notice.

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### Power Supply Module Specifications

The following charts detail the specifications of the various power supply modules. For specifications of the power supply module used with I/O expansion frames, see Expansion Power Supply Module Specifications below.

<b>12V DC Power Supply Module (Default)</b>	
Input Voltage	DC 10.8-16 V The low limit of the DC power supply (10.8-16V) can be configured to 10.5V. The default is 10.8.
Outputs	Motherboard connector (to CPU and I/O modules): equal to input voltage, max. 4 A AUX1A/AUX1B: equal to input voltage, max. 8 A, on/off controlled by user program AUX2A/AUX2B (configurable): equal to input voltage (default), max. 8A, or 3.3 (default), 5, 7.5, 9 V DC $\pm 10\%$ , max. 2.5A, on/off (default) controlled by user program Note: max. 8 A total current consumption from all outputs
No Load Power Consumption	Max. 50 mA
Diagnostic LEDs	Status LED for: input voltage, AUX1 and AUX2 outputs, 12V control for DO modules
Input Protection	Internal line fuse, replaceable
Output Protection	AUX2A/B short circuit, automatic recovery on 3.3, 5, 7.5, 9 V
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 0.43Kg (0.95 Lb)
<b>12V DC Low-Tier Power Supply Module</b>	
Input voltage	10.8-16 V DC
Outputs	Motherboard connector (to CPU and I/O modules): The same as input voltage / max. 4 A AUX1A/AUX1B: equal to input voltage max. 8A Note: max. 8 A total current consumption from all outputs
Input Protection	Internal line fuse, replaceable
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 0.43Kg (0.95 Lb)

Specifications subject to change without notice.

**18-72V DC Power Supply Modules**

Input Voltage	18-72 V DC
Total Power	18-72 V DC Max. 60 W continuous; max. 105 W peak @ 25% duty cycle
Outputs	Motherboard connector (to CPU and I/O modules): 13.2 V DC $\pm$ 20%, max. 4 A AUX1A/AUX1B: equal to input voltage, max. 8 A, on/off controlled by user program AUX2A/AUX2B (configurable): equal to input voltage (default), max. 8A, or 3.3 (default), 5, 7.5, 9 V DC $\pm$ 10%, max. 2.5A, on/off (default) controlled by user program Note: max. 8 A total current consumption from all outputs
Battery Charger	12 V Lead Acid battery charger (in PS model with charger) Automatic charging of 6.5 or 10 Ah backup battery, battery temperature sensing, overcharging protection, battery capacity test and diagnostics, automatic battery switch-over
Diagnostic LEDs	Status LED for: input voltage, AUX1 and AUX2 outputs, 12 V Control DO for DO modules, and battery
No Load Power Consumption	Max. 250 mA
Efficiency	80% typical, 76% with full load
Inrush Current	10 A maximum, for 2 mSec. Max. cold start at 25°C
Protection	Internal line input fuse (replaceable), short circuit automatic recover
Output Protection	AUX2A/B short circuit, automatic recovery on 3.3, 5, 7.5, 9 V
Insulation	Input to case: 500 V DC, input to output 500 V DC
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 1Kg (2.2 Lb)

Specifications subject to change without notice.

<b>AC Power Supply Modules</b>	
Input voltage	100-240 V AC, 50/60 Hz 100-240 V AC, 50/60 Hz with 12V smart battery charger
Total Power	Maximum 60 W continuous; maximum 105 W peak @ 25% duty cycle
Outputs	Motherboard connector (to CPU and I/O modules): 13.2 V DC $\pm$ 20%, max. 4 A AUX1A/AUX1B: 13.2 V DC $\pm$ 20%, max. 8 A, on/off controlled by user program AUX2A/AUX2B (configurable): equal to input voltage (default), max. 8 A, or 3.3 (default), 5, 7.5, 9 V DC $\pm$ 10%, max. 2.5A, on/off (default) controlled by user program Note: max. 8 A total current consumption from all outputs
Battery Charger	12 V Lead Acid battery charger (in PS with charger) Automatic charging of 6.5 or 10 Ah backup battery, battery temperature sensing, overcharging protection, battery capacity test and diagnostics, automatic battery switch-over
Diagnostic LEDs	Status LED for: input voltage, AUX1 and AUX2 outputs, 12V Control for DO modules, and battery
No Load Power Consumption	130 mA @ 220 V AC
Efficiency	80% typical @230 V AC, 76% typical @115 V AC (full load)
Inrush Current	25 A maximum, for 2 mSec. Max, cold start at 25°C
Power Factor	0.98 typical at 230 V AC, 0.99 typical at 115 V AC
Protection	Internal line fuse, replaceable
Output Protection	AUX2A/B short circuit, automatic recovery on 3.3, 5, 7.5, 9 V
Insulation	Input to case: 1500 V AC, input to output: 3000 V AC
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 1kg (2.2 lb)

Specifications subject to change without notice.

**CPU 3610/CPU 3640 Module Specifications**

Microprocessor	Freescale – Power PC II MPC8720, 32-bit, extended communication capability, DMA and floating point calculation support
Microprocessor Clock	200 MHz
Memory	Flash: 16 MB/3 MB free for user DRAM: 32 MB/10 MB free for user SRAM plug-in (Optional): 4 MB total, all free for user
Real-Time Clock	Full calendar with leap year support (year, month, day, hours, minutes, seconds). Time drift: max. 2.5 Seconds per day (when power is on)
SRAM and RTC Retention	3 V Rechargeable lithium backup battery
Serial Port 1	Configurable RS232 or RS485 port: - RS232: Asynch, Full Flow Control, up to 230.4 kb/s, GPS receiver interface - RS485, multi-drop 2-Wire up to 230.4 kb/s
Serial Port 2	RS232, Asynch, Full Flow Control, up to 230.4 kb/s, GPS receiver interface
Plug-In Port 1	Supports the following Plug-In ports: - Radio Modem, DPSK 1.2 kb/s, FSK 1.2/1.8/2.4 kb/s, DFM 2.4/3.6/4.8 kb/s - RS232, Sync/Asynch, Full Flow Control, up to 230.4 kb/s, GPS receiver interface - RS485, multi-drop 2-Wire up to 230.4 kb/s - Ethernet 10/100 Mb/s
Plug-In Port 2	Supports the following Plug-In ports: - Radio Modem, DPSK 1.2 kb/s, FSK 1.2/1.8/2.4 kb/s, DFM 2.4/3.6/4.8 kb/s - RS232, Sync/Asynch, Full Flow Control, up to 230.4 kb/s, GPS receiver interface - RS485, multi-drop 2-Wire up to 230.4 kb/s - Ethernet 10 Mb/s
Ethernet Port 1	10/100 Mb/s (on CPU 3640 only)
LEDs Display	4 CPU diagnostic LEDs, Port status LEDs and user application LEDs
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Operating Voltage	10.8-16 V DC (from the motherboard connector)
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 0.38 Kg (0.84 Lb)

Specifications subject to change without notice.

**DI Module Specifications**

<b>16/32 DI FAST 24V Modules</b>	
Total Number of Inputs	16 DI (Option V265); 32 DI (Option V379)
Input Arrangement	Isolated groups of 16 inputs with shared common
Fast Counter Inputs	Inputs that can be used as fast counters: - All inputs in 16 DI module; - First 20 inputs in 32 DI module
AC Input Frequency	45 – 65 Hz
AC Input Delay	Maximum 0.2 mS
Fast Counter Input Frequency	0 - 12.5 KHz, minimum pulse width 40 $\mu$ S
Max. DC Input Voltage	Max. $\pm$ 40 V DC (relative to input common)
“ON” DC Voltage Range	+9 to +30 V DC, -30 to -9 V DC
“OFF” DC Voltage Range	-3 to +3 V DC
“ON” AC Voltage Range	10 to 27 V AC (RMS)
“OFF” AC Voltage Range	0 to 5 V AC (RMS)
Input Current	Max. 3.5 mA
Fast Capture Resolution	1 mS (Interrupt upon change of state)
Event Time Tagging Resolution	1 mS (Interrupt upon change of state)
Input Filtering	0 to 50.8 mS (DC, programmable in 0.2 mSec steps)
Counter Input Filtering	0 to 12.75 mS (programmable in 0.05 mSec steps for inputs configured as high speed counters)
24 V DC Output	Supports optional isolated 24 V plug-in “Wetting” Power Supply (one in 16 DI, two in 32 DI)
Diagnostic LEDs	Status LED per each input, module error LED, 24V plug-in status LED
User Connection	2 or 4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	20 or 40 Wire Cable with TB Holder connector, 26 AWG wires
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Input Isolation	2.5 kV RMS between input and module logic per IEC60255-5
Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC, per IEC60255-5
Operating Voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D, (1.5" W x 8.7" H x 7.1" D)



Weight	16 DI: approx. 0.28 Kg (0.62 lb); 32 DI: approx. 0.29 Kg (0.63 lb)
<b>16/32 DI FAST 24V IEC 61131-2 TYPE II Modules</b>	
Total Number of Inputs	16 DI (Option V117) 32 DI (Option V959)
Input Arrangement	Isolated groups of 16 inputs with shared common
Fast Counter Inputs	Inputs that can be used as fast counter: - All inputs in 16 DI module - First 20 inputs in 32 DI module
Fast Counter Input Frequency	0 - 10 KHz, minimum pulse width 50 $\mu$ S
Max. DC Input Voltage	Max. $\pm$ 40 V DC (relative to input common)
“ON” DC Voltage Range	+11 to +30 V DC, -30 to -11 V DC
“OFF” DC Voltage Range	-5 to +5 V DC
Input Current	6-10 mA
Fast Capture Resolution	1 mS (Interrupt upon change of state)
Event Time Tagging Resolution	1 mS (Interrupt upon change of state)
Input Filtering	0 to 50.8 mS (DC, programmable in 0.2 mSec steps)
Counter Input Filtering	0 to 12.75 mS (programmable in 0.05 mSec steps for inputs configured as high speed counters)
24V DC Output	Supports optional isolated 24 V plug-in “Wetting” Power Supply (one in 16 DI, two in 32 DI)
Diagnostic LEDs	Status LED per each input, module error LED, 24V plug-in status LED
User Connection	2 or 4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	20 or 40 Wires Cable with Terminal Block Holder connector, 26 AWG wires
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Input Isolation	2.5 kV RMS between input and module logic per IEC60255-5
Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC, per IEC60255-5
Operating Voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D, (1.5" W x 8.7" H x 7.1" D)

## Appendix A – ACE3600 Specifications

Weight	16 DI: approx. 0.28 Kg (0.62 lb) 32 DI: approx. 0.29 Kg (0.63 lb)
<b>120/230V 16DI Module</b>	
Total Number of Inputs	16 DI
Input Characteristics	IEC 61131-2 Type 1
Input Arrangement	Two isolated groups of 6 inputs and one isolated group of 4 inputs.
AC Input Frequency	47 – 63 Hz
AC Input Change Delay	Maximum 25.0 msec
Max. DC Input Voltage	Max. $\pm 264$ V DC (relative to input common)
DC Input Pulse Width	Minimum 7.0 msec @ 230 V DC
“ON” DC Voltage Range	+79.0 V DC to +264.0 V DC, -79.0 V DC to -264.0 V DC
“OFF” DC Voltage Range	-40 to +40 V DC
“ON” AC Voltage Range	79 to 264 V AC (RMS)
“OFF” AC Voltage Range	0 to 40 V AC (RMS)
Input Current	At 110V DC 1.0 to 3.0 mA At 230V DC 0.4 to 2.0 mA At 110V AC > 2.0 mA RMS At 230V AC > 3.0 mA RMS
Permitted Voltage Difference Between Groups	2.5 kV RMS
Input Filtering	0 to 50.8 msec (DC, programmable in 0.2 msec steps) Note: Minimum effective filter value is 7.0 msec.
Diagnostic LEDs	Status LED per each input, module error LED
User Connection	3 Terminal Blocks (5.00mm pitch), Maximum 14 AWG
Cable and TB Holder	30 Wire Cable with TB Holder connector, 20 AWG wires
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Input Isolation	2.5 kV RMS between input and module logic per IEC60255-5
Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC
Operating Voltage	10.8-16 V DC and 3.3 V DC $\pm 10\%$ (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D, (1.5" W x 8.7" H x 7.1" D)
Weight	approx. 0.367 kg (0.80 lbs)

Specifications subject to change without notice.

**DO/DI FET Module Specifications**

Total Number of I/Os	16 (Option V480); 32 (Option V481)
I/O Arrangement	Two or four group of 8 I/Os with shared common Each group can be configured as FET DO or dry contact DI Selectable combinations (32 DO/DI): 32 DO/ 8 DI+24 DO/ 16 DI+16 DO/ 24 DI+8 DO/ 32 DI Selectable combinations (16 DO/DI): 16 DO/ 8 DI+8 DO/ 16 DI
Counter Inputs	The first 20 inputs (of the 32 DI) and all 16 inputs (of the 16 DI) can be used as counter inputs.
Counter Input Frequency	0 - 1 KHz, minimum pulse width 500 $\mu$ S. Note: Although filters are defined in steps of 0.2mSec and 0.05mSec, it is relevant only from 1mSec.
Max. DC Input Voltage	Max. 30 V DC (relative to input common)
Input "ON" Resistance	0-4 k $\Omega$
Input "OFF" Resistance	$\geq$ 50 k $\Omega$
Fast Capture Resolution	1 mS (Interrupt upon change of state)
Event Time Tagging Resolution	1 mS (Interrupt upon change of state)
Input Current	Max. 0.3 mA (when the input is shorted)
Input Filtering	0 to 50.8 mS (programmable in 0.2 mSec steps), minimum effective filter value - 1mSec
Counter Input Filtering	0 to 12.75 mS (programmable in 0.05 mSec steps), minimum effective filter value - 1mSec
Output Type	MOSFET
Output Voltage Range	5-30 V DC (user supplied voltage)
DO Frequency	Max. 1 KHz (resistive load)
DO Output Current	Max. 500 mA sink current (resistive load)
Output Fail State	Configurable output state on CPU fail: On, Off or 'last value'
Diagnostic LEDs	LED per each input / output status, module error LED
User Connection	4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	20 or 40 Wire Cable with Terminal Block Holder connector, 26 AWG
Module Replacement	Hot swap replacement– module extraction/insertion under voltage
Input/Output Isolation	2.5 kV between input/output and module logic
Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC per IEC60255-5
Operating Voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D (1.5" W x 8.7" H x 7.1" D)
Weight	Approx. 0.25 Kg (0.55 lb)

Specifications subject to change without notice.

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**DO Relay Module Specifications**

<b>8/16DO Relay EE/ML Modules</b>	
Total Number of Outputs	8 EE relay outputs (Option V508) 16 EE relay outputs (Option V616) 8 ML relay outputs (Option V314) 16 ML relay outputs (Option V516)
Output Arrangement	8 DO : 3 X Form C (SPDT) and 5 X Form A (SPST) 16 DO: 6 X Form C (SPDT) and 10 X Form A (SPST)
Contact Voltage Ratings	Max. 60 V DC or 30 V AC RMS (42.4 V peak).
Contact Power Ratings	2A @ 30 V DC, 0.6A @ 60V DC or 0.6A @ 30V AC (resistive load)
Relay Back Indication	Contact position - hardware back indication
DO Frequency	Max. 10 Hz
Diagnostic LEDs	LED per each output status, module error LED
User Connection	2 or 4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	20 or 40 Wire Cable with Terminal Block Holder connector, 26 AWG
Fail State	Configurable relay state on CPU fail: On, Off or 'last value'
All Relays Disable/Enable	Selectable per module, controlled from the power supply
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Output Isolation	Between open contacts: 1kV, Between contact and coil: 1.5 kV, Between contact sets: 1.5 kV
Insulation	Insulation resistance 100 MΩ @ 500 V DC per IEC60255-5, Insulation impulse 1.5 kV per IEC60255-5
Operating Voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D (1.5" W x 8.7" H x 7.1" D)
Weight	8 DO : approx. 0.29 Kg (0.64 lb) 16 DO: approx. 0.32 Kg (0.7 lb)

<b>120/230V 12DO Relay Modules</b>	
Total Number of Outputs	12 EE relay outputs 12 ML relay outputs
Output Arrangement	12 x 1 Form A
Contact Power Ratings	3A @ 250 V AC, 3A @ 30 V DC, or 0.20A @ 125 V DC (resistive load)
Minimum Contact Load Current	10.0 mA @+5.00 V DC
Maximum Switching Current	3.00 A
Relay Back Indication	Contact position - hardware back indication
DO Frequency	Max. 10 Hz (resistive load)
Diagnostic LEDs	LED per each output status, module error LED
User Connection	3 Terminal Blocks (5.00mm pitch), Maximum 14 AWG
Cable and TB Holder	30 Wire Cable with Terminal Block Holder connector, 20 AWG
Fail State	Configurable relay state on CPU fail: On, Off or 'last value'
All Relays Disable/Enable	Selectable per module, controlled from the power supply
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Output Isolation	Between output and module logic 2.5 kV per IEC60255-5
Insulation	Insulation resistance 100 MΩ @ 500 V DC per IEC60255-5, Insulation impulse 5 kV per IEC60255-5
Operating Voltage	10.8-16 V DC and 3.3 V DC ±10% (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D (1.5" W x 8.7" H x 7.1" D)
Weight	approx. 0.423 kg (0.90 lbs)

Specifications subject to change without notice.

**AI Module Specifications**

Total Number of Inputs	8 AI $\pm$ 20 mA (4-20 mA) (Option V318) 16 AI $\pm$ 20 mA (4-20 mA) (Option V463) 8 AI $\pm$ 5 V (0-5 V, 1-5 V) (Option V742) 16 AI $\pm$ 5 V (0-5 V, 1-5 V) (Option V743)
Input Configuration	Isolated (floating) analog inputs
A to D Resolution	16 bit (including sign)
Input Accuracy	$\pm$ 0.1% full scale @ -40°C to +70°C
Input Sampling Time	10 mSec @ 50 Hz filtering ;8.33 mSec @ 60 Hz filtering
Smoothing	Selectable input averaging: 1,2,4,8,16,32,64,128 samples (x10 mS)
Permitted Potential Between Inputs	75 V DC, 60 V AC (RMS)
Input Impedance	$\pm$ 20 mA input: Rin < 250 $\Omega$ $\pm$ 5 V input: Rin > 1 M $\Omega$
Crosstalk Rejection	Better than 80 dB between any pair of inputs
Temperature Stability	25 PPM/°C
Interference Suppression	Selectable 50 or 60 Hz filtering, Common mode rejection > 80 dB, Differential mode rejection > 50 dB
24 V DC Output	Supports optional isolated 24V plug-in Power Supply (one in 8 DI, two in 16 DI)
Diagnostic LEDs	Overflow and Underflow LED per each input status, Module error LED The module Overflow and Underflow levels can be configured to: Current inputs: $\pm$ 20mA / 4-20 mA Voltage inputs: $\pm$ 5 V / 0-5 V /1-5 V
User Connection	2 or 4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	20 or 40 Wire Cable with TB Holder connector, 26 AWG
Module Replacement	Hot swap replacement– module extraction/insertion under voltage
Input Isolation	1.5 kV RMS between input and module logic, per IEC60255-5
Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC, per IEC60255-5
Operating voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D, (1.5" W x 8.7" H x 7.1" D)
Weight	8 AI : approx.032 Kg (0.71 lb) 16 AI: approx. 0.34 Kg (0.75 lb)

Specifications subject to change without notice.

**AO Module Specifications**

Total Number of Outputs	4 AO current (0-20 mA) or voltage (0-10 V)
Output Arrangement	Isolated floating channels, each channel can be connected as 0-20 mA or 0-10 V DC voltage
D to A Resolution	14 bit
Output Accuracy	±0.1% full scale @ 25°C
Temperature Stability	25 PPM/°C
Internal Settling Time	Max. 1.0 msec
Output Load	Voltage: > 1.0 kΩ, < 1.0 μf Current: < 750 Ω (internal power source)
Crosstalk Rejection	Better than 50 dB between any pair of outputs
Interference suppression	Common mode rejection > 60 dB
Output Protection	Voltage output: short circuit current, max. 30 mA Current output: No-load voltage max. 22 V DC
Diagnostic LEDs	Module error LED, Voltage mode LED, Current mode LED, Calibration LED per channel
User Connection	2 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	20 Wire Cable with TB Holder connector, 26 AWG
Module Replacement	Hot swap replacement– module extraction/insertion under voltage
Isolation	1.5 kV between output and module logic
Insulation	Insulation resistance 100 MΩ @ 500 V DC, per IEC60255-5
Operating voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D, (1.5" W x 8.7" H x 7.1" D)
Weight	Approx. 0.29 Kg (0.64 Lb)

Specifications subject to change without notice.



**Mixed I/O Module Specifications**

Total Number of Inputs / Outputs	16 Digital Inputs + 4 EE Relay Outputs + 4 Analog Inputs ( $\pm 20$ mA) (Option V245) 16 Digital Inputs + 4 ML Relay Outputs + 4 Analog Inputs ( $\pm 20$ mA) (Option V453)
I/O Arrangement	1 group of 16 DIs with shared common 4 relay outputs - Form C 4 isolated analog inputs
DI Counter Inputs	The first 12 inputs can be configured as fast counters
DI Frequency	0 - 1 KHz
DI Fast Counter Frequency	0 - 5 KHz, minimum pulse width 100 $\mu$ S
DI Max. DC Voltage	Max. 40 V DC
DI "ON" DC Voltage Range	+11 to +30 V DC, -30 to -11 V DC
DI "OFF" DC Voltage Range	-5 to +5 V DC
DI Current	6-10 mA
Fast Capture Resolution	1 mS (Interrupt upon change of state)
Event Time Tagging Resolution	1 mS (Interrupt upon change of state)
DI Filtering	0 to 50.8 mS (DC, programmable in 0.2 mSec steps)
DI Counter Filtering	0 to 12.75 mS (programmable in 0.05 mSec steps for inputs configured as high speed counters)
DO Contact Voltage Ratings	Max. 60 V DC or 30 V AC RMS (42.4 V peak).
DO Contact Power Ratings	2A @ 30 V DC, 0.6A @ 60V DC or 0.6A @ 30V AC (resistive load)
DO Relay Back Indication	Contact position - hardware back indication
DO Fail State	Configurable relay state on CPU fail: On, Off or 'last value'
AI Resolution	16 Bit (including sign)
AI Accuracy	$\pm 0.1\%$ full scale @ -40°C to +70°C
AI Sampling Time	10 mSec @ 50 Hz filtering 8.33 mSec @ 60 Hz filtering
AI Smoothing	Selectable input averaging: 1, 2, 4, 8, 16, 30, 60 or 128 samples (x10 mS)
AI max. Potential between AIs	75 V DC, 60 V AC (RMS)
AI Impedance	$R_{in} < 250 \Omega$
AI Crosstalk Rejection	Better than 80 dB between any pair of inputs
AI Temperature Stability	25 PPM/°C

## Appendix A – ACE3600 Specifications

AI Interference Suppression	Selectable 50 or 60 Hz filtering, common mode rejection > 80 dB, differential mode rejection > 50 dB
Diagnostic LEDs	Module error LED, Status LED per each DO and DI. Overflow and Underflow LED per each AI, 24V Plug-in status LED (AI)  AI Overflow and Underflow levels can be configured to: Current inputs: $\pm 20\text{mA}$ / 4-20 mA Voltage inputs: $\pm 5\text{ V}$ / 0-5 V / 1-5 V
24 V DC Output	Supports one isolated 24V plug-in “wetting” power supply
User Connection	4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	40 wire cable with Terminal Block Holder connector, 26 AWG
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Input/Output Isolation	DI: 2.5 kV RMS between input and module logic per IEC60255-5 DO: Between open contacts: 1kV, between output and module logic: 1.5 kV, per IEC60255-5 AI: 1.5 kV between input and module logic, per IEC60255-5
Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC per IEC60255-5
Operating Voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D (1.5" W x 8.7" H x 7.1" D)
Weight	Approx. 0.31 Kg (0.68 lb)

Specifications subject to change without notice.

**Mixed Analog Module Specifications**

Total Number of I/Os	4 Analog Outputs + 8 Analog Inputs ( $\pm 20$ mA) or 4 Analog Outputs + 8 Analog Inputs ( $\pm 5$ V DC)
I/O Arrangement	AO - each channel can be connected as 0 -20 mA or 0-10 V, AI - Isolated (floating) analog inputs
AO D to A Resolution	14 bit
AO Accuracy	$\pm 0.1\%$ full scale @ 25°C
AO Temperature Stability	25 PPM/°C
AO Internal Settling Time	Max. 1.0 msec
AO Load	Voltage: > 1.0 k $\Omega$ , < 1.0 $\mu$ f Current: < 750 $\Omega$ (with internal power supply)
AO Crosstalk Rejection	Better than 50 dB between any pair of outputs
AO Interference suppression	Common mode rejection > 60 dB
AO Voltage Output Protection	Short circuit protection, max. 30 mA (all other operating channels remain fully functional)
AO Current Output No-load Voltage	Max. 22.0 V DC
AO Isolation	1.5 kV between output and module logic
AO Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC per IEC60255-5
AI A to D Resolution	16 Bit (including sign)
AI Accuracy	$\pm 0.1\%$ full scale
AI Sampling Time	10 mSec @ 50 Hz filtering 8.33 mSec @ 60 Hz filtering
AI Smoothing	Selectable input averaging: 1, 2, 4, 8, 16, 32, 64 or 128 samples (x10 mS)
Permitted Potential between Inputs	75 V DC, 60 V AC (RMS)
AI Input Impedance	$\pm 20$ mA input: Rin < 250 $\Omega$ $\pm 5$ V input: Rin > 1 M $\Omega$
AI Crosstalk Rejection	Better than 80 dB between any pair of inputs
AI Temperature Stability	25 PPM/°C
AI Interference Suppression	Selectable 50 or 60 Hz filtering, common mode rejection > 80 dB, differential mode rejection > 50 dB
24 V DC Output	Supports one isolated 24V Plug-in “wetting” power supply

Diagnostic LEDs	<p>AO - Voltage mode LED, Current mode LED, Calibration LED per channel</p> <p>AI - Overflow and Underflow LED per each input, 24V Plug-in status LED</p> <p>The module Overflow and Underflow levels can be configured to:</p> <p>Current inputs: <math>\pm 20\text{mA}</math> / 4-20 mA</p> <p>Voltage inputs: <math>\pm 5\text{ V}</math> / 0-5 V / 1-5 V</p> <p>General - Module error LED</p>
AI Input Isolation	1.5 kV between input and module logic
AI Input Insulation	Insulation resistance 100 M $\Omega$ @ 500 V DC per IEC60255-5
User Connection	4 Terminal Blocks (3.5mm pitch), Maximum 18 AWG
Cable and TB Holder	40 wire cable with Terminal Block Holder connector, 26 AWG
Module Replacement	Hot swap replacement– module extraction/insertion under voltage
Operating Voltage	10.8-16 V DC and 3.3 V DC (from the motherboard connector)
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Dimensions	37 mm W x 225 mm H x 180 mm D (1.5" W x 8.7" H x 7.1" D)
Weight	Approx. 0.34 Kg (0.75 Lb)

Specifications subject to change without notice.

**Expansion Power Supply Module Specifications**

Input Voltage	DC 10.8-16 V
Outputs	To Motherboard connector – +10.80 to +16.00 VDC, max. 4A To cascaded expansion power supply - +10.80 to +16.00 VDC, max. 8A
Over Current Protection	4.0 A (Slow blow fuse), protecting the expansion frame 8.0 A (Slow blow fuse), protecting the cascaded expansion power supply
Maximum Current via Power IN/OUT circuit	8.0 A (Slow blow fuse)
Over Voltage Protection	+17.00 ±1 VDC (protecting the expansion frame)
Absolute Maximum Voltage	+18.00 VDC
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 0.43Kg (0.94 Lb)

Specifications subject to change without notice.

**Expansion Module Specifications**

Microprocessor	Freescale – Power PC II, MPC8720, 32-bit
Microprocessor Clock	200 MHz
Serial Port	RS232C Asynch, Full Flow Control port, up to 230.4 kb/s; used for STS only
Ethernet Port	10/100 Mb/s – connection to the main frame
LAN Cable	Category 5E shielded (FTP), up to 50 meter
LEDs Display	4 CPU diagnostic LEDs, Port status LEDs and Expansion Address LEDs
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Operating Voltage	10.8-16 V DC (from the motherboard connector)
Dimensions	56 mm W x 225 mm H x 180 mm D (2.2" W x 8.7" H x 7.1" D)
Weight	Approx. 0.38 Kg (0.84 Lb)

Specifications subject to change without notice

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**Expansion LAN Switch Specifications**

Ethernet Port 1-8	8 on board 10/100 Mb/s Ethernet ports (Auto crossover)
LEDs Display	Error LED, Port status LEDs
Power Consumption	Refer to Appendix C: ACE3600 Maximum Power Ratings.
Module Replacement	Hot swap replacement – module extraction/insertion under voltage
Operating Voltage (from the motherboard connector)	10.8-16 V DC, 3.30 VDC +/-10%
User Connection (Ethernet Ports)	8 shielded RJ45 connectors
LAN Cable	Category 5E shielded (FTP), up to 50 meter
Dimensions	37 mm W x 225 mm H x 180 mm D (1.5" W x 8.7" H x 7.1" D)
Weight	Approx. 0.32 Kg (0.7 Lb)

Specifications subject to change without notice.

## **Appendix B - FCC Information Spectrum and Regulatory Update**

The Federal Communications Commission (FCC) has made a series of changes over the years to the rules and regulations that govern the use of frequencies that constitute the VHF and UHF bands. They affect in several ways how MOSCAD devices are used on traditional, conventional two-way radio channels. This update is a summary document and not intended as a complete licensing guide. Refer to the FCC rules or other applicable regulations for additional information or requirements. This summary will cover:

- FCC Rules Updates
- Licensing of Fixed Data Systems
- Spectrum available for Fixed Data Systems

### ***FCC Rules Update***

#### **Refarming and Narrow Banding**

In the mid 90's, the FCC began implementing a plan to increase the capacity and promote spectrum efficiency within the VHF and UHF frequency bands, 150MHz to 512 MHz. The rule changes established a channel plan that includes 25 kHz channels (the original 'legacy' channels), 12.5 kHz channels, (the old 'offset' frequencies) and 6.25 kHz channels. Users could, and until January 1, 2011 can still, license at all three bandwidths. The FCC instituted a minimum data efficiency standard of 4800 bps per 6.25 KHz (9600 bps per 12.5 kHz).

In the initial decision, the FCC declined to establish deadlines for existing users to convert systems to 12.5 and/or 6.25 kHz technologies, deciding instead to manage the narrowband conversion through the equipment certification process (type acceptance). Starting in January 1997, all new radio designs submitted for FCC approval by radio manufacturers were required to include a 12.5 kHz operational mode. Dual mode 25 kHz and 12.5 kHz designs were also permitted and manufacturers could continue to sell previously approved radios that only contained a 25 kHz mode of operation. Existing users/licensees of 25 kHz equipment were not mandated to migrate to narrowband operation.

#### **UHF Offset Channels**

Prior to the FCC's adoption of refarming, FCC Rule Section 90.267 allowed for the use of 25 kHz bandwidth "offset" channels in the 450-470 MHz band. These were channels offset 12.5 kHz from the primary UHF channels and limited to 2 watts ERP and antenna heights of 20 feet. The offset channels supported 25 kHz wide transmissions. These



were channels licensed for data (or voice) use on a “secondary” basis; that is usage could not interfere with operations licenses on the primary channels.

Through the adoption of the refarming decision, the low-power, secondary offset channels have been converted to primary channels with a maximum bandwidth of 12.5 kHz. Many of the old offset channels have been (or soon will be) converted to high power operations. However, a fairly large number of these channels have been designated for continued low power use and can be a good source of spectrum for some MOSCAD systems. More about this in the Spectrum section.

### **VHF Splinter Channels**

The FCC had defined certain frequencies in the 154 MHz and 173 MHz bands for data operation. The frequencies are few in number, are heavily used and have severe deviation restrictions. These splinter frequencies, whose availability and use were not affected by refarming, require the use of a radio certified with a less common F2 emission designator (digital FM emission with a modulated subcarrier). A few radios may be used with MOSCAD for these frequencies, but refer to the FCC rules for limitations on power output, antenna height and antenna gain.

### **Emission Designators**

MOSCAD units interface to the radio through several different modems, typically DFM, FSK or DPSK. The nature of these modems will determine the type of emission characteristics of the radio. FCC rules define and classify the basic characteristics of the radio waves according to the type of modulation of the main carrier as well as the nature of the signals that modulate the main carrier and the general type of information that is transmitted (see FCC rule sections 2.201 and 90.207)<sup>1</sup>. Traditional MOSCAD radios such as a MTS2000 use FM modulation (indicated by the FCC emission designator – F), operate in the analog mode (indicated by the FCC emission designator -3) and are used for voice (telephony) (indicated by FCC emission designator – E), or Data, (telemetry, or telecommand) (indicated by emission designator – D). Hence, a radio used for DPSK or FSK could use a F3E or F3D designation whereas a DFM application would require a F1D to reference a digital FM signal containing digital information. See section below on data efficiency.

### **Data Efficiency Standards**

As part of its initial refarming decisions, the FCC adopted a new minimum data efficiency standard of 4800 bits per second per 6.25 kHz of channel bandwidth. Initially, the FCC definition of data was not clear and caused confusion as to how the standard was

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<sup>1</sup> FCC Rules can be found in Title 47 of the Code of Federal Regulations. Part 90 of that title provides rules applicable to the private land mobile radio services. Among other things, Part 2 of that title provides rules governing the equipment authorization process. Current FCC rules can be found at this web site: <http://wireless.fcc.gov/rules.html>

to be applied. In a subsequent decision, (FCC MO&O96-492) the FCC clarified their intent and restated the previous classes of data operations. Key to the issue of the type of operation is determining the actual path of the signaling through the radio. The FCC acknowledged a difference between signals that pass through a radio's external microphone port and those that do not. The former path, since it includes FCC-proscribed audio filters does not have to meet the data rate standard. The interpretation of this statement however still allows for some confusion. If the signal is not required to meet the data efficiency standard, is it still considered data? The consensus opinion is that it is audio and can be considered as telephony, and not telemetry. This seemingly minor detail consideration is important, since it will influence what radio or model of radio that can be used. All Motorola radios carry a F3E designator, not all of them are also certified for F3D or F1 or F2 operation. This interpretation says MOSCAD can use radios only certified for F3E operation.

This opinion is based on the consideration that the source of the signal whether microphone or tone modem (MOSCAD) is of concern to the user of the system, but not the licensing party whose only concern is the type of signal, not content. Note however, that this opinion and the FCC stop short of considering this type of signaling used by MOSCAD as voice except for the express purpose of satisfying the data efficiency standards.

### **Narrowbanding Update**

The FCC set dates for mandatory moves to narrowband channels in February 2003. In December 2004, in response to several Petitions for Reconsideration, they modified the deadlines as follows:

- No new applications for operations using 25 kHz channels after 1/1/11 unless they meet the 12.5 kHz efficiency standards<sup>2</sup>.
- No modifications to existing 25 kHz systems that exceed existing interference contours after 1/1/11 unless the equipment meets the 12.5 kHz efficiency standard<sup>3</sup>
- No equipment capable of 1 voice path per 25 kHz will be certified beginning 1/1/05. (Deadline stayed as of 12/22/04 until FCC rules on issues raised in Third Further Notice in WT Docket 99-87)
- No manufacture or importation of 25 kHz equipment beginning 1/1/11 unless it meets the 12.5 kHz efficiency standard<sup>4</sup>.
- Mandatory migration to 12.5 kHz technology:
  - Non-Public Safety – 1/1/13
  - Public safety – 1/1/13

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<sup>2</sup> One voice channel per 12.5 khz of bandwidth or 4800 bits per second per 6.25 kHz of bandwidth for data

<sup>3</sup> Ibid

<sup>4</sup> Ibid

In February of 2003, the FCC asked for comments on its tentative conclusion that transition dates for 6.25 kHz conversion would have to be adopted. Many commenters said that it was too soon to establish a date for conversion to 6.25 kHz technologies; there is no interoperability standard for 6.25 kHz equivalent technologies and equipment has not been fielded and tested under real world conditions. The FCC has not yet made a decision, but transition deadlines may be issued for conversion to 6.25 kHz technology.

### ***Licensing of Fixed Data Systems***

There are a few important considerations when applying for a license for a MOSCAD system.

1. Location Description Code: Fixed, unless applying for certain frequencies that allow Mobile designations to be used for fixed sites, typically with power and/or antenna restrictions. Various Motorola radios can be licensed as mobile, but the MOSCAD units are almost always at fixed, permanent locations.
2. Define operations as telephony, transfer of analog information from one to multiple sites.
3. If the User is a Public entity, use the appropriate frequencies listed in the Public Safety Pool.

### ***Spectrum Available for Fixed Data Systems***

#### **UHF Low Power Pool**

There are several options available for licensing Fixed Data systems. One of the possible good ones is the new low power pool. In March of 2003, the FCC adopted new LMCC low power pool recommendations. These frequencies come from the old UHF offset channels and are grouped into five subsets, all 12.5 kHz. They are defined as:

- Group A – Campus type systems
- Group B – Data primary operations such as crane control
- Group C - Uncoordinated, itinerant use such as construction
- Group D – Central Station protection operation
- Public Safety

Using these low power pool channels, MOSCAD can be licensed as mobile, defining the service area by KMRA of set of coordinates. You must observe the mobile power restrictions. Fixed use on these channels is considered primary status unlike the old rules where data was secondary.

*Low Power Pool Group Specifications*

<b>Limitation</b>	<b>Group A</b>	<b>Group B</b>	<b>Group C</b>	<b>Group D</b>	<b>Public Safety</b>
<b># Channels</b>	39 pairs, 1 unpaired Group A1; 10 pairs Group A2	10 pairs	21 pairs, 4 unpaired	5 pairs	14 pairs
<b>Data</b>	Co-Primary	Primary	Co-Primary	Co-Primary	Co-Primary
<b>Low Power</b>	A1 within 50 miles of Top 100 cities; A2 Nationwide	Nationwide	Nationwide	Nationwide	Nationwide
<b>ERP Base</b>	20 watts*	6 watts	6 watts	N/A	6 watts
<b>ERP Mobile</b>	6 watts*	6 watts	6 watts	N/A	6 watts
<b>ERP Portable</b>	2 watts*	2 watts	2 watts	N/A	2 watts
<b>TPO</b>	N/A	N/A	N/A	2 watts	N/A
<b>Antenna Height to Tip</b>	75'	20'	20'	20'	20'
<b>Frequency Coordination</b>	Yes	Yes	No	Yes	Yes
<b>Itinerant</b>	No	No	Yes	No	No
*Outside 50 MIRA of top 100 cities, these frequencies can be used at full power, up to 500 watts (90.205)					

For Public Safety Operations, the following frequencies are available nationwide:

453/458.0375	453/458.1375	453/458.9625	460/465.5375
453/458.0625	453/458.8875	453/458.9875	460/465.5625
453/458.0875	453/458.9125	460/465.4875	
453/458.1125	453/458.9375	460/465.5125	

## Other Part 90 Frequency Options

There are several other options that could be used depending on the availability of frequencies or existing infrastructure.

- Section 90.235 – Secondary fixed signaling UHF or VHF high power bands. The fixed operations are secondary to mobile voice or data operations and must be licensed as part of the voice system. No additional channels can be added to accommodate the fixed operations.
- 800 or 900 MHz private or commercial trunked systems – Fixed data can be added to existing trunked systems, although they do not count toward channel loading.
- 700 MHz Guard band systems – Fixed data can be added to existing trunked systems although they do not count toward channel loading.
- 700 MHz Public Safety systems – NPSTC (National Public Safety Telecommunications Council) is seeking a clarification from the FCC as to whether fixed data is permitted in the 700 MHz band in the same manner it is permitted in the 800 MHz band.
- ASTRO 25 Digital Trunked Systems with Data option. Starting with release 6.3, MOSCAD data systems can be added to this digital trunked infrastructure. There are some differences in operation than with analog, so check with the MOSCAD product group for details.

## Appendix C: ACE3600 Maximum Power Ratings

The tables below list the typical maximum power consumption (at room temperature) for each of the ACE3600 RTU building blocks (CPU, Power Supply, I/O modules, radios, etc.) and the maximum peak power allowed for a fully loaded RTU, based on the housing type.

The values in the tables below are derived by using the power supply (AC: 100 to 240 VAC or DC: 18 to 72 VDC and 13.8 VDC) and have the power supply efficiency factor included in them.

Before deploying your RTU, add up the power consumption of all components of your system to verify that it is within the maximum peak power for your housing type. In systems with I/O expansion, consider all modules which consume power from their respective AC/DC main power sources when calculating the required power requirements.

**Table C-1 Maximum Peak Power Allowed for Fully Loaded RTU**

Housing Type Description	Maximum Input Power into Power Supply Module (Watts)
19" Rack (w/out metal enclosure)	100
Large NEMA metal housing (50x50 cm)	120*
Small NEMA metal housing (40x40 cm)	105*

**Table C-2 Power Consumption per RTU Module**

Module Name	Self Power Consumption, no active I/O (Watts)	Maximum Power Consumption, per Active I/O (Watts)	Self Power Consumption, no active I/O (Watts)	Maximum Power Consumption, per Active I/O (Watts)	Maximum Power Consumption, all I/Os, LEDs Active (Watts)
	AC: 100 to 240 VAC DC: 18 to 72 VDC		Vin = +13.8 VDC		
Power Supply (maximum)	12.60	N/A	2.20 (156 mA) (12 VDC Power Supply Module ONLY)	N/A	N/A
Power Supply (Expansion)	0.0	N/A	0.0	N/A	N/A
CPU (3640/3610)	5.20	N/A	4.20 (304 mA)	N/A	4.00 (290 mA)

\* NOTE: When powered at Vin = 100VAC, the maximum input power of the power supply module is limited to 80 Watts ONLY.

**Appendix C: ACE3600 Maximum Power Ratings**

Module Name	Self Power Consumption, no active I/O (Watts)	Maximum Power Consumption, per Active I/O (Watts)	Self Power Consumption, no active I/O (Watts)	Maximum Power Consumption, per Active I/O (Watts)	Maximum Power Consumption, all I/Os, LEDs Active (Watts)
	AC: 100 to 240 VAC DC: 18 to 72 VDC		Vin = +13.8 VDC		
Expansion Module	5.20	N/A	4.20 (304 mA)	N/A	4.00 (290 mA)
Expansion LAN Switch	1.50	0.220	1.20 (87 mA)	0.176 (12.75 mA)	3.10 (225 mA) (x8 ports ON)
Digital Input Fast 24V (x16/x32)	0.100	0.100 (powered by internal 24V PS)	0.080 (5.8 mA)	0.100 (7 mA) (powered by internal 24V PS)	3.50 (254 mA) (x32 inputs ON powered by x1 internal 24V PS)
Digital Input Fast 24V IEC Type 2 (x16/x32)	0.100	0.230 (powered by internal 24V PS)	0.080 (5.8 mA)	0.230 (17 mA) (powered by internal 24V PS)	8.20 (594 mA) (x32 inputs ON powered by x2 internal 24V PS)
Digital Input 120/230V	0.100	0.015	0.080 (5.8 mA)	0.012 (1 mA)	0.524 (38 mA) (x16 inputs ON)
Digital Output ML Relay (x8/x16)	0.120	0.010	0.100 (7.2 mA)	0.008 (0.5 mA)	0.483 (35 mA) (x16 relays ON)
Digital Output EE Relay (x8/x16)	0.170	0.200	0.136 (10 mA)	0.160 (11.6 mA)	3.26 (236 mA) (x16 relays ON)
Digital Output ML Relay 120/230V	0.200	0.006	0.160 (11.6 mA)	0.005 (0.4 mA)	0.248 (18.0 mA) (x12 relays ON)
Digital Output EE Relay 120/230V	0.290	0.260	0.232 (17 mA)	0.210 (0.15 mA)	3.12 (226 mA) (x12 relays ON)
FET Digital Output/Digital Input	0.120	DI = 0.014 (per input channel) DO = 0.014 (per output channel)	0.100 (7.2 mA)	DI = 0.011 (per input channel) DO = 0.011 (per output channel)	0.552 (40 mA) (x32 LEDs/ inputs ON)
Mixed I/O (DO ML +DI IEC Type 2)	0.480	DI = 0.250 (powered by internal 24V PS) DO = 0.010	0.384 (28 mA)	DI = 0.250 (powered by internal 24V PS) DO = 0.008	4.70 (341 mA) (x4 relays ON x16 inputs ON x4 AI ON powered by internal 24V PS)

**Appendix C: ACE3600 Maximum Power Ratings**

Module Name	Self Power Consumption, no active I/O (Watts)	Maximum Power Consumption, per Active I/O (Watts)	Self Power Consumption, no active I/O (Watts)	Maximum Power Consumption, per Active I/O (Watts)	Maximum Power Consumption, all I/Os, LEDs Active (Watts)
	AC: 100 to 240 VAC DC: 18 to 72 VDC		Vin = +13.8 VDC		
Mixed I/O (DO EE + DI IEC Type 2)	0.480	DI = 0.250 (powered by internal 24V PS) DO = 0.200	0.384 (28 mA)	DI = 0.250 (powered by internal 24V PS) DO = 0.160	5.50 (400 mA) (x4 relays ON x16 inputs ON x4 AI ON powered by internal 24V PS)
Analog Output	1.10	0.600 (per output channel @20.0 mA)	0.880 (64 mA)	0.480 (35 mA) (per output channel @20.0 mA)	3.33 (241 mA) (x4 outputs sourcing 20.0 mA)
Mixed Analog Current/Voltage	1.40	0.600 (per output channel @20.0 mA)	1.12 (81 mA)	0.480 (35 mA) (per output channel @20.0 mA)	3.61 (261 mA) (x4 outputs sourcing 20.0 mA)
Analog Input Current/Voltage (x8/x16)	0.530	N/A	0.440 (32.0 mA)	N/A	0.870 (63.0 mA)
24V Floating Plug-In Power Supply (No load)	0.410	N/A	0.328 (24 mA)	N/A	N/A
24V Floating Plug-In Power Supply (externally loaded 150 mA)	4.80	N/A	3.84 (278 mA)	N/A	N/A



**Appendix C: ACE3600 Maximum Power Ratings**

Plastic Box Interface	Typical Power (Watts)	Power when all I/Os are on (Watts)	Typical Power (Watts)	Power when all I/Os are on (Watts)
	AC: 100 to 240 VAC DC: 18 to 72 VDC		Vin = +13.8 VDC	
Audio Control and Tone (ACT) Module	0.60	2.20	0.480 (35 mA)	1.76 (127.50 mA)

Radios	Power in RX Mode (Watts)	Power in TX Mode (Watts)	Power in RX Mode (Watts)	Power in TX Mode (Watts)
	AC: 100 to 240 VAC DC: 18 to 72 VDC		Vin = +13.8 VDC	
XTL5000 (15 Watt)	8.80	66.90	7.10 (515 mA)	53.50 (4.0 A)
XTL2500 (15 Watt)	8.80	66.90	7.10 (515 mA)	53.50 (4.0 A)
XTS2500 (3 Watt)	1.20	9.90	1.00 (72.5 mA)	8.00 (580 mA)
HT750/GP320/PRO5150/GP328 (UHF 4 Watt/VHF 5 Watt)	0.70	13.10	0.560 (40.6 mA)	10.50 (761 mA)
CM200/CM140/EM200/GM3188 (UHF 20 Watt/VHF 25 Watt)	3.70	75.10	3.00 (217 mA)	60.00 (4.40 A)
GM328/338/339/340 (UHF 20 Watt/VHF 25 Watt)	3.60	73.20	2.90 (210 mA)	59.00 (4.3 A)
CDM750 (UHF 20 Watt/VHF 25 Watt)	3.90	74.50	3.20 (232 mA)	60.00 (4.40 A)