SIERRA SEMICONDUCTOR

Using the SC11210/SC11211 Caller I.D. Circuit

Purpose of Application Note

The purpose of this application note is to provide an introduction to the use of Sierra Semiconductor's Caller Identification (CID) decoding circuit, the SC11210/SC11211. This product has been designed to provide engineers with a highly integrated solution to decoding and detecting the FSK modem signals used in the Caller Identification Service.

A general overview of the functional and performance requirements of CID service first will be presented followed by descriptive and application information relative to the Sierra Caller ID chip. Data Access Arrangements (DAA) for general use as well as Caller ID systems also will be discussed. Specifically, a circuit application that combines a DAA with the Sierra Caller ID Chip will be detailed for designers.

System requirements for Caller ID electronics also will be presented including some discussion on signal flow algorithms and prototype microcontroller embodiments.

CID Service Overview and Discussion

In the following section, an outline of the CID service is provided. The material details the method of signaling, the specific signal level requirements, the delay and timing and the data sequence description. Also, general requirements for CID implementations specific to the Sierra Caller ID chip will be presented.

The Caller Number Delivery (CND) or Caller Identification Service is a new feature that has been introduced as part of the General Switched Telephone Network (GSTN). The service allows called parties to identify the calling party's number.

Electronic circuitry is provided that detects and decodes data that has been transmitted by the Central Office between the first and second ring signals on the subscriber line. Data is encoded as phase-coherent FSK and transmitted at 1200 Hz (Mark) and 2200 Hz (Space). The data stream also provides additional information concerning the called message including the date and time of the call. The transmission rate is 1200 bits per second and is in serial, simplex, binary, asynchronous format.

The transmission level into the subscriber loop is assumed to be -13 dBm at a 900 ohm impedance level. Worst case loss through the loop is assumed to be no more than 14 dB. Some loss, limited to less than a few dB, can be expected as a result of the coupling/protective (DAA) electronics. The Sierra CID chips will detect error-free CID messages over the normal range of levels expected in the CID environment.

A general CID system block diagram is shown in Figure 1 and general system timing shown in Figure 2. An optocoupler Ring Detection circuit is used to "wake up" the processor function and provide data stream loading to the Tip and Ring incoming line. Some delay (typically 500 Msec) is provided between the end of the Ring Signal and the beginning of the Data Stream. The Sierra CID chip provides demodulated data out to the microprocessor/microcontroller for further processing.

In the CID system, two types of messages are available: Single Data Message and Multiple Data Message. A Single Data Message consists of a sequence of 8 bit bytes as arranged in Figure 3. The initial part of the message is the Channel Seizure signal and is composed of 30 continuous bytes (250 ms) of Hex 55. This signal is followed by a carrier (Mark) of 150 ms. A Message Type word that provides information as to the service and the capability of the particular data message next follows as the first word in the Data Stream. Various values are allowed. For example, Hex 04 indicates that Calling Number Delivery Information is available in the message. (References 1 and 2).

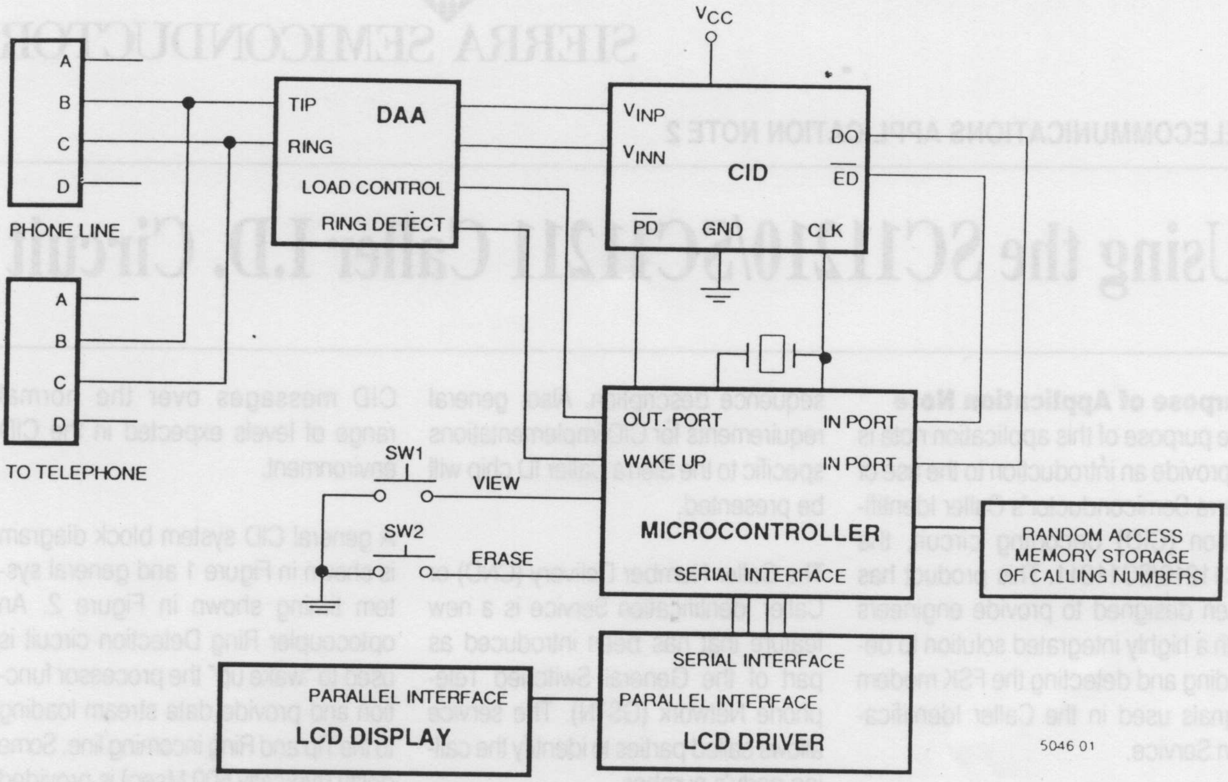

Figure 1. System Block Diagram

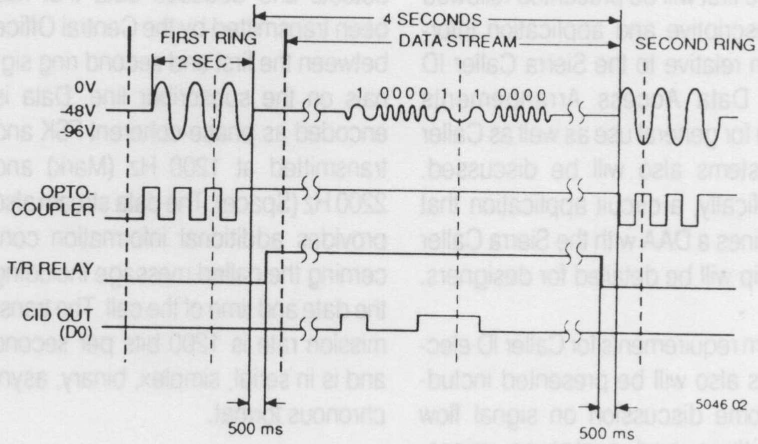

Figure 2. System Timing

The next word provides a byte to indicate the total number of data words that follow, excluding the error-detection word. The next sequence of words in the data stream are the Data Words. These words provide ASCII bytes of DN (Dialed Number), Date, Time Etc. Finally a checksum byte is provided at the end of this Single Data Message Format in order to provide a simple error correction mechanism for the Caller ID system. The checksum is formed by taking the 2's complement of the modulo 256 sum of the data words. The transmission would be successful if the calculated checksum added to the received checksum equals 0 modulo 256 (see Table 1). With regard to Multiple Data messages, the Caller ID service allows for a wide variety and complexity of message formats. Reference 2 provides further discussions of these formats.

For Power Ringing, data is sent during the silent interval between first and second rings. This silent period is nominally 4 seconds (2 seconds on and 4 seconds off). In order not to conflict with distinctive Ring Signaling, data is not sent until a 500-ms silent period has passed. Furthermore, it is intended that data end at least 475 ms before the end of the silent interval.

It should be pointed out that specifications describing CID service allow for data to be sent at any time as long as a voice path has been established. It is intended that Caller ID electronics provide a proper interface (DAA) to the subscriber line as well as CID data stream demodulation and processing.

#		7	6	5	4	3	2	1	0	Description	Dec Value	Hex Value	Mod 256 In Hex
		Binary Contents											
1	Msg Type	0	0	0	0	0	1	0	0	CND	04	04	04
2	Length	0	0	0	1	0	0	1	0	18	18	12	16
3	Month	0	0	1	1	0	0	0	0	0	48	30	46
4		0	0	1	1	0	1	0	0	4	52	34	7A
5	Day	0	0	1	1	0	0	1	0	2	50	32	AC
6		0	0	1	1	1	0	0	0	8	56	38	E4
7	Hour	0	0	1	1	0	0	0	1	1	49	31	15
8		0	0	1	1	0	0	1	1	3	51	33	48
9	Minutes	0	0	1	1	0	0	1	0	2	50	32	7A
10		0	0	1	1	0	0	0	0	0	48	30	AA
11	Calling	0	0	1	1	0	1	0	0	4	52	34	DE*
12	Number	0	0	1	1	0	0	0	0	0	48	30	0E
13		0	0	1	1	1	0	0	0	8	56	38	46
14		0	0	1	1	0	0	1	0	2	50	32	78
15		0	0	1	1	0	1	1	0	6	54	36	AE
16		0	0	1	1	0	0	1	1	3	51	35	E1
17		0	0	1	1	1	0	0	1	9	57	39	1A
18		0	0	1	1	0	0	1	1	3	51	33	4D
19		0	0	1	1	0	0	0	0	0	48	30	7D
20		0	0	1	1	0	0	0	0	0	48	30	AD
21	Checksum	0	1	0	1	0	0	1	1	Checksum	83	53	53

Calculated Checksum+Received Checksum=0 Modulo 256

*"P" = Blocked or "O" = Out of Area

Table 1.

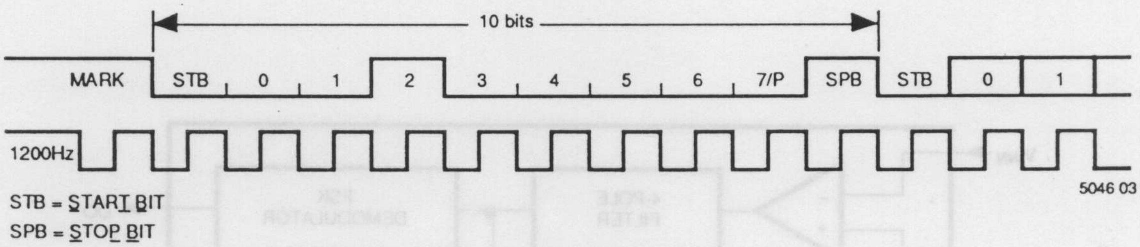

Figure 3. Data Structure

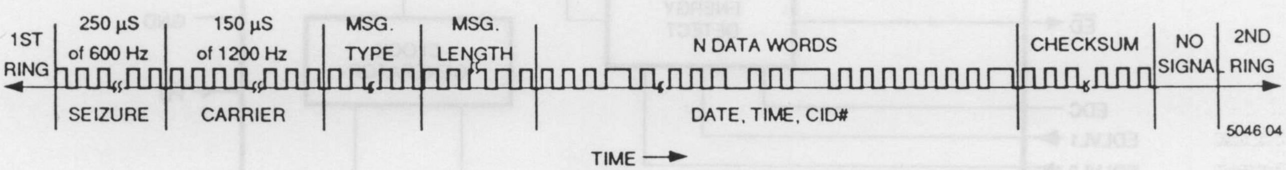

Figure 4. Timing Diagram

Sierra SC11210/SC11211 Caller ID Chip

The following sections provide a detailed description of the Sierra Caller ID Chip including functional and electrical parameters. Functionality will be described for each pin and suggestions for using the Sierra Caller ID chip is provided. Limits on electrical parameters will be discussed and an overall block diagram description will be provided. Figure 5 provides an overall block diagram of the part indicating five basic functional components.

The Caller ID's input buffer provides a balanced differential input to the part with an impedance of 100k ohm (typical), measured at 1 kHz. The bandpass filter is a four pole configuration allowing a flow through of modulation frequencies, constrained by the bandpass shown in Figure 6.

Selection of energy pass levels is provided by the Energy Detect block. This feature provides a method for the user to analyze incoming signal levels as part of the processing algorithm. For example, the user might decide to reject all signal levels below a certain value as undesirable noise, or may selectively allow signals within a certain range to indicate a line active status. Four level windows are possible and are programmed using the EDLVL1, EDLVL2 inputs. The Energy Detect circuitry requires an external capacitor to operate. This capacitor is attached from the EDC pin to ground. When this capacitor has a value of 0.1 μF the Energy Detect circuit has a response time of approximately 5 msec. (Figure 7).

The FSK Demodulator accepts the band limited, dual frequency modulation on its input and provides NRZ serial output on the Data Out line. An on chip oscillator is provided with the Clock Generator Block. The only external component required for this block is the crystal whose value is assumed to be 3.5795454 MHz (Figure 8).

A Call Progress Monitor function is also available which shifts the center frequency of the on chip filter to 1/3 of it's normal value (Figure 9). This function is achieved by bringing the $\overline{CPM}$ pin low.

The device uses CMOS technology and operates with a single supply of 5 volts ±10%. Operating power consumption is specified at 35 mW (max) and assumes a clock frequency of 3.579 MHz. Considerably lower power is achieved during Power Down Mode, enabled by bringing the Power Down control line low. Power consumption in this mode is equal to the product of supply voltage and quiescent current (See Data Sheet).

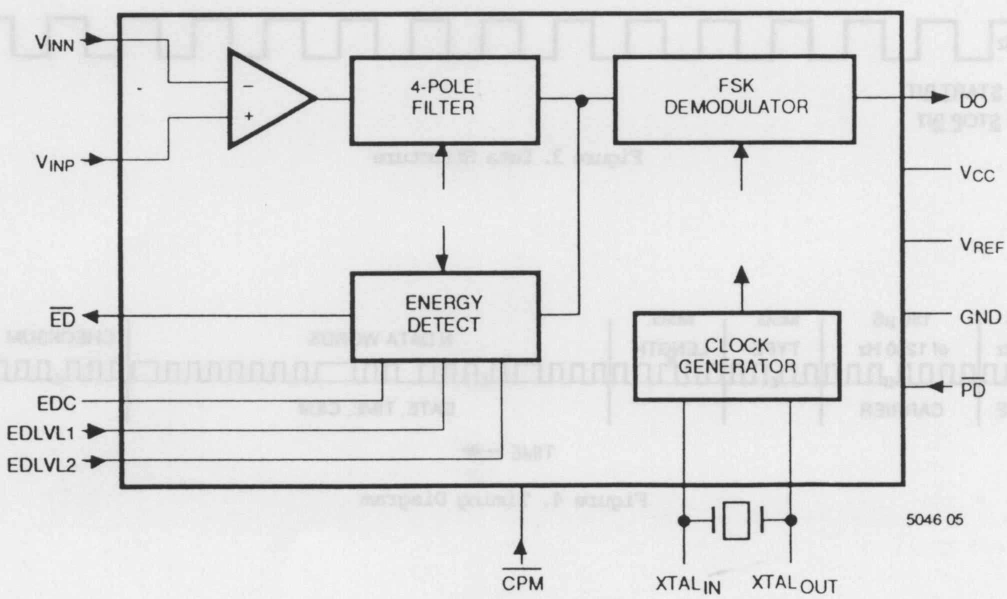

Figure 5. Sierra Caller ID Chip – Block Diagram

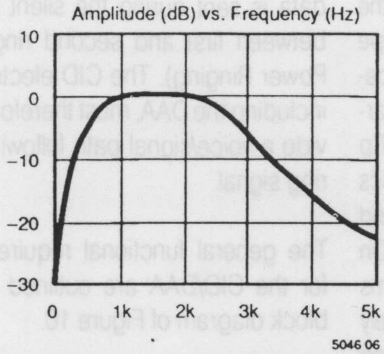

Figure 6. SC11210/11 – Bandpass in CND Mode

EDLVL2	EDLVL1	DETECT LEVEL[1]
0 (or open)	0 (or open)	−30 dBm on −35 dBm off
0 (or open)	1	−27 dBm on −32 dBm off
1	0 (or open)	−24 dBm on −29 dBm off
1	1	−21 dBm on −26 dBm off

[1] dBm = decibels above or below a reference power of mW into a 600Ω load.

Figure 7. Energy – Windows and Programming

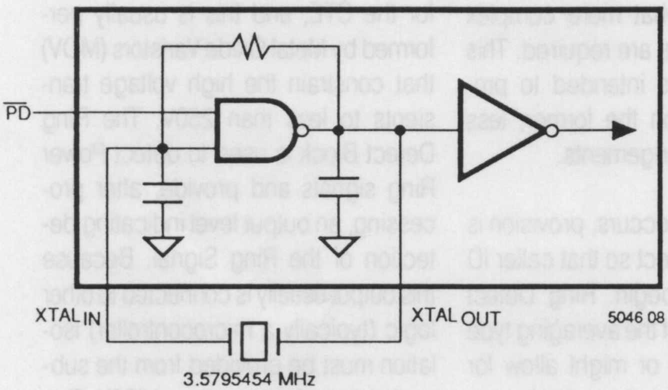

Figure 8. Oscillator Block

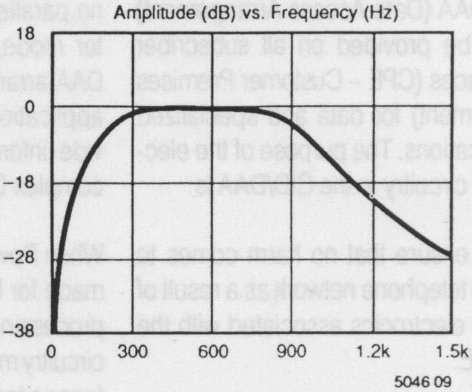

Figure 9. Call Progress Mode Bandpass

The following briefly describes the function of the various pins:

DO (Data Out): Provides the data out of the demodulated FSK input stream. DO is high when the input signal is 1200±12 Hz and is low when the input is 2200±22 Hz. (See Figures 1 & 2.)

$\overline{\text{CPM}}$ (Call Progress Mode): When this line is brought low the filter band pass is forced to one third of its normal value thus allowing Call Progress analysis of input signals.

$\overline{\text{ED}}$ (Energy Detect): This line goes low when Energy Detect criteria as defined by Energy Detect Control Inputs (Pins 3, 4) is valid.

EDC (Energy Detect Capacitor): As part of the Energy Detect circuit, a 0.1µF capacitor is required and is placed from this pin to ground.

EDLVL1, EDLVL2 (Energy Detect Control Lines): Used to define valid Energy Detect Levels as signal levels input to the chip. Note that these inputs have on chip pull-down resistors providing the most sensitive Energy Detect Level by default. (See Figure 7.)

PD (Power Down): This pin, when brought low, forces the on-chip oscillator to turn off and thus places the chip in a low-power quiescent mode. For current used by the chip in this mode see data sheet.

V_{INN}, V_{INP}: Differential input to the chip. Maximum input allowed is 500 mV RMS. Note that Single Ended input is allowed and should be brought to the V_{INN} pin, and the V_{INP} pin should be tied directly to V_{REF}.

V_{REF} (Reference Ground): For proper operation this pin is normally tied to ground through a 1 µF capacitor.

$XTAL_{IN}$, $XTAL_{OUT}$: Connection points for frequency determining crystal.

V_{CC} (GND): Power connection points for chip.

The Sierra Caller ID chip is available in both 14-pin (SC11211) and 8-pin (SC11210) versions. In the 8-pin version, programmability of Energy Detect Levels is not allowed and is preprogrammed to the most sensitive level detect i.e., -30 dBm (on) and -35 dBm (off). Power Down Mode and an on-chip oscillator are not available on the 8-pin version (SC11210).

DAA

The DAA (Data Access Arrangement) is to be provided on all subscriber interfaces (CPE – Customer Premises Equipment) for data and specialized applications. The purpose of the electronic circuitry in the CID/DAA is:

- To ensure that no harm comes to the telephone network as a result of the electronics associated with the CPE.
- To provide isolation and protection of the electronics in the CPE that might occur due to significant energy signals on the telephone line.
- As part of the DAA electronics, some additional functions might also be provided (e.g. Ring Detect circuitry).

Requirements for the DAA can be deduced from standards imposed by FCC and EIA documents. (See References 3 & 4.)

Various modes are possible for the CPE electronics depending on the type of system involved. In typical applications, a standard telephone set arrangement is in parallel with the Tip and Ring input of the CPE electronics requiring somewhat less complex (and less costly) DAA arrangements. On the other hand, complex CID systems are possible that provide completely automatic CID implementations along with bidirectional data flow, and with no parallel telephone set. For this latter mode, somewhat more complex DAA arrangements are required. This application note is intended to provide information on the former, less complex DAA arrangements.

When Power Ring occurs, provision is made for Ring Detect so that caller ID processing may begin. Ring Detect circuitry might be of the averaging type (capacitor output) or might allow for zero cross detection (using a microcontroller as processor) for more accurate processing of the Ring Signal waveform.

For many CID applications, it is assumed that a standard telephone arrangement (or its equivalent) is in parallel with the CID "box" electronics. Thus, the on-hook/off-hook function will be performed by the attached telephone subset. In operation, the CID data is sent during the silent period between first and second rings (for Power Ringing). The CID electronics, including the DAA, must therefore provide a voice/signal path following the ring signal.

The general functional requirements for the CID/DAA are outlined in the block diagram of Figure 10.

The Input Protection and Loading Block provide overvoltage protection for the CTE, and this is usually performed by Metal Oxide Varistors (MOV) that constrain the high voltage transients to less than 250V. The Ring Detect Block is used to detect Power Ring signals and provide, after processing, an output level indicating detection of the Ring Signal. Because this output usually is connected to other logic (typically a microcontroller) isolation must be provided from the subscriber line of greater than 1500V. This function is typically performed by opto-isolator devices. Counting of valid Ring pulses combined with sufficient delay, generates input to the Load Connect Control line. The Load Connect Control provides coupling of the data path to a proper termination during valid CID data times. With the need for sufficient isolation, both mechanical and solid-state relays are used to perform this function. Aside from Control

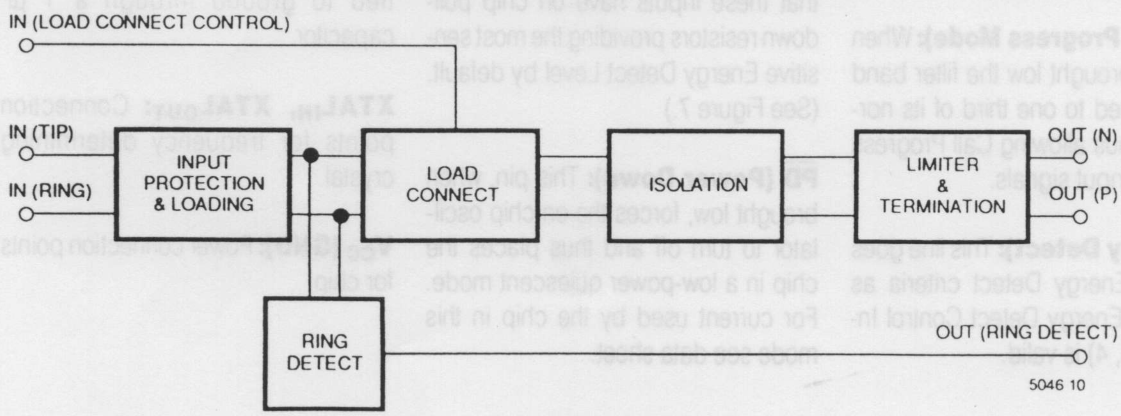

Figure 10. Generic CID/DAA

blocks, the signal path itself must be isolated from the line. This, more often than not, is performed by a 1:1 isolation transformer. The transformer also is used to couple to the load with minimum forward and return loss. Finally, signal limiting and termination are usually performed respectively by voltage limit diodes and pure resistive parallel loads.

The Figure 11 provides a schematic of a CID/DAA.

Various other DAA solutions are certainly possible. In an effort to provide additional alternative low cost solutions other circuits were investigated. One possible solution is shown in Figure 12 where capacitors are used to perform the isolation function. Note that the capacitor/resistance legs should be balanced to better than 0.1% and that the capacitors should have a breakdown voltage of greater than 1500V.

It is important that the CID system meet the EIA/FCC standards as outlined in the referenced documents. The following table (Table 2) provides a condensed description of these limits for both the Quiescent (Non Ringing) and Active (Ringing) state.

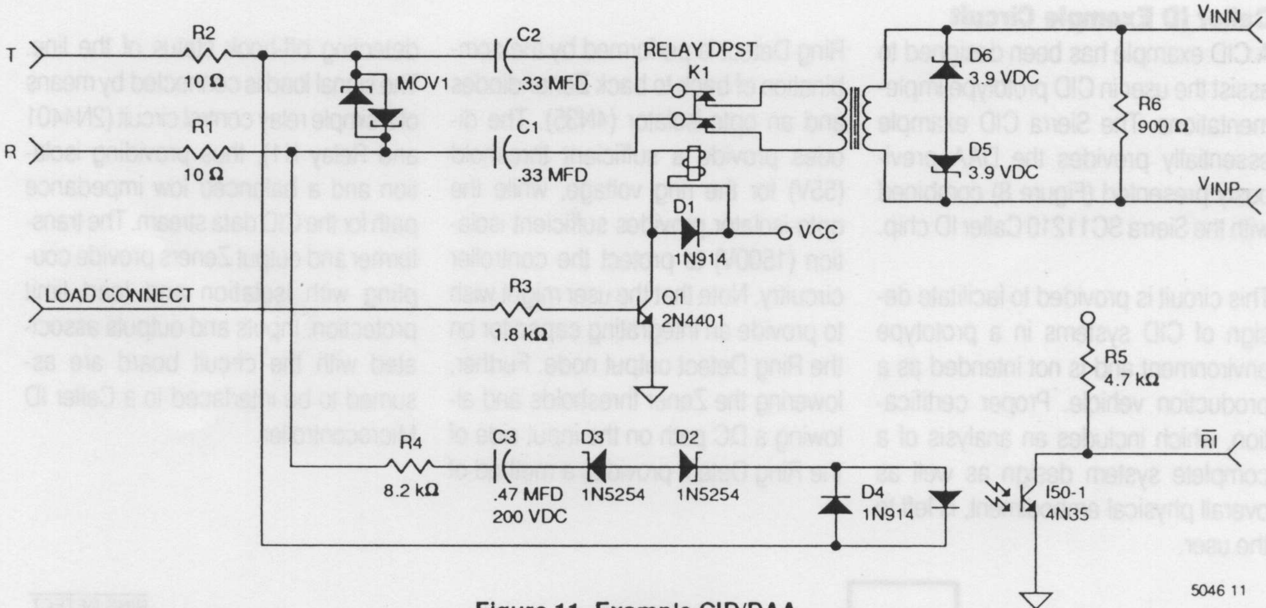

Figure 11. Example CID/DAA

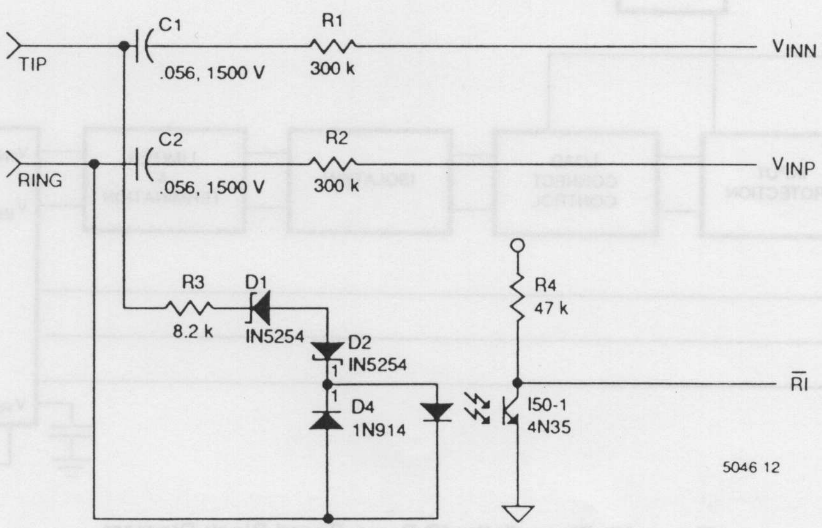

Figure 12. Alternative DAA Solution

EIA/FCC constraints also put limits on other electrical environmental factors. Telephone equipment must be protected from high voltage surges of typically 1500V and channel degradation caused by unusually high signal levels and imbalance on Tip and Ring loading. (See References 3 & 4 for more details.)

Function	Freq.	State	Volt	Std.	Limits (ohms)
DC Res.	N/A	Quiescent	<100V DC	EIA-470	>70 Meg
AC Res.	<200 Hz	Quiescent	<10V RMS	EIA-470	>7 k
AC Res.	697-1633 Hz	Quiescent	<3V RMS	EIA-470	>100 k
AC Res.	15.3-68 Hz	Active	40-150 vRMS	FCC-68	>8 k

Table 2. EIA/FCC Limits

Caller ID Example Circuit

A CID example has been designed to assist the user in CID prototype implementations. The Sierra CID example essentially provides the DAA previously presented (Figure 8) combined with the Sierra SC11210 Caller ID chip.

This circuit is provided to facilitate design of CID systems in a prototype environment and is not intended as a production vehicle. Proper certification, which includes an analysis of a complete system design as well as overall physical embodiment, is left to the user.

Ring Detect is performed by the combination of back to back Zener diodes and an opto-isolator (4N35). The diodes provide a sufficient threshold (55V) for the ring voltage, while the opto-isolator provides sufficient isolation (1500V) to protect the controller circuitry. Note that the user might wish to provide an integrating capacitor on the Ring Detect output node. Further, lowering the Zener thresholds and allowing a DC path on the input side of the Ring Detect provides a method of detecting off-hook status of the line. The signal load is connected by means of a simple relay control circuit (2N4401 and Relay K1), thus providing isolation and a balanced low impedance path for the CID data stream. The transformer and output Zeners provide coupling with isolation and load limit protection. Inputs and outputs associated with the circuit board are assumed to be interfaced to a Caller ID Microcontroller.

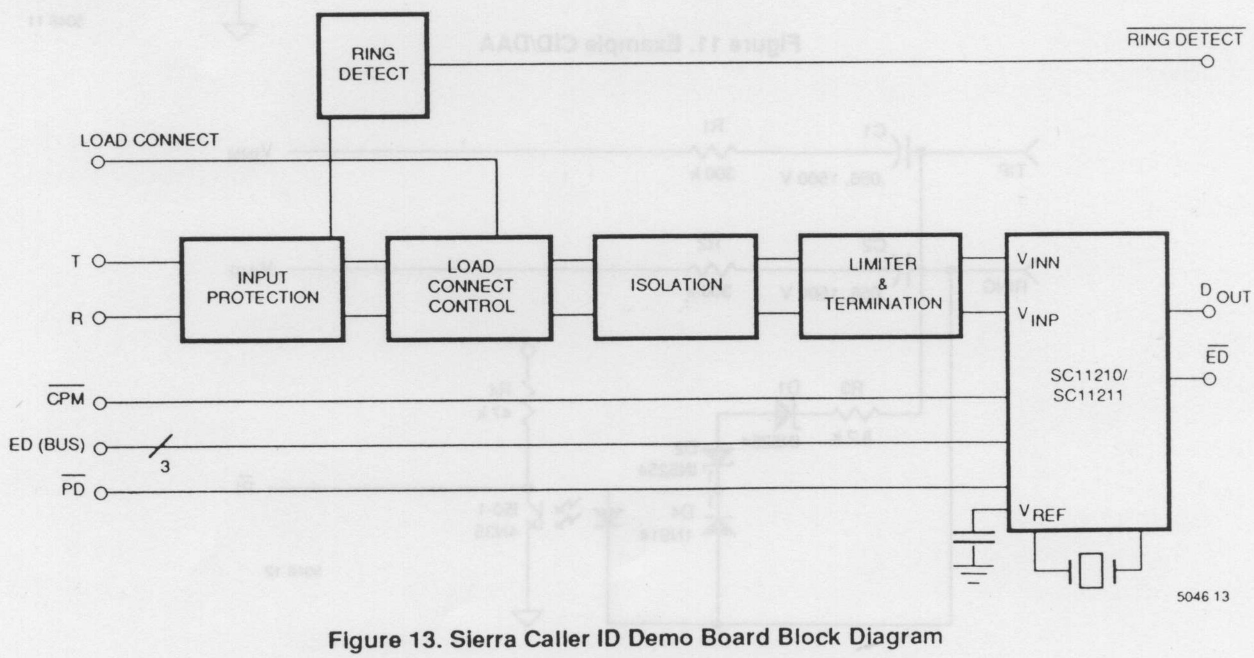

Figure 13. Sierra Caller ID Demo Board Block Diagram

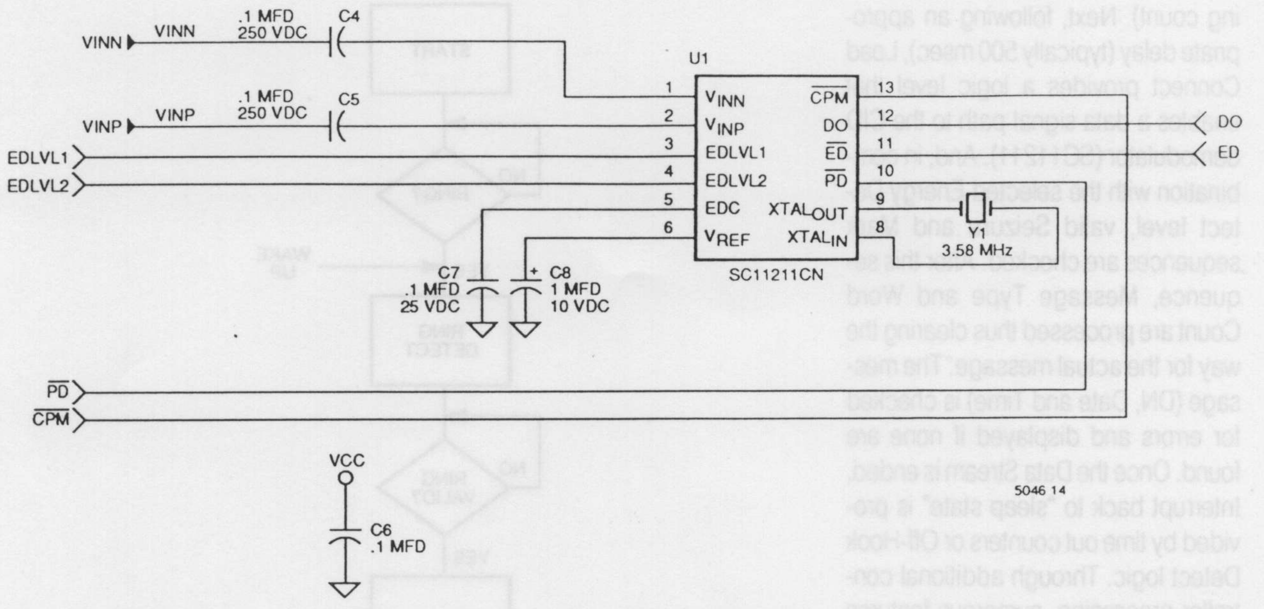

Figure 14. Sierra Caller ID Demo Board Schematic

Caller ID Microcontroller Interface

In order to perform the overall functional requirements for caller ID, additional controller functions are required. This requirement might be manifest using various controller vehicles including microcontrollers and personal computers.

A proposed System Block Diagram for use in system prototype development efforts is shown in Figure 15. The block diagram shown indicates the use of a specific microcontroller(80C51), however numerous other controllers are possible. In reviewing the System Block Diagram, note that the DAA and SC11210 blocks are contained on the Sierra CID Circuit Board. The 80C51 microcontroller performs control functions, serial data processing (RDX Input Port), hardware timeout functions and data store (e.g. called numbers).

Although the block diagram shows a PROM for program storage, this function is replaced by a ROM in the microcontroller for final volume production units. The block diagram also indicates a 1X16 (optional 2X16) Liquid Crystal Display. This alphanumeric, intelligent display is chosen to be compatible with the low power, versatile display requirements of CID systems.

CID software flow for a typical CID system is shown in Figure 16. The Ring Detect is used to detect first Power Ring. The logic level thus derived is used to "wake up" the processing and display electronics. Ring Signal Validity is then checked (e. g., zero cross-

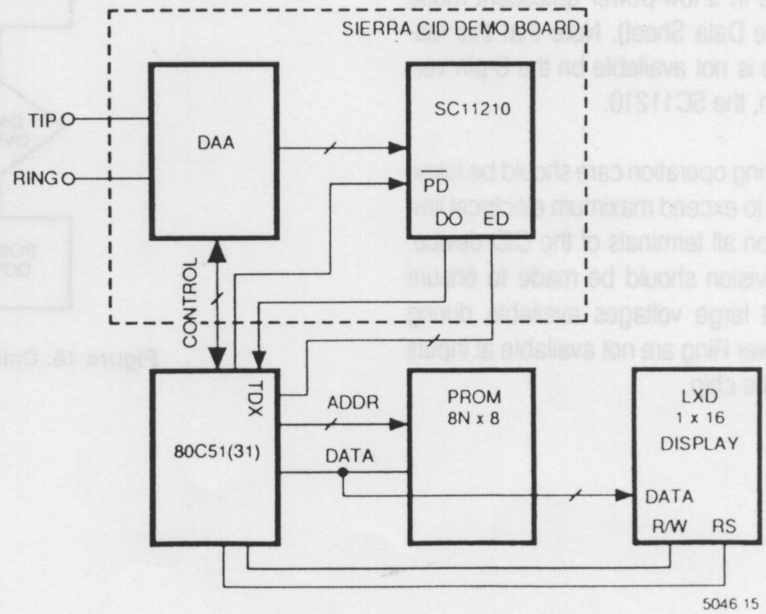

Figure 15. System Block Diagram

ing count). Next, following an appropriate delay (typically 500 msec), Load Connect provides a logic level that enables a data signal path to the CID demodulator (SC11211). And, in combination with the selected Energy Detect level, valid Seizure and Mark sequences are checked. After this sequence, Message Type and Word Count are processed thus clearing the way for the actual message. The message (DN, Date and Time) is checked for errors and displayed if none are found. Once the Data Stream is ended, Interrupt back to "sleep state" is provided by time out counters or Off-Hook Detect logic. Through additional controller processing, numerous features including Calling Number Store, Cross reference Name against Calling Number, etc., can be accessed.

In most applications, power for the CID system will be powered from a battery and system power budgeting thus becomes quite important. The Sierra SC11211 CID Circuit has been designed with this in mind by providing a separate power control line, PD, which, when brought low, sets the device in a low-power quiescent mode (See Data Sheet). Note that this feature is not available on the 8-pin version, the SC11210.

During operation care should be taken not to exceed maximum electrical limits on all terminals of the CID device. Provision should be made to ensure that large voltages available during Power Ring are not available at inputs to the chip.

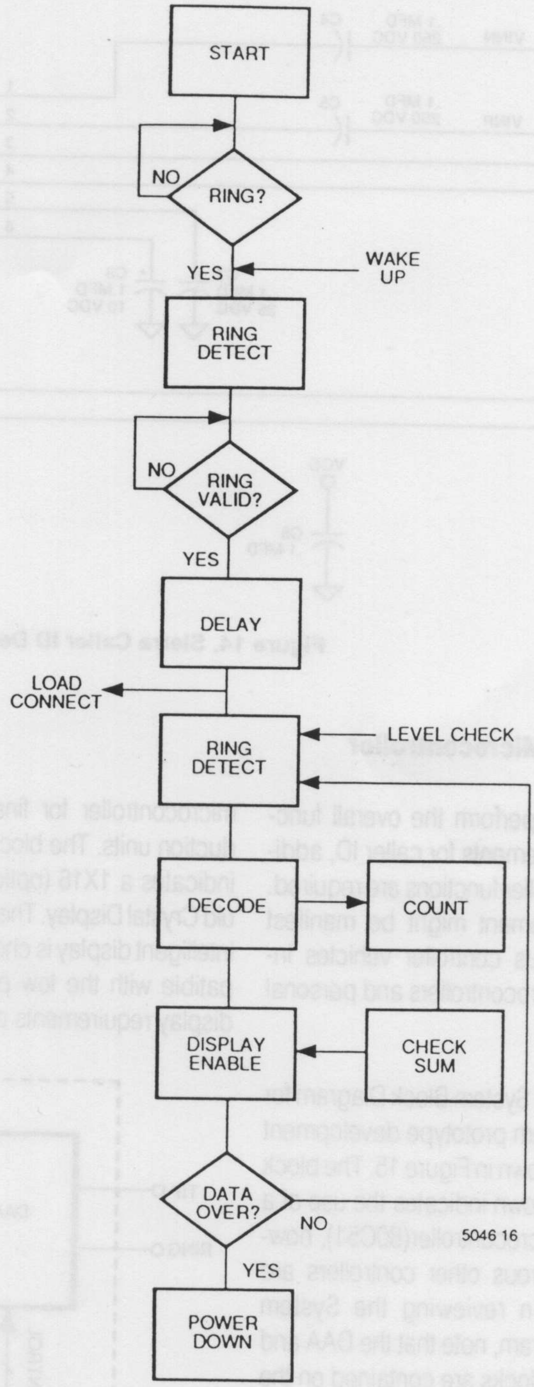

Figure 16. Caller ID Software Flow

Appendix

References

(1) SPCS Customer Premises Equipment Data Interface, TR-TSY-000030, Bellcore.

(2) CLASS Feature: Calling Number Delivery FSD-01-02-1051, TR-TSY-000031, Bellcore.

(3) FCC Rules and Regulations: Part 68.

(4) EIA Standard, Telephone Instruments With Loop Signaling, EIA-470-A, Electronic Industries Association.

Glossary

Binary Code - A pattern of 1's and 0's used to represent information.

Bit - A "1" or a "0".

Byte - A combination of 8 bits.

Central Office (CO) - An office providing switching equipment for local exchange telephone service.

Common Battery - Provided DC (Direct Current) from the Central Office for operation of telephone apparatus.

CND - Calling Number Delivery Feature...same as Caller ID feature.

CNDB - Calling Number Delivery Blocking - Provides method whereby subscriber can block or disable the CND feature.

CPE - Customer Premises Equipment.

DN - Directory Number.

Demodulation - The process of extracting intelligence from a carrier signal.

ESS (Electronic Switching System) - An electronic telephone switching apparatus containing crosspoints (low resistance switches) and a computer for stored program control.

FSK (Frequency Shift Keying) - A modulation method that represents a bit as two distinct frequencies.

Local Loop - The channel that connects the Central Office to the subscriber.

Loop Start - A Method of signaling an Off-Hook or line seizure where loop closure is detected by sensing current flow.

Off-Hook - A condition that indicates the active estate of subscriber telephone apparatus.

PABX - A private, automatic, branch exchange that provides a local telephone switching capability.

Power Ring - Ringing signal from Central Office.

POTS - "Plain Old Telephone Service", usually rotary dial, single line residential service.

SPCS - Stored Program Control Switching System.

Subscriber - Telephone customer.

Voice Grade Line - A Local Loop having a bandpass of approximately 300 to 3,000 Hz.