

DATA SHEET

TDA8005

Low-power smart card coupler

Product specification
Supersedes data of 1995 Apr 13
File under Integrated Circuits, IC17

1996 Sep 25

Low-power smart card coupler

TDA8005

FEATURES

- V_{CC} generation (5 V \pm 5%, 20 mA maximum with controlled rise and fall times)
- Clock generation (up to 8 MHz), with two times synchronous frequency doubling
- Clock STOP HIGH, clock STOP LOW or 1.25 MHz (from internal oscillator) for cards power-down mode
- Specific UART on I/O for automatic direct/inverse convention settings and error management at character level
- Automatic activation and deactivation sequences through an independent sequencer
- Supports the protocol T = 0 in accordance with ISO 7816, GSM11.11 requirements (Global System for Mobile communication); and EMV banking specification approved for Final GSM11.11 Test Approval (FTA)
- Several analog options are available for different applications (doubler or tripler DC/DC converter, card presence, active HIGH or LOW, threshold voltage supervisor, etc.
- Overloads and take-off protections
- Current limitations in the event of short-circuit
- Special circuitry for killing spikes during power-on or off
- Supply supervisor
- Step-up converter (supply voltage from 2.5 to 6 V)
- Power-down and sleep mode for low-power consumption
- Enhanced ESD protections on card side (6 kV minimum)
- Control and communication through a standard RS232 full duplex interface
- Optional additional I/O ports for:
 - keyboard
 - LEDs
 - display
 - etc.
- 80CL51 microcontroller core with 4 kbytes ROM and 256-byte RAM.

APPLICATIONS

- Portable smart card readers for protocol T = 0
- GSM mobile phones.

GENERAL DESCRIPTION

The TDA8005 is a low cost card interface for portable smart card readers. Controlled through a standard serial interface, it takes care of all ISO 7816 and GSM11-11 requirements. It gives the card and the set a very high level of security, due to its special hardware against ESD, short-circuiting, power failure, etc. Its integrated step-up converter allows operation within a supply voltage range of 2.5 to 6 V.

The very low-power consumption in Power-down and sleep modes saves battery power. A special version where the internal connections to the controller are fed outside through pins allows easy development and evaluation, together with a standard 80CL51 microcontroller.

Development tools, application report and support (hardware and software) are available.

The device can be supplied either as a masked chip with standard software handling all communication between smart card and a master controller in order to make the application easier, or as a maskable device.

Low-power smart card coupler

TDA8005

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{DD}	supply voltage	doubler and tripler option	2.5	–	6.0	V
$I_{DD(pd)}$	supply current in power-down mode	$V_{DD} = 5$ V; card inactive	–	–	100	μ A
$I_{DD(sm)}$	supply current in sleep mode doubler	card powered but clock stopped	–	–	500	μ A
$I_{DD(sm)}$	supply current in sleep mode tripler	card powered but clock stopped	–	–	500	μ A
$I_{DD(om)}$	supply current in operating mode	unloaded; $f_{xtal} = 13$ MHz; $f_{\mu C} = 6.5$ MHz; $f_{card} = 3.25$ MHz	–	–	5.5	mA
V_{CC}	card supply voltage	including static and dynamic loads on 100 nF capacitor	4.75	5.0	5.25	V
I_{CC}	card supply current	operating	–	–	20	mA
		limitation	–	–	30	mA
SR	slew rate on V_{CC} (rise and fall)	maximum load capacitor 150 nF (including typical 100 nF decoupling)	0.05	0.1	0.15	V/ μ s
t_{de}	deactivation cycle duration		–	–	100	μ s
t_{act}	activation cycle duration		–	–	100	μ s
f_{xtal}	crystal frequency		2	–	16	MHz
T_{amb}	operating ambient temperature		–25	–	+85	$^{\circ}$ C

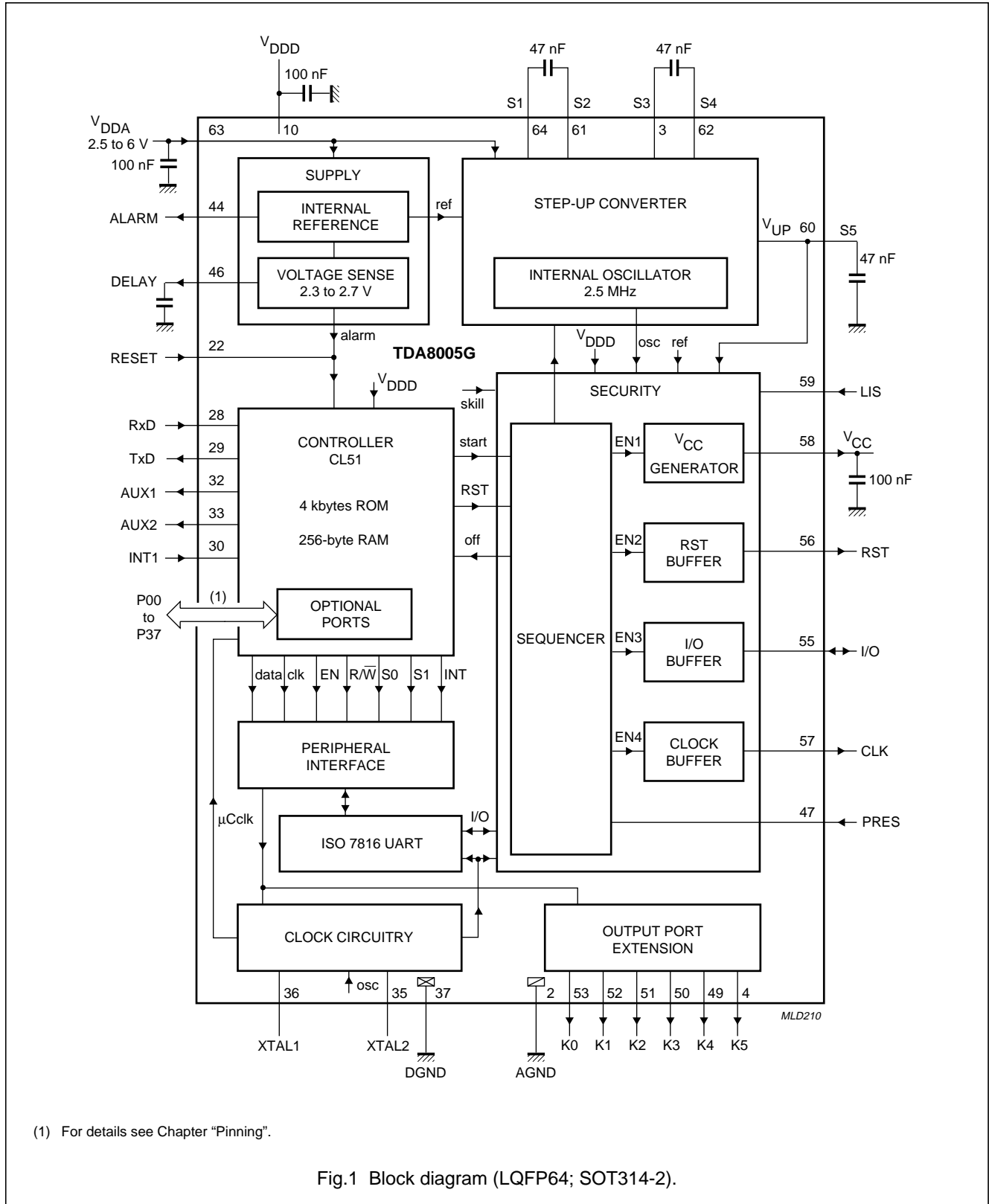
ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TDA8005G	LQFP64	plastic low profile quad flat package; 64 leads; body 10 × 10 × 1.4 mm	SOT314-2
TDA8005H	QFP44	plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 × 10 × 1.75 mm	SOT307-2

Low-power smart card coupler

TDA8005

BLOCK DIAGRAM



Low-power smart card coupler

TDA8005

PINNING

SYMBOL	PIN		DESCRIPTION
	LQFP64 SOT314-2	QFP44 SOT307-2	
n.c.	1	–	not connected
AGND	2	1	analog ground
S3	3	2	contact 3 for the step-up converter
K5	4	–	output port from port extension
P03	5	3	general purpose I/O port (connected to P03)
P02	6	4	general purpose I/O port (connected to P02)
P01	7	5	general purpose I/O port (connected to P01)
n.c.	8	–	not connected
P00	9	6	general purpose I/O port (connected to P00)
V _{DDD}	10	7	digital supply voltage
n.c.	11	–	not connected
TEST1	12	8	test pin 1 (connected to P10; must be left open-circuit in the application)
P11	13	9	general purpose I/O port or interrupt (connected to P11)
P12	14	10	general purpose I/O port or interrupt (connected to P12)
P13	15	11	general purpose I/O port or interrupt (connected to P13)
P14	16	12	general purpose I/O port or interrupt (connected to P14)
n.c.	17	–	not connected
P15	18	13	general purpose I/O port or interrupt (connected to P15)
P16	19	14	general purpose I/O port or interrupt (connected to P16)
TEST2	20	15	test pin 2 (connected to PSEN; must be left open-circuit in the application)
P17	21	16	general purpose I/O port or interrupt (connected to P17)
RESET	22	17	input for resetting the microcontroller (active HIGH)
n.c.	23	–	not connected
n.c.	24	–	not connected
n.c.	25	–	not connected
n.c.	26	–	not connected
n.c.	27	–	not connected
RxD	28	18	serial interface receive line
TxD	29	19	serial interface transmit line
INT1	30	20	general purpose I/O port or interrupt (connected to P33)
T0	31	21	general purpose I/O port (connected to P34)
AUX1	32	22	push-pull auxiliary output (± 5 mA; connected to timer T1 e.g. P35)
AUX2	33	23	push-pull auxiliary output (± 5 mA; connected to timer P36)
P37	34	24	general purpose I/O port (connected to P37)
XTAL2	35	25	crystal connection
XTAL1	36	26	crystal connection or external clock input
DGND	37	27	digital ground
n.c.	38	–	not connected

Low-power smart card coupler

TDA8005

SYMBOL	PIN		DESCRIPTION
	LQFP64 SOT314-2	QFP44 SOT307-2	
n.c.	39	–	not connected
P20	40	28	general purpose I/O port (connected to P20)
P21	41	–	general purpose I/O port (connected to P21)
P22	42	29	general purpose I/O port (connected to P22)
P23	43	30	general purpose I/O port (connected to P23)
ALARM	44	–	open-drain output for Power-On Reset (active HIGH or LOW by mask option)
n.c.	45	–	not connected
DELAY	46	31	external capacitor connection for delayed reset signal
PRES	47	32	card presence contact input (active HIGH or LOW by mask option)
TEST3	48	33	test pin 3 (must be left open-circuit in the application)
K4	49	–	output port from port extension
K3	50	–	output port from port extension
K2	51	–	output port from port extension
K1	52	–	output port from port extension
K0	53	–	output port from port extension
TEST4	54	34	test pin 4 (must be left open-circuit in the application)
I/O	55	35	data line to/from the card (ISO C7 contact)
RST	56	36	card reset output (ISO C2 contact)
CLK	57	37	clock output to the card (ISO C3 contact)
V _{CC}	58	38	card supply output voltage (ISO C1 contact)
LIS	59	39	supply for low-impedance on cards contacts
S5	60	40	contact 5 for the step-up converter
S2	61	41	contact 2 for the step-up converter
S4	62	42	contact 4 for the step-up converter
V _{DDA}	63	43	analog supply voltage
S1	64	44	contact 1 for the step-up converter

Low-power smart card coupler

TDA8005

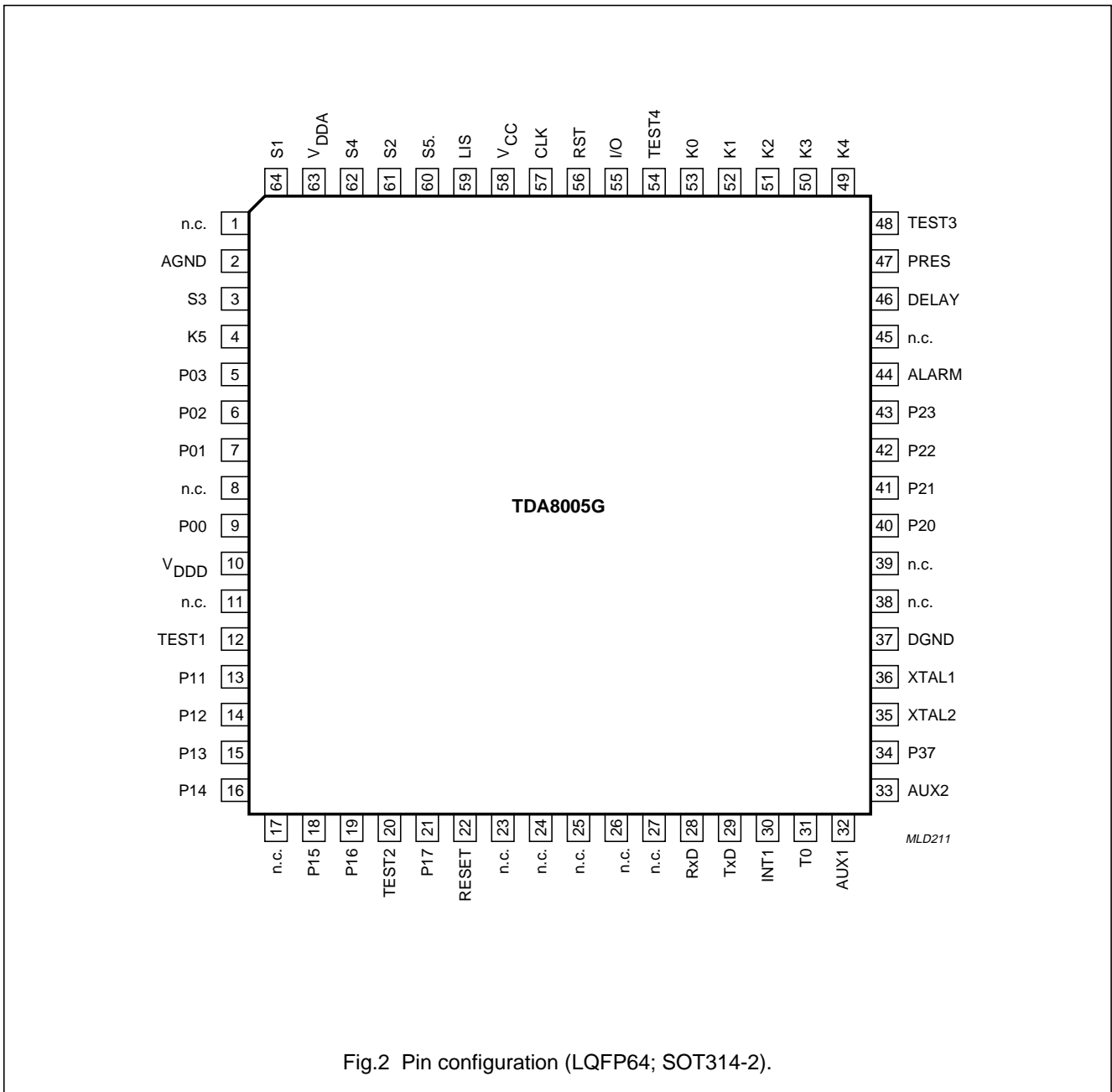


Fig.2 Pin configuration (LQFP64; SOT314-2).

Low-power smart card coupler

TDA8005

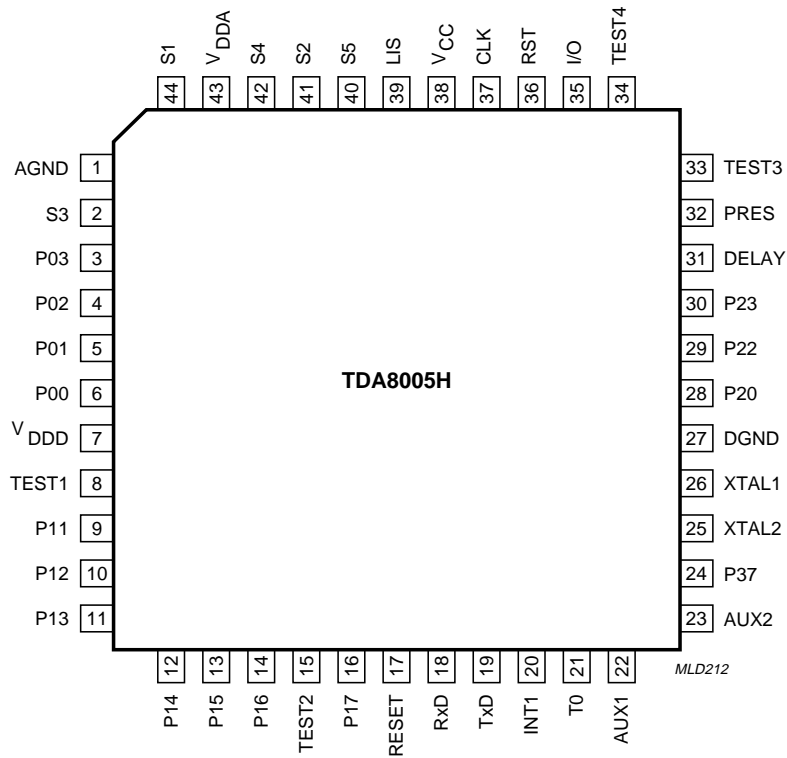


Fig.3 Pin configuration (QFP44; SOT307-2).

Low-power smart card coupler

TDA8005

FUNCTIONAL DESCRIPTION

Microcontroller

The microcontroller is an 80CL51 with 256 bytes of RAM instead of 128. The baud rate of the UART has been multiplied by four in modes 1, 2 and 3 (which means that the division factor of 32 in the formula is replaced by 8 in both reception and transmission, and that in the reception modes, only four samples per bit are taken with decision on the majority of samples 2, 3 and 4) and the delay counter has been reduced from 1536 to 24.

Remark: this has an impact when getting out of PDOWN mode. It is recommended to switch to internal clock before entering PDOWN mode (see "application report").

All the other functions remain unchanged. Please, refer to the published specification of the 80CL51 for any further information. Pins INT0, P10, P04 to P07 and P24 to P27 are used internally for controlling the smart card interface.

Mode 0 is unchanged. The baud rate for modes 1 and 3 is:

$$\frac{2^{\text{SMOD}}}{8} \times \frac{f_{\text{clk}}}{12 \times (256 - \text{TH1})}$$

The baud rate for mode 2 is: $\frac{2^{\text{SMOD}}}{16} \times f_{\text{clk}}$

Table 1 Mode 3 timing

BAUD RATE	$f_{\text{clk}} = 6.5 \text{ MHz};$ $V_{\text{DD}} = 5 \text{ V}$		$f_{\text{clk}} = 3.25 \text{ MHz};$ $V_{\text{DD}} = 5 \text{ or } 3 \text{ V}$	
	SMOD	TH1	SMOD	TH1
135416	1	255	–	–
67708	0	255	1	255
45139	1	253	–	–
33854	0	254	0	255
27083	1	251	–	–
22569	0	253	1	253
16927	–	–	0	254
13542	–	–	1	251
11285	0	250	0	253

Supply

The circuit operates within a supply voltage range of 2.5 to 6 V. The supply pins are V_{DD} , DGND and AGND. Pins V_{DDA} and AGND supply the analog drivers to the card and have to be externally decoupled because of the large current spikes that the card and the step-up converter can create. An integrated spike killer ensures the contacts to the card remain inactive during power-up or power-down. An internal voltage reference is generated which is used within the step-up converter, the voltage supervisor, and the V_{CC} generator.

The voltage supervisor generates an alarm pulse, whose length is defined by an external capacitor tied to the DELAY pin, when V_{DD} is too low to ensure proper operation (1 ms per 1 nF typical). This pulse is used as a RESET pulse by the controller, in parallel with an external RESET input, which can be tied to the system controller.

It is also used in order to either block any spurious card contacts during controllers reset, or to force an automatic deactivation of the contacts in the event of supply drop-out [see Sections "Activation sequence" and "Deactivation sequence (see Fig.10)"].

In the 64 pin version, this reset pulse is output to the open drain ALARM pin, which may be selected active HIGH or active LOW by mask option and may be used as a reset pulse for other devices within the application.

Low-power smart card coupler

TDA8005

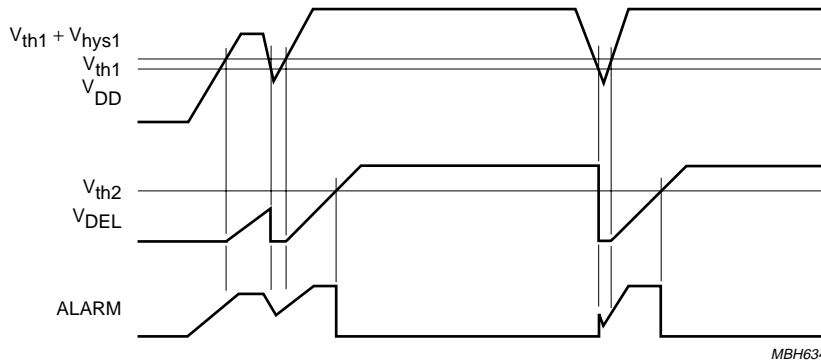


Fig.4 Supply supervisor.

Low impedance supply (pin LIS)

For some applications, it is mandatory that the contacts to the card (V_{CC} , RST, CLK and I/O) are low impedance while the card is inactive and also when the coupler is not powered. An auxiliary supply voltage on pin LIS ensures this condition where $I_{LIS} = <5 \mu A$ for $V_{LIS} = 5 V$. This low impedance situation is disabled when V_{CC} starts rising during activation, and re-enabled when the step-up converter is stopped during deactivation. If this feature is not required, the LIS pin must be tied to V_{DD} .

Step-up converter

Except for the V_{CC} generator, and the other cards contacts buffers, the whole circuit is powered by V_{DDD} and V_{DDA} . If the supply voltage is 3 V or 5 V, then a higher voltage is needed for the ISO contacts supply. When a card session is requested by the controller, the sequencer first starts the step-up converter, which is a switched capacitors type, clocked by an internal oscillator at a frequency approximately 2.5 MHz. The output voltage, V_{UP} , is regulated at approximately 6,5 V and then fed to the V_{CC} generator. V_{CC} and GND are used as a reference for all other cards contacts. The step-up converter may be

chosen as a doubler or a tripler by mask option, depending on the voltage and the current needed on the card.

ISO 7816 security

The correct sequence during activation and deactivation of the card is ensured through a specific sequencer, clocked by a division ratio of the internal oscillator.

Activation (START signal P05) is only possible if the card is present (PRES HIGH or LOW according to mask option), and if the supply voltage is correct (ALARM signal inactive), CLK and RST are controlled by RSTIN (P04), allowing the correct count of CLK pulses during Answer-to-Reset from the card.

The presence of the card is signalled to the controller by the OFF signal (P10).

During a session, the sequencer performs an automatic emergency deactivation in the event of card take-off, supply voltage drop, or hardware problems. The OFF signal falls thereby warning the controller.

Low-power smart card coupler

TDA8005

Clock circuitry

The clock to the microcontroller and the clock to the card are derived from the main clock signal (XTAL from 2 to 16 MHz, or an external clock signal).

Microcontroller clock (f_{clk}) after reset, and during power reduction modes, the microcontroller is clocked with $f_{INT}/8$, which is always present because it is derived from the internal oscillator and gives the lowest power consumption. When required, (for card session, serial communication or anything else) the microcontroller may choose to clock itself with $\frac{1}{2}f_{xtal}$, $\frac{1}{4}f_{xtal}$ or $\frac{1}{2}f_{INT}$. All frequency changes are synchronous, thereby ensuring no hang-up due to short spikes etc.

Cards clock: the microcontroller may select to send the card $\frac{1}{2}f_{xtal}$, $\frac{1}{4}f_{xtal}$, $\frac{1}{8}f_{xtal}$ or $\frac{1}{2}f_{INT}$ (≈ 1.25 MHz), or to stop the clock HIGH or LOW. All transition are synchronous, ensuring correct pulse length during start or change in accordance with ISO 7816.

After power on, CLK is set at STOP LOW, and f_{clk} is set at $\frac{1}{8}f_{INT}$.

Power-down and sleep modes

The TDA8005 offers a large flexibility for defining power reduction modes by software. Some configurations are described below.

In the power-down mode, the microcontroller is in power-down and the supply and the internal oscillator are

active. The card is not active; this is the smallest power consumption mode. Any change on P1 ports or on PRES will wake-up the circuit (for example, a key pressed on the keyboard, the card inserted or taken off).

In the sleep mode, the card is powered, but configured in the Idle or sleep mode. The step-up converter will only be active when it is necessary to reactivate V_{UP} . When the microcontroller is in Power-down mode any change on P1 ports or on PRES will wake up the circuit.

In both power reduction modes the sequencer is active, allowing automatic emergency deactivation in the event of card take-off, hardware problems, or supply drop-out.

The TDA8005 is set into Power-down or sleep mode by software. There are several ways to return to normal mode, Introduction or extraction of the card, detection of a change on P1 (which can be a key pressed) or a command from the system microcontroller. For example, if the system monitors the clock on XTAL1, it may stop this clock after setting the device into power-down mode and then wake it up when sending the clock again. In this situation, the internal clock should have been chosen before the f_{clk} .

Peripheral interface

This block allows synchronous serial communication with the three peripherals (ISO UART, CLOCK CIRCUITRY and OUTPUT PORTS EXTENSION).

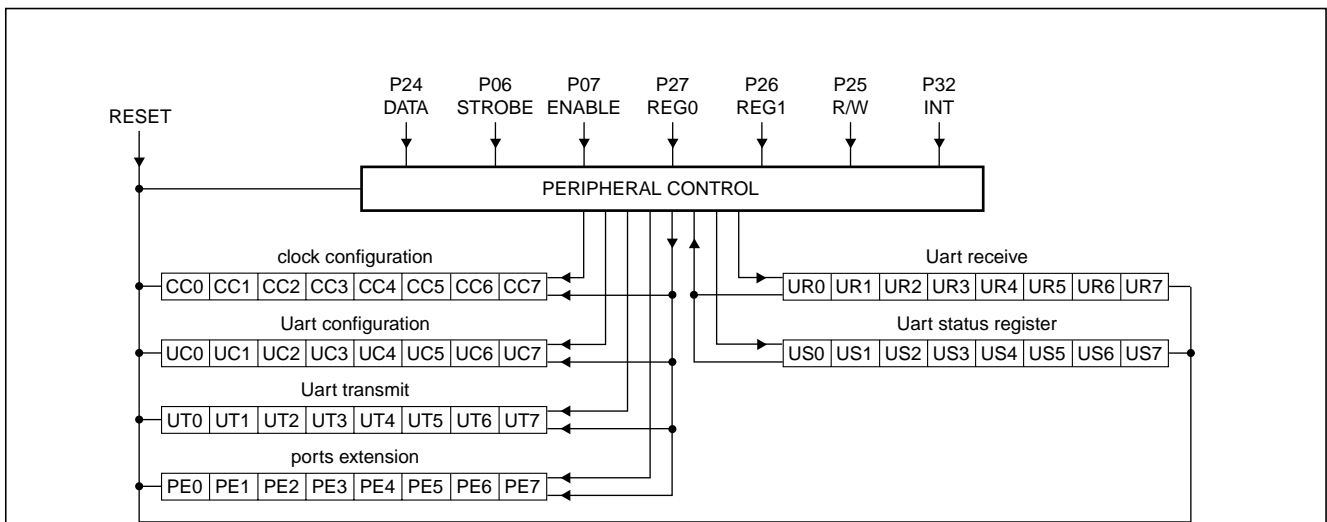


Fig.5 Peripheral interface diagram.

Low-power smart card coupler

TDA8005

Table 2 Description of Fig.5

BIT NAME	DESCRIPTION
REG0 = 0, REG1 = 0, R/W = 0; CLOCK CONFIGURATION (Configuration after reset is cards clock STOP LOW, $f_{clk} = 1/8f_{INT}$)	
CC0	cards clock = $1/2f_{xtal}$
CC1	cards clock = $1/4f_{xtal}$
CC2	cards clock = $1/8f_{xtal}$
CC3	cards clock = $1/2f_{INT}$
CC4	cards clock = STOP HIGH
CC5	$f_{clk} = 1/2f_{xtal}$
CC6	$f_{clk} = 1/4f_{xtal}$
CC7	$f_{clk} = 1/2f_{INT}$
REG0 = 1, REG1 = 0, R/W = 0; UART CONFIGURATION (after reset all bits are cleared)	
UC0	ISO UART RESET
UC1	START SESSION
UC2	LCT (Last Character to Transmit)
UC3	TRANSMIT/RECEIVE
UC4 to UC7	not used
REG0 = 0, REG1 = 1, R/W = 0; UART TRANSMIT	
UT0 to UT7	LSB to MSB of the character to be transmitted to the card
REG0 = 1, REG1 = 1, R/W = 0; PORTS EXTENSION (after reset all bits are cleared)	
PE0 to PE5	PE0 to PE5 is the inverse of the value to be written on K0 to K5
PE6, PE7	not used
REG0 = 0, REG1 = 0, R/W = 1; UART RECEIVE	
UR0 to UR7	LSB to MSB of the character received from the card
REG0 = 1, REG1 = 0, R/W = 1; UART STATUS REGISTER (after reset all bits are cleared)	
US0	UART TRANSMIT buffer empty
US1	UART RECEIVE buffer full
US2	first start bit detected
US3	parity error detected during reception of a character (the UART has asked the card to repeat the character)
US4	parity error detected during transmission of a character. The controller must write the previous character in UART TRANSMIT, or abort the session.
US5 to US7	not used

Low-power smart card coupler

TDA8005

USE OF PERIPHERAL INTERFACE

Write operation:

Select the correct register with R/W, REG0, REG1.
 Write the word in the peripheral shift register (PSR) with DATA and STROBE. DATA is shifted on the rising edge of STROBE. 8 shifts are necessary.
 Give a negative pulse on ENABLE. The data is parallel loaded in the register on the falling edge of ENABLE.

Read operation:

Select the correct register with R/W, REG0 and REG1.
 Give a first negative pulse on ENABLE. The word is parallel loaded in the peripheral shift register on the rising edge of ENABLE.
 Give a second negative pulse on ENABLE for configuring the PSR in shift right mode.
 Read the word from PSR with DATA and STROBE. DATA is shifted on the rising edge of STROBE. 7 shifts are necessary.

Table 3 Example of peripheral interface

CHANGE OF CLOCK CONFIGURATION ⁽¹⁾		READ CHARACTER ARRIVED IN UART RECEIVE ⁽²⁾	
	CLR REG0		CLR REG0
	CLR REG1		CLR REG1
	CLR R/W		SET R/W
	MOV R2, #8		CLR ENABLE
LOOP	RRC A		SET ENABLE
	MOV DATA C		CLR ENABLE
	CLR STROBE		SET ENABLE
	SET STROBE		MOV R2, #8
	DJNZ R2, LOOP	LOOP	MOV C, DATA
	CLR ENABLE		RRC A
	SET ENABLE		CLR STROBE
	SET DATA		SET STROBE
	RET		DJNZ R2, LOOP
			SET DATA
			RET

Notes

1. The new configuration is supposed to be in the accumulator.
2. The character will be in the accumulator.

Low-power smart card coupler

TDA8005

ISO UART

The ISO UART handles all the specific requirements defined in ISO T = 0 protocol type. It is clocked with the cards clock, which gives the $f_{\text{clk}}/31$ sampling rate for start bit detection (the start bit is detected at the first LOW level on I/O) and the $f_{\text{clk}}/372$ frequency for ETU timing (in the reception mode the bit is sampled at $1/2$ ETU). It also allows the cards clock frequency changes without interfering with the baud rate.

This hardware UART allows operating of the microcontroller at low frequency, thus lowering EM radiations and power consumption. It also frees the microcontroller of fastidious conversions and real time jobs thereby allowing the control of higher level tasks.

The following occurs in the reception mode (see Fig.6):

- Detection of the inverse or direct convention at the begin of ATR.
- Automatic convention setting, so the microcontroller only receives characters in direct convention.
- Parity checking and automatic request for character repetition in case of error (reception is possible at 12 ETU).

In the transmission mode (see Fig.7):

- Transmission according to the convention detected during ATR, consequently the microcontroller only has to send characters in direct convention. Transmission of the next character may start at 12 ETU in the event of no error or 13 ETU in case of error.
- Parity calculation and detection of repetition request from the card in the event of error.
- The bit LCT (Last Character to Transmit) allows fast reconfiguration for receiving the answer 12 ETU after the start bit of the last transmitted character.

The ISO UART status register can inform which event has caused an interrupt. (Buffer full, buffer empty, parity error detected etc.) of Peripheral Interface.

This register is reset when the microcontroller reads the status out of it.

The ISO UART configuration register enables the microcontroller to configure the ISO UART. cf Peripheral Interface.

After power-on, all ISO UART registers are reset.

The ISO UART is configured in the reception mode. When the microcontroller wants to start a session, it sets the bits START SESSION and RESET ISO UART in UART CONFIGURATION and then sets START LOW. When the first start bit on I/O is detected (sampling rate $f_{\text{clk}}/31$), the UART sets the bit US2 (First Start Detect) in the status register which gives an interrupt on INT0 one CLK pulse later.

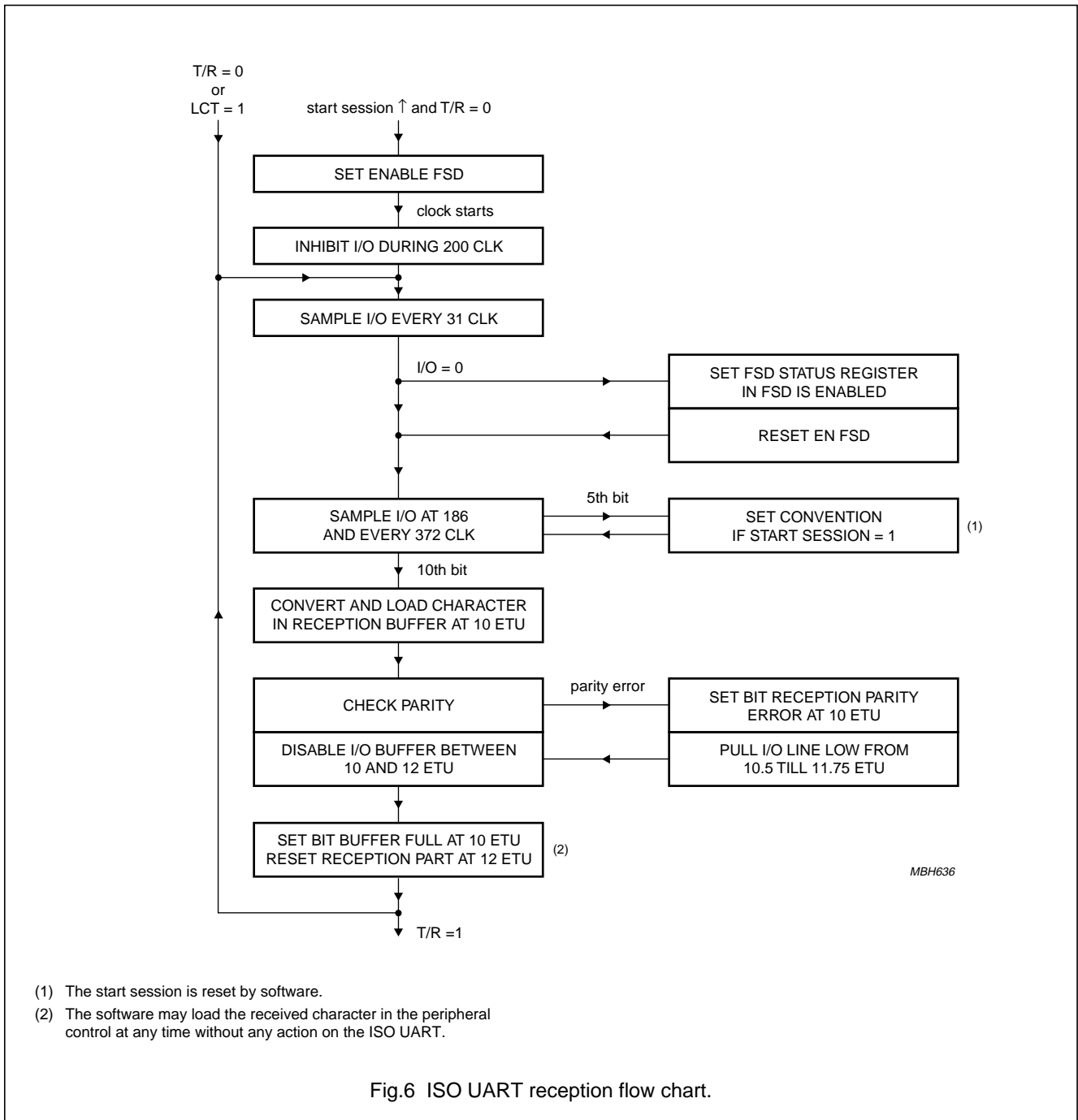
The convention is recognized on the first character of the ATR and the UART configures itself in order to exchange direct data without parity processing with the microcontroller whatever the convention of the card is. The bit START SESSION must be reset by software. At the end of every character, the UART tests the parity and resets what is necessary for receiving another character.

If no parity error is detected, the UART sets the bit US1 (BUFFER FULL) in the STATUS REGISTER which warns the microcontroller it has to read the character before the reception of the next one has been completed. The STATUS REGISTER is reset when read from the controller.

If a parity error has been detected, the UART pulls the I/O line LOW between 10.5 and 12 ETU. It also sets the bits BUFFER FULL and US3 (parity error during reception) in the STATUS REGISTER which warns the microcontroller that an error has occurred. The card is supposed to repeat the previous character.

Low-power smart card coupler

TDA8005



When the controller needs to transmit data to the card, it first sets the bit UC3 in the UART CONFIGURATION which configures the UART in the transmission mode. As soon as a character has been written in the UART TRANSMIT register, the UART makes the conversion,

calculates the parity and starts the transmission on the rising edge of ENABLE. When the character has been transmitted, it surveys the I/O line at 11 ETU in order to know if an error has been detected by the card.

Low-power smart card coupler

TDA8005

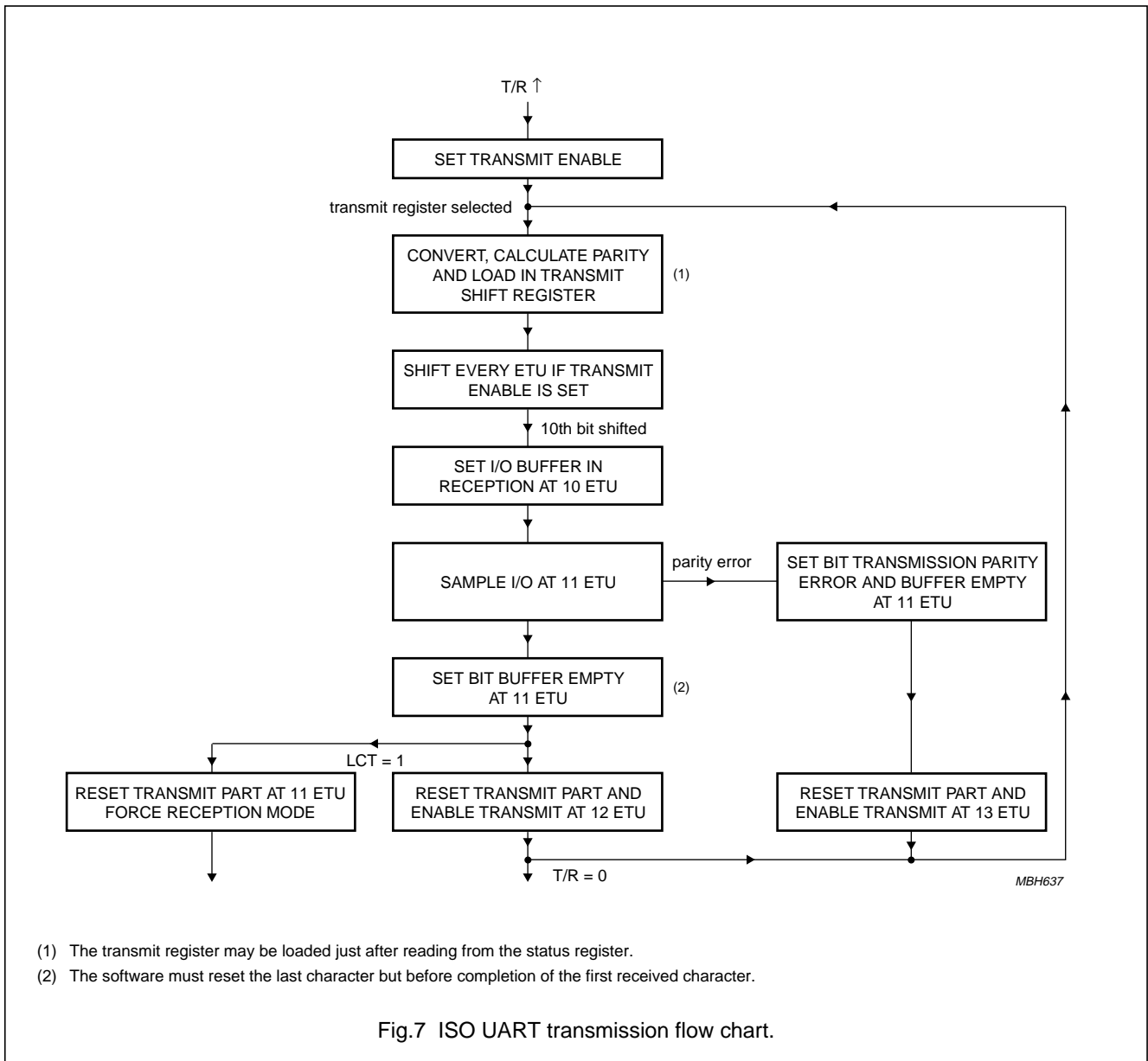
If no error has occurred, the UART sets the bit US0 (BUFFER EMPTY) in the STATUS REGISTER and waits for the next character. If the next character has been written before 12 ETU, the transmission will start at 12 ETU. If it was written after 12 ETU it will start on the rising edge of ENABLE.

If an error has occurred, it sets the bits BUFFER EMPTY and US4 (parity error during transmission) which warns the microcontroller to rewrite the previous character in the UART TRANSMIT register. If the character has been rewritten before 13 ETU, the transmission will start at

13 ETU. If it has been written after 13 ETU it will start on the rising edge of ENABLE.

When the transmission is completed, the microcontroller may set the bit LCT (Last Character to Transmit) so that the UART will force the reception mode into ready to get the reply from the card at 12 ETU. This bit must be reset before the end of the first reception. The bit T/R must be reset to enable the reception of the following characters.

When the session is completed, the microcontroller re-initializes the whole UART by resetting the bit RESET ISO UART.



Low-power smart card coupler

TDA8005

I/O buffer modes (see Fig.8)

The following are the I/O buffer modes:

1. I/O buffer disabled by ENIO.
2. I/O buffer in input, 20 k Ω pull-up resistor connected between I/O and V_{CC}, I/O masked till 200 clock pulses.
3. I/O buffer in input, 20 k Ω pull-up resistor connected between I/O and V_{CC}, I/O is sampled every 31 clock pulses.
4. I/O buffer in output, 20 k Ω pull-up resistor connected between I/O and V_{CC}.
5. I/O buffer in output, I/O is pulled LOW by the N transistor of the buffer.
6. I/O buffer in output, I/O is strongly HIGH or LOW by the P or N transistor.

Output ports extension

In the LQFP64 version, 6 auxiliary output ports may be used for low frequency tasks (for example, keyboard scanning). These ports are push-pull output types (cf use in software document).

Activation sequence

When the card is inactive, V_{CC}, CLK, RST and I/O are LOW, with low impedance with respect to GND. The step-up converter is stopped. The I/O is configured in the reception mode with a high impedance path to the ISO UART, subsequently no spurious pulse from the card during power-up will be taken into account until I/O is enabled. When everything is satisfactory (voltage supply, card present, no hardware problems), the microcontroller may initiate an activation sequence by setting START LOW (t₀):

- The step-up converter is started (t₁)
- LIS signal is disabled by ENLI, and V_{CC} starts rising from 0 to 5 V with a controlled rise time of 0.1 V/ μ s typically (t₂)
- I/O buffer is enabled (t₃)
- Clock is sent to the card (t₄)
- RST buffer is enabled (t₅).

In order to allow a precise count of clock pulses during ATR, a defined time window (t₃; t₅) is opened where the clock may be sent to the card by means of RSTIN. Beyond this window, RSTIN has no more action on clock, and only monitors the cards RST contact (RST is the inverse of RSTIN).

The sequencer is clocked by f_{INT}/64 which leads to a time interval T of 25 μ s typical. Thus t₁ = 0 to 1/64T, t₂ = t₁ + 1/23T, t₃ = t₁ + 4T, t₄ = t₃ to t₅ and t₅ = t₁ + 7T (see Fig.9).

Deactivation sequence (see Fig.10)

When the session is completed, the microcontroller sets START HIGH. The circuit then executes an automatic deactivation sequence:

- Card reset (RST falls LOW) at t₁₀
- Clock is stopped at t₁₁
- I/O becomes high impedance to the ISO UART (t₁₂)
- V_{CC} falls to 0 V with typical 0.1 V/ μ s slew rate (t₁₃)
- The step-up converter is stopped and CLK, RST, V_{CC} and I/O become low impedance to GND (t₁₄).
- t₁₀ < 1/64T; t₁₁ = t₁₀ + 1/2T; t₁₂ = t₁₀ + T; t₁₃ = t₁₀ + 1/23T; t₁₄ = t₁₀ + 5T.

Protections

Main hardware fault conditions are monitored by the circuit

- Overcurrent on V_{CC}
- Short circuits between V_{CC} and other contacts
- Card take-off during transaction.

When one of these problems is detected, the security logic block pulls the interrupt line OFF LOW, in order to warn the microcontroller, and initiates an automatic deactivation of the contacts. When the deactivation has been completed, the OFF line returns HIGH, except if the problem was due to a card extraction in which case it remains LOW till a card is inserted.

Low-power smart card coupler

TDA8005

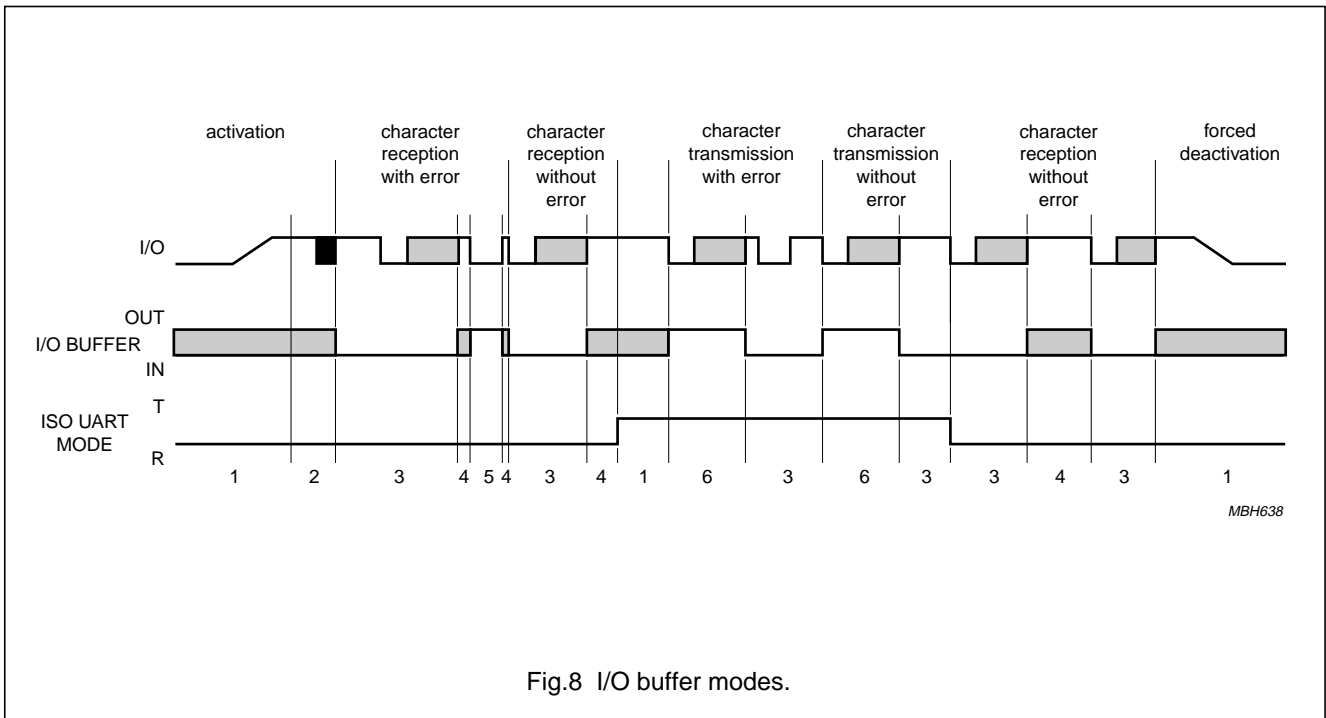


Fig.8 I/O buffer modes.

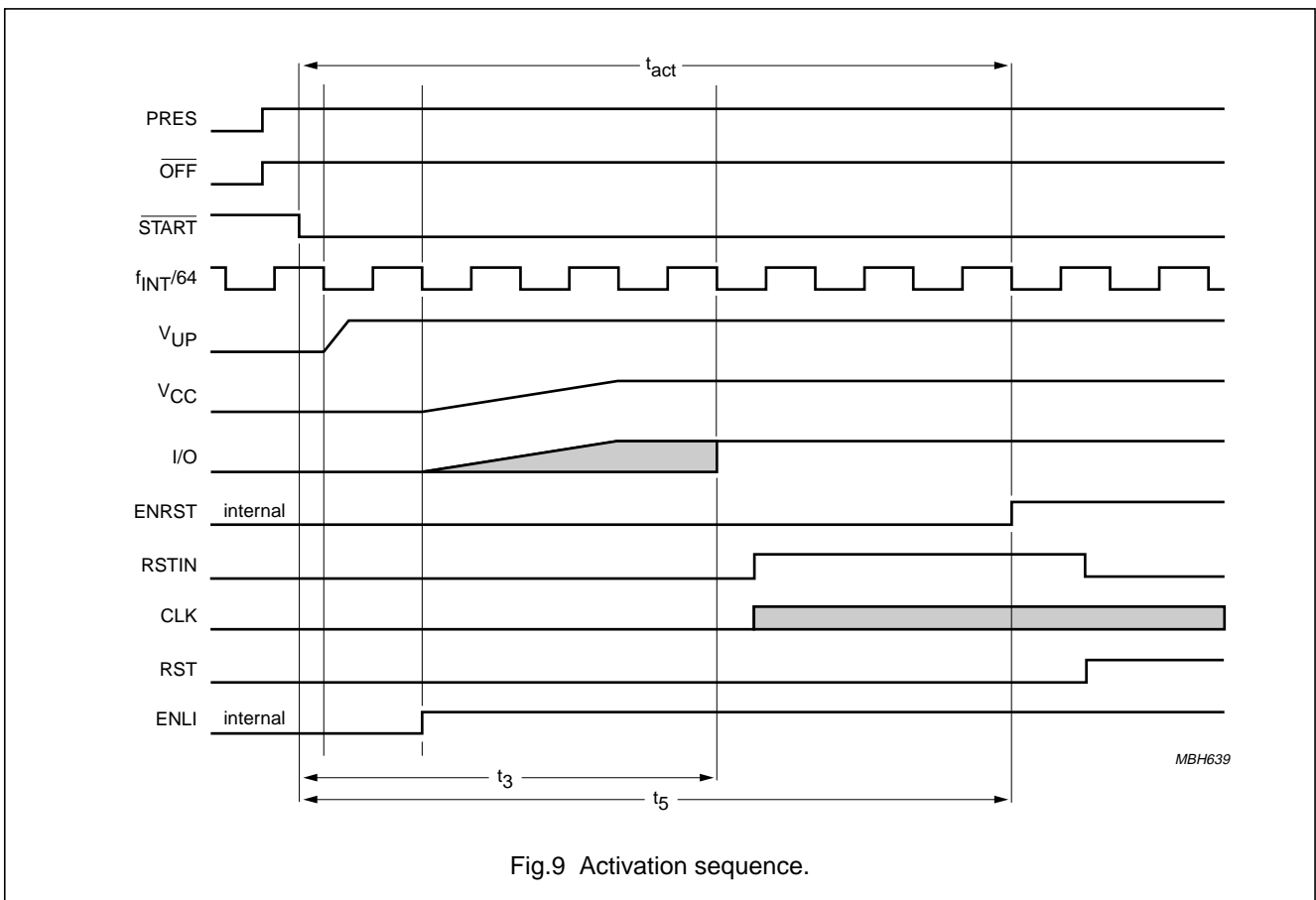


Fig.9 Activation sequence.

Low-power smart card coupler

TDA8005

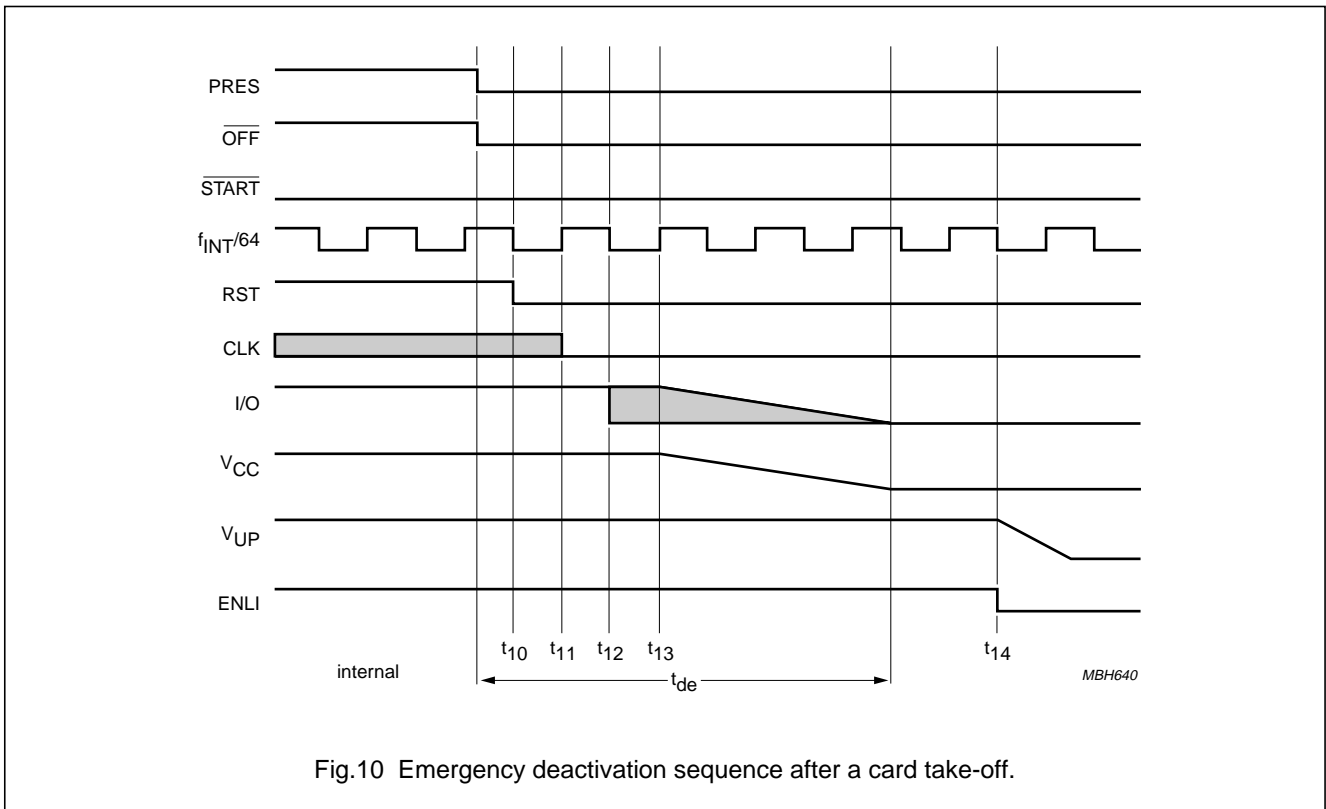


Fig.10 Emergency deactivation sequence after a card take-off.

Low-power smart card coupler

TDA8005

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{DDA}	analog supply voltage		-0	6.5	V
V_{DDD}	digital supply voltage		-0	6.5	V
V_n	all input voltages		-0	$V_{DD} + 0.5$	V
I_{n1}	DC current into XTAL1, XTAL2, RX, TX, RESET, INT1, P34, P37, P00 to P03, P11 to P17, P20 to P23 and TEST1 to TEST4		-	5	mA
I_{n2}	DC current from or to AUX1, AUX2		-10	+10	mA
I_{n3}	DC current from or to S1 to S5		-30	+30	mA
I_{n4}	DC current into DELAY		-5	+10	mA
I_{n5}	DC current from or to PRES		-5	+5	mA
I_{n6}	DC current from and to K0 to K5		-5	+5	mA
I_{n7}	DC current from or into ALARM (according to option choice)		-5	+5	mA
P_{tot}	continuous total power dissipation	$T_{amb} = -20$ to $+85^\circ\text{C}$	-	500	mW
T_{stg}	IC storage temperature		-55	+150	$^\circ\text{C}$
V_{es}	electrostatic discharge	on pins I/O, V_{CC} , RST, CLK and PRES	-6	+6	kV
		on other pins	-2	+2	kV
T_j	Operating Junction Temp.	-	-	125	$^\circ\text{C}$

HANDLING

Inputs and outputs are protected against electrostatic discharge in normal handling. However, to be totally safe, it is desirable to take normal precautions appropriate to handling MOS devices.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j-a}$	from junction to ambient in free air		
	LQFP64	70	K/W
	QFP44	60	K/W

Low-power smart card coupler

TDA8005

CHARACTERISTICS

$V_{DD} = 5\text{ V}$; $V_{SS} = 0\text{ V}$; $T_{amb} = 25\text{ °C}$; for general purpose I/O ports see 80CL51 data sheet; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply						
V_{DD}	supply voltage	Option dependant	2.5	–	6.0	V
$I_{DD(pd)}$	supply current power-down mode	$V_{DD} = 5\text{ V}$; card inactive $V_{DD} = 3\text{ V}$; “ “	–	90	–	μA
$I_{DD(sm)}$	supply current sleep mode	card powered, but with clock stopped	–	500	–	μA
$I_{DD(om)}$	supply current operating mode	unloaded; $f_{xtal} = 13\text{ MHz}$; $f_{clk} = 6.5\text{ MHz}$; $f_{card} = 3.25\text{ MHz}$	–	5.5	–	mA
		$V_{DD} = 3\text{ V}$; $f_{xtal} = 13\text{ MHz}$; $f_{clk} = 3.25\text{ MHz}$; $f_{card} = 3.25\text{ MHz}$	–	3	–	mA
V_{th1}	threshold voltage on V_{DD} (falling)	supervisor option	2	–	2.3	V
			2.45	–	3	V
			3.8	–	4.5	V
V_{hys1}	hysteresis on V_{th1}		40	–	350	mV
V_{th2}	threshold voltage on DELAY		–	1.38	–	V
V_{DEL}	voltage on pin DELAY		4.6	–	V_{DD}	V
I_{DEL}	output current at DELAY	pin grounded (charge)	–1.5	–1	–0.4	μA
		$V_{DEL} = V_{DD}$ (discharge)	4	6.8	10	mA
t_W	ALARM pulse width	$C_{DEL} = 10\text{ nF}$	–	10	–	ms
ALARM (open drain active HIGH or LOW output)						
I_{OH}	HIGH level output current	active LOW option; $V_{OH} = 5\text{ V}$	–	–	10	μA
V_{OL}	LOW level output voltage	active LOW option; $I_{OL} = 2\text{ mA}$	–	–	0.4	V
I_{OL}	LOW level output current	active HIGH option, $V_{OL} = 0\text{ V}$	–	–	–10	μA
V_{OH}	HIGH level output voltage	active HIGH option, $I_{OH} = -2\text{ mA}$	$V_{DD} - 1$	–	–	V
Crystal oscillator (note 1)						
f_{xtal}	crystal frequency		2	–	16	MHz
f_{EXT}	external frequency applied on XTAL1		0	–	16	MHz
Step-up converter						
f_{INT}	oscillation frequency		2	–	3	MHz
V_{UP}	voltage on S5		–	6.5	–	V
Low impedance supply (LIS)						
V_{LIS}	voltage on LIS		0	–	V_{DD}	V
I_{LIS}	current at LIS		–	–	7	μA

Low-power smart card coupler

TDA8005

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Reset output to the card (RST)						
$V_{inactive}$	output voltage	when inactive	-0.3	-	0.4	V
		when LIS is used; $I_{inactive} = 1\text{ mA}$	-0.3	-	0.4	V
$I_{inactive}$	current from RST when inactive and pin grounded		-	-	-1	mA
V_{OL}	LOW level output voltage	$I_{OL} = 200\ \mu\text{A}$	-0.25	-	0.4	V
V_{OH}	HIGH level output voltage	$I_{OH} < -200\ \mu\text{A}$	4	-	$V_{CC} + 0.3$	V
t_r	rise time	$C_L = 30\ \text{pF}$	-	-	1	μs
t_f	fall time	$C_L = 30\ \text{pF}$	-	-	1	μs
Clock output to the card (CLK)						
$V_{inactive}$	output voltage	when inactive	-0.3	-	0.4	V
		when LIS is used; $I_{inactive} = 1\text{ mA}$	-0.3	-	0.4	V
$I_{inactive}$	current from CLK when inactive and pin grounded		-	-	-1	mA
V_{OL}	LOW level output voltage	$I_{OL} = 200\ \mu\text{A}$	-0.25	-	0.4	V
V_{OH}	HIGH level output voltage	$I_{OH} < -200\ \mu\text{A}$	$V_{CC} - 0.5$	-	$V_{CC} + 0.25$	V
t_r	rise time	$C_L = 30\ \text{pF}$	-	-	15	ns
t_f	fall time	$C_L = 30\ \text{pF}$	-	-	15	ns
f_{clk}	clock frequency	1 MHz Idle configuration	1	-	1.5	MHz
		low operating speed	-	-	2	MHz
		middle operating speed	-	-	4	MHz
		high operating speed	-	-	8	MHz
δ	duty cycle	$C_L = 30\ \text{pF}$	45	-	55	%
Card supply voltage (V_{CC})						
$V_{inactive}$	output voltage	when inactive	-0.3	-	0.4	V
		when LIS is used; $I_{inactive} = 1\text{ mA}$	-0.3	-	0.4	V
$I_{inactive}$	current from VCC when inactive and pin grounded		-	-	-1	mA
V_{CC}	output voltage in active mode with 100 nF capacitor;	$I_{max} = 200\ \text{mA}$, $f_{max} = 5\ \text{MHz}$, and duration $< 400\ \text{ns}$	-	-	-	V
	static load (up to 20 mA) dynamic current of 40 nA		4.75 4.5	-	5.25 5.5	
I_{CC}	output current	$V_{CC} = 5\text{V}$	-	-	-20	mA
		V_{CC} shorted to GND	-	-	-40	mA
SR	slew rate	up or down (max capacitance is 150 nF)	0.04	0.1	0.16	V/ μs

Low-power smart card coupler

TDA8005

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Data line (I/O)						
$V_{inactive}$	output voltage	when inactive	-0.3	-	0.4	V
		when LIS is used; $I_{inactive} = 1 \text{ mA}$	-0.3	-	0.4	V
$I_{inactive}$	current from I/O when inactive and pin grounded		-	-	-1	mA
V_{OL}	LOW level output voltage (I/O configured as an output)	$I_{OL} = 1 \text{ mA}$	-0.25	-	0.3	V
V_{OH}	HIGH level output voltage (I/O configured as an output)	$I_{OH} < -100 \mu\text{A}$	$V_{CC}+0.8$	-	$V_{CC}+0.25$	V
V_{IL}	input voltage LOW (I/O configured as an input)	$I_{IL} = 1 \text{ mA}$	0	-	0.5	V
V_{IH}	input voltage HIGH (I/O configured as an input)	$I_{IL} = 100 \mu\text{A}$	$V_{CC}+0.6$	-	V_{CC}	V
t_r	rise time	$C_L = 30 \text{ pF}$	-	-	1	μs
t_f	fall time	$C_L = 30 \text{ pF}$	-	-	1	μs
R_{pu}	pull-up resistor connected to V_{CC} when I/O is input	see Table 4 for options	-	-	-	
Protections						
$I_{CC(sd)}$	shutdown current at V_{CC}		-	-30	-	mA
Timing						
t_{act}	activation sequence duration		-	-	225	μs
t_{de}	deactivation sequence duration		-	-	150	μs
$t_{3(start)}$	start of the window for sending clock to the card		-	-	130	μs
$t_{5(end)}$	end of the window for sending clock to the card		140	-	-	μs
Auxiliary outputs (AUX1, AUX2)						
V_{OL}	LOW level output voltage	$I_{OL} = 5 \text{ mA}$	-	-	0.4	V
V_{OH}	HIGH level output voltage	$I_{OH} = -5 \text{ mA}$	$V_{DD} - 1$	-	-	V
Output ports from extension (K0 to Kn)						
V_{OL}	LOW level output voltage	$I_{OL} = 2 \text{ mA}$	-	-	0.4	V
V_{OH}	HIGH level output voltage	$I_{OH} = -2 \text{ mA}$	$V_{DD} - 1$	-	-	V
Card presence input (PRES)						
V_{IL}	LOW level input voltage	$I_{IL} = -1 \text{ mA}$	-	-	0.6	V
V_{IH}	HIGH level input voltage	$I_{IH} = 100 \mu\text{A}$	$0.7V_{DD}$	-	-	V
I_{IH}	HIGH level input current	$V_{IH}=+5V$	0.2	-	3	μA

Note

1. The crystal oscillator is the same as OPTION 3 of the 80CL51.

Low-power smart card coupler

TDA8005

APPLICATION INFORMATION

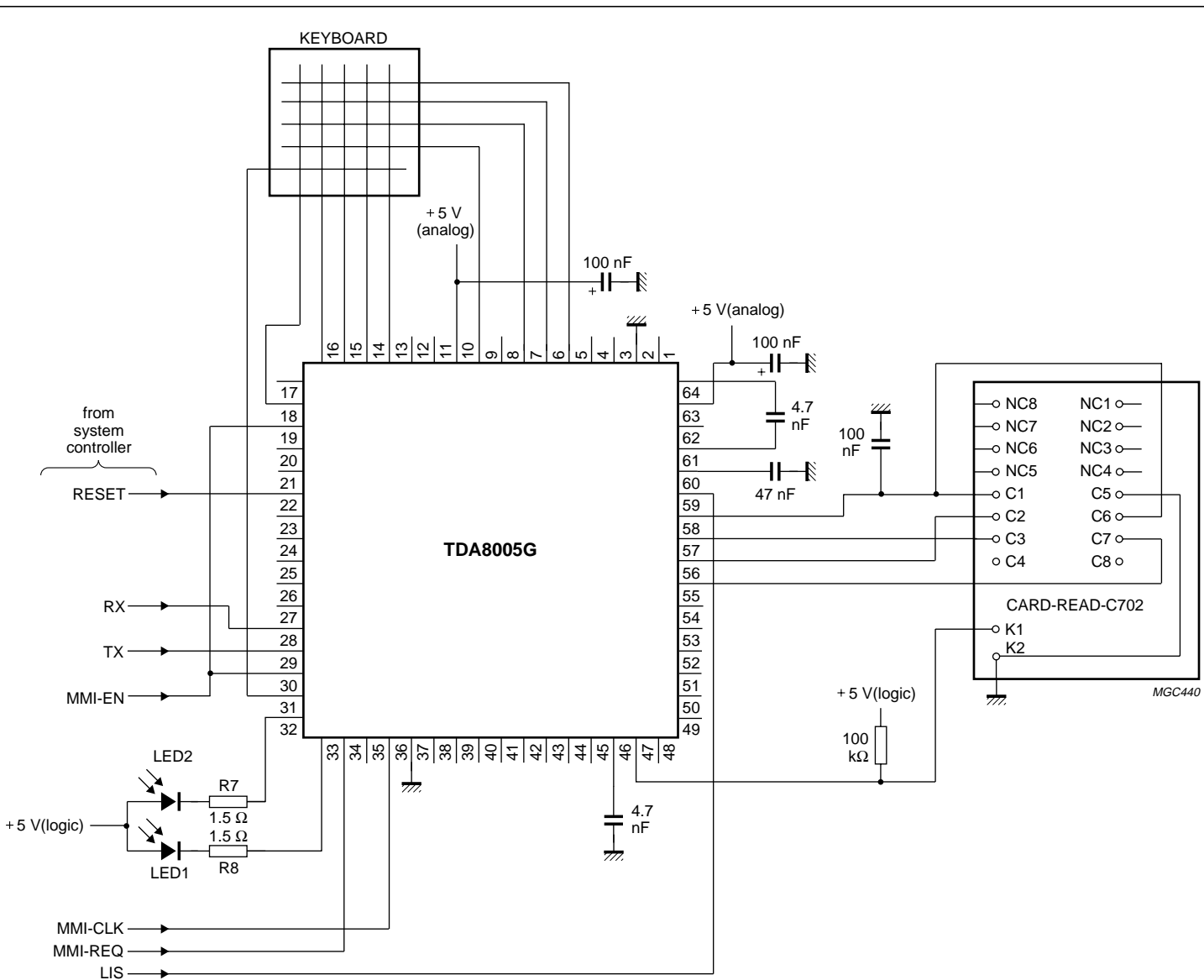


Fig.11 Possible GSM application.

Low-power smart card coupler

TDA8005

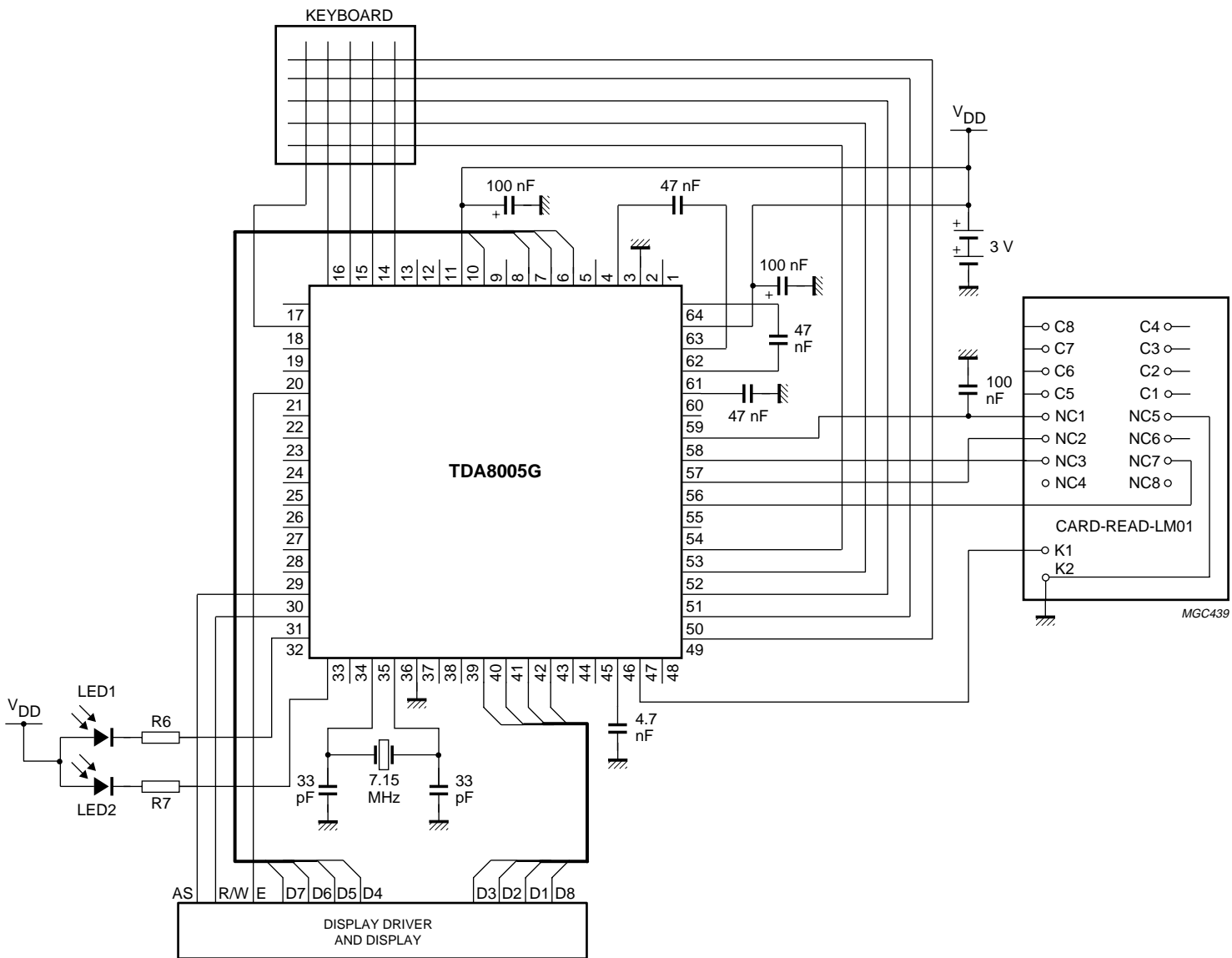


Fig.12 Possible stand-alone application.

Low-power smart card coupler

TDA8005

Table 4 TDA8005 option choice form

FUNCTION	DESCRIPTION	OPTION
Ports		
P00		
P01		
P02		
P03		
P04	RSTIN (fixed)	3 S
P05	START (fixed)	3 S
P06	STR (fixed)	3 S
P07	EN (fixed)	3 S
P10	OFF (fixed)	2 S
P11		
P12		
P13		
P14		
P15		
P16		
P17		
P20		
P21		
P22		
P23		
P24	DATA (fixed)	1 S
P25	R/W (fixed)	3 S
P26	REG1 (fixed)	3 S
P27	REG0 (fixed)	3 S
P30		
P31		
P32	INT (fixed)	1 S
P33		
P34		
P35	AUX1 (fixed)	3 S
P36	AUX2 (fixed)	3 S
P37		

FUNCTION	DESCRIPTION	OPTION
Analog options		
Step-up	doubler (updo) or tripler (uptri)	
Supervisor	2.3 (supervb, 3 (supervtr) or 4.5 (superVCI)	
I/O	low impedance (UARTI) or high impedance (UARTZ)	
I/O pull-up	10, 20 or 30 k Ω	
R_CLK	0, 50, 100, 150 or 200 Ω	
R_RST	0, 50, 80, 130 or 180 Ω	
ALARM	active HIGH (alarmbufp) or active LOW (alarmbufn)	
PRES	active HIGH (prestopp) or active LOW (prestopn)	

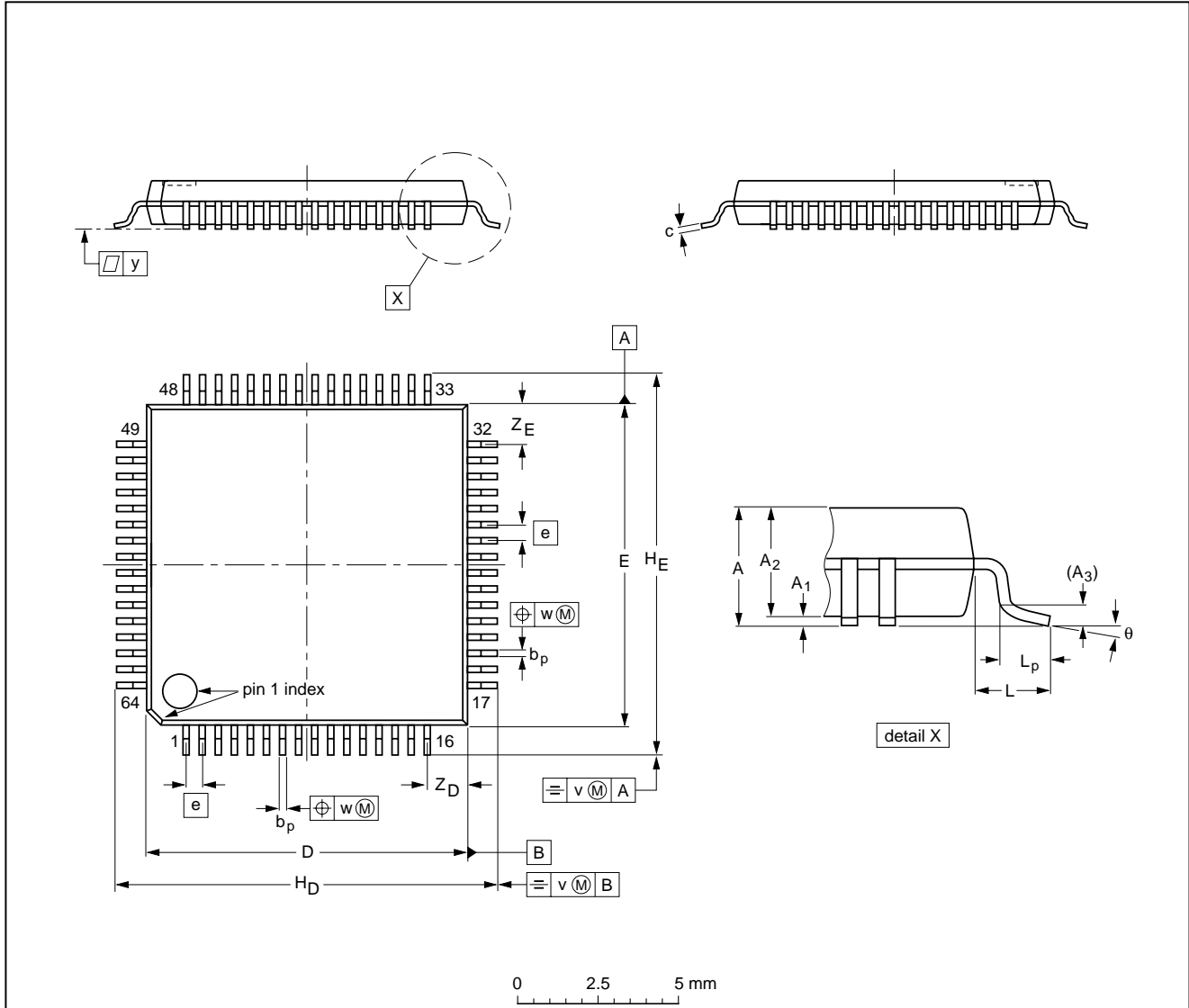
Low-power smart card coupler

TDA8005

PACKAGE OUTLINES

LQFP64: plastic low profile quad flat package; 64 leads; body 10 x 10 x 1.4 mm

SOT314-2



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽¹⁾	e	H _D	H _E	L	L _p	v	w	y	Z _D ⁽¹⁾	Z _E ⁽¹⁾	θ
mm	1.60	0.20 0.05	1.45 1.35	0.25	0.27 0.17	0.18 0.12	10.1 9.9	10.1 9.9	0.5	12.15 11.85	12.15 11.85	1.0	0.75 0.45	0.2	0.12	0.1	1.45 1.05	1.45 1.05	7° 0°

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

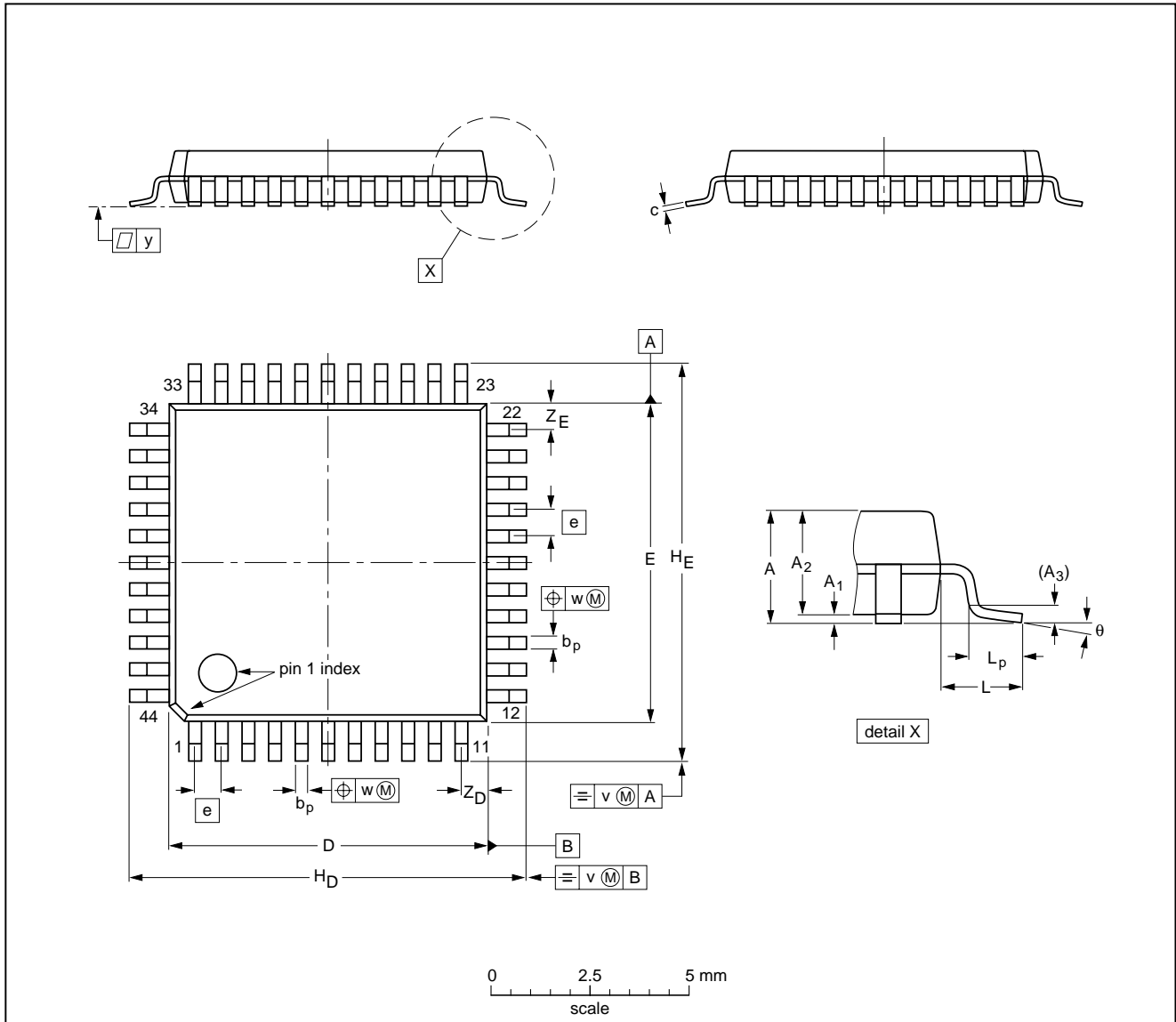
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT314-2						95-12-19 97-08-01

Low-power smart card coupler

TDA8005

QFP44: plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 x 10 x 1.75 mm

SOT307-2



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽¹⁾	e	H _D	H _E	L	L _p	v	w	y	Z _D ⁽¹⁾	Z _E ⁽¹⁾	θ
mm	2.10	0.25 0.05	1.85 1.65	0.25	0.40 0.20	0.25 0.14	10.1 9.9	10.1 9.9	0.8	12.9 12.3	12.9 12.3	1.3	0.95 0.55	0.15	0.15	0.1	1.2 0.8	1.2 0.8	10° 0°

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT307-2						95-02-04 97-08-01

Low-power smart card coupler

TDA8005

SOLDERING

Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our "IC Package Databook" (order code 9398 652 90011).

Reflow soldering

Reflow soldering techniques are suitable for all LQFP and QFP packages.

The choice of heating method may be influenced by larger plastic QFP packages (44 leads, or more). If infrared or vapour phase heating is used and the large packages are not absolutely dry (less than 0.1% moisture content by weight), vaporization of the small amount of moisture in them can cause cracking of the plastic body. For more information, refer to the Drypack chapter in our "Quality Reference Handbook" (order code 9397 750 00192).

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

Wave soldering

Wave soldering is **not** recommended for LQFP or QFP packages. This is because of the likelihood of solder bridging due to closely-spaced leads and the possibility of incomplete solder penetration in multi-lead devices.

If wave soldering cannot be avoided, the following conditions must be observed:

- **A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.**
- **The footprint must be at an angle of 45° to the board direction and must incorporate solder thieves downstream and at the side corners.**

Even with these conditions:

- **Do not consider wave soldering LQFP packages LQFP48 (SOT313-2), LQFP64 (SOT314-2) or LQFP80 (SOT315-1).**
- **Do not consider wave soldering QFP packages QFP52 (SOT379-1), QFP100 (SOT317-1), QFP100 (SOT317-2), QFP100 (SOT382-1) or QFP160 (SOT322-1).**

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Repairing soldered joints

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

Low-power smart card coupler

TDA8005

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

Low-power smart card coupler

TDA8005

NOTES

Philips Semiconductors – a worldwide company

Argentina: see South America

Australia: 34 Waterloo Road, NORTH RYDE, NSW 2113,
Tel. +61 2 9805 4455, Fax. +61 2 9805 4466

Austria: Computerstr. 6, A-1101 WIEN, P.O. Box 213,
Tel. +43 1 60 101, Fax. +43 1 60 101 1210

Belarus: Hotel Minsk Business Center, Bld. 3, r. 1211, Volodarski Str. 6,
220050 MINSK, Tel. +375 172 200 733, Fax. +375 172 200 773

Belgium: see The Netherlands

Brazil: see South America

Bulgaria: Philips Bulgaria Ltd., Energoproject, 15th floor,
51 James Bourchier Blvd., 1407 SOFIA,
Tel. +359 2 689 211, Fax. +359 2 689 102

Canada: PHILIPS SEMICONDUCTORS/COMPONENTS,
Tel. +1 800 234 7381

China/Hong Kong: 501 Hong Kong Industrial Technology Centre,
72 Tat Chee Avenue, Kowloon Tong, HONG KONG,
Tel. +852 2319 7888, Fax. +852 2319 7700

Colombia: see South America

Czech Republic: see Austria

Denmark: Prags Boulevard 80, PB 1919, DK-2300 COPENHAGEN S,
Tel. +45 32 88 2636, Fax. +45 31 57 1949

Finland: Sinikalliontie 3, FIN-02630 ESPOO,
Tel. +358 615 800, Fax. +358 615 80920

France: 4 Rue du Port-aux-Vins, BP317, 92156 SURESNES Cedex,
Tel. +33 1 40 99 6161, Fax. +33 1 40 99 6427

Germany: Hammerbrookstraße 69, D-20097 HAMBURG,
Tel. +49 40 23 53 60, Fax. +49 40 23 536 300

Greece: No. 15, 25th March Street, GR 17778 TAVROS,
Tel. +30 1 4894 339/911, Fax. +30 1 4814 240

Hungary: see Austria

India: Philips INDIA Ltd, Shivsagar Estate, A Block, Dr. Annie Besant Rd.
Worli, MUMBAI 400 018, Tel. +91 22 4938 541, Fax. +91 22 4938 722

Indonesia: see Singapore

Ireland: Newstead, Clonskeagh, DUBLIN 14,
Tel. +353 1 7640 000, Fax. +353 1 7640 200

Israel: RAPAC Electronics, 7 Kehilat Saloniki St, TEL AVIV 61180,
Tel. +972 3 645 0444, Fax. +972 3 649 1007

Italy: PHILIPS SEMICONDUCTORS, Piazza IV Novembre 3,
20124 MILANO, Tel. +39 2 6752 2531, Fax. +39 2 6752 2557

Japan: Philips Bldg 13-37, Kohnan 2-chome, Minato-ku, TOKYO 108,
Tel. +81 3 3740 5130, Fax. +81 3 3740 5077

Korea: Philips House, 260-199 Itaewon-dong, Yongsan-ku, SEOUL,
Tel. +82 2 709 1412, Fax. +82 2 709 1415

Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA, SELANGOR,
Tel. +60 3 750 5214, Fax. +60 3 757 4880

Mexico: 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905,
Tel. +9-5 800 234 7381

Middle East: see Italy

Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,
Tel. +31 40 27 82785, Fax. +31 40 27 88399

New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. +64 9 849 4160, Fax. +64 9 849 7811

Norway: Box 1, Manglerud 0612, OSLO,
Tel. +47 22 74 8000, Fax. +47 22 74 8341

Philippines: Philips Semiconductors Philippines Inc.,
106 Valero St. Salcedo Village, P.O. Box 2108 MCC, MAKATI,
Metro MANILA, Tel. +63 2 816 6380, Fax. +63 2 817 3474

Poland: Ul. Lukiska 10, PL 04-123 WARSZAWA,
Tel. +48 22 612 2831, Fax. +48 22 612 2327

Portugal: see Spain

Romania: see Italy

Russia: Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW,
Tel. +7 095 926 5361, Fax. +7 095 564 8323

Singapore: Lorong 1, Toa Payoh, SINGAPORE 1231,
Tel. +65 350 2538, Fax. +65 251 6500

Slovakia: see Austria

Slovenia: see Italy

South Africa: S.A. PHILIPS Pty Ltd., 195-215 Main Road Martindale,
2092 JOHANNESBURG, P.O. Box 7430 Johannesburg 2000,
Tel. +27 11 470 5911, Fax. +27 11 470 5494

South America: Rua do Rocio 220, 5th floor, Suite 51,
04552-903 São Paulo, SÃO PAULO - SP, Brazil,
Tel. +55 11 821 2333, Fax. +55 11 829 1849

Spain: Balmes 22, 08007 BARCELONA,
Tel. +34 3 301 6312, Fax. +34 3 301 4107

Sweden: Kottbygatan 7, Akalla, S-16485 STOCKHOLM,
Tel. +46 8 632 2000, Fax. +46 8 632 2745

Switzerland: Allmendstrasse 140, CH-8027 ZÜRICH,
Tel. +41 1 488 2686, Fax. +41 1 481 7730

Taiwan: PHILIPS TAIWAN Ltd., 23-30F, 66,
Chung Hsiao West Road, Sec. 1, P.O. Box 22978,
TAIPEI 100, Tel. +886 2 382 4443, Fax. +886 2 382 4444

Thailand: PHILIPS ELECTRONICS (THAILAND) Ltd.,
209/2 Sanpavuth-Bangna Road Prakanong, BANGKOK 10260,
Tel. +66 2 745 4090, Fax. +66 2 398 0793

Turkey: Talatpasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL,
Tel. +90 212 279 2770, Fax. +90 212 282 6707

Ukraine: PHILIPS UKRAINE, 4 Patrice Lumumba str., Building B, Floor 7,
252042 KIEV, Tel. +380 44 264 2776, Fax. +380 44 268 0461

United Kingdom: Philips Semiconductors Ltd., 276 Bath Road, Hayes,
MIDDLESEX UB3 5BX, Tel. +44 181 730 5000, Fax. +44 181 754 8421

United States: 811 East Arques Avenue, SUNNYVALE, CA 94088-3409,
Tel. +1 800 234 7381

Uruguay: see South America

Vietnam: see Singapore

Yugoslavia: PHILIPS, Trg N. Pasica 5/v, 11000 BEOGRAD,
Tel. +381 11 825 344, Fax. +381 11 635 777

For all other countries apply to: Philips Semiconductors, Marketing & Sales Communications,
Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Fax. +31 40 27 24825

Internet: <http://www.semiconductors.philips.com>

© Philips Electronics N.V. 1996

SCA51

All rights are reserved. Reproduction in whole or in part is prohibited without the prior written consent of the copyright owner.

The information presented in this document does not form part of any quotation or contract, is believed to be accurate and reliable and may be changed without notice. No liability will be accepted by the publisher for any consequence of its use. Publication thereof does not convey nor imply any license under patent- or other industrial or intellectual property rights.

Printed in The Netherlands

647021/1200/02/pp32

Date of release: 1996 Sep 25

Document order number: 9397 750 01154

Let's make things better.

**Philips
Semiconductors**



PHILIPS