



Smart Card Interface

DS8113

General Description

The DS8113 smart card interface is a low-cost, analog front-end for a smart card reader, designed for all ISO 7816, EMV™, and GSM11-11 applications. The DS8113 supports 5V, 3V, and 1.8V smart cards. The DS8113 provides options for low active- and stop-mode power consumption, with as little as 10nA stop-mode current.

The DS8113 is designed to interface between a system microcontroller and the smart card interface, providing all power supply, ESD protection, and level shifting required for IC card applications.

An EMV Level 1 library (written for the MAXQ2000 microcontroller) and hardware reference design is available. Contact Maxim technical support at www.maxim-ic.com/support regarding requirements for other microcontroller platforms. An evaluation kit, DS8113-KIT, is available to aid in prototyping and evaluation.

Applications

Consumer Set-Top Boxes
Access Control
Banking Applications
POS Terminals
Debit/Credit Payment Terminals
PIN Pads
Automated Teller Machines
Telecommunications
Pay/Premium Television

Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|-------------|----------------|-------------|
| DS8113-RNG+ | -40°C to +85°C | 28 SO |

Note: Contact the factory for availability of other variants and package options.

+Denotes a lead-free package.

Selector Guide appears at end of data sheet.

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Note: Some revisions of this device may incorporate deviations from published specifications known as errata. Multiple revisions of any device may be simultaneously available through various sales channels. For information about device errata, go to: www.maxim-ic.com/errata.



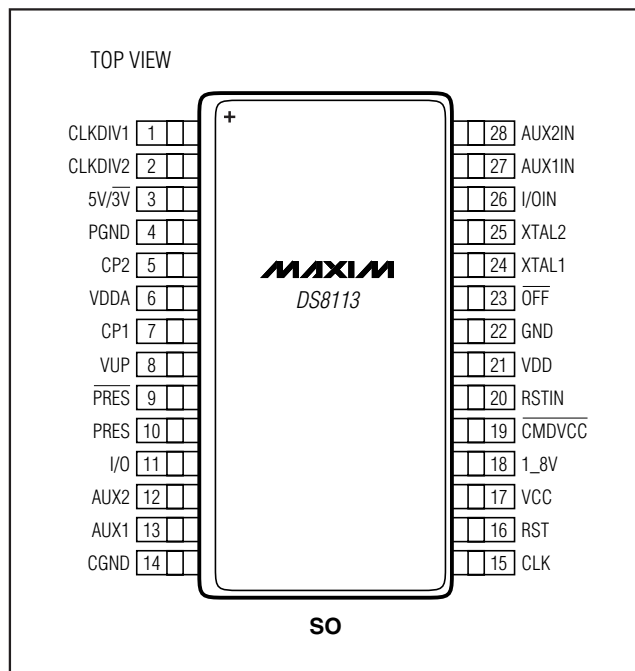
Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Features

- ◆ Analog Interface and Level Shifting for IC Card Communication
- ◆ 8kV (min) ESD (IEC) Protection on Card Interface
- ◆ Ultra-Low Stop-Mode Current, Less Than 10nA Typical
- ◆ Internal IC Card Supply-Voltage Generation:
 - 5.0V ±5%, 80mA (max)
 - 3.0V ±8%, 65mA (max)
 - 1.8V ±10%, 30mA (max)
- ◆ Automatic Card Activation and Deactivation Controlled by Dedicated Internal Sequencer
- ◆ I/O Lines from Host Directly Level Shifted for Smart Card Communication
- ◆ Flexible Card Clock Generation, Supporting External Crystal Frequency Divided by 1, 2, 4, or 8
- ◆ High-Current, Short-Circuit and High-Temperature Protection
- ◆ Low Active-Mode Current

Pin Configuration



Smart Card Interface

ABSOLUTE MAXIMUM RATINGS

Voltage Range on VDD Relative to GND.....-0.5V to +6.5V
 Voltage Range on VDDA Relative to PGND.....-0.5V to +6.5V
 Voltage Range on CP1, CP2, and VUP
 Relative to PGND.....-0.5V to +7.5V
 Voltage Range on All Other Pins
 Relative to GND.....-0.5V to (VDD + 0.5V)

Maximum Junction Temperature+125°C
 Maximum Power Dissipation (T_A = -25°C to +85°C)700mW
 Storage Temperature Range-55°C to +150°C
 Soldering Temperature.....Refer to the IPC/JEDEC J-STD-020 Specification.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED DC OPERATING CONDITIONS

(V_{DD} = +3.3V, V_{DDA} = +5.0V, T_A = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|----------------------|--|------|-------|-------|-------|
| POWER SUPPLY | | | | | | |
| Digital Supply Voltage | V _{DD} | | 2.7 | | 6.0 | V |
| Card Voltage-Generator Supply Voltage | V _{DDA} | V _{DDA} > V _{DD} | 5.0 | | 6.0 | V |
| Reset Voltage Thresholds | V _{TH2} | Threshold voltage (falling) | 2.35 | 2.45 | 2.60 | V |
| | V _{HYS2} | Hysteresis | 50.0 | 100 | 150 | mV |
| CURRENT CONSUMPTION | | | | | | |
| Active V _{DD} Current 5V Cards (Including 80mA Draw from 5V Card) | I _{DD_50V} | I _{CC} = 80mA, f _{XTAL} = 20MHz, f _{CLK} = 10MHz, V _{DDA} = 5.0V | | 80.75 | 85.00 | mA |
| Active V _{DD} Current 5V Cards (Current Consumed by DS8113 Only) | I _{DD_IC} | I _{CC} = 80mA, f _{XTAL} = 20MHz, f _{CLK} = 10MHz, V _{DDA} = 5.0V (Note 2) | | 0.75 | 5.00 | mA |
| Active V _{DD} Current 3V Cards (Including 65mA Draw from 3V Card) | I _{DD_30V} | I _{CC} = 65mA, f _{XTAL} = 20MHz, f _{CLK} = 10MHz, V _{DDA} = 5.0V | | 65.75 | 70.00 | mA |
| Active V _{DD} Current 3V Cards (Current Consumed by DS8113 Only) | I _{DD_IC} | I _{CC} = 65mA, f _{XTAL} = 20MHz, f _{CLK} = 10MHz, V _{DDA} = 5.0V (Note 2) | | 0.75 | 5.00 | mA |
| Active V _{DD} Current 1.8V Cards (Including 30mA Draw from 1.8V Card) | I _{DD_18V} | I _{CC} = 30mA, f _{XTAL} = 20MHz, f _{CLK} = 10MHz, V _{DDA} = 5.0V | | 30.75 | 35.00 | mA |
| Active V _{DD} Current 1.8V Cards (Current Consumed by DS8113 Only) | I _{DD_IC} | I _{CC} = 30mA, f _{XTAL} = 20MHz, f _{CLK} = 10MHz, V _{DDA} = 5.0V (Note 2) | | 0.75 | 5.00 | mA |
| Inactive-Mode Current | I _{DD} | Card inactive, active-high PRES, DS8113 not in stop mode | | 50.0 | 200 | μA |
| Stop-Mode Current | I _{DD_STOP} | DS8113 in ultra-low-power stop mode (CMDVCC, 5V/3V, and 1_8V set to logic 1) (Note 3) | | 0.01 | 2.00 | μA |

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RECOMMENDED DC OPERATING CONDITIONS (continued)

($V_{DD} = +3.3V$, $V_{DDA} = +5.0V$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|----------------------------------|--|---------------------------|--------------------------------|-----------------------|-----------------------|-------|
| CLOCK SOURCE | | | | | | |
| Crystal Frequency | f _{XTAL} | External crystal | 0 | | 20 | MHz |
| XTAL1 Operating Conditions | f _{XTAL1} | | 0 | | 20 | MHz |
| | V _{IL_XTAL1} | Low-level input on XTAL1 | -0.3 | | 0.3 x V _{DD} | V |
| | V _{IH_XTAL1} | High-level input on XTAL1 | 0.7 x V _{DD} | | V _{DD} + 0.3 | V |
| External Capacitance for Crystal | C _{XTAL1} , C _{XTAL2} | | | | 15 | pF |
| Internal Oscillator | f _{INT} | | | 2.7 | | MHz |
| SHUTDOWN TEMPERATURE | | | | | | |
| Shutdown Temperature | T _{SD} | | | +150 | | °C |
| RST PIN | | | | | | |
| Card-Inactive Mode | Output Low Voltage | V _{OL_RST1} | I _{OL_RST} = 1mA | 0 | 0.3 | V |
| | Output Current | I _{OL_RST1} | V _{O_LRST} = 0V | 0 | -1 | mA |
| Card-Active Mode | Output Low Voltage | V _{OL_RST2} | I _{OL_RST} = 200µA | 0 | 0.3 | V |
| | Output High Voltage | V _{OH_RST2} | I _{OH_RST} = -200µA | V _{CC} - 0.5 | V _{CC} | V |
| | Rise Time | t _{R_RST} | C _L = 30pF | | 0.1 | µs |
| | Fall Time | t _{F_RST} | C _L = 30pF | | 0.1 | µs |
| | Shutdown Current Threshold | I _{RST(SD)} | | | -20 | mA |
| | Current Limitation | I _{RST(LIMIT)} | | -20 | +20 | mA |
| | RSTIN to RST Delay | t _{D(RSTIN-RST)} | | | 2 | µs |
| CLK PIN | | | | | | |
| Card-Inactive Mode | Output Low Voltage | V _{OL_CLK1} | I _{OLCLK} = 1mA | 0 | 0.3 | V |
| | Output Current | I _{OL_CLK1} | V _{OLCLK} = 0V | 0 | -1 | mA |
| Card-Active Mode | Output Low Voltage | V _{OL_CLK2} | I _{OLCLK} = 200µA | 0 | 0.3 | V |
| | Output High Voltage | V _{OH_CLK2} | I _{OHCLK} = -200µA | V _{CC} - 0.5 | V _{CC} | V |
| | Rise Time | t _{R_CLK} | C _L = 30pF (Note 4) | | 8 | ns |
| | Fall Time | t _{F_CLK} | C _L = 30pF (Note 4) | | 8 | ns |
| | Current Limitation | I _{CLK(LIMIT)} | | -70 | +70 | mA |
| | Clock Frequency | f _{CLK} | Operational | 0 | 10 | MHz |
| | Duty Factor | δ | C _L = 30pF | 45 | 55 | % |
| | Slew Rate | SR | C _L = 30pF | 0.2 | | V/ns |
| VCC PIN | | | | | | |
| Card-Inactive Mode | Output Low Voltage | V _{CC1} | I _{CC} = 1mA | 0 | 0.3 | V |
| | Output Current | I _{CC1} | V _{CC} = 0V | 0 | -1 | mA |

Smart Card Interface

RECOMMENDED DC OPERATING CONDITIONS (continued)

($V_{DD} = +3.3V$, $V_{DDA} = +5.0V$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 1)

| PARAMETER | | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|--------------------------|---|--|----------------------|------|------------|------------|
| Card-Active Mode | Output Low Voltage | V_{CC2} | $65mA < I_{CC(5V)} < 80mA$ | 4.55 | 5.00 | 5.25 | V |
| | | | $I_{CC(5V)} < 65mA$ | 4.75 | 5.00 | 5.25 | |
| | | | $I_{CC(3V)} < 65mA$ | 2.78 | 3.00 | 3.22 | |
| | | | $I_{CC(1.8V)} < 30mA$ | 1.65 | 1.80 | 1.95 | |
| | | | 5V card; current pulses of 40nC with $I < 200mA$, $t < 400ns$, $f < 20MHz$ | 4.6 | | 5.4 | |
| | | | 3V card; current pulses of 24nC with $I < 200mA$, $t < 400ns$, $f < 20MHz$ | 2.75 | | 3.25 | |
| | | | 1.8V card; current pulses of 12nC with $I < 200mA$, $t < 400ns$, $f < 20MHz$ | 1.62 | | 1.98 | |
| | Output Current | I_{CC2} | $V_{CC(5V)} = 0 \text{ to } 5V$ | | | -80 | mA |
| | | | $V_{CC(3V)} = 0 \text{ to } 3V$ | | | -65 | |
| | | | $V_{CC(1.8V)} = 0 \text{ to } 1.8V$ | | | -30 | |
| Shutdown Current Threshold | $I_{CC(SD)}$ | | | 120 | | mA | |
| Slew Rate | V_{CCSR} | Up/down; $C < 300nF$ (Note 5) | 0.05 | 0.16 | 0.25 | V/ μs | |
| DATA LINES (I/O AND I/OIN) | | | | | | | |
| I/O \leftrightarrow I/OIN Falling Edge Delay | | $t_D(I/O-I/OIN)$ | | | | 200 | ns |
| Pullup Pulse Active Time | | t_{PU} | | | | 100 | ns |
| Maximum Frequency | | f_{IOMAX} | | | | 1 | MHz |
| Input Capacitance | | C_I | | | | 10 | pF |
| I/O, AUX1, AUX2 PINS | | | | | | | |
| Card-Inactive Mode | Output Low Voltage | V_{OL_IO1} | $I_{OL_IO} = 1mA$ | 0 | | 0.3 | V |
| | Output Current | I_{OL_IO1} | $V_{OL_IO} = 0V$ | 0 | | -1 | mA |
| | Internal Pullup Resistor | R_{PU_IO} | To V_{CC} | 9 | 11 | 19 | k Ω |
| Card-Active Mode | Output Low Voltage | V_{OL_IO2} | $I_{OL_IO} = 1mA$ | 0 | | 0.3 | V |
| | Output High Voltage | V_{OH_IO2} | $I_{OH_IO} = < -20\mu A$ | $0.8 \times V_{CC}$ | | V_{CC} | V |
| | | | $I_{OH_IO} = < -40\mu A (3V/5V)$ | $0.75 \times V_{CC}$ | | V_{CC} | |
| | Output Rise/Fall Time | t_{OT} | $C_L = 30pF$ | | | 0.1 | μs |
| | Input Low Voltage | V_{IL_IO} | | -0.3 | | +0.8 | V |
| | Input High Voltage | V_{IH_IO} | | 1.5 | | V_{CC} | |
| | Input Low Current | I_{IL_IO} | $V_{IL_IO} = 0V$ | | | 600 | μA |
| | Input High Current | I_{IH_IO} | $V_{IH_IO} = V_{CC}$ | | | 20 | μA |
| | Input Rise/Fall Time | t_{IT} | | | | 1.2 | μs |
| Current Limitation | $I_{IO(LIMIT)}$ | $C_L = 30pF$ | -15 | | +15 | mA | |
| Current When Pullup Active | I_{PU} | $C_L = 80pF$, $V_{OH} = 0.9 \times V_{DD}$ | -1 | | | mA | |

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RECOMMENDED DC OPERATING CONDITIONS (continued)

($V_{DD} = +3.3V$, $V_{DDA} = +5.0V$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|----------------|---|----------------------|-----|---------------------|-----------|
| I/OIN, AUX1IN, AUX2IN PINS | | | | | | |
| Output Low Voltage | V_{OL} | $I_{OL} = 1mA$ | 0 | | 0.3 | V |
| Output High Voltage | V_{OH} | No Load | $0.9 \times V_{DD}$ | | $V_{DD} + 0.1$ | V |
| | | $I_{OH} < -40\mu A$ | $0.75 \times V_{DD}$ | | $V_{DD} + 0.1$ | |
| Output Rise/Fall Time | t_{OT} | $C_L = 30pF$, 10% to 90% | | | 0.1 | μs |
| Input Low Voltage | V_{IL} | | -0.3 | | $0.3 \times V_{DD}$ | V |
| Input High Voltage | V_{IH} | | $0.7 \times V_{DD}$ | | $V_{DD} + 0.3$ | V |
| Input Low Current | I_{IL_IO} | $V_{IL} = 0V$ | | | 700 | μA |
| Input High Current | I_{IH_IO} | $V_{IH} = V_{DD}$ | | | 10 | μA |
| Input Rise/Fall Time | t_{IT} | V_{IL} to V_{IH} | | | 1.2 | μs |
| Integrated Pullup Resistor | R_{PU} | Pullup to V_{DD} | 9 | 11 | 13 | $k\Omega$ |
| Current When Pullup Active | I_{PU} | $C_L = 30pF$, $V_{OH} = 0.9 \times V_{DD}$ | -1 | | | mA |
| CONTROL PINS (CLKDIV1, CLKDIV2, CMDVCC, RSTIN, 5V/3V, 1_8V) | | | | | | |
| Input Low Voltage | V_{IL} | | -0.3 | | $0.3 \times V_{DD}$ | V |
| Input High Voltage | V_{IH} | | $0.7 \times V_{DD}$ | | $V_{DD} + 0.3$ | V |
| Input Low Current | I_{IL_IO} | $0 < V_{IL} < V_{DD}$ | | | 5 | μA |
| Input High Current | I_{IH_IO} | $0 < V_{IH} < V_{DD}$ | | | 5 | μA |
| INTERRUPT OUTPUT PIN (\overline{OFF}) | | | | | | |
| Output Low Voltage | V_{OL} | $I_{OL} = 2mA$ | 0 | | 0.3 | V |
| Output High Voltage | V_{OH} | $I_{OH} = -15\mu A$ | $0.75 \times V_{DD}$ | | | V |
| Integrated Pullup Resistor | R_{PU} | Pullup to V_{DD} | 16 | 20 | 24 | $k\Omega$ |
| PRES, PRES PINS | | | | | | |
| Input Low Voltage | V_{IL_PRES} | | | | $0.3 \times V_{DD}$ | V |
| Input High Voltage | V_{IH_PRES} | | $0.7 \times V_{DD}$ | | | V |
| Input Low Current | I_{IL_PRES} | $V_{IL_PRES} = 0V$ | | | 40 | μA |
| Input High Current | I_{IH_PRES} | $V_{IH_PRES} = V_{DD}$ | | | 40 | μA |

Smart Card Interface

RECOMMENDED DC OPERATING CONDITIONS (continued)

($V_{DD} = +3.3V$, $V_{DDA} = +5.0V$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 1)

| PARAMETER | | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------------|--------------|----------------|------------|-----|-----|-----|---------|
| TIMING | | | | | | | |
| Activation Time | | t_{ACT} | | 50 | | 220 | μs |
| Deactivation Time | | t_{DEACT} | | 50 | 80 | 100 | μs |
| CLK to Card Start Time | Window Start | t_3 | | 50 | | 130 | μs |
| | Window End | t_5 | | 140 | | 220 | |
| PRES/ \overline{PRES} Debounce Time | | $t_{DEBOUNCE}$ | | 5 | 8 | 11 | ms |

Note 1: Operation guaranteed at $-40^\circ C$ and $+85^\circ C$ but not tested.

Note 2: I_{DD_IC} measures the amount of current used by the DS8113 to provide the smart card current minus the load.

Note 3: Stop mode is enabled by setting \overline{CMDVCC} , $5V/3V$, and 1_8V to a logic-high.

Note 4: Parameters are guaranteed to meet all ISO 7816, GSM11-11, and EMV 2000 requirements. For the 1.8V card, the maximum rise and fall time is 10ns.

Note 5: Parameter is guaranteed to meet all ISO 7816, GSM11-11, and EMV 2000 requirements. For the 1.8V card, the minimum slew rate is $0.05V/\mu s$ and the maximum slew rate is $0.5V/\mu s$.

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Pin Description

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| PIN | NAME | FUNCTION |
|--------|----------------------------|---|
| 1, 2 | CLKDIV1, CLKDIV2 | Clock Divider. Determines the divided-down input clock frequency (presented at XTAL1 or from a crystal at XTAL1 and XTAL2) on the CLK output pin. Dividers of 1, 2, 4, and 8 are available. |
| 3 | 5V/3V | 5V/3V Selection Pin. Allows selection of 5V or 3V for communication with an IC card. Logic-high selects 5V operation; logic-low selects 3V operation. The 1_8V pin overrides the setting on this pin if active. See Table 3 for a complete description of choosing card voltages. |
| 4 | PGND | Analog Ground |
| 5, 7 | CP2, CP1 | Step-Up Converter Contact. Unused for the DS8113. |
| 6 | VDDA | Charge Pump Supply. Must be equal to or higher than V _{DD} . For the DS8113 this must be at least 5.0V. |
| 8 | VUP | Charge Pump Output. Unused for the DS8113. |
| 9 | $\overline{\text{PRES}}$ | Card Presence Indicator. Active-low card presence inputs. When the presence indicator becomes active, a debounce timeout begins. After 8ms (typ) the $\overline{\text{OFF}}$ signal becomes active. |
| 10 | PRES | Card Presence Indicator. Active-high card presence inputs. When the presence indicator becomes active, a debounce timeout begins. After 8ms (typ) the $\overline{\text{OFF}}$ signal becomes active. |
| 11 | I/O | Smart Card Data-Line Output. Card data communication line, contact C7. |
| 12, 13 | AUX2, AUX1 | Smart Card Auxiliary Line (C4, C8) Output. Data line connected to card reader contacts C4 (AUX1) and C8 (AUX2). |
| 14 | CGND | Smart Card Ground |
| 15 | CLK | Smart Card Clock. Card clock, contact C3. |
| 16 | RST | Smart Card Reset. Card reset output from contact C2. |
| 17 | VCC | Smart Card Supply Voltage. Decouple to CGND (card ground) with 2 x 100nF or 100 + 220nF capacitors (ESR < 100mΩ). |
| 18 | 1_8V | 1.8V Operation Selection. Active-high selection for 1.8V smart card communication. An active-high signal on this pin overrides any setting on the 5V/3V pin. |
| 19 | $\overline{\text{CMDVCC}}$ | Activation Sequence Initiate. Active-low input from host. |
| 20 | RSTIN | Card Reset Input. Reset input from the host. |
| 21 | VDD | Supply Voltage |
| 22 | GND | Digital Ground |
| 23 | $\overline{\text{OFF}}$ | Status Output. Active-low interrupt output to the host. Use a 20kΩ integrated pullup resistor to VDD. |
| 24, 25 | XTAL1, XTAL2 | Crystal/Clock Input. Connect an input from an external clock to XTAL1 or connect a crystal across XTAL1 and XTAL2. For the low idle-mode current variant, an external clock must be driven on XTAL1. |
| 26 | I/OIN | I/O Input. Host-to-interface chip data I/O line. |
| 27, 28 | AUX1IN, AUX2IN | C4/C8 Input. Host-to-interface I/O line for auxiliary connections to C4 and C8. |

Smart Card Interface

Detailed Description

The DS8113 is an analog front-end for communicating with 1.8V, 3V, and 5V smart cards. It is a dual input-voltage device, requiring one supply to match that of a host microcontroller and a separate +5V supply for generating correct smart card supply voltages. The DS8113 translates all communication lines to the correct voltage level and provides power for smart card operation. It is a low-power device, consuming very little current in active-mode operation (during a smart card communication session), and is suitable for use in

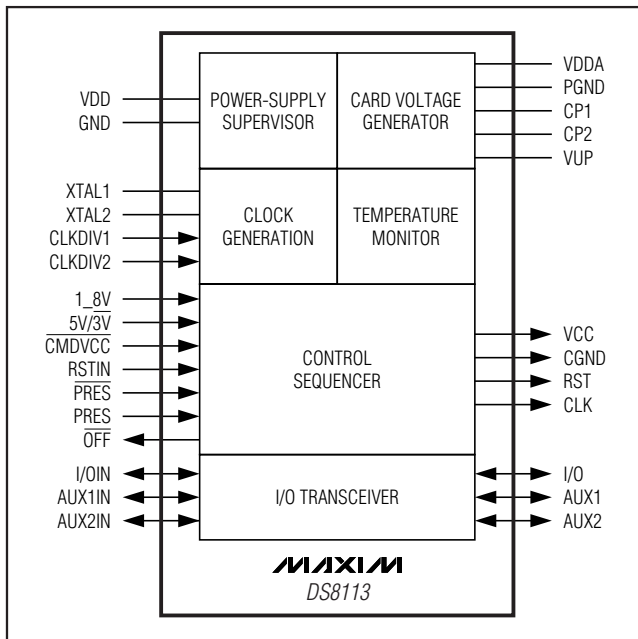


Figure 1. Functional Diagram

battery-powered devices such as laptops and PDAs, consuming only 10nA in stop mode. See Figure 1 for a functional diagram.

Power Supply

The DS8113 is a dual-supply device. The supply pins for the device are VDD, GND, VDDA, and PGND. VDD should be in the range of 2.7V to 6.0V, and is the supply for signals that interface with the host controller. It should, therefore, be the same supply as used by the host controller. All smart card contacts remain inactive during power-on or power-off. The internal circuits are kept in the reset state until VDD reaches $V_{TH2} + V_{HYS2}$ and for the duration of the internal power-on reset pulse, t_W . A deactivation sequence is executed when VDD falls below V_{TH2} .

An internal regulator generates the 1.8V, 3V, or 5V card supply voltage (VCC). The regulator should be supplied separately by VDDA and PGND. VDDA should be connected to a minimum 5.0V supply in order to provide the correct supply voltage for 5V smart cards.

Voltage Supervisor

The voltage supervisor monitors the VDD supply. A 220µs reset pulse (t_W) is used internally to keep the device inactive during power-on or power-off of the VDD supply. See Figure 2.

The DS8113 card interface remains inactive no matter the levels on the command lines until duration t_W after VDD has reached a level higher than $V_{TH2} + V_{HYS2}$. When VDD falls below V_{TH2} , the DS8113 executes a card deactivation sequence if its card interface is active.

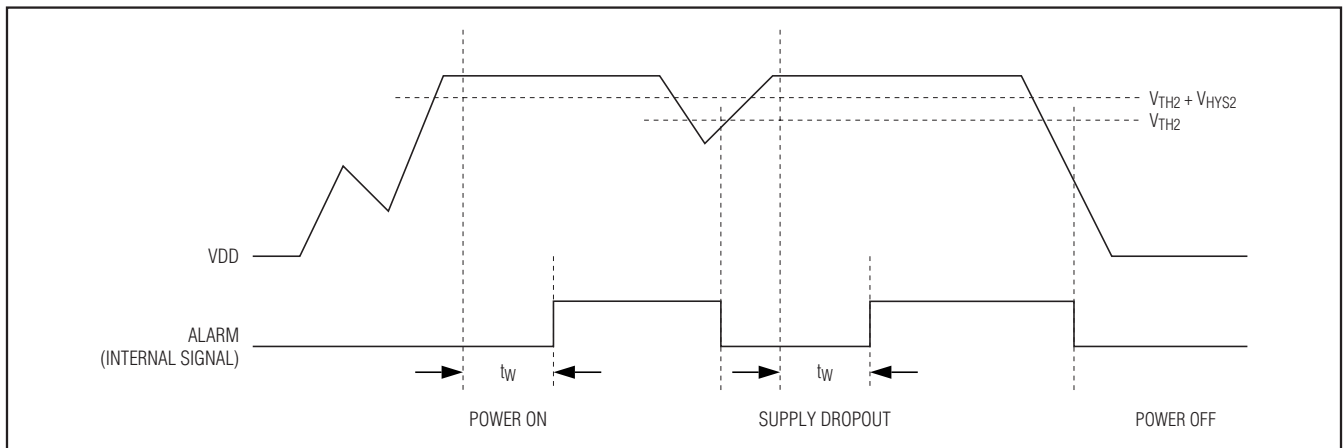


Figure 2. Voltage Supervisor Behavior

Smart Card Interface

Clock Circuitry

The card clock signal (CLK) is derived from a clock signal input to XTAL1 or from a crystal operating at up to 20MHz connected between XTAL1 and XTAL2. The output clock frequency of CLK is selectable through inputs CLKDIV1 and CLKDIV2. The CLK signal frequency can be f_{XTAL} , $f_{XTAL}/2$, $f_{XTAL}/4$, or $f_{XTAL}/8$. See Table 1 for the frequency generated on the CLK signal given the inputs to CLKDIV1 and CLKDIV2.

Note that CLKDIV1 and CLKDIV2 must not be changed simultaneously; a delay of 10ns minimum between changes is needed. The minimum duration of any state of CLK is eight periods of XTAL1.

The frequency change is synchronous: during a transition of the clock divider, no pulse is shorter than 45% of the smallest period, and the first and last clock pulses about the instant of change have the correct width. When changing the frequency dynamically, the change is effective for only eight periods of XTAL1 after the command.

The f_{XTAL} duty factor depends on the input signal on XTAL1. To reach a 45% to 55% duty factor on CLK, XTAL1 should have a 48% to 52% duty factor with transition times less than 5% of the period.

With a crystal, the duty factor on CLK can be 45% to 55% depending on the circuit layout and on the crystal characteristics and frequency. In other cases, the duty factor on CLK is guaranteed between 45% and 55% of the clock period.

If the crystal oscillator is used or if the clock pulse on XTAL1 is permanent, the clock pulse is applied to the card as shown in the activation sequences in Figures 3 and 4. If the signal applied to XTAL1 is controlled by the host microcontroller, the clock pulse is applied to the card when it is sent by the system microcontroller (after completion of the activation sequence).

Table 1. Clock Frequency Selection

| CLKDIV1 | CLKDIV2 | f _{CLK} |
|---------|---------|------------------|
| 0 | 0 | $f_{XTAL}/8$ |
| 0 | 1 | $f_{XTAL}/4$ |
| 1 | 1 | $f_{XTAL}/2$ |
| 1 | 0 | f_{XTAL} |

I/O Transceivers

The three data lines I/O, AUX1, and AUX2 are identical. This section describes the characteristics of I/O and I/OIN but also applies to AUX1, AUX1IN, AUX2, and AUX2IN.

I/O and I/OIN are pulled high with an 11k Ω resistor (I/O to VCC and I/OIN to VDD) in the inactive state. The first side of the transceiver to receive a falling edge becomes the master. When a falling edge is detected (and the master is decided), the detection of falling edges on the line of the other side is disabled; that side then becomes a slave. After a time delay $t_{D(EDGE)}$, an n transistor on the slave side is turned on, thus transmitting the logic 0 present on the master side.

When the master side asserts a logic 1, a p transistor on the slave side is activated during the time delay t_{PU} and then both sides return to their inactive (pulled up) states. This active pullup provides fast low-to-high transitions. After the duration of t_{PU} , the output voltage depends only on the internal pullup resistor and the load current. Current to and from the card I/O lines is limited internally to 15mA. The maximum frequency on these lines is 1MHz.

Inactive Mode

The DS8113 powers up with the card interface in the inactive mode. Minimal circuitry is active while waiting for the host to initiate a smart card session.

- All card contacts are inactive (approximately 200 Ω to GND).
- Pins I/OIN, AUX1IN, and AUX2IN are in the high-impedance state (11k Ω pullup resistor to VDD).
- Voltage generators are stopped.
- XTAL oscillator is running (if included in the device).
- Voltage supervisor is active.
- The internal oscillator is running at its low frequency.

Activation Sequence

After power-on and the reset delay, the host microcontroller can monitor card presence with signals \overline{OFF} and \overline{CMDVCC} , as shown in Table 2.

Table 2. Card Presence Indication

| \overline{OFF} | \overline{CMDVCC} | STATUS |
|------------------|---------------------|--------------------------|
| High | High | Card present. |
| Low | High | Card not present. |

Smart Card Interface

If the card is in the reader (if PRES is active), the host microcontroller can begin an activation sequence (start a card session) by pulling $\overline{\text{CMDVCC}}$ low. The following events form an activation sequence (Figure 3):

- 1) $\overline{\text{CMDVCC}}$ is pulled low.
- 2) The internal oscillator changes to high frequency (t_0).
- 3) The voltage generator is started (between t_0 and t_1).
- 4) V_{CC} rises from 0 to 5V, 3V, or 1.8V with a controlled slope ($t_2 = t_1 + 1.5 \times T$). T is 64 times the internal oscillator period (approximately 25 μ s).
- 5) I/O, AUX1, and AUX2 are enabled ($t_3 = t_1 + 4T$) (they were previously pulled low).
- 6) The CLK signal is applied to the C3 contact (t_4).
- 7) RST is enabled ($t_5 = t_1 + 7T$).

To apply the clock to the card interface:

- 1) Set RSTIN high.

- 2) Set $\overline{\text{CMDVCC}}$ low.
- 3) Set RSTIN low between t_3 and t_5 ; CLK will now start.
- 4) RST stays low until t_5 , then RST becomes the copy of RSTIN.
- 5) RSTIN has no further effect on CLK after t_5 .

If the applied clock is not needed, set $\overline{\text{CMDVCC}}$ low with RSTIN low. In this case, CLK starts at t_3 (minimum 200ns after the transition on I/O, see Figure 4); after t_5 , RSTIN can be set high to obtain an answer to request (ATR) from an inserted smart card. Do not perform activation with RSTIN held permanently high.

Active Mode

When the activation sequence is completed, the DS8113 card interface is in active mode. The host microcontroller and the smart card exchange data on the I/O lines.

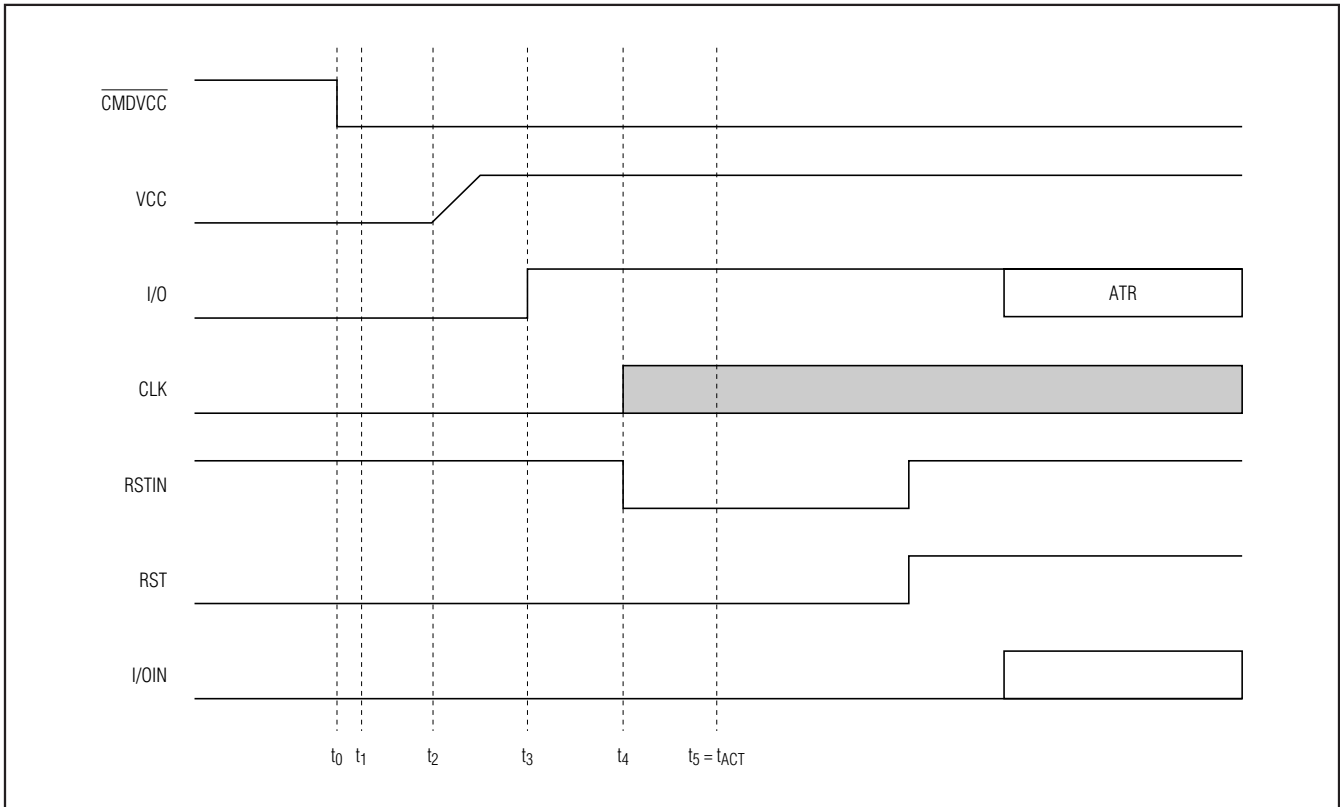


Figure 3. Activation Sequence Using RSTIN and $\overline{\text{CMDVCC}}$

Smart Card Interface

DS8113

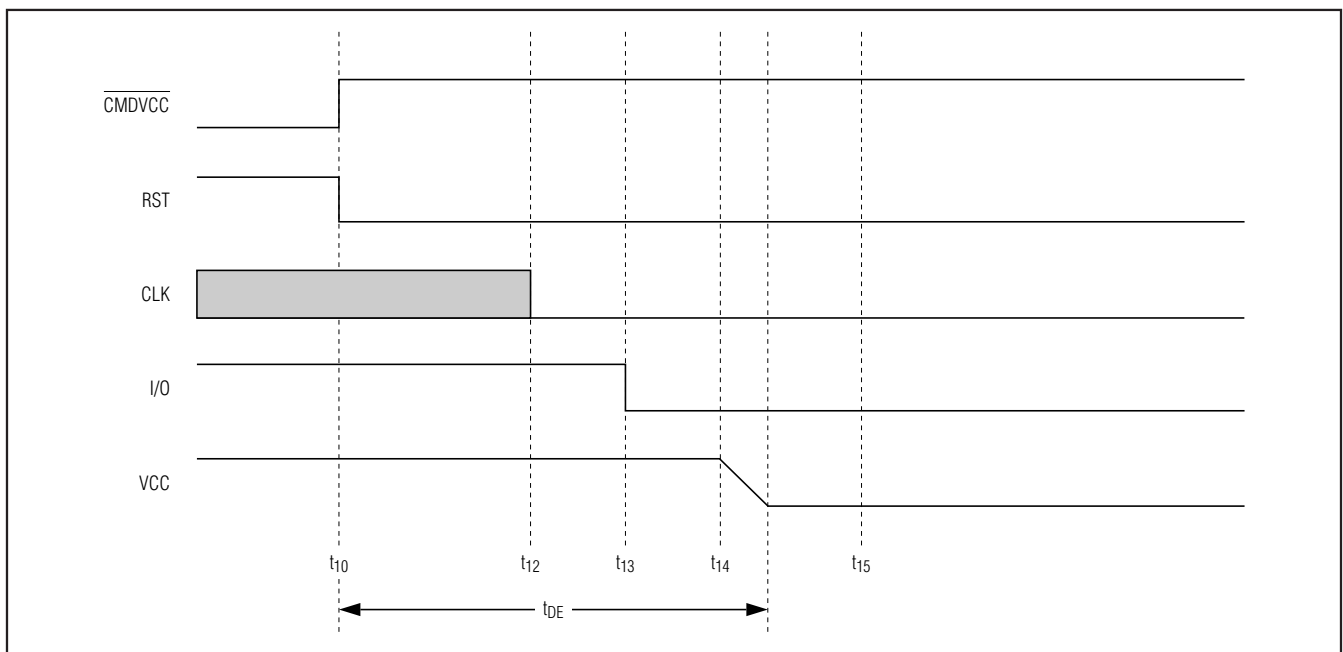
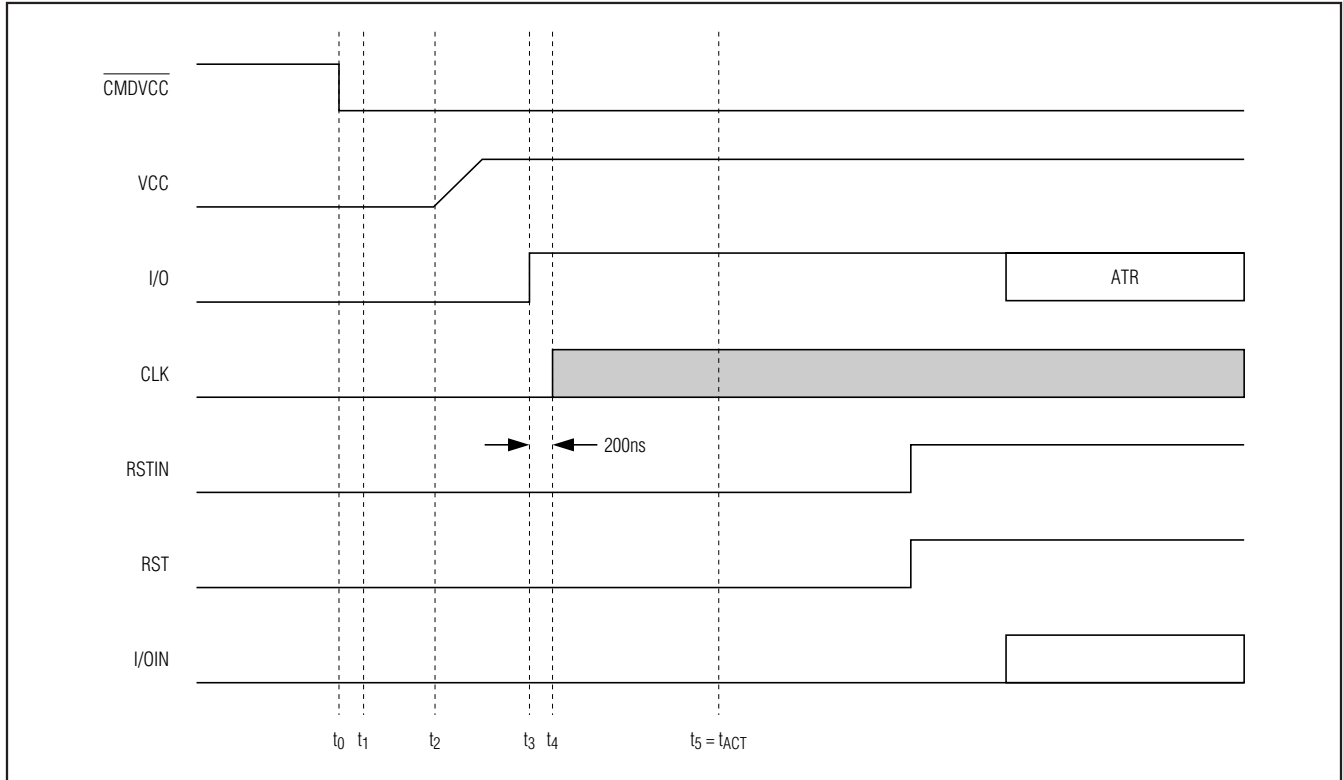


Figure 5. Deactivation Sequence

Smart Card Interface

Deactivation Sequence

When a session is completed, the host microcontroller sets the $\overline{\text{CMDVCC}}$ line high to execute an automatic deactivation sequence and returns the card interface to the inactive mode (Figure 5).

- 1) RST goes low (t_{10}).
- 2) CLK is held low ($t_{12} = t_{10} + 0.5 \times T$) where T is 64 times the period of the internal oscillator (approximately 25 μ s).
- 3) I/O, AUX1, and AUX2 are pulled low ($t_{13} = t_{10} + T$).
- 4) VCC starts to fall ($t_{14} = t_{10} + 1.5 \times T$).
- 5) When VCC reaches its inactive state, the deactivation sequence is complete (at t_{DE}).
- 6) All card contacts become low impedance to GND; I/OIN, AUX1IN, and AUX2IN remain at V_{DD} (pulled up through an 11k Ω resistor).
- 7) The internal oscillator returns to its lower frequency.

VCC Generator

The VCC generator has a capacity to supply up to 80mA continuously at 5V, 65mA at 3V, and 30mA at 1.8V. An internal overload detector triggers at approximately 120mA. Current samples to the detector are filtered. This allows spurious current pulses (with a duration of a few μ s) up to 200mA to be drawn without causing deactivation. The average current must stay below the specified maximum current value. To maintain VCC voltage accuracy, a 100nF capacitor (with an ESR < 100m Ω) should be connected to CGND and placed near the DS8113's VCC pin, and a 100nF or 220nF capacitor (220nF is the best choice) with the same ESR should be connected to CGND and placed near the smart card reader's C1 contact.

Fault Detection

The following fault conditions are monitored:

- Short-circuit or high current on VCC
- Removal of a card during a transaction
- VDD dropping
- Card voltage generator operating out of the specified values (V_{DDA} too low or current consumption too high)
- Overheating

There are two different cases (Figure 6):

- **CMDVCC High Outside a Card Session.** Output $\overline{\text{OFF}}$ is low if a card is not in the card reader and high if a card is in the reader. The V_{DD} supply is monitored—a decrease in input voltage generates an internal power-on reset pulse but does not affect the $\overline{\text{OFF}}$ signal. Short-circuit and temperature detection is disabled because the card is not powered up.
- **CMDVCC Low Within a Card Session.** Output $\overline{\text{OFF}}$ goes low when a fault condition is detected, and an emergency deactivation is performed automatically (Figure 7). When the system controller resets $\overline{\text{CMDVCC}}$ to high, it may sense the $\overline{\text{OFF}}$ level again after completing the deactivation sequence. This distinguishes between a card extraction and a hardware problem ($\overline{\text{OFF}}$ goes high again if a card is present). Depending on the connector's card-present switch (normally closed or normally open) and the mechanical characteristics of the switch, bouncing can occur on the PRES signals at card insertion or withdrawal.

The DS8113 has a debounce feature with an 8ms typical duration (Figure 6). When a card is inserted, output $\overline{\text{OFF}}$ goes high after the debounce time delay. When the card is extracted, an automatic deactivation sequence of the card is performed on the first true/false transition on PRES and output $\overline{\text{OFF}}$ goes low.

Smart Card Interface

DS8113

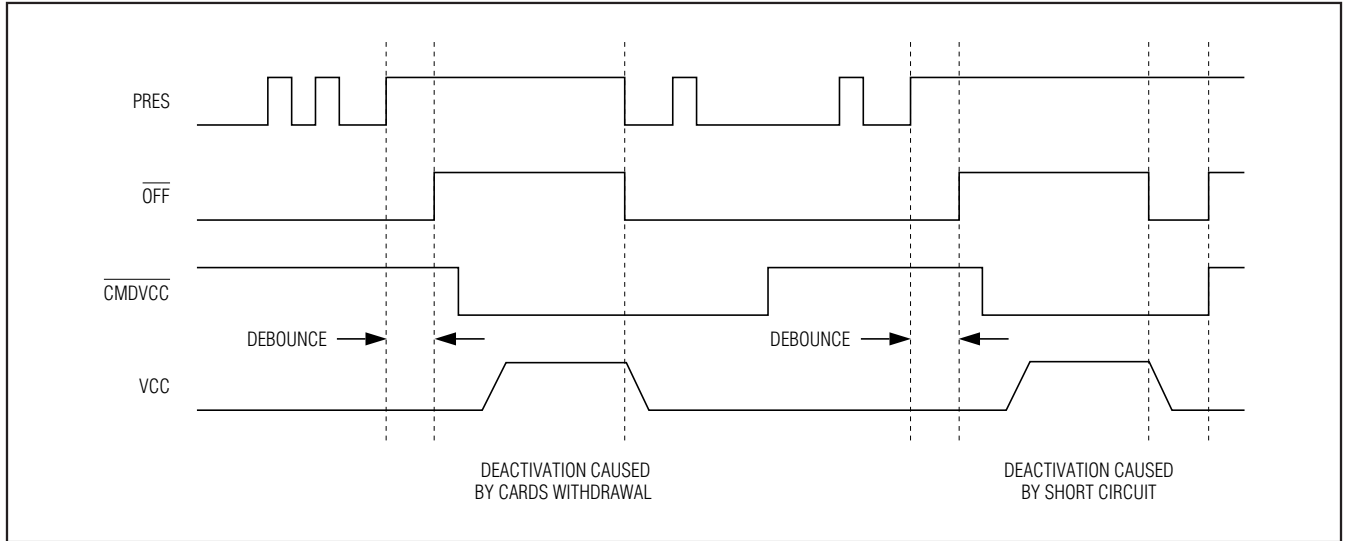


Figure 6. Behavior of PRES, $\overline{\text{OFF}}$, $\overline{\text{CMDVCC}}$, and VCC

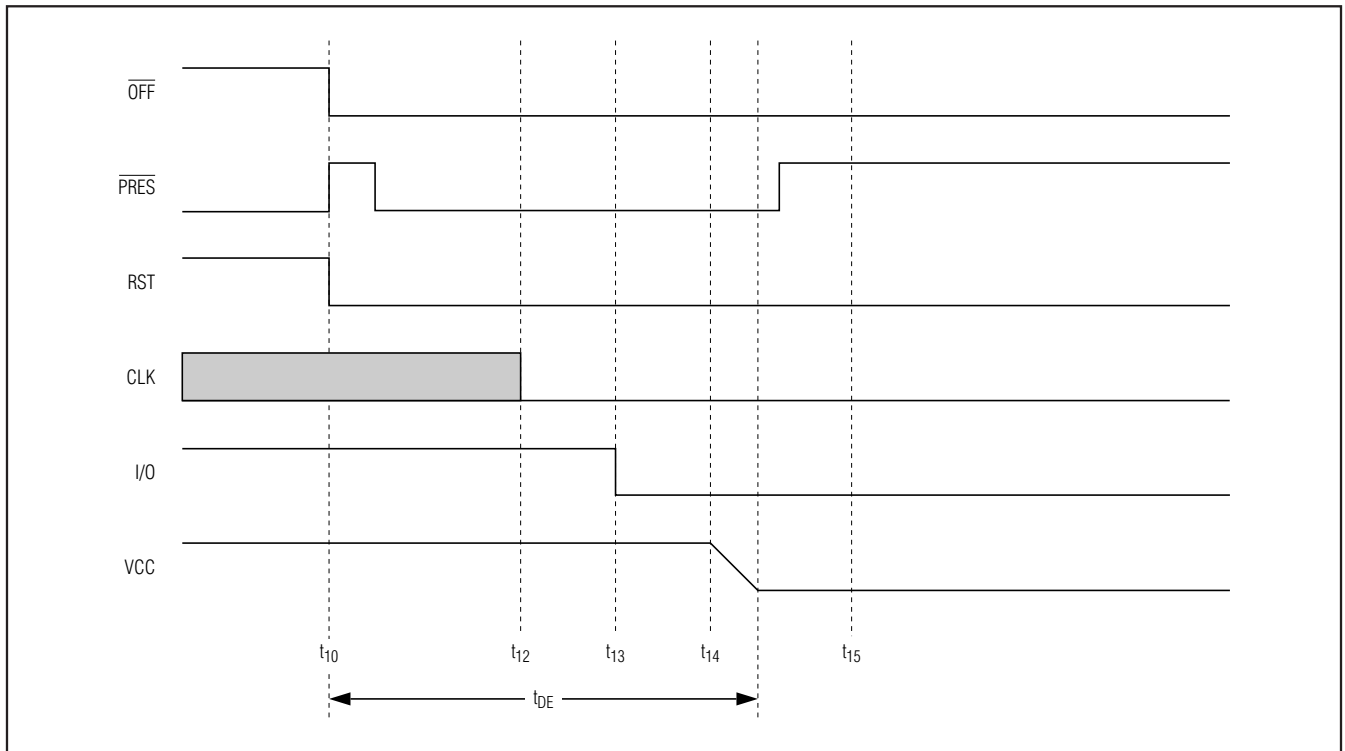


Figure 7. Emergency Deactivation Sequence (Card Extraction)

Smart Card Interface

Stop Mode (Low-Power Mode)

A low-power state, stop mode, can be entered by forcing the $\overline{\text{CMDVCC}}$, 5V/3V, and 1_8V input pins to a logic-high state. Stop mode can only be entered when the smart card interface is inactive. In stop mode all internal analog circuits are disabled. The $\overline{\text{OFF}}$ pin follows the status of the PRES pin. To exit stop mode, change the state of one or more of the three control

pins to a logic-low. An internal 220 μs (typ) power-up delay and the 8ms PRES debounce delay are in effect and $\overline{\text{OFF}}$ is asserted to allow the internal circuitry to stabilize. This prevents smart card access from occurring after leaving the stop mode. Figure 8 shows the control sequence for entering and exiting stop mode. Note that an in-progress deactivation sequence always finishes before the DS8113 enters low-power stop mode.

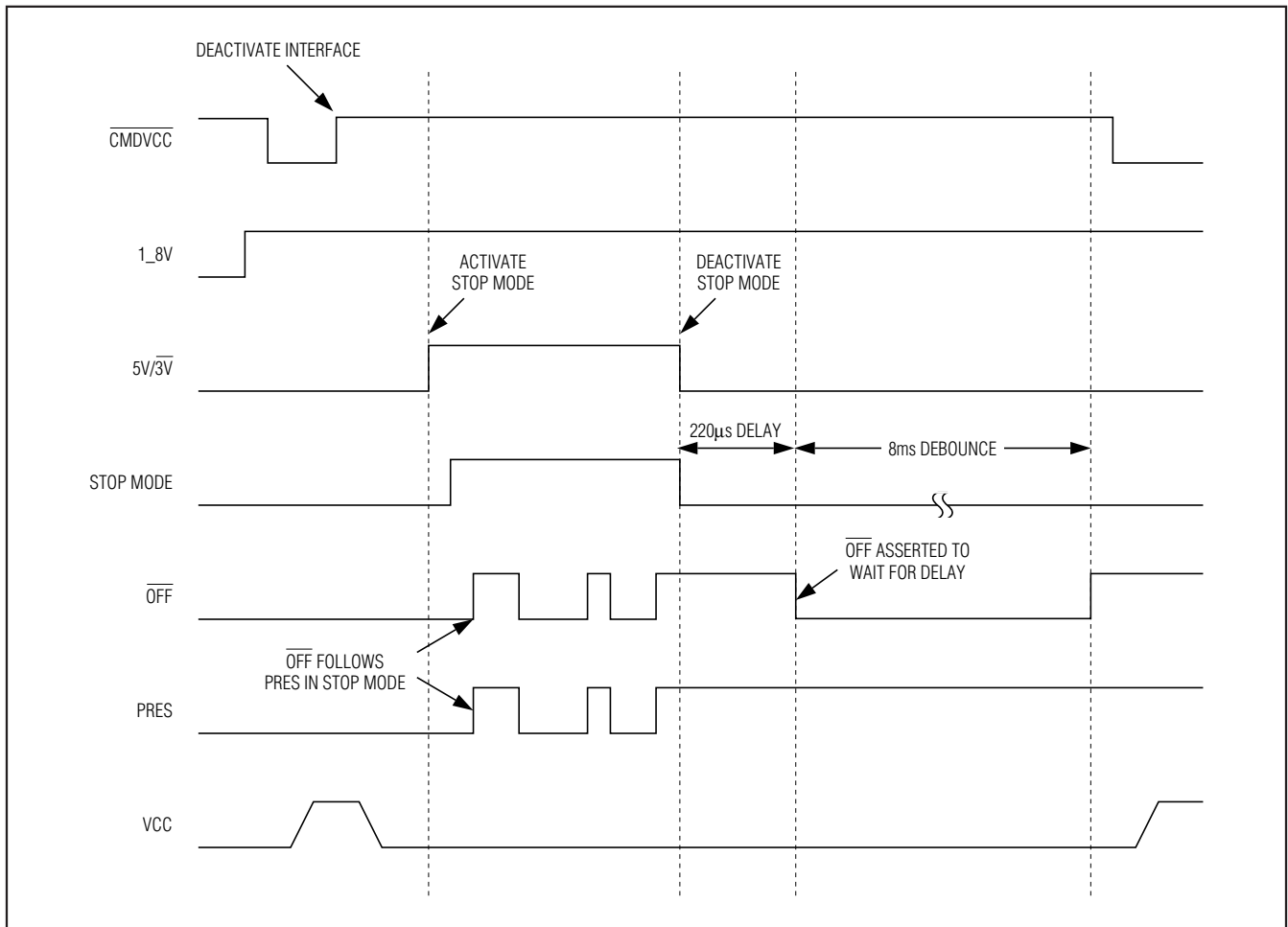


Figure 8. Stop-Mode Sequence

Smart Card Interface

Smart Card Power Select

The DS8113 supports three smart card V_{CC} voltages: 1.8V, 3V, and 5V. The power select is controlled by the 1_8V and 5V/3V signals as shown in Table 3. The 1_8V signal has priority over 5V/3V. When 1_8V is asserted high, 1.8V is applied to V_{CC} when the smart card is active. When 1_8V is deasserted, 5V/3V dictates V_{CC} power range. V_{CC} is 5V if 5V/3V is asserted to a logic-high state, and V_{CC} is 3V if 5V/3V is pulled to a

logic-low state. Care must be exercised when switching from one V_{CC} power selection to the other. If both 1_8V and 5V/3V are high with $\overline{\text{CMDVCC}}$ high at the same time, the DS8113 enters stop mode. To avoid accidental entry into stop mode, the state of 1_8V and 5V/3V must not be changed simultaneously. A minimum delay of 100ns should be observed between changing the states of 1_8V and 5V/3V. See Figure 9 for the recommended sequence of changing the V_{CC} range.

Table 3. V_{CC} Select and Operation Mode

| 1_8V | 5V/3V | $\overline{\text{CMDVCC}}$ | V _{CC} SELECT (V) | CARD INTERFACE STATUS |
|------|-------|----------------------------|----------------------------|--------------------------|
| 0 | 0 | 0 | 3 | Activated |
| 0 | 0 | 1 | 3 | Inactivated |
| 0 | 1 | 0 | 5 | Activated |
| 0 | 1 | 1 | 5 | Inactivated |
| 1 | 0 | 0 | 1.8 | Activated |
| 1 | 0 | 1 | 1.8 | Inactivated |
| 1 | 1 | 0 | 1.8 | Reserved (Activated) |
| 1 | 1 | 1 | 1.8 | Not Applicable—Stop Mode |

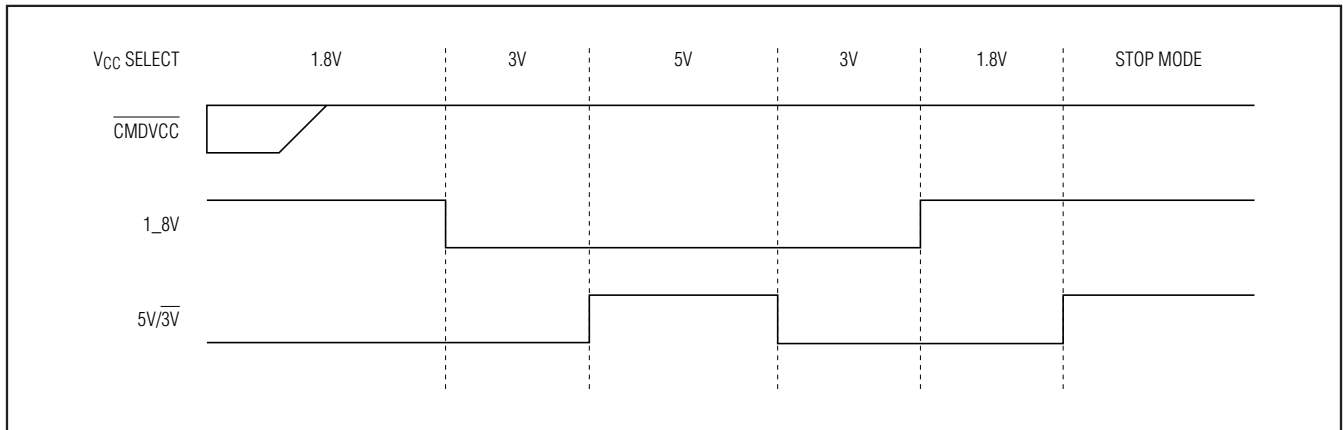


Figure 9. Smart Card Power Select

Smart Card Interface

Applications Information

Performance can be affected by the layout of the application. For example, an additional cross-capacitance of 1pF between card reader contacts C2 (RST) and C3 (CLK) or C2 (RST) and C7 (I/O) can cause contact C2 to be polluted with high-frequency noise from C3 (or C7). In this case, include a 100pF capacitor between contacts C2 and CGND.

Application recommendations include the following:

- Ensure there is ample ground area around the DS8113 and the connector; place the DS8113 very near to the connector; decouple the VDD and VDDA lines separately. These lines are best positioned under the connector, connected in a star on the main trace.
- The DS8113 and the host microcontroller must use the same VDD supply. Pins CLKDIV1, CLKDIV2, RSTIN, PRES, AUX1IN, I/OIN, AUX2IN, 5V/3V, 1_8V, CMDVCC, and OFF are referenced to VDD; if pin XTAL1 is to be driven by an external clock, also reference this pin to VDD.
- Trace C3 (CLK) should be placed as far as possible from the other traces.
- The trace connecting CGND to C5 (GND) should be straight (the two capacitors on C1 (VCC) should be connected to this ground trace).
- Avoid ground loops among CGND, PGND, and GND.

With all these layout precautions, noise should be kept to an acceptable level and jitter on C3 (CLK) should be less than 100ps. Reference layouts, designs, and an evaluation kit are available on request.

Selector Guide

| PART | LOW STOP- MODE POWER | LOW ACTIVE- MODE POWER | PIN- PACKAGE |
|-------------|-------------------------|---------------------------|-----------------|
| DS8113-RNG+ | Yes | Yes | 28 SO |

Note: Contact the factory for availability of other variants and package options.

+Denotes a lead-free package.

Package Information

(For the latest package outline information, go to www.maxim-ic.com/packages.)

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. |
|------------------|--------------|-------------------------|
| 28 SO (300 mils) | — | 21-0042 |

Smart Card Interface

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 0 | 1/08 | Initial release. | — |
| 1 | 2/08 | In the <i>Recommended DC Operating Conditions</i> table, changed I/OIN, AUX1IN/AUX2IN specs to reference V _{DD} rather than V _{CC} and corrected I _{OH} to μ A. | 5 |
| | | In the <i>Pin Description</i> , removed references to active low from the PRES description. | 7 |
| 2 | 5/08 | In the <i>Recommended DC Operating Conditions</i> table, clarified specifications of V _{TH2} , f _{INT} , V _{CCSR} , and I _{L_IO} . | 2–5 |

DS8113

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