

SIM Card Interface Level Shifter with EMI Filter and ESD

Protection

Features

- Clock speeds up to 10 MHz
- SIM card supply voltages range: from 1.65 V to 3.6 V
- Host micro-controller operating voltage range: 1.08 V to 1.95 V
- Compliant with all ETSI, IMT-2000 and ISO-7816-3 SIM/Smart card interface requirements
- Automatic level translation of I/O, RST and CLK between SIM card and host side interface with capacitance isolation
- Automatic enable and disable through V_{CCB}
- No external resistors required with integrated pull-up and pull-down resistors
- Integrated EMI filters suppress higher harmonics of digital I/Os
- Level-shifting buffers keep ESD stress away from the host
- ESD protection: IEC61000-4-2 level 4, contact and air discharge on all SIM card-side pins, V_{CCB}, and GND are ±8 kV and ±15 kV respectively
- Packaged in WLCSP-9 (0.3 mm pitch) and QFN1.8*1.4-10

Descriptions

The DIO74557 is designed for interfacing a SIM card with a low-voltage host-side interface (1.08 V to 1.95 V). It contains three level shifters, converting the I/O data, RST and CLK signals between a SIM card and a host micro-controller. The device is integrated with pull-up resistors, which means no external resistors is required, providing small overall solution size.

The DIO74557 is compliant with all ETSI, IMT-2000 and ISO-7816-3 SIM/Smart card interface requirements.

The DIO74557 is housed in QFN1.8*1.4-10 and WLCSP-9 packages.

Applications

- Mobile and personal phones
- Wireless modems
- SIM card terminals

Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T _A	Package	
DIO74557LP10	YW5G	1	Green	-40 to 85°C	QFN1.8*1.4-10	Tape & Reel, 3000
DIO74557WL9	DE5G	1	Green	-40 to 85°C	WLCSP-9	Tape & Reel, 3000



Pin Assignments



Figure 1. Pin assignment (Top view)

Pin Description

Pin name	Description
RST_HOST	Reset input from the host controller.
	Supply voltage for the host controller side input/output pins (CLK_HOST, RST_HOST, IO_HOST).
V _{CCA}	The V_{CCA} voltage ranges from 1.08 V to 1.95 V. This pin should be bypassed with a 0.1 μF ceramic
	capacitor close to the pin.
RST_SIM	Reset the output pin for the SIM card. This pin is pulled low during shutdown through a 400 Ω resistor.
CLK_HOST	Clock input from the host controller.
GND	Ground. This pin is the ground reference for the integrated circuit and associated signals.
CLK_SIM	Clock output pin for the SIM card. This pin is pulled low during shutdown through a 400 Ω resistor.
IO_HOST	Host controller bidirectional data input/output. The host output must be on an open-drain driver.
	SIM card supply voltage. When V_{CCB} is below the $V_{CCB_{DIS}}$, the device is disabled. The V_{CCB} voltage
V _{CCB}	ranges from 1.65 V to 3.6 V. This pin should be bypassed with a 0.1 μF ceramic capacitor close to
	the pin.
	SIM card bidirectional data input/output. The SIM card output must be on an open-drain driver.
10_51101	This pin is pulled low during shutdown through a 400 Ω resistor.
EN	Enable pin. This pin should be HIGH (V _{CCA}) for normal operation, and LOW to help avoid race
	conditions specifically during the shutdown sequence. This pin is only for QFN1.8*1.4-10 package.

SIM Card Interface Level Shifter with EMI Filter and ESD Protection



Functional Description

Supply \	/oltage	Input	Input/	Operational	
Vcca	V _{CCB}	EN ^{[1] [2]}	Host SIM Card		Mode
1.08 V to 1.95 V	1.65 V to 3.6 V	н	HOST = SIM Card SIM Card = HOST		Active
1.08 V to 1.95 V	1.65 V to 3.6 V	L	See the below ta	Shutdown	
GND	1.65 V to 3.6 V	х	See the below ta	Shutdown	
1.08 V to 1.95 V	GND	х	See the below ta	Shutdown	
GND	GND	х	See the below ta	able, Condition A	Shutdown

Notes:

[1] H = HIGH voltage level; L = LOW voltage level; X = inconsequential.

[2] V_{IL} and V_{IH} are referenced to V_{CCA} . The EN can be controlled by an external device limit of V_{CCA} + 0.3 V.

Pin condition	Condition A	Condition B
RST_HOST	100 k Ω pull low	100 kΩ pull low
CLK_HOST	100 k Ω pull low	100 k Ω pull low
IO_HOST	5 k Ω pull to V _{CCA}	5 k Ω pull to V_CCA
RST_SIM	100 kΩ pull low	400 Ω pull low
CLK_SIM	100 kΩ pull low	400 Ω pull low
IO_SIM	High Z	400 Ω pull low



Absolute Maximum Ratings

Stresses beyond those listed under the Absolute Maximum Rating table may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition 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.

Symbol	Parameter	Conditions	Min	Мах	Unit
V _{CCA}	Host supply voltage		GND - 0.5	2.2	V
V _{CCB}	SIM supply voltage		GND - 0.5	4.0	V
VI(CLK_HOST), VI(RST_HOST), VI(IO_HOST)	Input voltage on CLK_HOST, RST_HOST, IO_HOST pins	Input signal voltage, HOST side	GND - 0.5	2.2	V
VI(CLK_SIM), VI(RST_SIM), VI(IO_SIM)	Input voltage on CLK_SIM, RST_SIM, IO_SIM pins	Input signal voltage, SIM side	GND - 0.5	4.0	V
T _{STG}	Storage temperature		-55	125	°C
T _A	Ambient temperature		-40	85	°C
		Contact discharge at SIM card side pins, V_{CCB} , and GND pins	-8	8	kV
ESD	Electrostatic discharge voltage	Air discharge ^[1] at SIM card side pins, V_{CCB} , and GND pins	-15	15	kV
		Human body model at all pins	-4	4	kV
		Charge device model at all pins	-2	2	kV
Latch up	Input/Output latch-up current		-100	100	mA

Note:

[1] According to the IEC 61000-4-2 standards, a Level 4 contact discharge of 8 kV is considered equivalent to a 15 kV air discharge. Air discharge is provided for information only and was not tested.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications.

Symbol	Parameter	Conditions	Min	Мах	Unit
V _{CCA}	Host supply voltage		1.08	1.95	V
V _{CCB}	SIM supply voltage		1.65	3.6	V
VIH	High-level input voltage	IO_HOST, RST_HOST, CLK_HOST	0.7 × V _{CCA}		V
		IO_SIM	0.7 × V _{CCB}		V
VIL	Low-level input voltage	IO_HOST, RST_HOST, CLK_HOST		0.3 × V _{CCA}	V
		IO_SIM		0.3 × V _{CCB}	V
Δt/ΔV	Input transition rise or fall rate			200	ns/V



Electrical Characteristics

1.65 V ≤ V_{CCB} ≤ 3.6 V; 1.08 V ≤ V_{CCA} ≤ 1.95 V; T_A = -40°C to +85°C; unless otherwise specified.

Symbol	Parameter	Conditions	ditions Min		Мах	Unit
Supplies	I					
V _{CCA}	Supply voltage		1.08		1.95	V
		Operating mode; f _{CLK_HOST} = 1 MHz; EN = V _{CCA}		5	10	μA
I _{CCA}	Supply current	Quiescent current; EN = V _{CCA}		0.01	1	V μA μA μA V V V
		Shutdown mode; EN = GND			1	μA
V _{CCB}	SIM supply voltage		1.65		3.6	V
I _{CCB}	SIM supply current	Quiescent current; EN = V _{CCA}		3.6	6.0	μA
Automatic e	nable feature: V _{CCB}	I	I	1	I	I
V _{CCB_EN}	Enable voltage level	$V_{CCA} \ge 1.0 \text{ V}, V_{CCB} \text{ rising edge}$	1.65			V
V _{CCB_DIS}	Disable voltage level	$V_{CCA} \ge 1.0 \text{ V}, V_{CCB} \text{ falling edge}$			1.35	V
ΔV_{CCBen}	V _{CCBen} hysteresis voltage			100		mV
Hardware er	hable pin	I	I		I	I
VIH	High-level input voltage	EN pin threshold	0.7 × V _{CCA}		V _{CCA} + 0.3	V
VIL	Low-level input voltage	EN pin threshold	-0.15		0.3 × V _{CCA}	V
Level shifte	r	I	I	I	I	I
VIH		IO_HOST, RST_HOST, CLK_HOST	0.7 × V _{CCA}		V _{CCA} + 0.3	V
	High-level input voltage	IO_SIM	0.7 × V _{ссв}		V _{CCB} + 0.3	V
		IO_HOST, RST_HOST, CLK_ HOST	-0.15		0.3 × V _{CCA}	V V
VIL	Low-level input voltage	IO_SIM	-0.15		0.3 × V _{ССВ}	V
5		IO_SIM connected to V _{CCB}	4	6	8	kΩ
Rpu	Pull-up resistance	IO_HOST connected to V _{CCA}	3.5	5	10 1 1 3.6 6.0 1.35 1.35 0.3 × VccA VccA + 0.3 VccB + 0.3 0.3 × VccB 0.12 × VccB 0.12 × VccB 0.25 × VccA	kΩ
		RST_SIM, CLK_SIM; I _{OH} = -1 mA	0.85 × V _{ссв}		V _{CCB} + 0.3	V
Voh	High-level output voltage	IO_SIM; I _{OH} = -10 μA	0.85 × V _{ссв}		V _{CCB} + 0.3	V
		IO_HOST; I _{OH} = -10 μA	0.85 × V _{CCA}		V _{CCA} + 0.3	V
		RST_SIM, CLK_SIM; I _{OL} = 1 mA	0		0.12 × V _{ССВ}	V
V _{OL}	Low-level output voltage	IO_SIM; I _{OL} = 1 mA	0		0.12 × V _{ССВ}	V
		IO_HOST; I _{OL} = 1 mA	0		0.25 × V _{CCA}	V
R _{PD}	Pull-down resistance	CLK_SIM, RST_SIM, IO_SIM; when EN = 0		400		Ω
EMI filter						
Rs	Series resistance			42		Ω



		RST_SIM	42	Ω
		CLK_SIM	42	Ω
		IO_SIM	10	pF
C _{io} ^[1]	C _{io} ^[1] Input/Output capacitance	RST_SIM	10	pF
		CLK_SIM	10	pF

Note:

[1] Guaranteed by design.

[2] Specification subject to change without notice.

Dynamic Characteristics

 $1.65 \text{ V} \le \text{V}_{\text{CCB}} \le 3.6 \text{ V}$; $1.08 \text{ V} \le \text{V}_{\text{CCA}} \le 1.95 \text{ V}$; $f_{\text{clk}} = f_{\text{io}} = 1 \text{ MHz}$; $T_{\text{A}} = -40 \text{ °C to } +85 \text{ °C}$; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Тур	Max	Unit			
V _{CCA} = 1.8 V;	V _{CCA} = 1.8 V; V _{CCB} = 3.0 V; SIM card C _L ≤ 30 pF; host C _L ≤ 10 pF								
	Propagation delay	I/O channel; SIM card side to host side		12		ns			
ίρD	(See Figure 2)	All channels; host side to SIM card side		10		ns			
	Transition time	I/O channel; SIM card side to host side		7		ns			
Lt.	(See Figure 2)	All channels; host side to SIM card side		4		ns			
t _{sk(o)}	$t_{sk(o)}$ Output skew time Between channels IO_SIM and CLK_SIM			2		ns			
f _{clk}	Clock frequency	CLK_SIM		10		MHz			
V _{CCA} = 1.2 V;	$V_{CCB} = 1.8 \text{ V}; \text{ SIM card } C_L \leq$	30 pF; host C∟ ≤ 10 pF							
	Propagation delay	I/O channel; SIM card side to host side		16		ns			
[PD	(See Figure 2)	All channels; host side to SIM card side		15		ns			
+	Transition time	I/O channel; SIM card side to host side		7		ns			
Lt	(See Figure 2)	All channels; host side to SIM card side		4		ns			
t _{sk(o)}	Output skew time	tput skew time Between channels IO_SIM and CLK_SIM		2		ns			
f _{CLK}	Clock frequency	CLK_SIM		10		MHz			

Note: Specification subject to change without notice.



Figure 2. Data input to data output propagation delay times

Note: V_{OL} and V_{OH} are typical output voltage levels that occur with the output load. t_{PHL} and t_{PLH} are t_{PD} propagation delay; t_{THL} and t_{TLH} are the transition time.



Block Diagram



Figure 3. Block diagram

Note:

[1] EN pin is only for QFN1.8*1.4-10.

Typical Applications





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Descriptions

Embedded Enable

The embedded enable feature is available for WLCSP-9 package and the QFN1.8*1.4-10 package when the enable pin of the QFN package is tied to V_{CCA} . The DIO74557 includes an automatic enable function that activates the level shifter function when the voltage of V_{CCB} exceeds V_{CCB_EN} . Conversely, the SIM card side drivers and level shifter function are deactivated as soon as V_{CCB} falls below V_{CCB_DIS} . Additionally, the IO pin on the host side is set up as an input with a 5 k Ω resistor that is pulled up to V_{CCA} .

When V_{CCB} falls below $V_{CCB_{DIS}}$ but remains above the MOS threshold voltage (V_{TH}), the pull-down NMOS in the one-directional and bidirectional drivers will be turned off, while the NMOS controlled by CTL will be turned on. As a result, the CLK/RST/IO pins on the card side will be pulled low by the 400 Ω resistor. Furthermore, both the host and card side CLK/RST pins have a 100 k Ω pull-down resistor. The 400 Ω resistor is used for discharge during V_{CCB} power off (when $V_{TH} < V_{CCB} < V_{CCB_{EN}}$), while the 100 k Ω resistor is used to keep RST_SIM/CLK_SIM low when V_{CCB} is below V_{TH} .



Figure 5. RST/CLK voltage level translation architecture





EN Shutdown Mode (only for QFN1.8*1.4-10)

To properly turn off the SIM card and save power, the SIM card signals should be shut down in accordance with the specification specified in the ISO-7816-3 standard. The proper shutdown of these signals also helps prevent any inappropriate writing and data corruption during the hot swap.

To properly initiate the shutdown sequence, it's crucial to ensure that the EN pin is pulled LOW before the V_{CCA} and V_{CCB} supplies go LOW. When the EN pin is asserted LOW, the RST_SIM channel is powered down, which then triggers the sequential power down of CLK_SIM and IO_SIM channels one by one. The SIM pins are pulled LOW by their respective internal pull-down resistors. The entire shutdown sequence is completed within a few microseconds.



Figure 7. Shutdown sequence

Input/output Capacitor Selections

Place a 100 nF capacitor with low Equivalent Series Resistance (ESR) in close proximity to the V_{CCA} and V_{CCB} input terminals each. The preferred capacitor types are X5R or X7R multi-layer ceramic capacitors (MLCC) due to their consistent value and ESR performance across temperature variations. The maximum ESR should be under 500 m Ω (with a typical value being 50 m Ω).

Level Shifter Stage

The device eliminates the need for an additional input signal to control the direction of data flow between the host and SIM. The control logic enables a change in driving direction only when both sides are in a HIGH state. The first falling edge is recognized by the control logic, granting it control over the other signal side. In the event of a rising edge signal, a one-shot circuit is employed to drive the non-driving output and accelerate the rising edge. The internal logic of the device safeguards against communication errors or unforeseen incidents that may drive both connected sides to be drivers simultaneously, thereby preventing a stuck-at situation. Once released from being driven LOW, both I/Os will return to a HIGH level automatically.

The RST and CLK channels just contain single direction drivers without the holding mechanism of the I/O channel, as these are just driven from the host to the SIM card side.

EMI Filter

EMI filters at the input/output driver stages reduce interference to sensitive mobile communications.

ESD Protection

The DIO74557 has strong ESD protections on all SIM card pins as well as on the V_{CCB} pin. The feature prevents any stress for the host: the voltage converter releases any stress to the supply floor.



Physical Dimensions: QFN1.8*1.4-10



TOP VIEW



<u>SIDE VIEW</u>





Two options



Common Dimensions (Units of measure = Millimeter)							
Symbol	Min Nom Max						
А	0.50	0.55	0.60				
A1	0.00	0.02	0.05				
A3		0.152 RE	F				
b	0.15	0.20	0.25				
D	1.30	1.40	1.50				
E	1.70	1.80	1.90				
е	0.30 0.40 0.50						
L	0.35	0.40	0.45				
L1	0.45	0.50	0.55				













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