SIM Card Interface Level Shifter with EMI Filter and ESD Protection

Features

- 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
- Support clock speeds up to 10 MHz
- 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
- 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
- Compliant with all ETSI, IMT-2000 and ISO-7816-3 SIM/Smart card interface requirements
- Operating temperature range: -40°C to 85°C

Applications

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

Package Information

Part Number	Package	Body Size
DIO74557S	QFN-10	1.8 mm × 1.4 mm

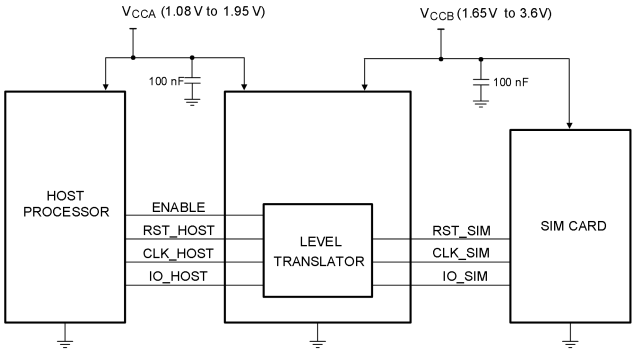
Description

The DIO74557S 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 DIO74557S is compliant with all ETSI, IMT-2000 and ISO-7816-3 SIM/Smart card interface requirements.

The DIO74557S is packaged in QFN1.8*1.4-10.

Simplified Schematic



Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIO74557SLP10	YW7S	1	Green	-40 to 85°C	QFN1.8*1.4-10	Tape & Reel, 3000

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user

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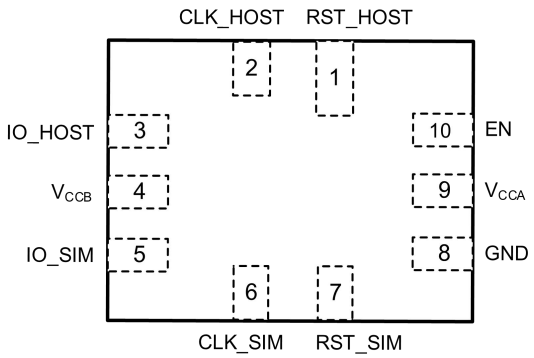


*Figure 1. QFN1.8*1.4-10 (Top view)*

Pin Name	Description
RST_HOST	Reset input from the host controller.
V_{CCA}	Supply voltage for the host controller side input/output pins (CLK_HOST, RST_HOST, IO_HOST). 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 450 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 450 Ω resistor.
IO_HOST	Host controller bidirectional data input/output. The host output must be on an open-drain driver.
V_{CCB}	SIM card supply voltage. When V_{CCB} is below the V_{CCB_DIS}, the device is disabled. The V_{CCB} voltage 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.
IO_SIM	SIM card bidirectional data input/output. The SIM card output must be on an open-drain driver. This pin is pulled low during shutdown through a 450 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.

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CCA}	Host supply voltage		GND - 0.5	2.2	V
V_{CCB}	SIM supply voltage		GND - 0.5	4.0	V
$V_{I(CLK\_HOST)}$, $V_{I(RST\_HOST)}$, $V_{I(IO\_HOST)}$	Input voltage on CLK_HOST, RST_HOST, IO_HOST pins	Input signal voltage, HOST side	GND - 0.5	2.2	V
$V_{I(CLK\_SIM)}$, $V_{I(RST\_SIM)}$, $V_{I(IO\_SIM)}$	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

3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CCA}	Host supply voltage		1.08	1.95	V
V_{CCB}	SIM supply voltage		1.65	3.6	V
V_{IH}	High-level input voltage	IO_HOST, RST_HOST, CLK_ HOST	0.7 × V_{CCA}		V
		IO_SIM	0.7 × V_{CCB}		V
V_{IL}	Low-level input voltage	IO_HOST, RST_HOST, CLK_ HOST		0.3 × V_{CCA}	V
		IO_SIM		0.25 × V_{CCB}	V
Δt/ΔV	Input transition rise or fall rate			200	ns/V

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Model	Condition	Value	Unit
HBM	ANSI/ESDA/JEDEC JS-001	±4000	V
CDM	ANSI/ESDA/JEDEC JS-002	±2000	V
	Contact discharge at SIM card side pins, VCCB, and GND pins	±8000	V
	Air discharge(1) at SIM card side pins, VCCB, and GND pins	±15000	V

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.

5. 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	Min	Typ	Max	Unit
Supplies						
V_{CCA}	Supply voltage		1.08		1.95	V
I_{CCA}	Supply current	Operating mode; f_{CLK_HOST} = 1 MHz; EN = V_{CCA}		2.5	10	μA
		Quiescent current; EN = V_{CCA}		0.01	1	μA
		Shutdown mode; EN = GND		0.42	1	μA
V_{CCB}	SIM supply voltage		1.65		3.6	V
I_{CCB}	SIM supply current	Quiescent current; EN = V_{CCA}		2.6	6.0	μA
Automatic enable feature: V_{CCB}						
V_{CCB_EN}	Enable voltage level	V_{CCA} ≥ 1.0 V, V_{CCB} rising edge	1.65			V
V_{CCB_DIS}	Disable voltage level	V_{CCA} ≥ 1.0 V, V_{CCB} falling edge			1.2	V
ΔV_{CCBen}	V_{CCBen} hysteresis voltage			120		mV
Hardware enable pin						
V_{IH}	High-level input voltage	EN pin threshold	0.7 × V_{CCA}		V_{CCA} + 0.3	V
V_{IL}	Low-level input voltage	EN pin threshold	-0.15		0.3 × V_{CCA}	V
Level shifter						
V_{IH}	High-level input voltage	RST_HOST, CLK_ HOST	0.65 × V_{CCA}		V_{CCA} + 0.3	V
		IO_HOST	0.6 × V_{CCA}		V_{CCA} + 0.3	V
		IO_SIM	0.6 × V_{CCB}		V_{CCB} + 0.3	V
V_{IL}	Low-level input voltage	RST_HOST, CLK_ HOST	-0.15		0.35 × V_{CCA}	V
		IO_HOST	-0.15		0.3 × V_{CCA}	V
		IO_SIM	-0.15		0.25 × V_{CCB}	V
R_{PU}	Pull-up resistance	IO_SIM connected to V_{CCB}		6		kΩ
		IO_HOST connected to V_{CCA}		5		kΩ
V_{OH}	High-level output voltage(1)	RST_SIM, CLK_SIM; I_{OH} = -1 mA	0.85 × V_{CCB}		V_{CCB} + 0.3	V
		IO_SIM; I_{OH} = -10 μA	0.85 × V_{CCB}		V_{CCB} + 0.3	V
		IO_HOST; I_{OH} = -10 μA	0.85 × V_{CCA}		V_{CCA} + 0.3	V
V_{OL}	Low-level output voltage(1)	RST_SIM, CLK_SIM; I_{OL} = 1 mA	0		0.12 × V_{CCB}	V
		IO_SIM; I_{OL} = 1 mA	0		0.12 × V_{CCB}	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		450		Ω
EMI filter						
R_S	Series resistance	IO_SIM		44		Ω
		RST_SIM		44		Ω
		CLK_SIM		44		Ω
C_{io}(2)	Input/Output capacitance	IO_SIM		10		pF
		RST_SIM		10		pF
		CLK_SIM		10		pF

Note:

(1) See Figure 2.

(2) Guaranteed by design.

(3) Specifications subject to change without notice.

6. Dynamic Characteristics

1.65 V ≤ V_{CCB} ≤ 3.6 V; 1.08 V ≤ V_{CCA} ≤ 1.95 V; f_{CLK} = f_{io} = 1 MHz; T_A = -40 °C to 85 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CCA} = 1.8 V; V_{CCB} = 3.0 V; SIM card C_L ≤ 30 pF; host C_L ≤ 10 pF						
t_{PD}(1)	Propagation delay	I/O channel; SIM card side to host side		12		ns
		All channels; host side to SIM card side		10		ns
t_{TLH}(1)	Transition time, rising	I/O channel; SIM card side to host side		4		ns
		All channels; host side to SIM card side		4		ns
t_{THL}(1)	Transition time, falling	I/O channel; SIM card side to host side		4		ns
		All channels; host side to SIM card side		4		ns
$t_{sk(o)}$	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 V; SIM card C_L ≤ 30 pF; host C_L ≤ 10 pF						
t_{PD}(1)	Propagation delay	I/O channel; SIM card side to host side		16		ns
		All channels; host side to SIM card side		15		ns
t_{TLH}(1)	Transition time, rising	I/O channel; SIM card side to host side		4		ns
		All channels; host side to SIM card side		7		ns
t_{THL}(1)	Transition time, falling	I/O channel; SIM card side to host side		4		ns
		All channels; host side to SIM card side		4		ns
$t_{sk(o)}$	Output skew time	Between channels IO_SIM and CLK_SIM		2		ns
f_{CLK}	Clock frequency	CLK_SIM		10		MHz

Note:

(1) See Figure 2.

(2) Specification subject to change without notice.

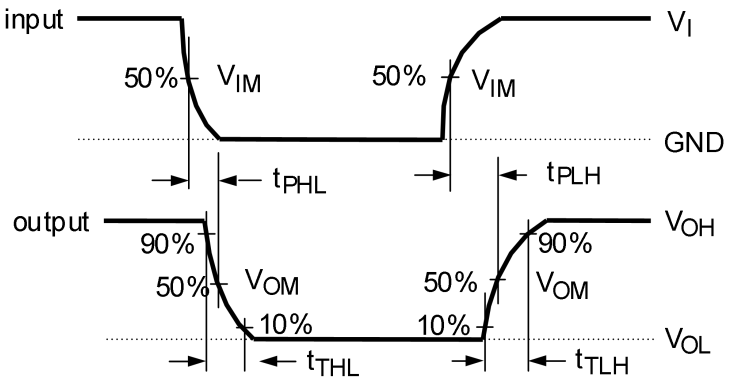
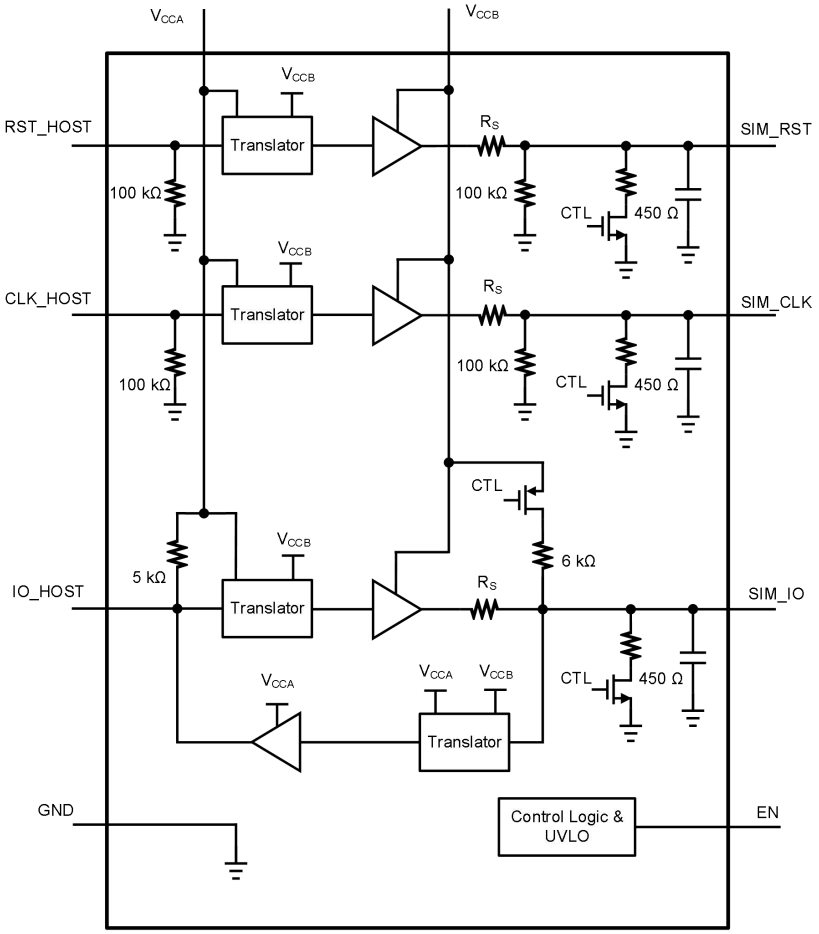


Figure 2. Data input to data output propagation delay times

Note:

(1) 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.

7. Block Diagram



8. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

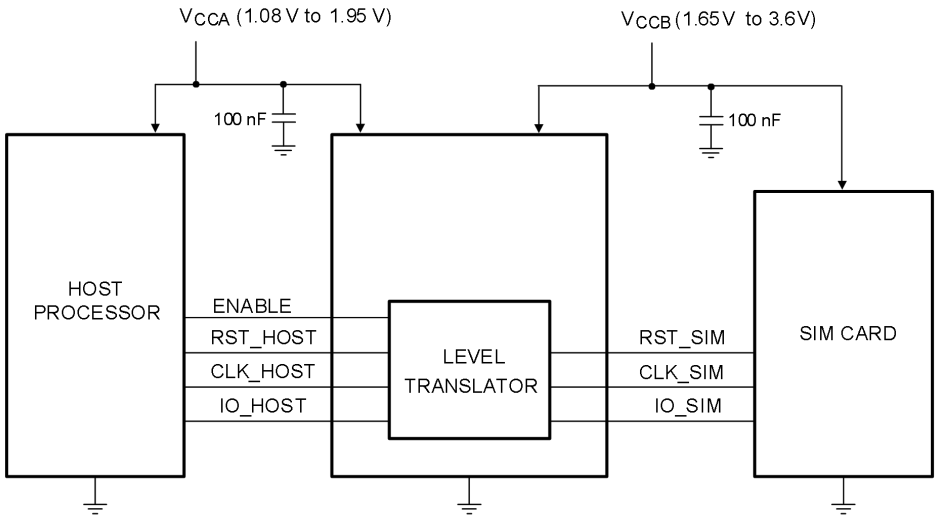


Figure 3. Application circuit interfacing with typical SIM card

8.1. Embedded enable

The embedded enable feature is available for the QFN1.8*1.4-10 package when the enable pin of the QFN package is tied to V_{CCA}. The DIO74557S 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 I/O pin on the host side is set up as an input with a 5 kΩ 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 450 Ω resistor. Furthermore, both the host and card side CLK/RST pins have a 100 kΩ pull-down resistor. The 450 Ω resistor is used for discharge during V_{CCB} power off (when $V_{TH} < V_{CCB} < V_{CCB\_EN}$), while the 100 kΩ resistor is used to keep RST_SIM/CLK_SIM low when V_{CCB} is below V_{TH}.

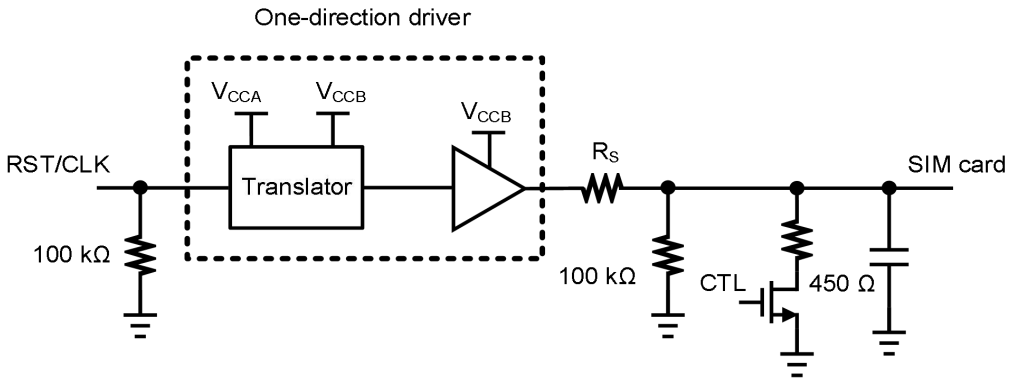


Figure 4. RST/CLK voltage level translation architecture

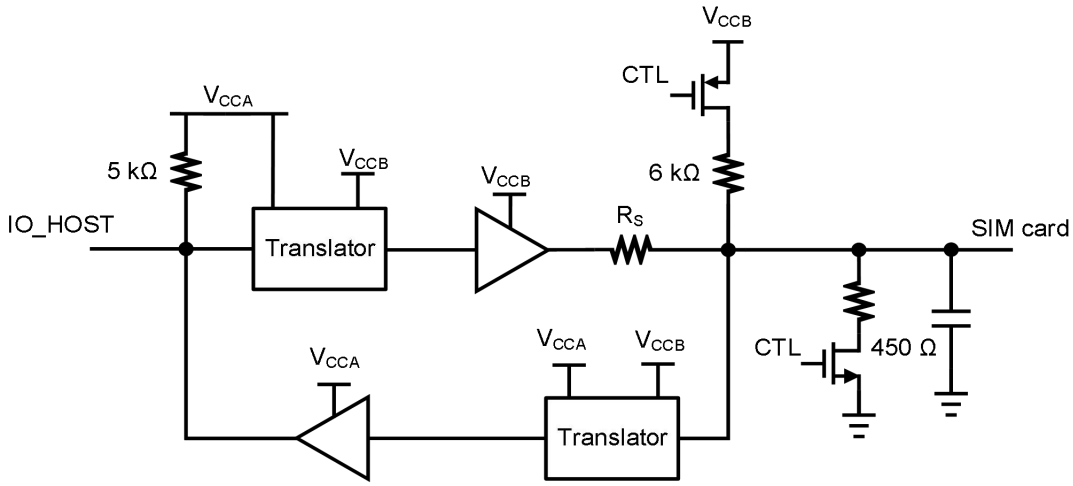


Figure 5. I/O voltage level translation architecture

8.2. EN shutdown mode

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.

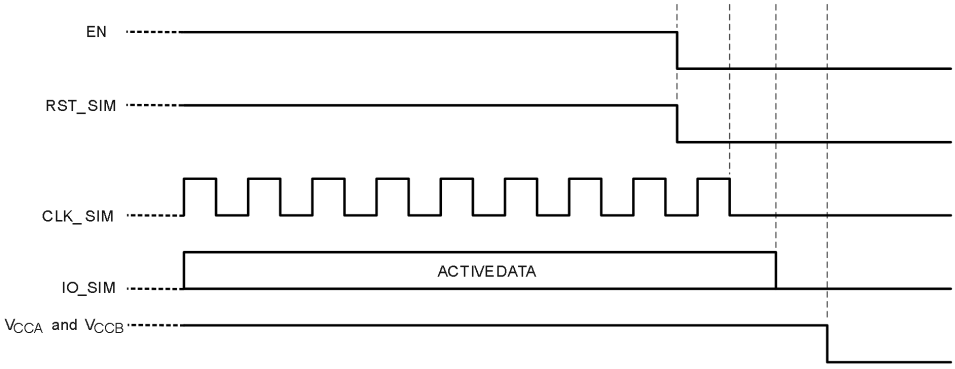


Figure 6. Shutdown sequence

8.3. 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 mΩ (with a typical value being 50 mΩ).

8.4. 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.

8.5. EMI filter

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

8.6. ESD protection

The DIO74557S 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.

9. Function Description

Supply Voltage		Input	Input/Output		Operational Mode
V_{CCA}	V_{CCB}	EN (1, 2)	Host	SIM Card	
1.08 V to 1.95 V	1.65 V to 3.6 V	H	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 table, Condition B		Shutdown
GND	1.65 V to 3.6 V	X	See the below table, Condition B		Shutdown
1.08 V to 1.95 V	GND	X	See the below table, Condition A		Shutdown
GND	GND	X	See the below table, Condition A		Shutdown

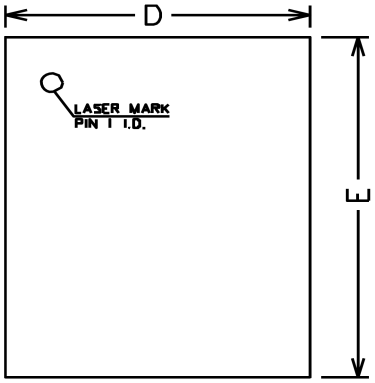
Note:

(1) H = HIGH voltage level; L = LOW voltage level; X = inconsequential.

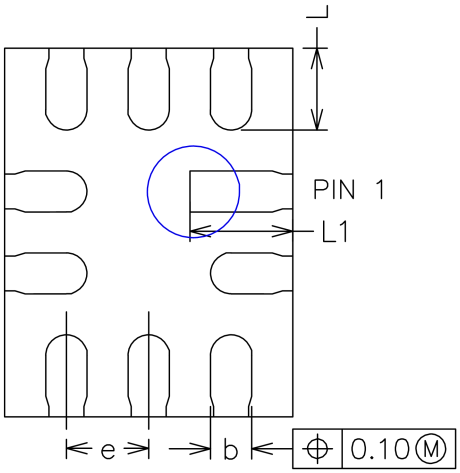
(2) V_{IL} and V_{IH} are referenced to V_{CCA}. The EN can be controlled by an external device limit of V_{CCA} + 0.3 V.

Pin Condition	Condition A	Condition B
RST_HOST	100 kΩ pull low	100 kΩ pull low
CLK_HOST	100 kΩ pull low	100 kΩ pull low
IO_HOST	5 kΩ pull to V_{CCA}	5 kΩ pull to V_{CCA}
RST_SIM	100 kΩ pull low	450 Ω pull low
CLK_SIM	100 kΩ pull low	450 Ω pull low
IO_SIM	High Z	450 Ω pull low

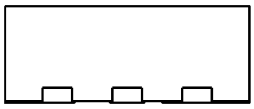
10. Physical Dimensions: QFN1.8*1.4-10



TOP VIEW

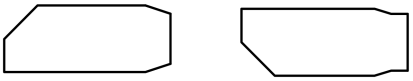


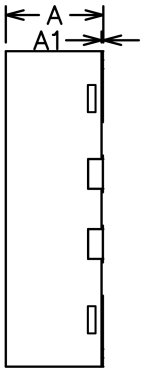
BOTTOM VIEW



SIDE VIEW

Two options





SIDE VIEW

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

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