1.8 V Dual-Channel, Single-lane USB 3.2 Gen1 Redriver

Features

- Dual-channel, single-lane USB 3.2 Gen1 5 Gbps redriver with 1.8 V power supply
- Support full USB 3.2 Gen1 mode switching with automatic power saving
- Ultra-low-power architecture
  - Power down mode: 40 μA
  - Suspend mode: 85 μA
  - Power saving mode: 2.5 mA
  - Active: 130 mA
- Optimal receiver equalization
  - 4, 6, 10 and 14 dB
- Output driver de-emphasis
  - 0, 2, 2.5 and 4 dB
- Support low frequency periodic signaling (LFPS) detection
- Support hot plug with automatic receiver detection
- Integrated 50 Ω termination resistors for RX & TX Internal soft start limits the inrush current
- Operating temperature range: -40°C to 85°C

Applications

- Desktop and laptop computers
- Workstations
- Docking station

Package Information

Part Number	Package	Body Size
DIO36812	QFN-24	4 mm × 4 mm

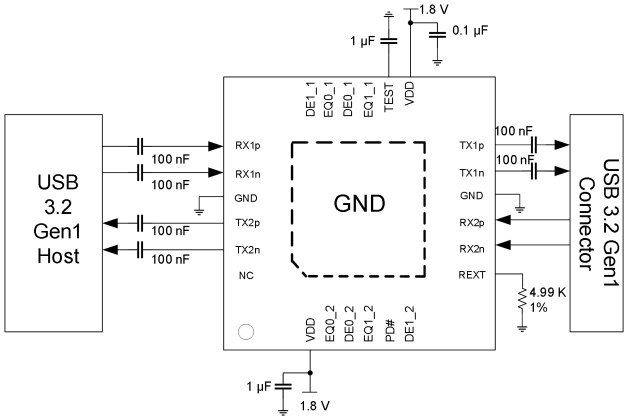
Description

The DIO36812 is a dual-channel, single-lane USB 3.2 Gen1 5 Gbps redriver. The device offers low power consumption on a 1.8 V supply with its ultra-low-power architecture. The redriver also supports the suspend mode, which further reduces power consumption.

The dual-channel capability enables the system to maintain signal integrity on both transmit and receive data paths. The receiver equalization has four gain settings to overcome channel degradation from insertion loss and inter-symbol interference. These settings are controlled from the EQ pins. To compensate for transmission line losses, the output driver supports configuration of de-emphasis with pins DE.

The DIO36812 can be placed close to USB connector to compensate for board electrical signal losses and regenerate high-quality USB 3.2 Gen1 electrical signals.

Simplified Schematic



Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIO36812CN24	DCFH1B	3	Green	-40 to 85°C	QFN4*4-24	Tape & Reel, 5000

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 experience.

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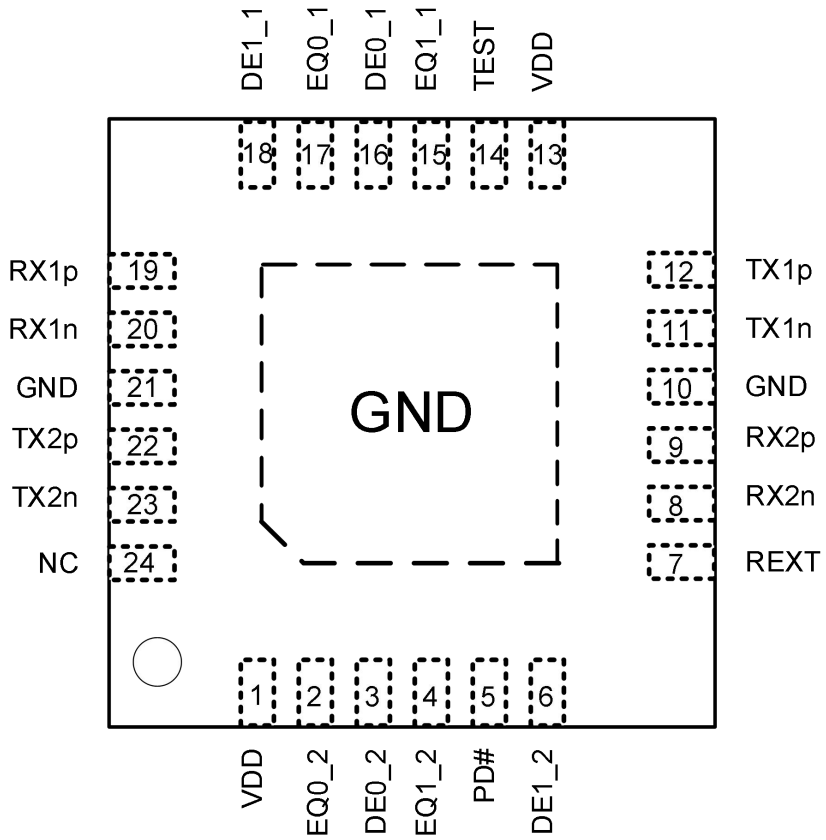
1. Pin Assignment and Functions



QFN4*4-24
Top view

Pin No.	Name	I/O	Description
19	RX1p	I	Differential input for 5 Gbps positive signal on Channel 1
20	RX1n	I	Differential input for 5 Gbps negative signal on Channel 1
12	TX1p	O	Differential output for 5 Gbps positive signal on Channel 1
11	TX1n	O	Differential output for 5 Gbps negative signal on Channel 1
9	RX2p	I	Differential input for 5 Gbps positive signal on Channel 2
8	RX2n	I	Differential input for 5 Gbps negative signal on Channel 2
22	TX2p	O	Differential output for 5 Gbps positive signal on Channel 2
23	TX2n	O	Differential output for 5 Gbps negative signal on Channel 2
7	REXT	I/O	This pin should be connected to a 4.99 kΩ resistor to GND
5	PD#	I	Chip power down, active low. A tolerance of 1.8 V. Internally pulled up at 100 kΩ

17,15	EQ0_1 EQ1_1	I	Equalizer control and program for channel 1. 1.8 V tolerant. Internally pulled down at 100 kΩ. [EQ1_1, EQ0_1] == LL: program EQ for channel loss up to 4 dB (default) LH: program EQ for channel loss up to 6 dB HL: program EQ for channel loss up to 10 dB HH: program EQ for channel loss up to 14 dB
16, 18	DE0_1 DE1_1	I	Programmable output de-emphasis level setting for channel 1. 1.8 V tolerant. Internally pulled down at 100 kΩ. [DE1_1, DE0_1] == LL: 2.5 dB de-emphasis (default) LH: No de-emphasis HL: 2 dB de-emphasis HH: 4 dB de-emphasis
2, 4	EQ0_2 EQ1_2	I	Equalizer control and program for channel 2. 1.8 V tolerant. Internally pulled down at 100 kΩ. [EQ1_2, EQ0_2] == LL: program EQ for channel loss up to 4 dB (default) LH: program EQ for channel loss up to 6 dB HL: program EQ for channel loss up to 10 dB HH: program EQ for channel loss up to 14 dB
3, 6	DE0_2 DE1_2	I	Programmable output de-emphasis level setting for channel 2. 1.8 V tolerant. Internally pulled down at 100 kΩ. [DE1_2, DE0_2] == LL: 2.5 dB de-emphasis (default) LH: No de-emphasis HL: 2 dB de-emphasis HH: 4 dB de-emphasis
14	TEST	I	Floating or ground connection, 1 μF capacitor connected to ground.
24	NC		No connection.
10, 21	GND	P	Ground connection.
1, 13	VDD	P	1.8 V power supply
	Exposed pad		Ground connection.

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	Rating	Unit
V_{DD}	Supply voltage	-0.5 to V_{DD} + 0.5	V
$V_{I/O}$	Normal I/O voltage	-0.5 to V_{DD} + 0.5	V
P_D	Maximum power dissipation rating, T_A = 85ºC	850	mW

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	Rating	Unit
V_{DD}	Supply voltage	1.8	V
$V_{I/O}$	Normal I/O voltage	1.8	V
T_A	Operating free-air temperature	-40 to 85	ºC

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	Human-body model	±8	kV
CDM	Charged-device model	±2	kV

5. Thermal Considerations

The thermal resistance determines the heat insulation property of a material. The higher the thermal resistance is, the lower the heat loss. Accumulation of heat energy degrades the performance of semiconductor components.

Symbol	Condition	Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	50	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25	°C/W

6. Electrical Characteristics

The values are obtained under these conditions unless otherwise specified: T_A = -40°C to 85°C, typical values are at V_{DD} = 1.8 V, T_A = 25°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Operation						
V_{DD}	Supply voltage		1.71	1.8	1.89	V
$C_{COUPLING}$	AC coupling capacitors		75		265	nF
I_{DD}	Normal supply current	REXT = 4.99 kΩ; default setting; K28.5 at 5 Gbps		130		mA
$I_{POWER-SAVING}$	Power saving mode current	Default setting; bus electrical idle		2.5		mA
$I_{SUSPEND}$	Suspend mode current	Default setting; cable unplugged (or disabled state); RX.Detect mode		85		µA
$I_{POWER-DOWN}$	Power down supply current	PD# = GND		40		µA
P_{NORM}	Power consumption at normal operation mode	REXT = 4.99 kΩ; default setting; K28.5 at 5 Gbps		234		mW
$P_{POWER-SAVING}$	Power consumption at power saving mode	Default setting; bus electrical idle		4.5		mW
$P_{SUSPEND}$	Power consumption at suspend mode	Default setting; cable unplugged (or disabled state); RX.Detect mode		0.153		mW
$P_{POWER-DOWN}$	Power consumption at power-down mode	PD# = GND		0.072		mW
Receiver AC/DC characteristics						
$V_{RX\_DIFF\_PP}$	Differential input peak to peak voltage		100		1200	mV
$R_{RX-HIGHIMP-DC-POS}$	Common-mode input impedance with termination disabled (DC)	RX1p-RX1n	50			kΩ
$R_{RX\_DC\_CM}$	RX DC common mode impedance		18		30	Ω
$R_{RX\_DIFF\_DC}$	RX DC differential impedance		72		120	Ω
$V_{RX\_CM\_DC}$	RX common mode voltage			0		V
$V_{RX\_LFPS\_DET}$	LFPS signal detection threshold		100		300	mV
$t_{POWER-SAVING-ENTER}$	Bus idle time before entering power saving mode	See Figure 4		4		ms
$t_{POWER\_SAVING\_EXIT}$	Power saving to normal operation exit time	See Figure 4		5		µs

t_{IDLE_ENTER}	Electrical idle enter time	See Figure 2			10	ns
t_{IDLE_EXIT}	Electrical idle exit time	See Figure 2			6	ns
Transmitter AC/DC characteristics						
$V_{TX\_DIFF\_PP}$	Differential peak to peak output voltage	R_{LOAD} = 100 Ω; REXT = 4.99 kΩ ; See Figure 3	800	1100	1200	mV
$R_{TX\_DIFF\_DC}$	DC differential impedance	Normal operation	72		120	Ω
$V_{TX\_CM\_DC}$	TX common mode voltage	See Figure 3		0.7		V
$V_{TX\_CM\_AC}$	TX AC common mode voltage				100	mVpp
t_{RISE} / t_{FALL}	TX output 20% to 80% rise time / fall time			80		ps
t_{SKEW_INTRA}	TX output intra-pair skew			10		ps
$t_{PROPAGATION}$	Differential propagation delay			300		ps
Control Logic						
V_{IH}	High level input voltage		0.65V_{DD}			V
V_{IL}	Low level input voltage				0.35V_{DD}	V
I_{IH}	High level input current				30	μA
I_{IL}	Low level input current		-30			μA
Equalization						
D_J(1)	Deterministic jitter	Default setting; FR4 trace to the input: 13.5 inches by length and 4-mil by width, see Figure1; K28.5 at 5 Gbps		0.1		UIpp(2)
T_J(1, 3)	Total jitter			0.25		UIpp(2)

Note:

(1) Measured at the TP C with K28.5 pattern, V_{ID} = 1000 mVpp, 5.0 Gbps.

(2) UI = 200 ps.

(3) R_J calculated as 14.069 times the RMS random jitter for 10^{-12} BER, source R_J is included.

(4) Specifications subject to change without notice.

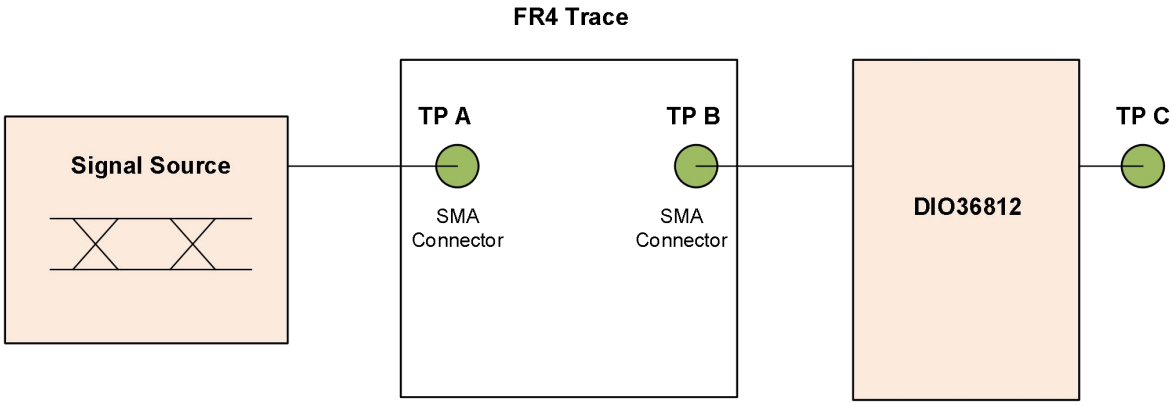


Figure 1. Measurement setup

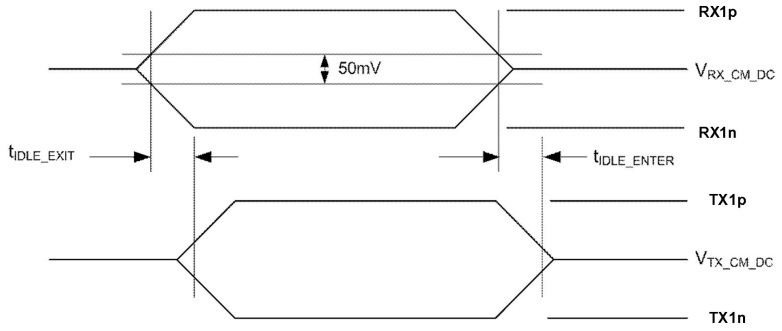


Figure 2. Idle mode exit and enter timing

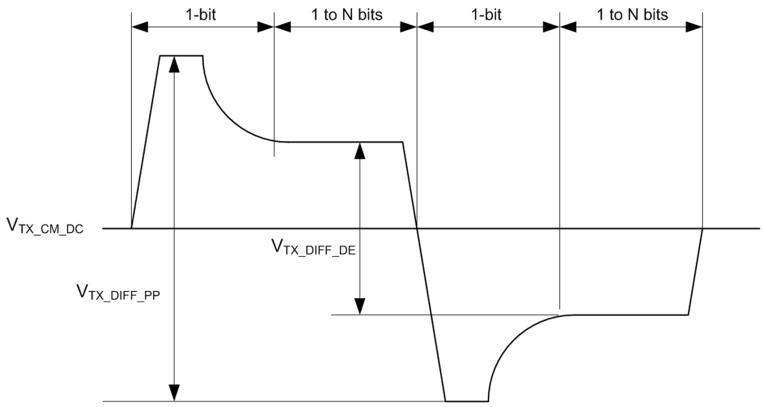


Figure 3. TX differential output with de-emphasis

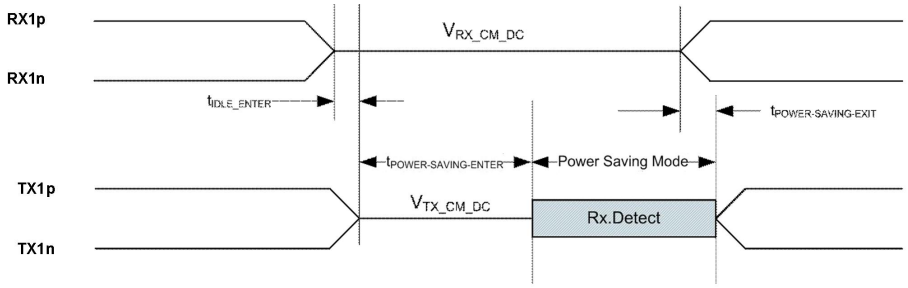


Figure 4. Automatic power saving

7. Block Diagram

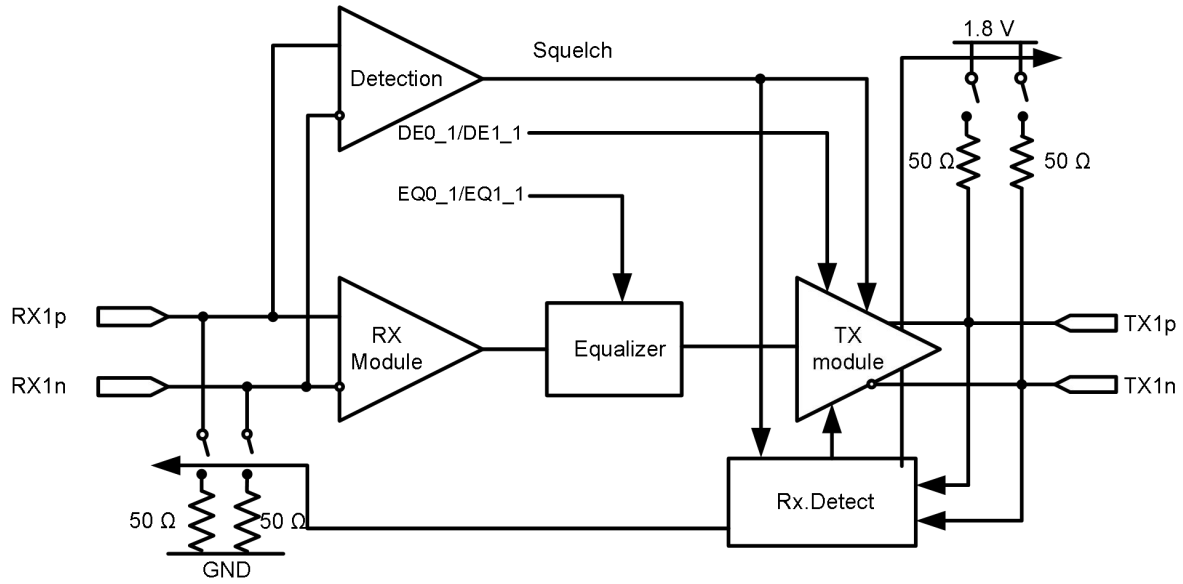


Figure 5. Block diagram for channel 1

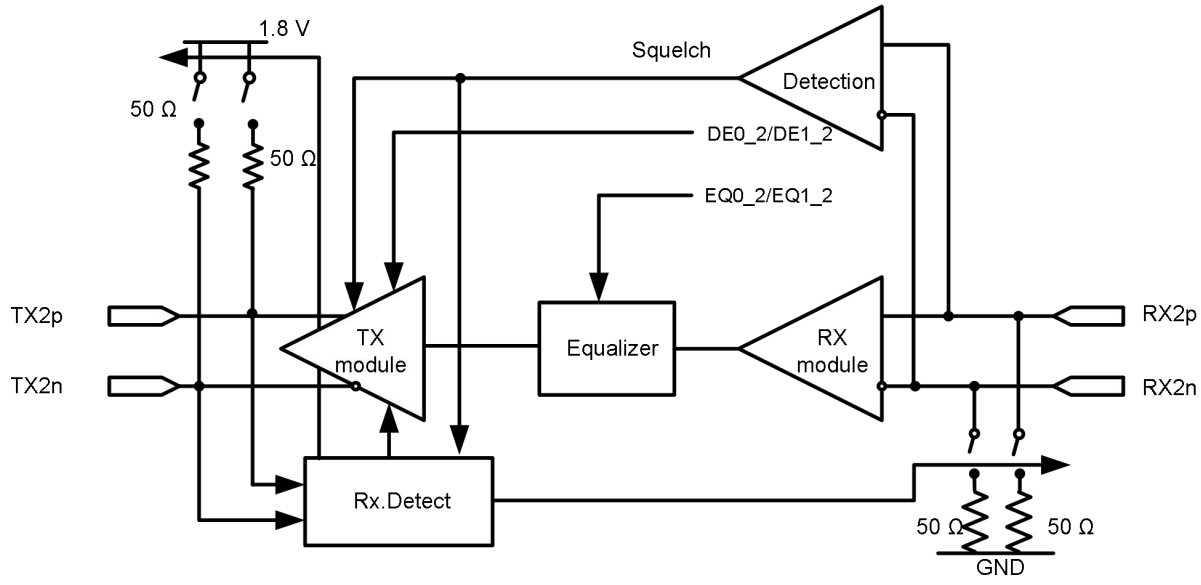


Figure 6. Block diagram for channel 2

8. Function Description

8.1. Programmable receiving equalization

The DIO36812 is the bidirectional USB 3.2 Gen1 repeater / redriver that integrates two channel equalizers and drivers to re-condition USB 3.2 Gen1 signals. The DIO36812 supports USB 3.2 Gen1 with an operation speed of 5.0 Gbps. Placing the device close to USB connector can compensate for board electrical signal losses and regenerate high-quality USB 3.2 Gen1 electrical signals.

8.2. Output de-emphasis

The DIO36812 provides 2 dB, 2.5 dB (default) and 4 dB programmable output de-emphasis levels for both channels. The de-emphasis levels can be programmed by external pins to optimize the output eye diagrams and thus the output performances.

8.3. Automatic squelch

The input and output signals shall be AC coupled to DIO36812. The LFPS signaling is supported with fast amplitude detection on the inputs and the squelch on the corresponding outputs.

When input signals fall below the threshold level at the inputs for each channel, the squelch circuit will drive the outputs to common mode voltage. The DIO36812 also implements the automatic power saving feature; when the input is detected has no signal (bus idle) for a predefined time ($t_{POWER-SAVING-ENTER}$) on this channel, the corresponding channel goes into power saving mode .

8.4. Receiver detection

Rx.Detect (receiver termination detection) detects the states of unplug / plug or disable / enable from the link connection. To perform the Rx.Detect cycle, first set Rx termination to high impedance for each channel and then monitor the receiver termination to determine the input termination turned on or not. The device attempts to detect Rx termination in a typical 5 ms interval as specified in USB 3.2 specifications.

8.5. Automatic power saving

Because the data payload only occupies the USB 3.2 Gen1 interface for a fraction time, the automatic power saving management will be particularly useful for the power sensitive applications such as in notebook computers. Whenever the channel in idle is longer than a prolonged time, the corresponding channel will enter power saving mode automatically. As soon as any LFPS signaling is detected on this channel, the channel will exit the power saving mode immediately and be able to function as a conditioner in normal operation. By automatic power saving management, the DIO36812 in power saving mode could save 98% power consumption more than in full operating mode.

The DIO36812 supports four power modes as the following describes:

- **Normal operation mode**

  In normal operation mode, the chip is fully functional and loss of signal (LOS) detection monitors the input signal amplitude at channel 1 and channel 2.

- **Power saving mode**

  As soon as the input signal amplitude on the channel falls below the threshold level for a predefined

time ($t_{POWER-SAVING-ENTER}$), the main link of this channel is powered down, thereafter the channel enters power saving mode. In this mode, the LOS detection still monitors the input signal amplitudes when the Rx.Detect is monitoring the far end Rx termination conditions to determine whether the input terminations need to be high impedance and transfer to suspend mode.

- Suspend mode

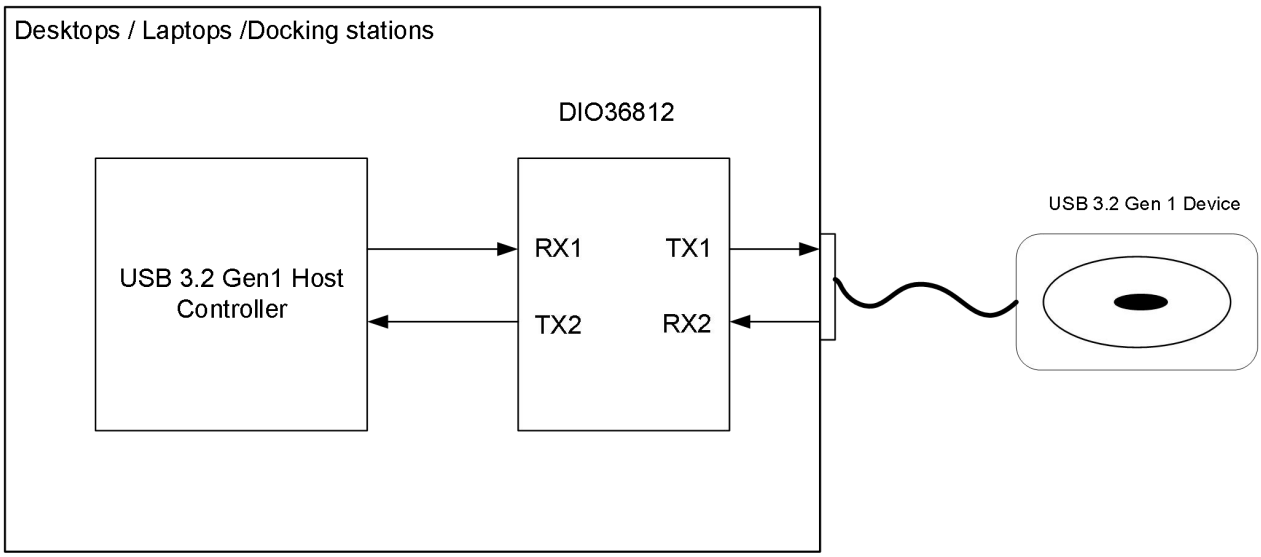
As soon as the Rx.Detect detects a break in link or fails to find a remote device after power up, the corresponding channel will enter suspend mode. In this mode, Rx.Detect monitors the far end Rx termination conditions continuously. As soon as the termination resistors are detected, the corresponding input terminations will be turned on.

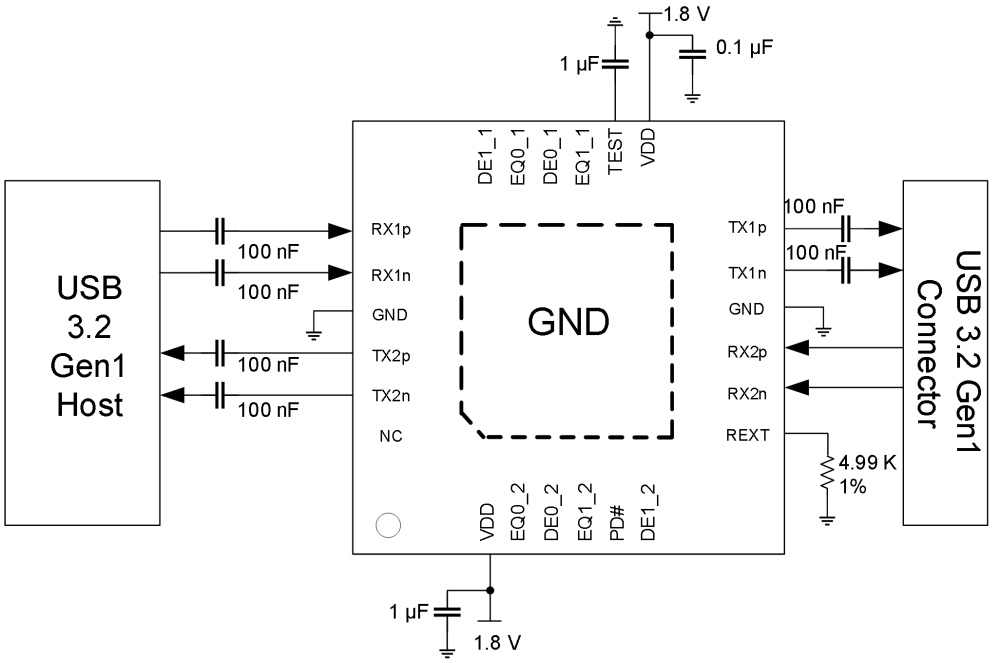
- Power down mode

Pulling the PD# low drives the DIO36812 into power down mode.

9. 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.



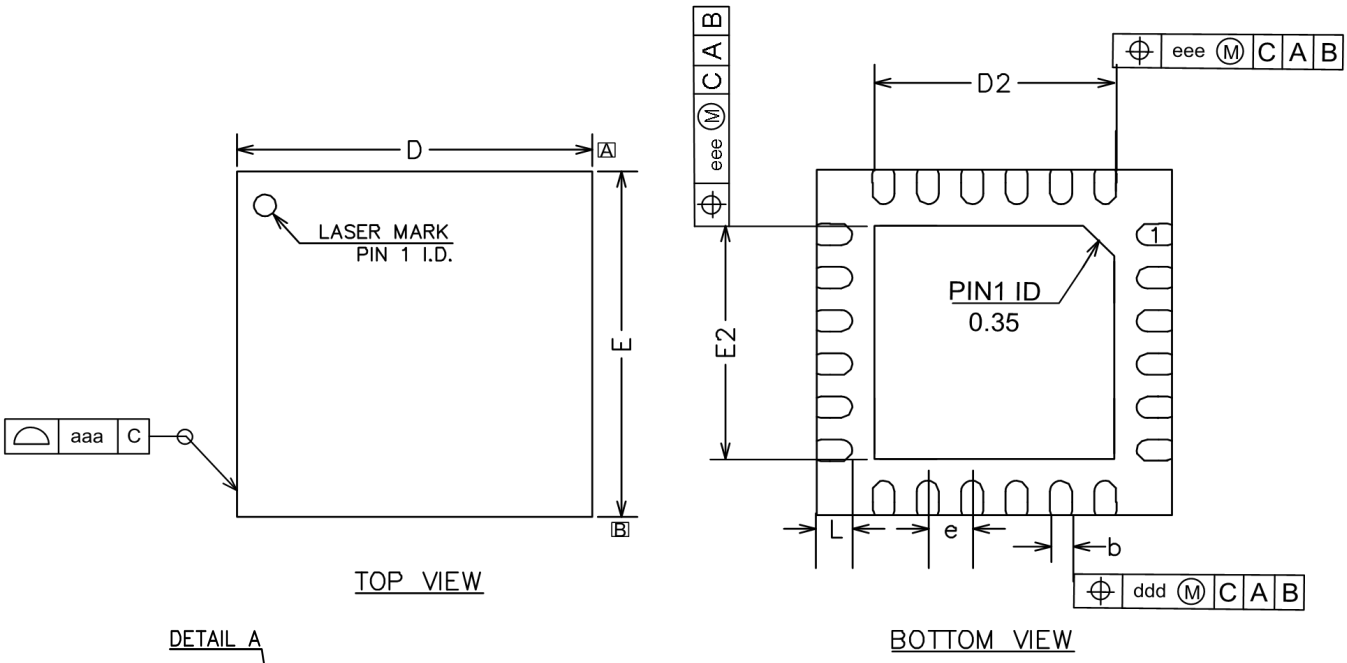


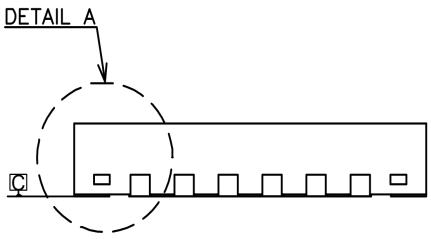
Note:

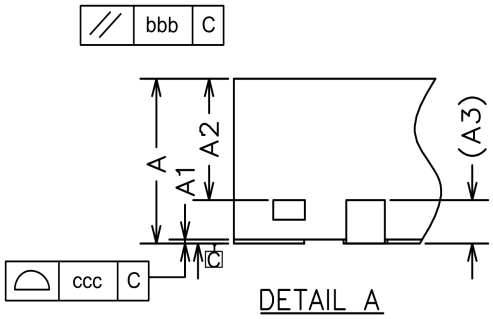
(1) PD# pin has an internal pull-up resistor of 100 kΩ. In normal application, it can be left open or controlled by GPIO.

(2) EQ1_1, EQ0_1, DE1_1, DE0_1, EQ1_2, EQ0_2, DE1_2, and DE0_2 have an internal pull-down resistor of 100 kΩ. To adjust performance, add an optional resistor of 4.7 kΩ to 1.8 V.

10. Physical Dimensions: QFN4*4-24







Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	-	0.55	-
A3	0.203 REF		
b	0.20	0.25	0.30
D	3.90	4.00	4.10
E	3.90	4.00	4.10
D2	2.60	2.70	2.80
E2	2.60	2.70	2.80
L	0.3	0.4	0.5
e	0.50 BSC		
aaa	0.10		
bbb	0.10		
ccc	0.08		
ddd	0.10		
eee	0.10		

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