2Pai Semi

Enhanced ESD, 3.0 kV rms 10Mbps Single-Channel Digital Isolators

Data Sheet **π110M**

FEATURES

- **Ultra low power consumption:**
  - **0.55mA/Channel**
- **High data rate:** **π110A3x: 600Mbps**
  π110E3x: 200Mbps
  π110M3x: 10Mbps
- **High common-mode transient immunity: 50 kV/μs typical**
- **High robustness to radiated and conducted noise**
- **Low propagation delay:**
  - **7.5 ns typical for 5 V operation**
  - **9 ns typical for 3.3 V operation**
- **Isolation voltages:**
  - **π110x3x: AC 3000Vrms**
- **High ESD rating:**
  - **ESDA/JEDEC JS-001-2017**
  - **Human body model (HBM) ±7kV, all pins**
- **Safety and regulatory approvals：**
  - **UL certificate number: E494497**
    - **3000Vrms for 1 minute per UL 1577**
  - **CSA Component Acceptance Notice 5A(Pending)**
  - **VDE certificate number: 40047929**
    - **DIN V VDE V 0884-10 (VDE V 0884-10):2006-12**
    - **V_{IORM} = 565V peak**
  - **CQC certification per GB4943.1-2011(Pending)**
- **3 V to 5.5 V level translation**
- **AEC-Q100 qualification**
- **Wide temperature range: -40°C to 125°C**
- **8-lead, RoHS-compliant, SOIC package**

APPLICATIONS

- **General-purpose multichannel isolation**
- **Industrial field bus isolation**

GENERAL DESCRIPTION

The π1xxxxx are 2PaiSemi digital isolators product family. By using maturated standard semiconductor CMOS technology and innovative design, these isolation components provide outstanding performance characteristics superior to alternatives such as optocoupler devices and other integrated isolators. The π1xxxxx isolator data channels are independent and are available in a variety of configurations with a withstand voltage rating of 3.0 kV rms to 6.0 kV rms and the data rate from DC up to 600Mbps (see the Ordering Guide). The devices operate with the supply voltage on either side ranging from 3.0 V to 5.5 V, providing compatibility with lower voltage systems as well as enabling voltage translation functionality across the isolation barrier.

The fail-safe state is available in which the outputs transition to a preset state when the input power supply is not applied.

FUNCTIONAL BLOCK DIAGRAMS

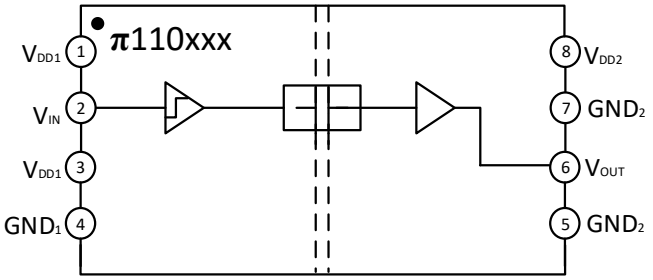


Figure1. π110xxx functional Block Diagram

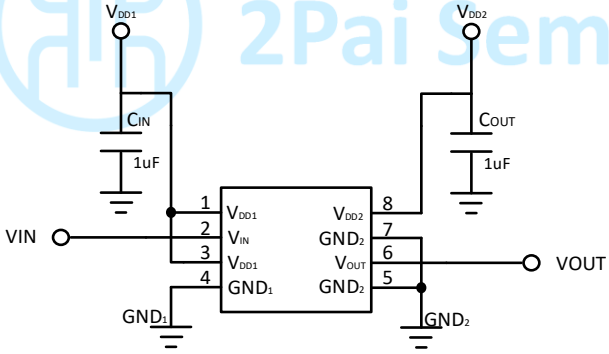


Figure2. π110xxx Typical Application Circuit

Room 19307, Building 8, No.498, GuoShouJing Road, Pudong New District, Shanghai, 201203, China 021-50850681

http://www.rpsemi.com/

PIN CONFIGURATIONS AND FUNCTIONS

π110M3x Pin Function Descriptions

Pin No.	Name	Description
1	V_{DD1}	Supply Voltage for Isolator Side 1.
2	V_{IN}	Logic Input.
3	V_{DD1}	Supply Voltage for Isolator Side 1.
4	GND_1	Ground 1. This pin is the ground reference for Isolator Side 1.
5	GND_2	Ground 2. This pin is the ground reference for Isolator Side 2.
6	V_{OUT}	Logic Output.
7	GND_2	Ground 2. This pin is the ground reference for Isolator Side 2.
8	V_{DD2}	Supply Voltage for Isolator Side 2.

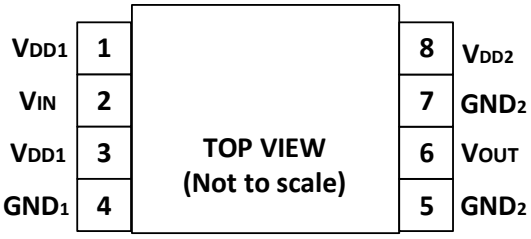


Figure3. π110M3x Pin Configuration

ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted.

Table 1. Absolute Maximum Ratings[4]

Parameter	Rating
Supply Voltages (V_{DD1}-GND_1, V_{DD2}-GND_2)	−0.5 V to +7.0 V
Input Voltages (V_{IA}, V_{IB})[1]	−0.5 V to V_{DDx} + 0.5 V
Output Voltages (V_{OA}, V_{OB})[1]	−0.5 V to V_{DDx} + 0.5 V
Average Output Current per Pin[2] Side 1 Output Current (I_{O1})	−10 mA to +10 mA
Average Output Current per Pin[2] Side 2 Output Current (I_{O2})	−10 mA to +10 mA
Common-Mode Transients Immunity[3]	−150 kV/µs to +150 kV/µs
Storage Temperature (T_{ST}) Range	−65°C to +150°C
Ambient Operating Temperature (T_A) Range	−40°C to +125°C

Notes:

[1] V_{DDx} is the side voltage power supply V_{DD}, where x = 1 or 2.

[2] See Figure4 for the maximum rated current values for various temperatures.

[3] See Figure13 for Common-mode transient immunity (CMTI) measurement.

[4] Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

RECOMMENDED OPERATING CONDITIONS

Table 2. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{DDx} [1]	3		5.5	V
High Level Input Signal Voltage	V_{IH}	0.7*V_{DDx}[1]		V_{DDx}[1]	V
Low Level Input Signal Voltage	V_{IL}	0		0.3*V_{DDx}[1]	V
High Level Output Current	I_{OH}	-6			mA
Low Level Output Current	I_{OL}			6	mA
Maximum Data Rate		0		10	Mbps
Junction Temperature	T_J	-40		150	°C
Ambient Operating Temperature	T_A	-40		125	°C

Notes:

[1] V_{DDx} is the side voltage power supply V_{DD}, where x = 1 or 2.

Truth Tables

Table 3. π110xxx Truth Table

V_{Ix} Input[1]	V_{DDI} State[1]	V_{DDO} State[1]	Default Low V_{Ox} Output[1]	Default High V_{Ox} Output[1]	Test Conditions /Comments
Low	Powered[2]	Powered[2]	Low	Low	Normal operation
High	Powered[2]	Powered[2]	High	High	Normal operation
Open	Powered[2]	Powered[2]	Low	High	Default output
Don't Care[4]	Unpowered[3]	Powered[2]	Low	High	Default output[5]
Don't Care[4]	Powered[2]	Unpowered[3]	High Impedance	High Impedance	

Notes:

[1] V_{Ix}/V_{Ox} are the input/output signals of a given channel (A or B). V_{DDI}/V_{DDO} are the supply voltages on the input/output signal sides of this given channel.

[2] Powered means V_{DDx}≥ 2.9 V

[3] Unpowered means V_{DDx} < 2.3V

[4] Input signal (V_{Ix}) must be in a low state to avoid powering the given V_{DDI}[1] through its ESD protection circuitry.

[5] If the V_{DDI} goes into unpowered status, the channel outputs the default logic signal after around 1us. If the V_{DDI} goes into powered status, the channel outputs the input status logic signal after around 1us.

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

Table 4. Switching Specifications

V_{DD1} - V_{GND1} = V_{DD2} - V_{GND2} = 3.3V_{DC}±10% or 5V_{DC}±10%, T_A=25°C, unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
Minimum Pulse Width	PW			100	ns	Within pulse width distortion (PWD) limit
Maximum Data Rate		10			Mbps	Within PWD limit
Propagation Delay Time[1,4]	t_{pHL}, t_{pLH}	5.5	7.5	9.6	ns	The different time between 50% input signal to 50% output signal 50% @ 5V_{DC} supply
		6.5	9	11.5	ns	@ 3.3V_{DC} supply
Pulse Width Distortion[4]	PWD	0	0.3	0.8	ns	The max different time between t_{pHL} and t_{pLH}@ 5V_{DC} supply. And The value is | t_{pHL} - t_{pLH} |
		0	0.3	0.8	ns	@ 3.3V_{DC} supply
Part to Part Propagation Delay Skew[4]	t_{PSK}			1	ns	The max different propagation delay time between any two devices at the same temperature, load and voltage @ 5V_{DC} supply
				1	ns	@ 3.3V_{DC} supply
Output Signal Rise/Fall Time[4]	t_r/t_f		0.7		ns	10% to 90% signal terminated 50Ω, See figure9.
Dynamic Input Supply Current per Channel	$I_{DDI (D)}$		9		μA /Mbps	Inputs switching, 50% duty cycle square wave, CL = 0 pF @ 5V_{DC} Supply
Dynamic Output Supply Current per Channel	$I_{DDO (D)}$		38		μA /Mbps	Inputs switching, 50% duty cycle square wave, CL = 0 pF @ 5V_{DC} Supply
Dynamic Input Supply Current per Channel	$I_{DDI (D)}$		5		μA /Mbps	Inputs switching, 50% duty cycle square wave, CL = 0 pF @ 3.3V_{DC} Supply
Dynamic Output Supply Current per Channel	$I_{DDO (D)}$		23		μA /Mbps	Inputs switching, 50% duty cycle square wave, CL = 0 pF @ 3.3V_{DC} Supply
Common-Mode Transient Immunity[3]	CMTI		50		kV/μs	V_{IN} = V_{DDx}[2] or 0V, V_{CM} = 1000 V
Jitter			120		ps p-p	See the Jitter Measurement section

		20	ps rms	See the Jitter Measurement section
ESD（HBM - Human body model）	ESD	±7	kV	all pins

Notes:
[1] t_{pLH} = low-to-high propagation delay time, t_{pHL} = high-to-low propagation delay time. See figure 10.
[2] V_{DDx} is the side voltage power supply V_{DD}, where x = 1 or 2.
[3] See Figure13 for Common-mode transient immunity (CMTI) measurement.
[4] Output Signal Terminated 50Ω.

Table 5. DC Specifications

V_{DD1} - V_{GND1} = V_{DD2} - V_{GND2} = 3.3V_{DC}±10% or 5V_{DC}±10%, T_A=25°C, unless otherwise noted.

	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
High Level Input Signal Voltage	V_{IH}			0.7*V_{DDx}[1]	V	
Low Level Input Signal Voltage	V_{IL}	0.3* V_{DDX}[1]			V	
High Level Output Voltage	V_{OH} [1]	V_{DDx} – 0.1	V_{DDx}		V	−20 µA output signal
		V_{DDx} – 0.2	V_{DDx} – 0.1		V	−2 mA output signal
Low Level Output Voltage	V_{OL}		0	0.1	V	20 µA output signal
			0.1	0.2	V	2 mA output signal
Input Current per Signal Channel	I_{IN}	−10	0.5	10	µA	0 V ⩽ Signal voltage ⩽ V_{DDX}[1]
V_{DDx}[1] Undervoltage Rising Threshold	V_{DDxUV+}	2.45	2.65	2.9	V	
V_{DDx}[1] Undervoltage Falling Threshold	V_{DDxUV-}	2.3	2.5	2.75	V	
V_{DDx}[1] Hysteresis	V_{DDxUVH}		0.15		V	

Notes:
[1] V_{DDx} is the side voltage power supply V_{DD}, where x = 1 or 2.

Table 6. Quiescent Supply Current

V_{DD1} - V_{GND1} = V_{DD2} - V_{GND2} = 3.3V_{DC}±10% or 5V_{DC}±10%, T_A=25°C, C_L = 0 pF, unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
π110Mxx Quiescent Supply Current @ 5V_{DC} Supply	$I_{DD1 (Q)}$	117	146	190	µA	0V Input signal
	$I_{DD2 (Q)}$	326	407	529	µA	0V Input signal
	$I_{DD1 (Q)}$	118	148	192	µA	5V Input signal
	$I_{DD2 (Q)}$	293	366	476	µA	5V Input signal
@ 3.3V_{DC} Supply	$I_{DD1 (Q)}$	89	111	144	µA	0V Input signal
	$I_{DD2 (Q)}$	308	385	501	µA	0V Input signal
	$I_{DD1 (Q)}$	90	112	146	µA	3.3V Input signal
	$I_{DD2 (Q)}$	280	350	455	µA	3.3V Input signal

Table 7. Total Supply Current vs. Data Throughput (C_L = 0 pF)

V_{DD1} - V_{GND1} = V_{DD2} - V_{GND2} = 3.3V_{DC}±10% or 5V_{DC}±10%, T_A=25°C, C_L = 0 pF, unless otherwise noted.

Parameter	Symbol	150 Kbps			1 Mbps			10 Mbps			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
π110Mxx Supply Current @ 5V_{DC}	I_{DD1}		0.15	0.22		0.15	0.23		0.19	0.29	mA
	I_{DD2}		0.39	0.59		0.42	0.63		0.74	1.11	mA
@ 3.3V_{DC}	I_{DD1}		0.11	0.17		0.11	0.17		0.15	0.23	mA
	I_{DD2}		0.37	0.56		0.39	0.59		0.59	0.89	mA

INSULATION AND SAFETY RELATED SPECIFICATIONS

Table 8. Insulation Specifications

Parameter	Symbol	Value	Unit	Test Conditions/Comments
Rated Dielectric Insulation Voltage		3000	V rms	1-minute duration
Minimum External Air Gap (Clearance)	L (I01)	4.0	mm min	Measured from input terminals to output terminals, shortest distance through air
Minimum External Tracking (Creepage)	L (I02)	4.0	mm min	Measured from input terminals to output terminals, shortest distance path along body
Minimum Clearance in the Plane of the Printed Circuit Board (PCB Clearance)	L (PCB)	4.5	mm min	Measured from input terminals to output terminals, shortest distance through air, line of sight, in the PCB mounting plane
Minimum Internal Gap (Internal Clearance)		8	µm min	Insulation distance through insulation
Tracking Resistance (Comparative Tracking Index)	CTI	>400	V	DIN IEC 112/VDE 0303 Part 1
Material Group		II		Material Group (DIN VDE 0110, 1/89, Table 1)

PACKAGE CHARACTERISTICS

Table 9. Package Characteristics

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions/Comments
Resistance (Input to Output)[1]	R_{I-O}		10^{11}		Ω	
Capacitance (Input to Output)[1]	C_{I-O}		0.6		pF	@1MHz
Input Capacitance[2]	C_I		3.0		pF	@1MHz
IC Junction to Ambient Thermal Resistance	θ_{JA}		100		°C/W	Thermocouple located at center of package underside

Notes:

[1]The device is considered a 2-terminal device; SOIC-8 Pin 1 - Pin 4 are shorted together as the one terminal, and SOIC-8 Pin 5 - Pin 8 are shorted together as the other terminal.

[2]Testing from the input signal pin to ground.

REGULATORY INFORMATION

See Table 10 and the Insulation Lifetime section for details regarding recommended maximum working voltages for specific cross isolation waveforms and insulation levels.

Table10. Regulatory

Regulatory	π110M3x
UL	Recognized under UL 1577 Component Recognition Program[1] Single Protection, 3000 V rms Isolation Voltage File (E494497)
CSA	Approved under CSA Component Acceptance Notice 5A

	CSA 60950-1-07+A1+A2 and IEC 60950-1, second edition, +A1+A2: Basic insulation at 400 V rms (565 V peak) Reinforced insulation at 200 V rms (283 V peak) File (pending)
VDE	DIN V VDE V 0884-10 (VDE V 0884-10):2006-12[2] Basic insulation, V_{IORM} = 565 V peak, V_{IOSM} = 4615 V peak File (40047929)
CQC	Certified under CQC11-471543-2012 GB4943.1-2011 Basic insulation at 400 V rms (565 V peak) working voltage Reinforced insulation at 200 V rms (283 V peak) File (pending)

Notes:
[1] In accordance with UL 1577, each π110M3xis proof tested by applying an insulation test voltage ≥ 3600 V rms for 1 sec
[2] In accordance with DIN V VDE V 0884-10, eachπ110M3xis proof tested by applying an insulation test voltage ≥ 1059 V peak for 1 sec (partial discharge detection limit = 5 pC). The * marking branded on the component designates DIN V VDE V 0884-10 approval.

DIN V VDE V 0884-10 (VDE V 0884-10) INSULATION CHARACTERISTICS

These isolators are suitable for reinforced electrical isolation only within the safety limit data. Protective circuits ensure the maintenance of the safety data. The * marking on packages denotes DIN V VDE V 0884-10 approval.

Table 11. VDE Insulation Characteristics

Description	Test Conditions/Comments	Symbol	Characteristic	Unit
Installation Classification per DIN VDE 0110				
For Rated Mains Voltage ⩽ 150 V rms			I to IV	
For Rated Mains Voltage ≤ 300 V rms			I to III	
For Rated Mains Voltage ≤ 400 V rms			I to III	
Climatic Classification			40/105/21	
Pollution Degree per DIN VDE 0110, Table 1			2	
Maximum Working Insulation Voltage		V_{IORM}	565	Vpeak
Input to Output Test Voltage, Method B1	V_{IORM} × 1.875 = $V_{pd\ (m)}$, 100% production test, tini = t_m = 1 sec, partial discharge < 5 pC	$V_{pd\ (m)}$	1059	Vpeak
Input to Output Test Voltage, Method A				
After Environmental Tests Subgroup 1	V_{IORM} × 1.5 = $V_{pd\ (m)}$, t_{ini} = 60 sec, t_m = 10 sec, partial discharge < 5 pC	$V_{pd\ (m)}$	848	Vpeak
After Input and/or Safety Test Subgroup 2 and Subgroup 3	V_{IORM} × 1.2 = $V_{pd\ (m)}$, t_{ini} = 60 sec, t_m = 10 sec, partial discharge < 5 pC		678	Vpeak
Highest Allowable Overvoltage		V_{IOTM}	4200	Vpeak
Surge Isolation Voltage Basic	Basic insulation, 1.2 µs rise time, 50 µs, 50% fall time	V_{IOSM}	4615	Vpeak
Surge Isolation Voltage Reinforced	Reinforced insulation, 1.2 µs rise time, 50 µs, 50% fall time	V_{IOSM}		Vpeak

Safety Limiting Values	Maximum value allowed in the event of a failure (see Figure 4)			
Maximum Junction Temperature		T_S	150	°C
Total Power Dissipation at 25°C		P_S	1.25	W
Insulation Resistance at T_S	V_{IO} = 800 V	R_S	>10^9	Ω

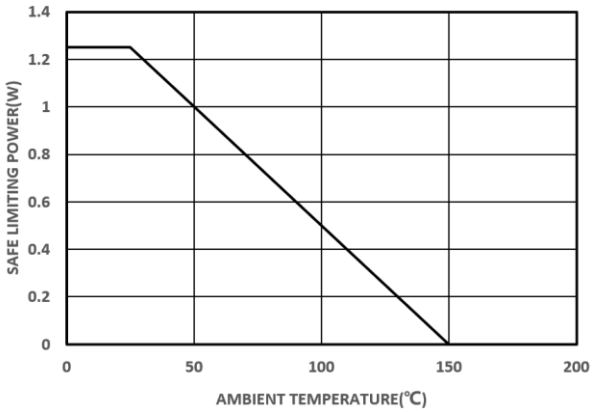


Figure4. Thermal Derating Curve, Dependence of Safety Limiting Values with Ambient Temperature per VDE

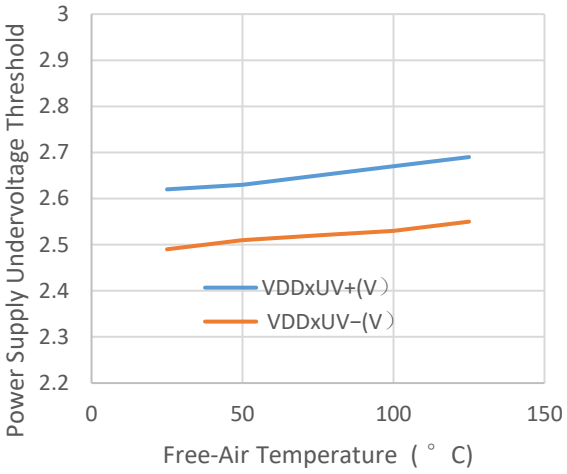


Figure5. UVLO vs. Free-Air Temperature

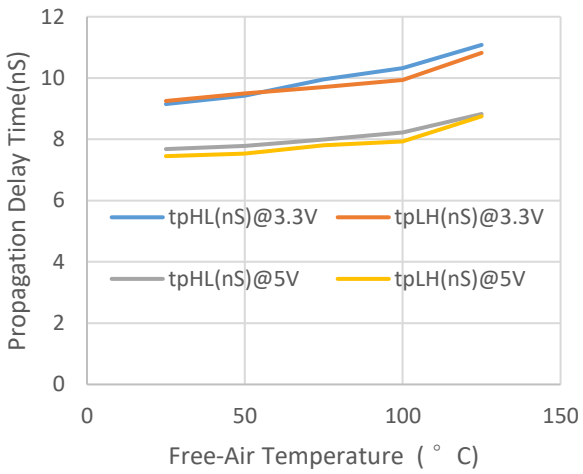


Figure6. Propagation Delay Time vs. Free-Air Temperature

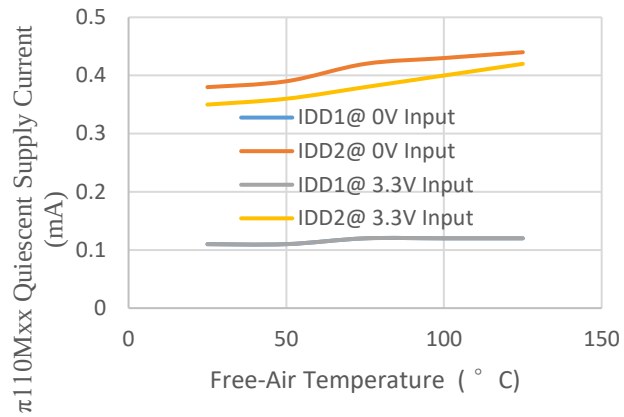


Figure7. π110Mxx Quiescent Supply Current with 3.3V Supply vs. Free-Air Temperature

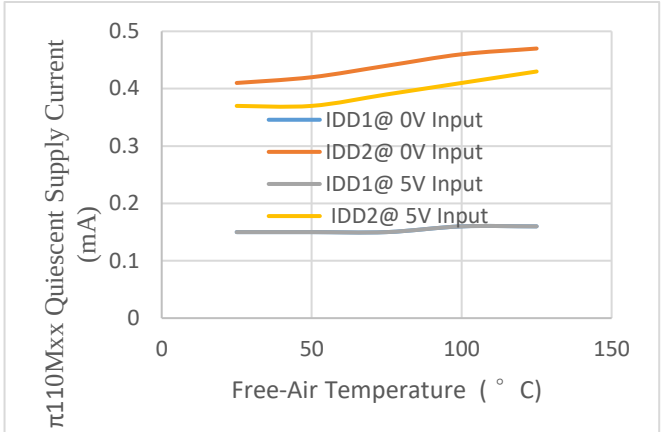


Figure8. π110Mxx Quiescent Supply Current with 5.0V Supply vs. Free-Air Temperature

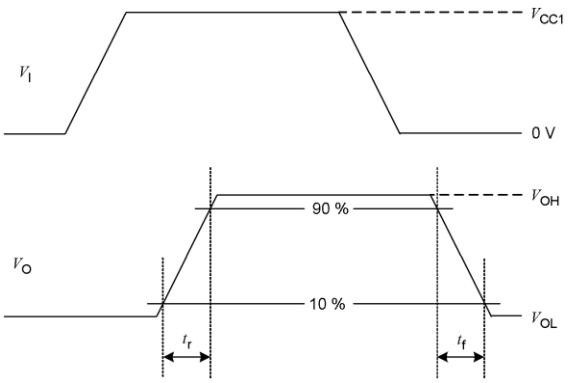


Figure9. Transition time waveform measurement

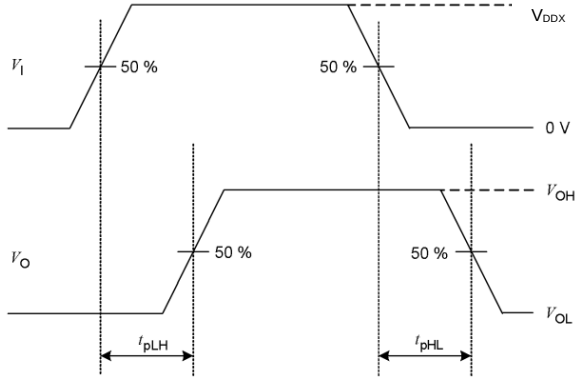


Figure10. Propagation delay time waveform measurement

APPLICATIONS INFORMATION

OVERVIEW

The π1xxxxx are 2PaiSemi digital isolators product family. By using maturated standard semiconductor CMOS technology and innovative design, these isolation components provide outstanding performance characteristics superior to alternatives such as optocoupler devices and other integrated isolators. The π1xxxxx isolator data channels are independent and are available in a variety of configurations with a withstand voltage rating of 3.0 kV rms to 6.0 kV rms and the data rate from DC up to 600Mbps (see the Ordering Guide).

The π110M3x are the outstanding 10 Mbps single-channel digital isolators with the enhanced ESD capability. the devices transmit data across an isolation barrier by layers of silicon dioxide isolation.

The devices operate with the supply voltage on either side ranging from 3.0 V to 5.5 V, offering voltage translation of 3.3 V, and 5 V logic.

The π110M3x have very low propagation delay and high speed. The input/output design techniques allow logic and supply voltages over a wide range from 3.0 V to 5.5 V, offering voltage translation of 3.3 V,and 5 V logic. The architecture is designed for high common-mode transient immunity and high immunity to electrical noise and magnetic interference.

See the Ordering Guide for the model numbers that have the fail-safe output state of low or high.

PCB LAYOUT

The low-ESR ceramic bypass capacitors must be connected between V_{DD1} and GND_1 and between V_{DD2} and GND_2. The bypass capacitors are placed on the PCB as close to the isolator device as possible. The recommended bypass capacitor value is between 0.1 μF and 10 μF.

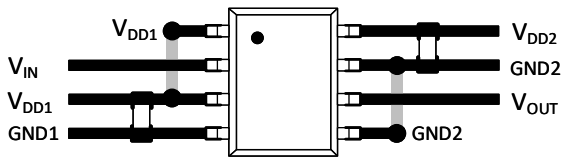


Figure11.Recommended Printed Circuit Board Layout

Avoid reducing the isolation capability, Keep the space underneath the isolator device free from metal such as planes, pads, traces and vias.

To minimize the impedance of the signal return loop, keep the solid ground plane directly underneath the high-speed signal path, the closer the better. The return path will couple between the nearest ground plane to the signal path. Keep suitable trace width for controlled impedance transmission lines interconnect.

To reduce the rise time degradation, keep the length of input/output signal traces as short as possible, and route low inductance loop for the signal path and It's return path.

JITTER MEASUREMENT

The eye diagram shown in the figure18 provides the jitter measurement result for the π110M3x. The Keysight 81160A pulse function arbitrary generator works as the data source for the π110M3x, which generates 10Mbps pseudo random bit sequence（PRBS）. The Keysight DSOS104A digital storage oscilloscope captures the π110M3x output waveform and recoveries the eye diagram with the SDA tools and eye diagram analysis tools. The result shows a typical measurement 120ps p-p jitter.

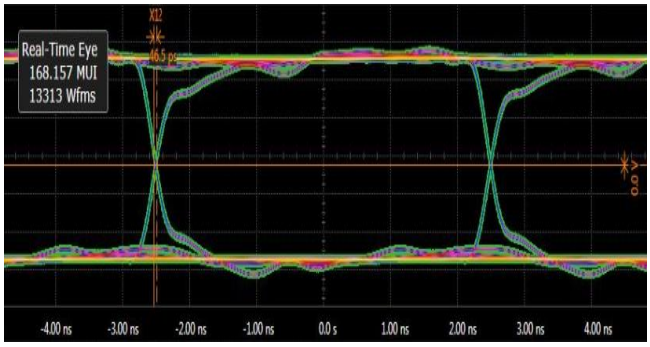


Figure12. π110M3x Eye Diagram

CMTI MEASUREMENT

To measure the Common-Mode Transient Immunity (CMTI) of π1xxx isolator under specified common-mode pulse magnitude (V_{CM}) and specified slew rate of the common-mode pulse (dV_{CM}/dt) and other specified test or ambient conditions, The common-mode pulse generator (G_1) will be capable of providing fast rising and falling pulses of specified magnitude and duration

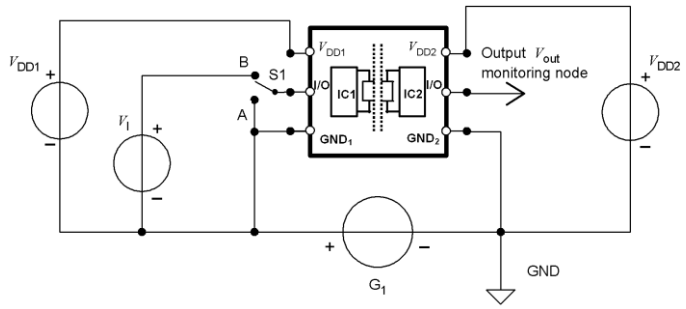


Figure13. Common-mode transient immunity (CMTI) measurement

of the common-mode pulse (V_{CM}) and the maximum common-mode slew rates (dV_{CM}/dt) can be applied to π1xxxxx isolator coupler under measurement. The common-mode pulse is applied between one side ground GND1 and the other side ground GND2 of π1xxxxx isolator and shall be capable of providing positive transients as well as negative transients.

OUTLINE DIMENSIONS

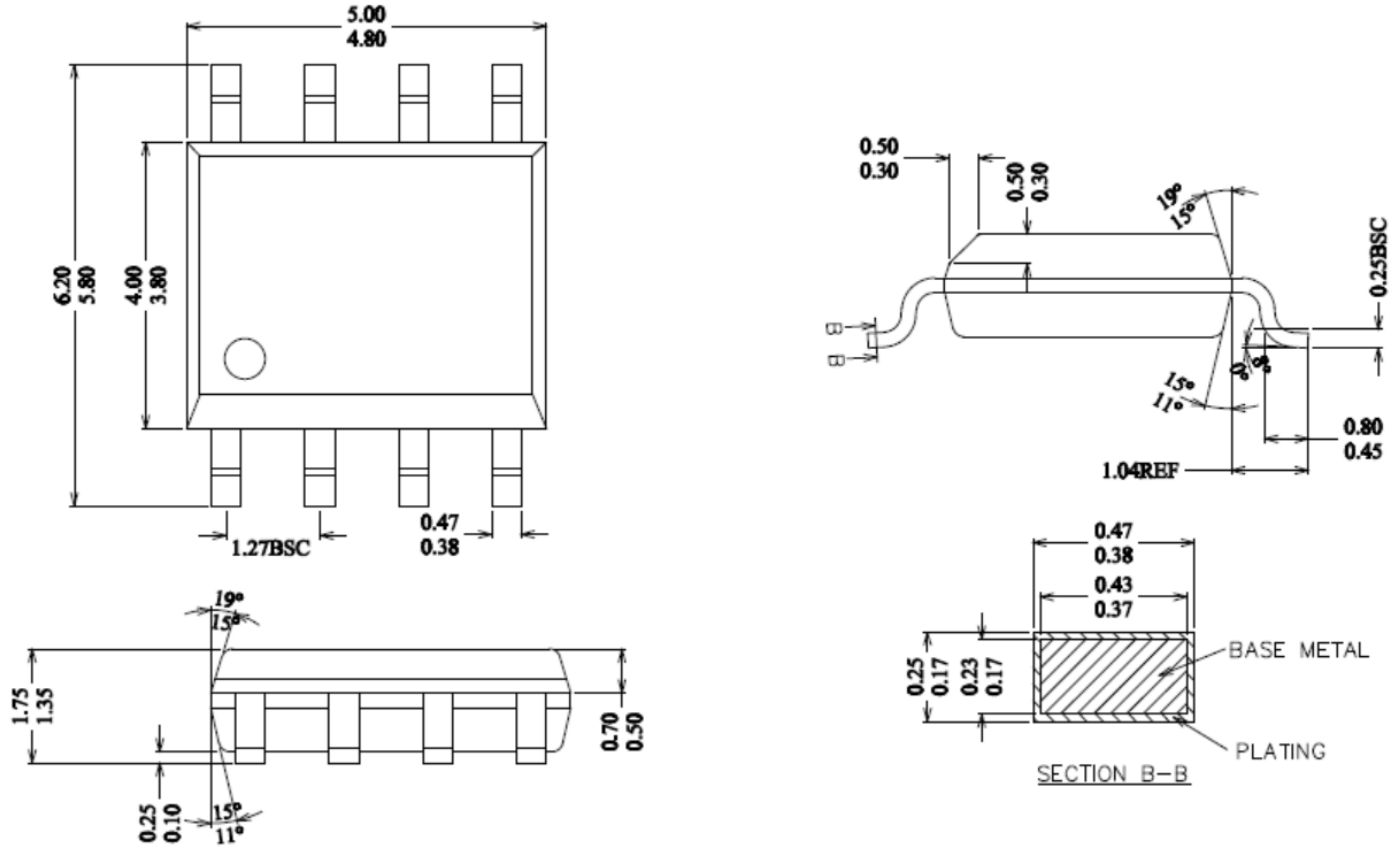
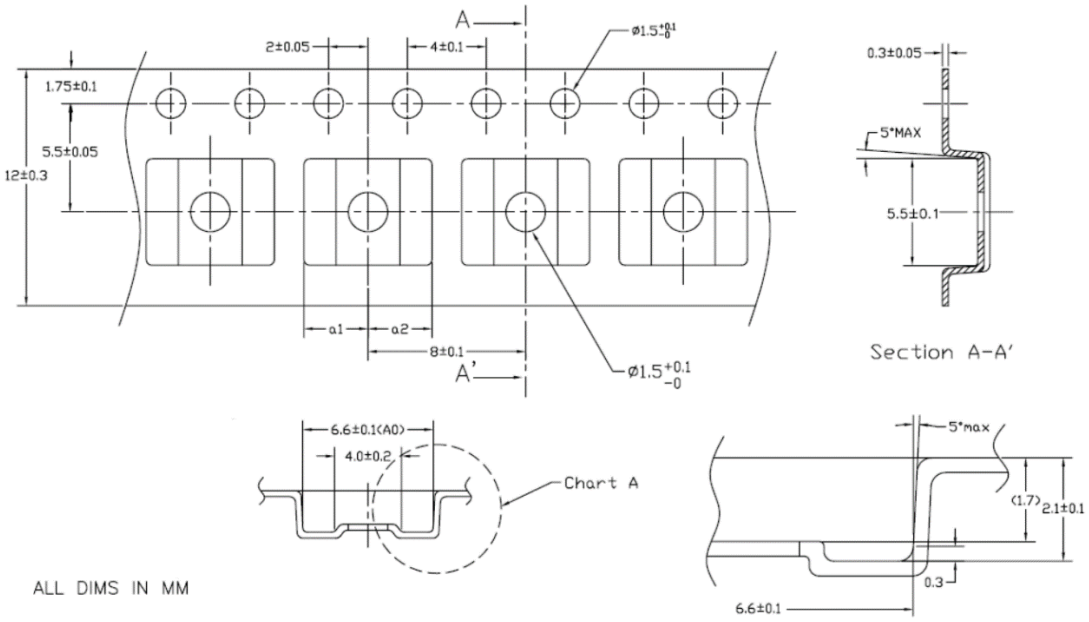


Figure14. 8-Lead Standard Small Outline Package [8-Lead SOIC_N]

REEL INFORMATION

8-Lead SOIC_N



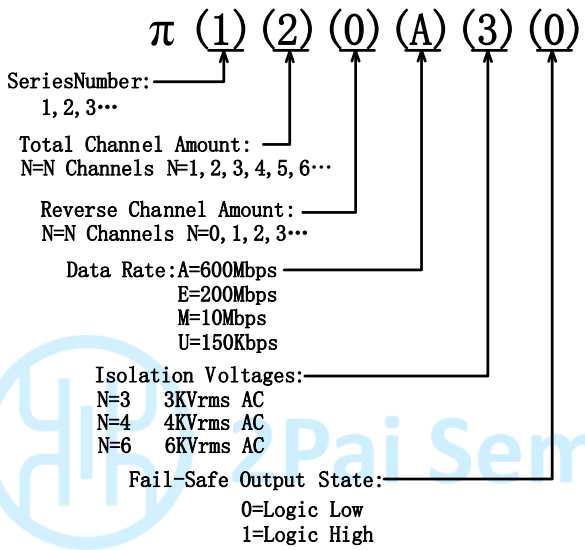
ORDERING GUIDE

Model Name		Temperature Range	No. of Inputs, V_{DD1} Side	No. of Inputs, V_{DD2} Side	Withstand Voltage Rating (kV rms)	Fail-Safe Output State	Package Description	Package Option	Quantity
π110M31	Pai110M31	−40°C to +125°C	1	0	3	High	8-Lead SOIC_N	S-8-N	4000 per reel
π110M30	Pai110M30	−40°C to +125°C	1	0	3	Low	8-Lead SOIC_N	S-8-N	4000 per reel

Notes:

[1] π11xxxxQ special for Auto, qualified for AEC-Q100

PART NUMBER NAMED RULE



Notes:Pai11xxxx is equals to π11xxxx in the customer BOM

REVISION HISTORY

Revision	Updated	Date	Page	Change Record
1	Devin	2018/09/19	All	Initial version
2	Devin	2018/11/28	P1,P9	Changed C_{IN}, C_{OUT} in Figure2 from 0.1uF to 1uF Changed the recommended bypass capacitor value from between 0.1 µF and 1 µF to between 0.1 µF and 10 µF.