SGM4576
6-Bit Bidirectional Voltage-Level Translator for Open-Drain and Push-Pull Applications

GENERAL DESCRIPTION

The SGM4576 is a 6-bit, non-inverting, bidirectional voltage-level translator which features two independent configurable power-supply lines. The A and B ports track the V_{CCA} supply and V_{CCB} supply respectively. The supply voltage range is 1.65V to 5.5V for A ports and 2.3V to 5.5V for B ports. The device provides a bidirectional translation function between the different voltage nodes (including 1.8V, 2.5V, 3.3V and 5V).

The SGM4576 has an output enable (OE) function, which controls the inputs and outputs states. When OE goes low, all I/Os enter into the high-impedance state. It is beneficial for reducing quiescent current consumption. When V_{CCA} is powered, OE has an internal pull-down current source.

The SGM4576 is available in Green TQFN-2.6×1.8-16L package. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **Power Supply Voltage Ranges ($V_{CCA} \le V_{CCB}$)**
  - **A Ports: 1.65V to 5.5V**
  - **B Ports: 2.3V to 5.5V**
- **Direction-Control Signal is Not Required**
- **Data Rates**
  - **Push-Pull: 24Mbps**
  - **Open-Drain: 2Mbps**
- **Support V_{CCA} or V_{CCB} Isolation**
  - **When V_{CCA} or V_{CCB} is Low, Device Enters Power-Down Mode**
- **No Specific Power Sequences Required for V_{CCA} and V_{CCB}**
- **Support Partial-Power-Down Function**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in Green TQFN-2.6×1.8-16L Package**

APPLICATIONS

Universal Asynchronous Receiver/Transmitter

I^2C/SMBus Interfaces

General Purpose I/O (GPIO)

TYPICAL APPLICATION

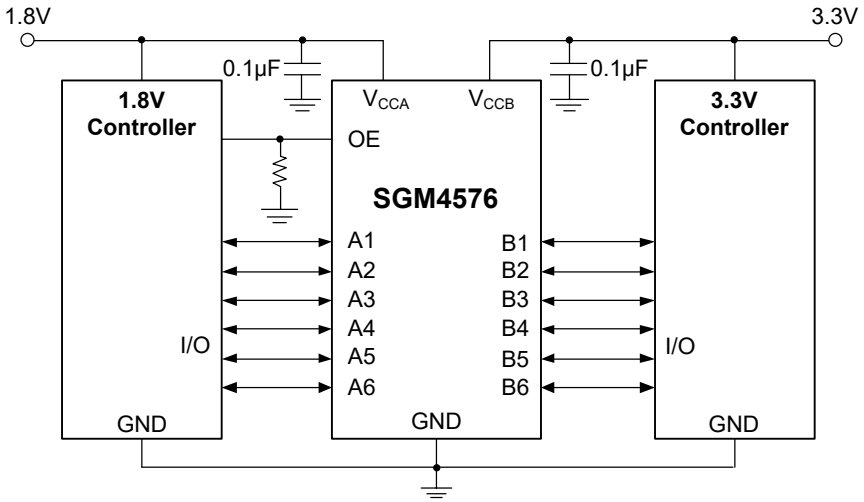


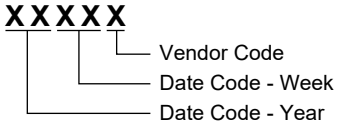
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM4576	TQFN-2.6×1.8-16L	-40℃ to +85℃	SGM4576YTQA16G/TR	4576 XXXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXXX = Date Code and Vendor Code.



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

ESD SENSITIVITY CAUTION

This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage Range
V_{CCA} ..... -0.3V to 6V
V_{CCB} ..... -0.3V to 6V
A Ports, B Ports, OE Input Voltage Range, V_I (1)
..... -0.3V to 6V
Output Voltage Range for the High-Impedance or Power-Off State, V_O (1)
A Ports ..... -0.3V to 6V
B Ports ..... -0.3V to 6V
Output Voltage Range for the High or Low State, V_O (1) (2)
A Ports ..... -0.3V to V_{CCA} + 0.3V
B Ports ..... -0.3V to V_{CCB} + 0.3V
Input Clamp Current, I_{IK} (V_I < 0) ..... -50mA
Output Clamp Current, I_{OK} (V_O < 0) ..... -25mA
Continuous Output Current, I_O ..... ±50mA
Continuous Current through V_{CCA}, V_{CCB}, or GND ..... ±100mA
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 4000V
MM 300V
CDM 1000V

NOTES:
1. When the input and output current ratings are observed, the input and I/O negative voltage ratings may be exceeded.
2. V_{CCA} and V_{CCB} values are shown in the recommended operating conditions table.

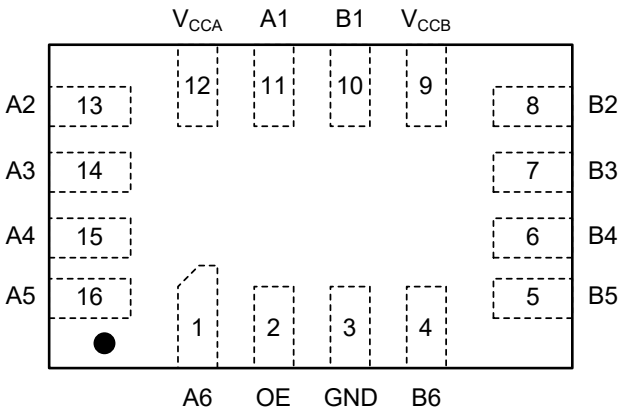
RECOMMENDED OPERATING CONDITIONS (3, 4)

Supply Voltage Range (5)
V_{CCA} ..... 1.65V to 5.5V
V_{CCB} ..... 2.3V to 5.5V
High-Level Input Voltage, V_{IH}
A Port I/Os (V_{CCA} = 1.65V, V_{CCB} = 2.3V to 5.5V)
..... V_{CCI} - 0.1V to V_{CCI}
A Port I/Os (V_{CCA} = 1.95V to 5.5V, V_{CCB} = 2.3V to 5.5V)
..... V_{CCI} - 0.4V to V_{CCI}
B Port I/Os ..... V_{CCI} - 0.4V to V_{CCI}
OE Input ..... V_{CCA} × 0.8V to 5.5V
Low-Level Input Voltage, V_{IL}
A Port I/Os ..... 0V to 0.15V
B Port I/Os ..... 0V to 0.15V
OE Input ..... 0V to V_{CCA} × 0.25V
Operating Temperature Range ..... -40℃ to +85℃

NOTES:
3. V_{CCI} is the supply voltage associated with the input ports.
4. V_{CCO} is the supply voltage associated with the output ports.
5. Ensure that $V_{CCA} \le V_{CCB}$ and V_{CCA} must not exceed 5.5V.

PIN CONFIGURATION

(TOP VIEW)



TQFN-2.6×1.8-16L

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	A6	I/O	Input/Output 6. It tracks the V_{CCA} supply.
2	OE	I	Output Enable Control Pin. Active high. When OE goes low, all outputs enter into the high-impedance state. It tracks the V_{CCA} supply.
3	GND	G	Ground.
4	B6	I/O	Input/Output 6. It tracks the V_{CCB} supply.
5	B5	I/O	Input/Output 5. It tracks the V_{CCB} supply.
6	B4	I/O	Input/Output 4. It tracks the V_{CCB} supply.
7	B3	I/O	Input/Output 3. It tracks the V_{CCB} supply.
8	B2	I/O	Input/Output 2. It tracks the V_{CCB} supply.
9	V_{CCB}	P	Supply Voltage on B Ports. It can be operated from 2.3V to 5.5V.
10	B1	I/O	Input/Output 1. It tracks the V_{CCB} supply.
11	A1	I/O	Input/Output 1. It tracks the V_{CCA} supply.
12	V_{CCA}	P	Supply Voltage on A Ports. It can be operated from 1.65V to 5.5V, and V_{CCA} is always ≤ V_{CCB}.
13	A2	I/O	Input/Output 2. It tracks the V_{CCA} supply.
14	A3	I/O	Input/Output 3. It tracks the V_{CCA} supply.
15	A4	I/O	Input/Output 4. It tracks the V_{CCA} supply.
16	A5	I/O	Input/Output 5. It tracks the V_{CCA} supply.

ELECTRICAL CHARACTERISTICS

(V_{CCA} = 1.65V to 5.5V, V_{CCB} = 2.3V to 5.5V, Full = -40℃ to +85℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER		SYMBOL	CONDITIONS		TEMP	MIN	TYP	MAX	UNITS
A Ports High-Level Output Voltage		V_{OHA}	I_{OH} = -20μA, V_{IB} ≥ V_{CCB} - 0.4V		Full	V_{CCA} × 0.67			V
A Ports Low-Level Output Voltage		V_{OLA}	I_{OL} = 1mA, V_{IB} ≤ 0.15V		Full			0.4	V
B Ports High-Level Output Voltage		V_{OHB}	I_{OH} = -20μA, V_{IA} ≥ V_{CCA} - 0.4V		Full	V_{CCB} × 0.67			V
B Ports Low-Level Output Voltage		V_{OLB}	I_{OL} = 1mA, V_{IA} ≤ 0.15V		Full			0.4	V
Input Leakage Current	OE Input	I_I			+25℃			±1	μA
					Full			±1.5	μA
Power Off Leakage Current	A Ports	I_{OFF}	V_{CCA} = 0V, V_{CCB} = 0V to 5.5V		+25℃			±0.5	μA
					Full			±1	μA
	B Ports		V_{CCA} = 0V to 5.5V, V_{CCB} = 0V		+25℃			±0.5	μA
					Full			±1	μA
3-State Output Leakage	A or B Ports	I_{OZ}	OE = 0V		+25℃			±0.5	μA
					Full			±1	μA
Quiescent Supply Current		I_{CCA}	V_I = V_O = OPEN, I_O = 0A	V_{CCA} = 1.65V to V_{CCB}, V_{CCB} = 2.3V to 5.5V	Full			13	μA
				V_{CCA} = 5.5V, V_{CCB} = 0V	Full			13	μA
				V_{CCA} = 0V, V_{CCB} = 5.5V	Full			-1	μA
		I_{CCB}	V_I = V_O = OPEN, I_O = 0A	V_{CCA} = 1.65V to V_{CCB}, V_{CCB} = 2.3V to 5.5V	Full			17	μA
				V_{CCA} = 5.5V, V_{CCB} = 0V	Full			-1	μA
				V_{CCA} = 0V, V_{CCB} = 5.5V	Full			8	μA
		I_{CCA} + I_{CCB}	V_I = V_O = OPEN, I_O = 0A	V_{CCA} = 1.65V to V_{CCB}, V_{CCB} = 2.3V to 5.5V	Full			21	μA
		I_{CCZA}	V_I = V_{CCI} or 0V, I_O = 0A, OE = 0V	V_{CCA} = 1.65V to V_{CCB}, V_{CCB} = 2.3V to 5.5V	Full			13	μA
		I_{CCZB}	V_I = V_{CCI} or 0V, I_O = 0A, OE = 0V	V_{CCA} = 1.65V to V_{CCB}, V_{CCB} = 2.3V to 5.5V	Full			8	μA
OE Input Capacitance		C_I	V_{CCA} = 3.3V, V_{CCB} = 3.3V		+25℃		6		pF
Input/Output Capacitance	A Ports	C_{IO}	V_{CCA} = 3.3V, V_{CCB} = 3.3V		+25℃		6		pF
	B Ports				+25℃		6		pF

TIMING REQUIREMENTS

(T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	V_{CCB} = 2.5V	V_{CCB} = 3.3V	V_{CCB} = 5V	UNITS
			TYP	TYP	TYP	
(V_{CCA} = 1.8V)						
Data Rate		Push-pull driving	24	24	24	Mbps
		Open-drain driving	2	2	2	
Pulse Duration (Data Inputs)	t_W	Push-pull driving	41	41	41	ns
		Open-drain driving	500	500	500	
(V_{CCA} = 2.5V)						
Data Rate		Push-pull driving	24	24	24	Mbps
		Open-drain driving	2	2	2	
Pulse Duration (Data Inputs)	t_W	Push-pull driving	41	41	41	ns
		Open-drain driving	500	500	500	
(V_{CCA} = 3.3V)						
Data Rate		Push-pull driving		24	24	Mbps
		Open-drain driving		2	2	
Pulse Duration (Data Inputs)	t_W	Push-pull driving		41	41	ns
		Open-drain driving		500	500	
(V_{CCA} = 5V)						
Data Rate		Push-pull driving			24	Mbps
		Open-drain driving			2	
Pulse Duration (Data Inputs)	t_W	Push-pull driving			41	ns
		Open-drain driving			500	

SWITCHING CHARACTERISTICS

(V_{CCA} = 1.8V, T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		V_{CCB} = 2.5V	V_{CCB} = 3.3V	V_{CCB} = 5V	UNITS
				TYP	TYP	TYP	
Propagation Delay	t_{PHL}	A to B	Push-pull driving	3.5	3.5	5.1	ns
			Open-drain driving	56.2	27.0	27.9	
	t_{PLH}		Push-pull driving	5.1	4.5	4.4	
			Open-drain driving	142.7	119.8	92.1	
	t_{PHL}	B to A	Push-pull driving	3.0	2.8	3.4	ns
			Open-drain driving	25.6	25.3	25.4	
	t_{PLH}		Push-pull driving	3.7	3.2	2.6	
			Open-drain driving	55.1	49.4	48.0	
Enable Time	t_{EN} (t_{PZH} & t_{PZL})	OE to A or B		28.4	24.6	22.5	ns
Disable Time	t_{DIS} (t_{PHZ} & t_{PLZ})	OE to A or B		674	677	671	
Rise Time	t_{rA}	A Ports	Push-pull driving	7.2	8.1	9.1	ns
			Open-drain driving	12.3	11.3	10.1	
	t_{rB}	B Ports	Push-pull driving	7.2	6.1	5.4	ns
			Open-drain driving	99.3	72.9	36.7	
Fall Time	t_{fA}	A Ports	Push-pull driving	5.7	5.9	6.9	ns
			Open-drain driving	3.8	3.6	3.6	
	t_{fB}	B Ports	Push-pull driving	7.9	7.8	8.4	ns
			Open-drain driving	3.5	8.4	5.0	
Data Rate		Push-pull driving		24	24	24	Mbps
		Open-drain driving		2	2	2	

SWITCHING CHARACTERISTICS (continued)

(V_{CCA} = 2.5V, T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		V_{CCB} = 2.5V	V_{CCB} = 3.3V	V_{CCB} = 5V	UNITS
				TYP	TYP	TYP	
Propagation Delay	t_{PHL}	A to B	Push-pull driving	4.5	4.5	5.0	ns
			Open-drain driving	26.2	27.1	26.2	
	t_{PLH}		Push-pull driving	3.8	3.3	3.1	
			Open-drain driving	111.0	95.6	76.0	
	t_{PHL}	B to A	Push-pull driving	4.2	4.0	4.1	ns
			Open-drain driving	25.8	25.5	25.6	
	t_{PLH}		Push-pull driving	3.7	3.5	3.6	
			Open-drain driving	52.7	50.6	49.8	
Enable Time	t_{EN} (t_{PZH} & t_{PZL})	OE to A or B		21.6	17.4	15.5	ns
Disable Time	t_{DIS} (t_{PHZ} & t_{PLZ})	OE to A or B		689	688	678	
Rise Time	t_{rA}	A Ports	Push-pull driving	6.4	6.7	6.9	ns
			Open-drain driving	10.5	7.7	7.8	
	t_{rB}	B Ports	Push-pull driving	6.2	5.4	4.9	ns
			Open-drain driving	67.0	50.9	30.5	
Fall Time	t_{fA}	A Ports	Push-pull driving	8.6	8.2	7.3	ns
			Open-drain driving	3.6	3.3	3.1	
	t_{fB}	B Ports	Push-pull driving	8.5	7.7	8.1	ns
			Open-drain driving	3.4	3.9	5.4	
Data Rate		Push-pull driving		24	24	24	Mbps
		Open-drain driving		2	2	2	

SWITCHING CHARACTERISTICS (continued)

(V_{CCA} = 3.3V, T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		V_{CCB} = 3.3V	V_{CCB} = 5V	UNITS
				TYP	TYP	
Propagation Delay	t_{PHL}	A to B	Push-pull driving	4.4	5.0	ns
			Open-drain driving	25.5	27.5	
	t_{PLH}		Push-pull driving	3.5	2.7	
			Open-drain driving	52.4	51.4	
	t_{PHL}	B to A	Push-pull driving	4.1	4.4	ns
			Open-drain driving	25.8	54.3	
	t_{PLH}		Push-pull driving	3.1	2.8	
			Open-drain driving	50.3	49.4	
Enable Time	t_{EN} (t_{PZH} & t_{PZL})	OE to A or B		15.9	13.8	ns
Disable Time	t_{DIS} (t_{PHZ} & t_{PLZ})	OE to A or B		699	678	
Rise Time	t_{rA}	A Ports	Push-pull driving	5.2	6.2	ns
			Open-drain driving	6.3	6.2	
	t_{rB}	B Ports	Push-pull driving	5.3	4.7	ns
			Open-drain driving	8.3	6.8	
Fall Time	t_{fA}	A Ports	Push-pull driving	7.3	7.6	ns
			Open-drain driving	3.1	3.0	
	t_{fB}	B Ports	Push-pull driving	7.7	7.3	ns
			Open-drain driving	3.8	4.6	
Data Rate		Push-pull driving		24	24	Mbps
		Open-drain driving		2	2	

SWITCHING CHARACTERISTICS (continued)

(V_{CCA} = 5V, T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		V_{CCB} = 5V	UNITS
				TYP	
Propagation Delay	t_{PHL}	A to B	Push-pull driving	5.3	ns
			Open-drain driving	27.4	
	t_{PLH}		Push-pull driving	2.4	
			Open-drain driving	50.6	
	t_{PHL}	B to A	Push-pull driving	5.0	ns
			Open-drain driving	26.3	
	t_{PLH}		Push-pull driving	2.2	
			Open-drain driving	49.3	
Enable Time	t_{EN} (t_{PZH} & t_{PZL})	OE to A or B		22.6	ns
Disable Time	t_{DIS} (t_{PHZ} & t_{PLZ})	OE to A or B		665	
Rise Time	t_{rA}	A Ports	Push-pull driving	5.3	ns
			Open-drain driving	5.0	
	t_{rB}	B Ports	Push-pull driving	4.9	ns
			Open-drain driving	6.5	
Fall Time	t_{fA}	A Ports	Push-pull driving	8.5	ns
			Open-drain driving	2.8	
	t_{fB}	B Ports	Push-pull driving	7.7	ns
			Open-drain driving	4.2	
Data Rate		Push-pull driving		24	Mbps
		Open-drain driving		2	

WAVEFORMS

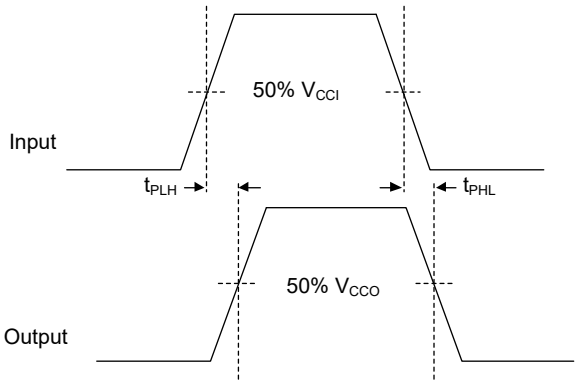


Figure 2. Propagation Delay

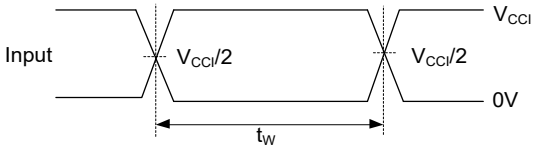


Figure 3. Pulse Duration

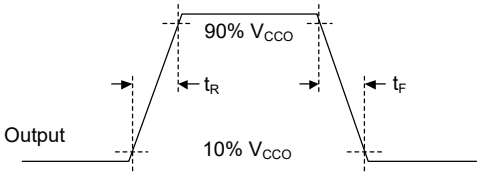
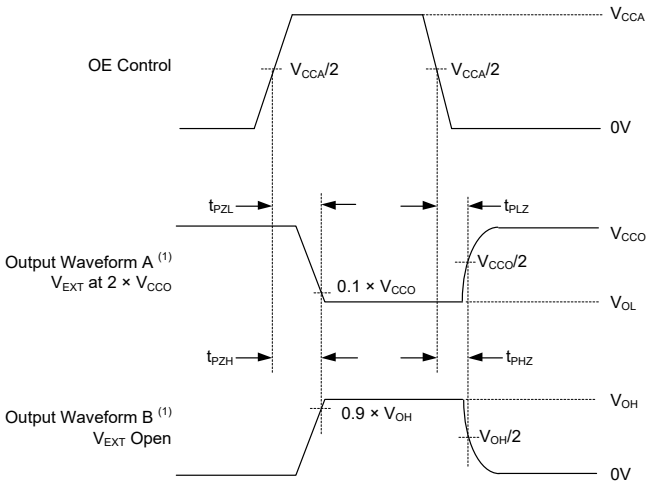


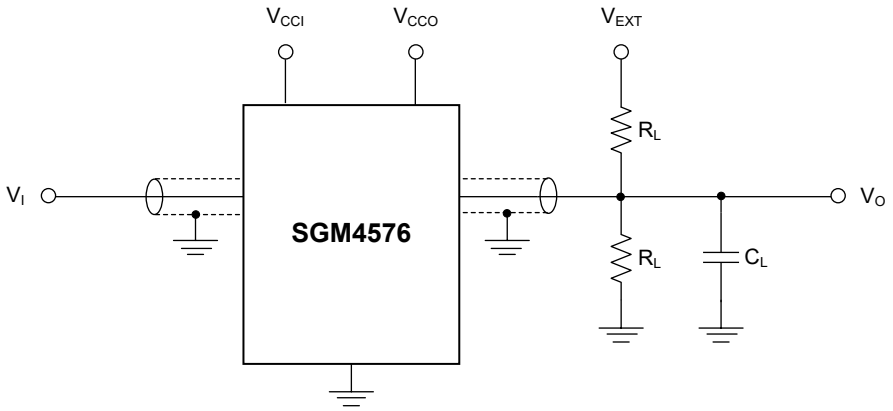
Figure 4. Rise Time and Fall Time of Data Output



NOTE:
1. Waveform A indicates an output that is high except for OE is high. Waveform B indicates an output that is low except for OE is high.

Figure 5. Enable and Disable Times

TEST CIRCUIT



Definitions for test circuit:
R_L = Load resistance.
C_L = Load capacitance includes jig and probe capacitance.
V_{EXT} = External voltage for measuring switching times.
V_{CCI} = Supply voltage associated with the input.
V_{CCO} = Supply voltage associated with the output.

Figure 6. Test Circuit for Measuring Switching Times

DETAILED DESCRIPTION

Applications

The SGM4576 is a bridge between two digital systems with different power supplies as it can transmit the signal transparently. For the application of the SGM4576, the output driver is open-drain or push-pull to drive the I^2C or one-wire bus. In addition, if a device with push-pull driver is connected to the I/O pin of the SGM4576, it will operate as normal.

Architecture

The SGM4576 can switch the direction of the transmission for port A and port B automatically without any external control.

There is no need to add an external direction control for the application of the SGM4576. Also, each I/O pin can be an input or output of the voltage translator.

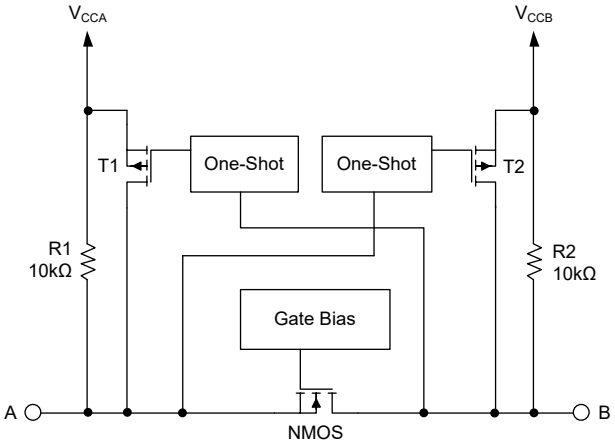


Figure 7. Architecture of an SGM4576 Cell

The explanation of two main parts of the internal circuit for the SGM4576 is shown as below:

- There is an NMOS between port A and port B to switch on or off the transmission.
- The one-shot accelerator can be used to accelerate the rising edges of the signal for port A and port B automatically.

Input Driver Requirements

The falling time of port A and port B and t_{PHL} depend on the output impedance of the connected device. The values of parameters which are t_{fA}, t_{fB}, t_{PHL} and data rates are specified when the resistance of external driver is less than 50Ω.

Power-Up

For the application of the SGM4576, the V_{CCA} should be less than V_{CCB}. However, it does not matter if the power supply voltage is ramping, and the sequence of power-up for both V_{CCA} and V_{CCB} is not defined.

Output Load Considerations

To decrease the extend of capacitive loading and ensure the proper triggering of O.S., the trace in PCB should be as short as possible. Also, to ensure that the round-trip reflection delay is smaller than the time period of one-shot, the users should also decrease the length of trace, which means that the signal integrity is guaranteed because of the low impedance for the reflection. The period of on-state for the O.S. part is 30ns. In addition, for the one-shot circuit, it can support lumped capacitive load. In addition, the one-shot circuit has the time-out function, which aims to handle the extremely heavy capacitive load. For the function of O.S. part of the SGM4576, it can optimize the trade-off between the capability of load driving, maximum bit-rate and dynamic supply current. The length of PCB trace and output connectors will be considered as the capacitive load of the device, which may result in the retriggering of O.S., contention of bus and the oscillations of the output.

Enable and Disable

The function of OE is used to disable SGM4576 by setting the transmitting I/O pins to high-impedance mode. The pull-down current source is integrated inside OE once it is powered by V_{CCA}. The definition of disable time (t_{DIS}) is the time period between OE goes low and when all of the I/O pins are in high-impedance mode. The enable time (t_{EN}) is defined as the time period between OE goes to high position and one-shot part starts to operate.

Pull-Up or Pull-Down Resistors on I/O Lines

For the I/O pin of A and B side, there is a 10kΩ pull-up resistor to provide a high position for each I/O pin. However, if a smaller pull-up resistor is required, the users can add an external resistor which is parallel with the 10kΩ resistor. Also, the value of V_{OL} can be affected by the added external resistor. In addition, if the user wants to disable the device, the OE pin can be simply set to low position.

REVISION HISTORY

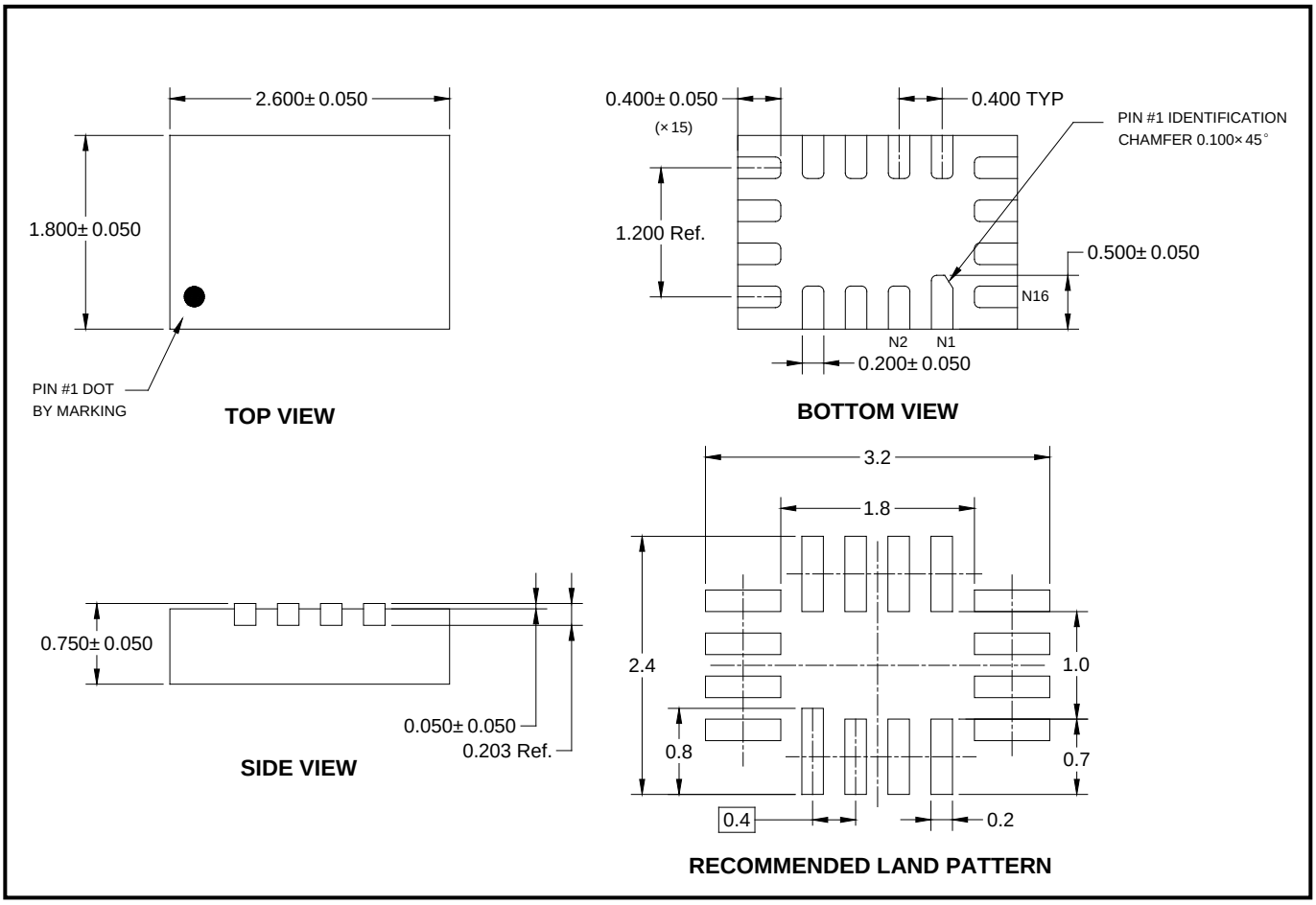
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (JUNE 2018) to REV.A

Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

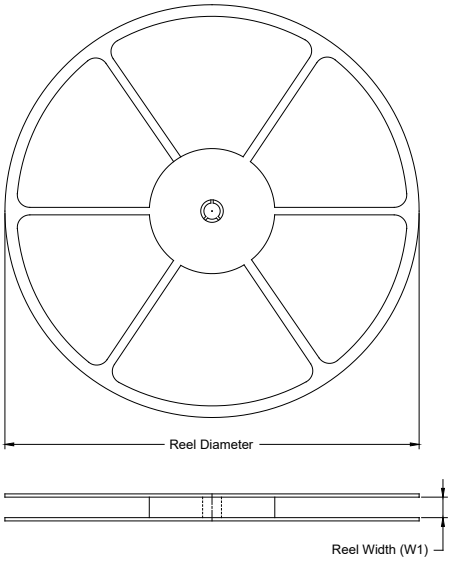
TQFN-2.6×1.8-16L



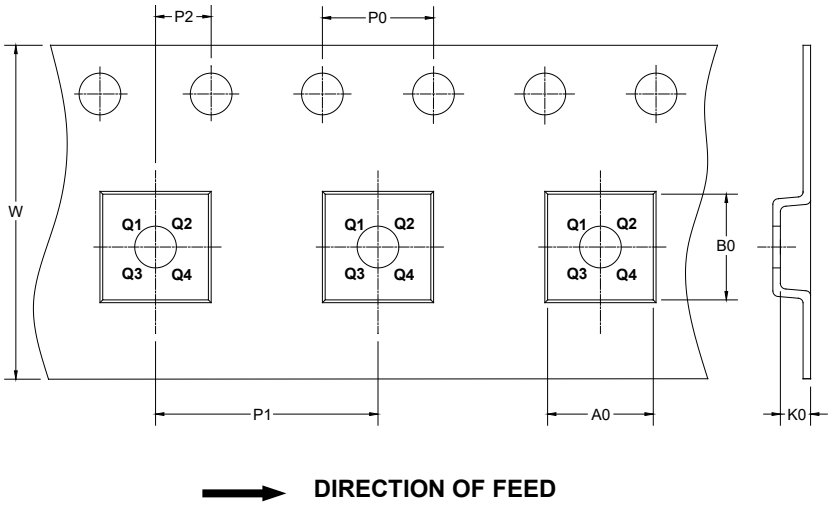
NOTES:
1. All linear dimensions are in millimeters.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

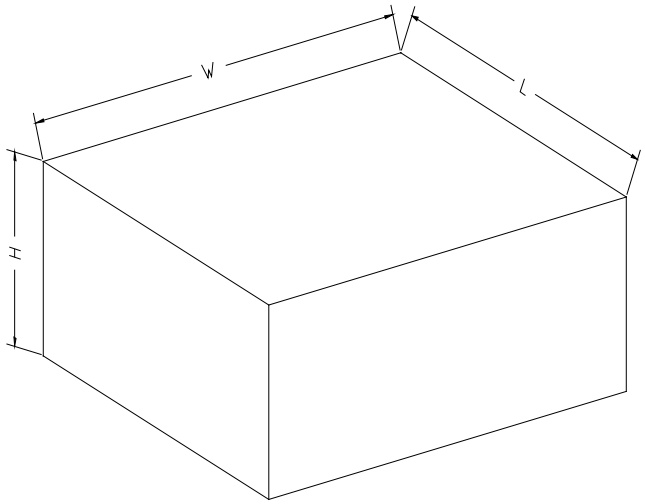
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TQFN-2.6×1.8-16L	7″	9.0	2.01	2.81	0.93	4.0	4.0	2.0	8.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002