



# SGM5353-16

## 16-Bit, Serial Input, Voltage-Output Digital-to-Analog Converter

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### GENERAL DESCRIPTION

The SGM5353-16 is a 16-bit, single channel, serial input, voltage-output DAC. It operates from a 2.7V to 5.5V supply. The DAC output range is from 0V to  $V_{REF}$ .

The SGM5353-16 output is monotonic and is 1LSB integral nonlinearity (INL) in the whole working temperature range.

The SGM5353-16 features a low noise and fast settling time output (settling to 0.5LSB of full-scale output within 1.5 $\mu$ s).

The SGM5353-16 uses a 3-wire serial SPI-compatible interface.

The SGM5353-16 is available in a Green SOIC-8 package. It operates over an ambient temperature range of -40°C to +125°C.

### FEATURES

- **16-Bit DAC, Monotonicity Guaranteed by Design**
- **Single-Supply Operation: 3V and 5V**
- **Settling Time: 1.5 $\mu$ s (TYP)**
- **Support Unbuffered Voltage-Output Capability**
- **Power-On Reset to Zero-Scale**
- **Low Power Consumption: 0.39mW (TYP)**
- **Low Glitch Impulse: 1.2nV-s**
- **SPI-Compatible Serial Interface**
- **Available in a Green SOIC-8 Package**

### APPLICATIONS

Process Control  
Field Transducer  
Automatic Test Equipment

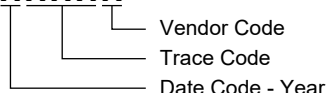
**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM5353-16	SOIC-8	-40°C to +125°C	SGM5353-16XS8G/TR	SGM 535316XS8 XXXXX	Tape and Reel, 4000

**MARKING INFORMATION**

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.

**XXXXX**



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.

**ABSOLUTE MAXIMUM RATINGS**

- Input Voltage Range ..... -0.3V to 6V
- Digital Input Voltage Range ..... -0.3V to  $V_{DD} + 0.3V$
- Output Voltage Range ..... -0.3V to  $V_{DD} + 0.3V$
- AGND, AGNDF, AGNDS to DGND ..... -0.3V to 0.3V
- Input Current to Any Pin except Supplies.....  $\pm 10mA$
- Package Thermal Resistance
  - SOIC-8,  $\theta_{JA}$  ..... 116°C/W
  - SOIC-8,  $\theta_{JC}$  ..... 55°C/W
- Junction Temperature ..... +150°C
- Storage Temperature Range ..... -65°C to +150°C
- Lead Temperature (Soldering, 10s) ..... +260°C
- ESD Susceptibility
  - HBM..... 4000V
  - CDM ..... 1000V

**RECOMMENDED OPERATING CONDITIONS**

- Operating Temperature Range ..... -40°C to +125°C

**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.

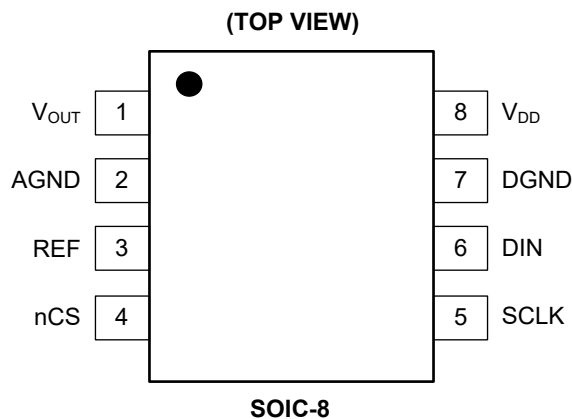
**ESD SENSITIVITY CAUTION**

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.

**DISCLAIMER**

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

## PIN CONFIGURATION



## PIN DESCRIPTION

PIN	NAME	TYPE <sup>(1)</sup>	FUNCTION
1	V <sub>OUT</sub>	O	Analog Output.
2	AGND	G	Analog Ground.
3	REF	I	Reference Voltage Input Pin.
4	nCS	I	Chip Select Signal. Active low.
5	SCLK	I	Serial Clock Input Pin.
6	DIN	I	Serial Data Input Pin.
7	DGND	G	Digital Ground.
8	V <sub>DD</sub>	P	Analog Power Supply Voltage.

## NOTE:

1. I = Input, O = Output, P = Power, G = Ground.

**ELECTRICAL CHARACTERISTICS**(V<sub>DD</sub> = 2.7V to 5.5V, 2V ≤ V<sub>REF</sub> ≤ V<sub>DD</sub>, AGND = DGND = 0V, T<sub>A</sub> = -40°C to +125°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>Static Performance</b>						
Resolution			16			Bits
Relative Accuracy	INL			0.15	1	LSB
Differential Nonlinearity	DNL	Guaranteed monotonic		0.3	1	LSB
Gain Error		T <sub>A</sub> = +25°C		0.8	1.7	LSB
					2.2	
Gain Error Temperature Coefficient				0.04		ppm/°C
Unipolar Zero-Code Error		T <sub>A</sub> = +25°C		0.4	1	LSB
					1.8	
Unipolar Zero-Code Temperature Coefficient				0.04		ppm/°C
<b>Output Characteristics</b>						
Output Voltage Range			0		V <sub>REF</sub> - 1LSB	V
Output Voltage Settling Time		To 1/2LSB of FS, C <sub>L</sub> = 10pF		1.5		μs
Slew Rate		C <sub>L</sub> = 10pF, measured from 0% to 63%		17		V/μs
Digital-to-Analog Glitch Impulse		1LSB change around the major carry		1.2		nV-s
Digital Feedthrough		All 1s loaded to DAC, V <sub>REF</sub> = 2.5V		0.2		nV-s
DAC Output Impedance		Tolerance typically 20%		6		kΩ
Output Noise Spectral Density		DAC code = 0x8400, f = 1kHz		12		nV/√Hz
Output Noise		0.1Hz to 10Hz		0.15		μV <sub>PP</sub>
Power Supply Rejection Ratio	PSRR	ΔV <sub>DD</sub> ± 10%			0.6	LSB
<b>DAC Reference Input</b>						
Reference Input Range			2		V <sub>DD</sub>	V
Reference Input Impedance			9.5			kΩ
<b>Logic Inputs</b>						
Input Current					1	μA
Input Low Voltage	V <sub>IL</sub>				0.7	V
Input High Voltage	V <sub>IH</sub>		2.1			V
Input Capacitance <sup>(1)</sup>				7		pF
Hysteresis Voltage <sup>(1)</sup>				0.1		V
<b>Reference <sup>(1)</sup></b>						
Reference -3dB Bandwidth		All 1s loaded		3		MHz
Reference Feedthrough		All 0s loaded, V <sub>REF</sub> = 1V <sub>PP</sub> at 100kHz		1		mV <sub>PP</sub>
Signal-to-Noise Ratio	SNR			92		dB
Reference Input Capacitance		Code 0x0000		45		pF
		Code 0xFFFF		45		
<b>Power Requirements</b>						
Supply Voltage	V <sub>DD</sub>	Digital inputs at rails	2.7		5.5	V
Supply Current	I <sub>DD</sub>			78	100	μA
Power Dissipation				0.39	0.55	mW

## NOTES:

1. Guaranteed by design. Not production tested.

**TIMING CHARACTERISTICS**

( $V_{DD} = 2.7V$  to  $5.5V \pm 10\%$ ,  $V_{REF} = 2.5V$ ,  $V_{INH} = 3V$  and  $90\%$  of  $V_{DD}$ ,  $V_{INL} = 0V$  and  $10\%$  of  $V_{DD}$ ,  $AGND = DGND = 0V$ ,  $T_A = -40^\circ C$  to  $+125^\circ C$ , unless otherwise noted.) <sup>(1) (2)</sup>

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SCLK Cycle Frequency	$f_{SCLK}$				25	MHz
SCLK Cycle Time	$t_1$		40			ns
SCLK High Time	$t_2$		20			ns
SCLK Low Time	$t_3$		20			ns
nCS Low to SCLK High Setup	$t_4$		10			ns
nCS High to SCLK High Setup	$t_5$		15			ns
SCLK High to nCS Low Hold Time	$t_6$		30			ns
SCLK High to nCS High Hold Time	$t_7$		20			ns
Data Setup Time	$t_8$		15			ns
Data Hold Time	$t_9$	$V_{IH} = 90\%$ of $V_{DD}$ , $V_{IL} = 10\%$ of $V_{DD}$	4			ns
		$V_{IH} = 3V$ , $V_{IL} = 0V$	7.5			ns
nCS High Time between Active Periods	$t_{10}$		30			ns

NOTES:

- 1 Guaranteed by design and characterization. Not production tested.
- 2 All input signals are specified with  $t_R = t_F = 1ns/V$  and timed from a voltage level of  $(V_{IL} + V_{IH})/2$ .

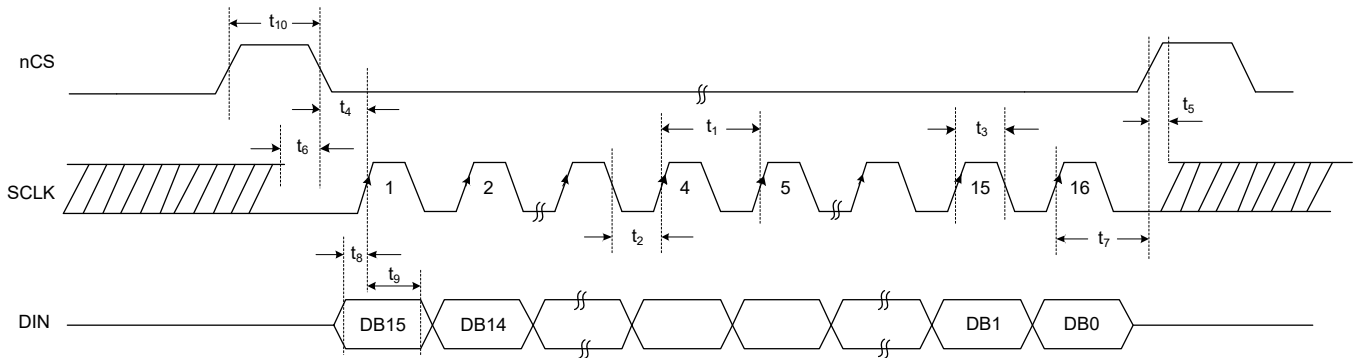
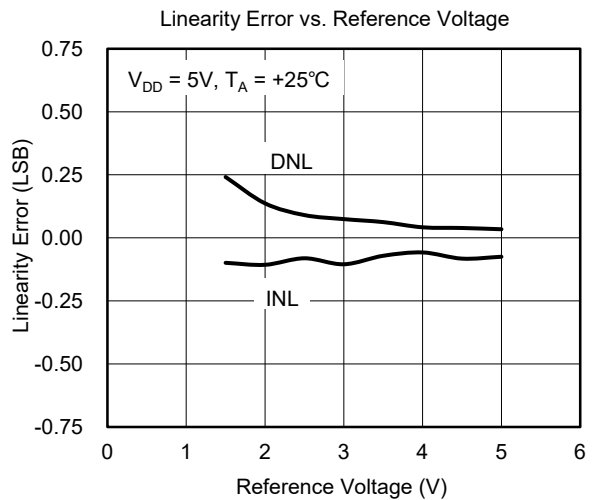
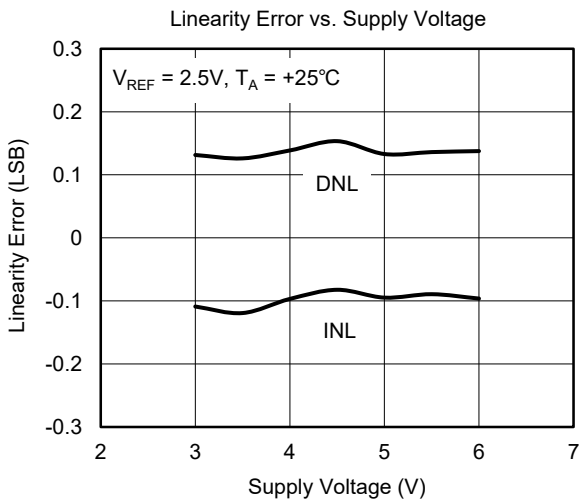
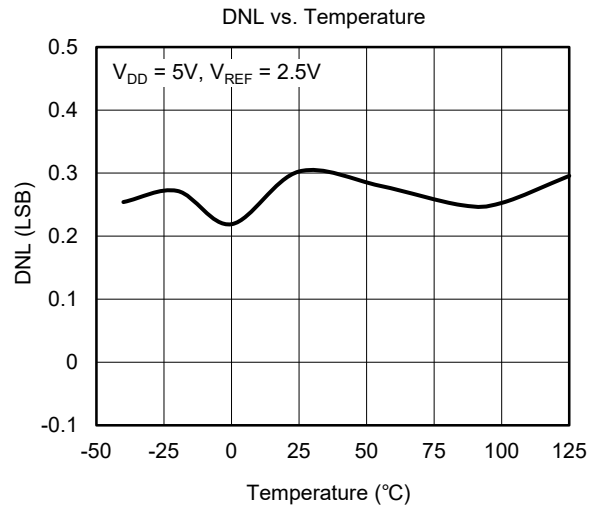
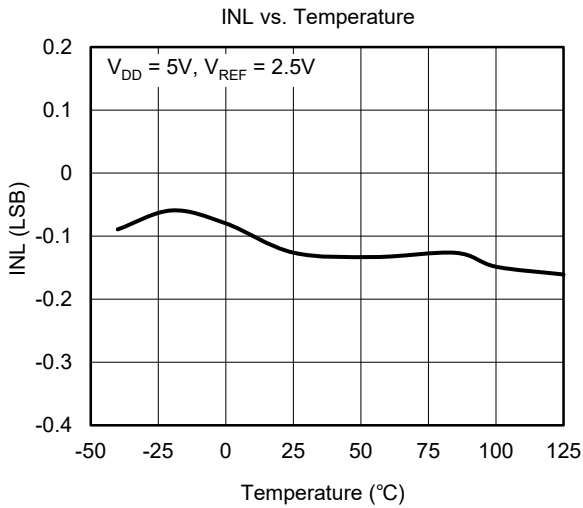
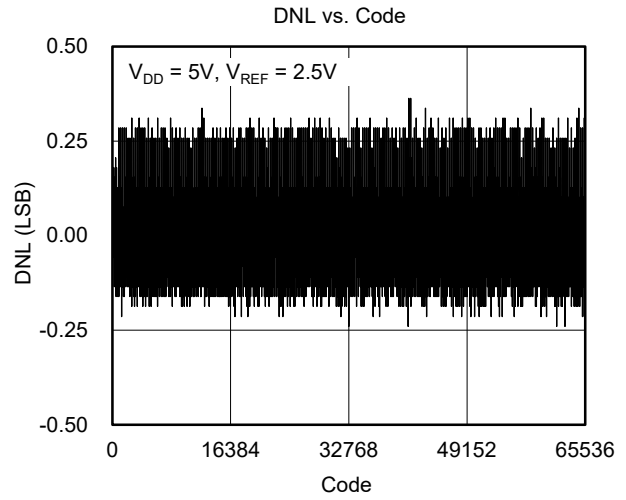
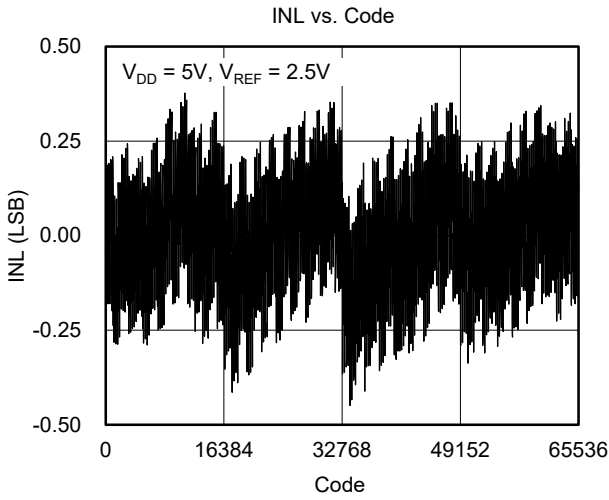
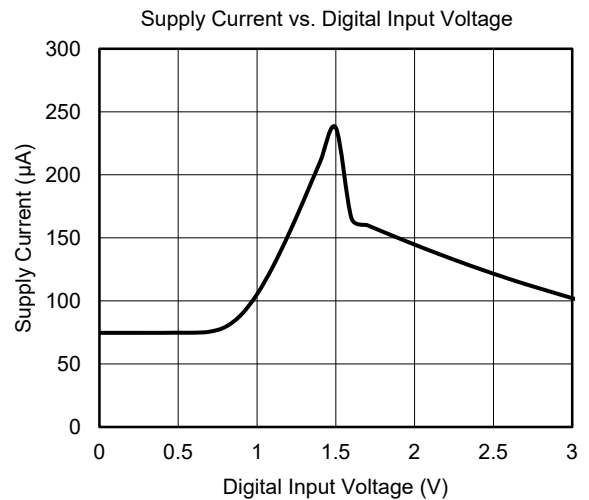
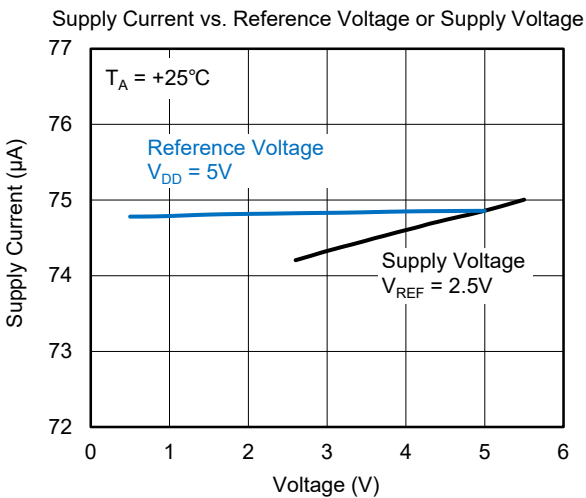
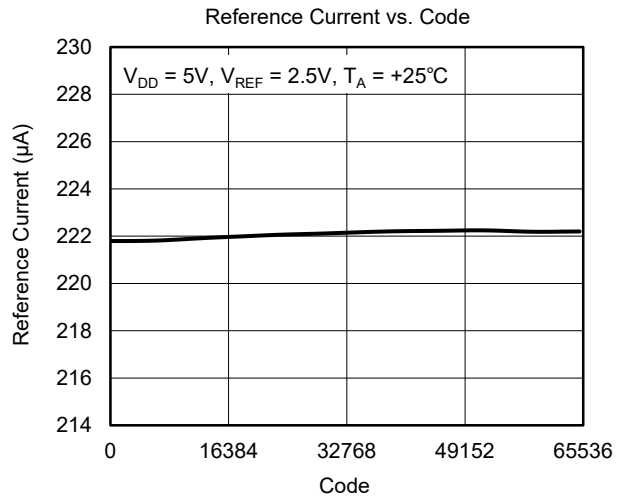
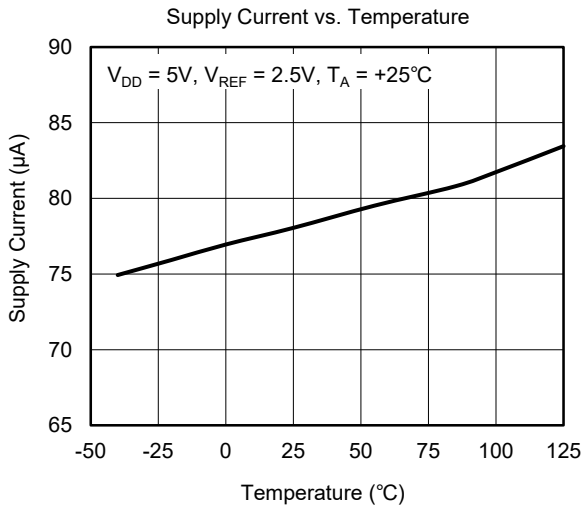
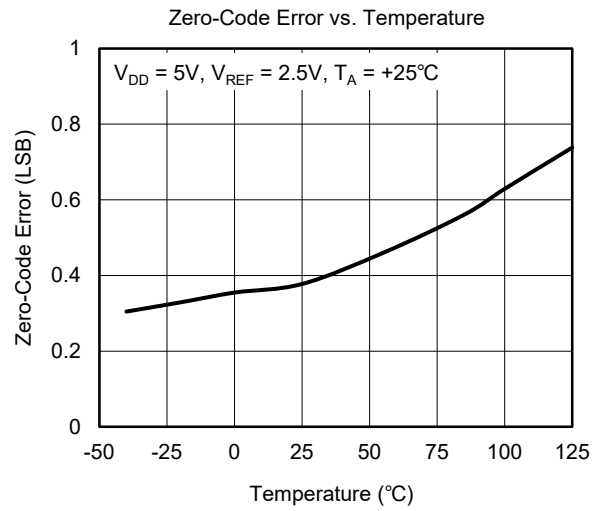
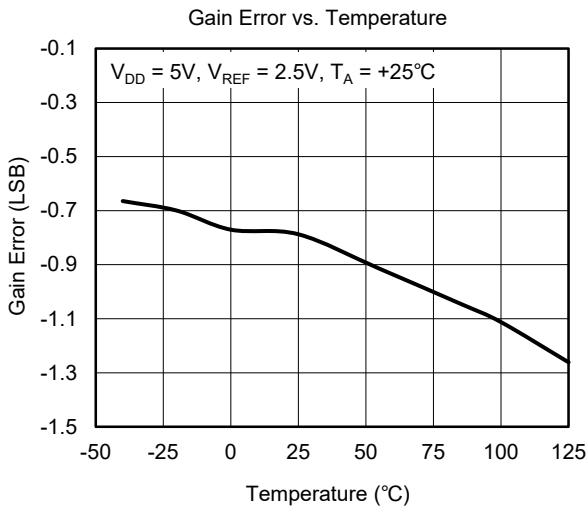


Figure 1. Timing Diagram

TYPICAL PERFORMANCE CHARACTERISTICS

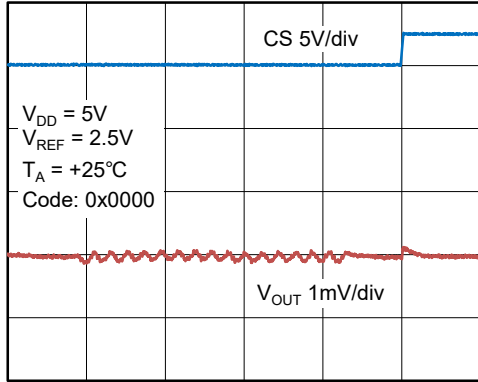


TYPICAL PERFORMANCE CHARACTERISTICS (continued)



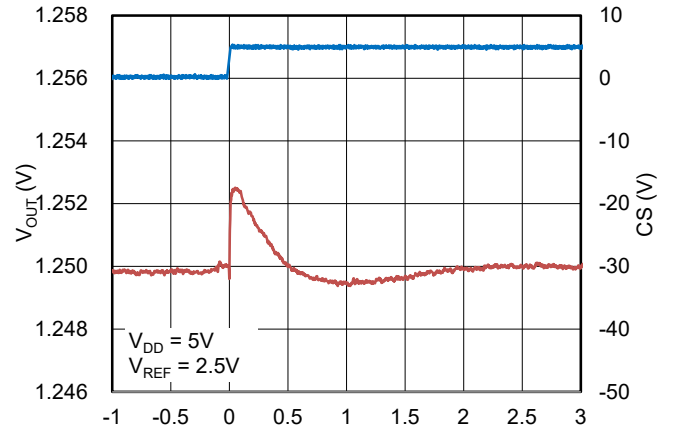
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Digital Feedthrough



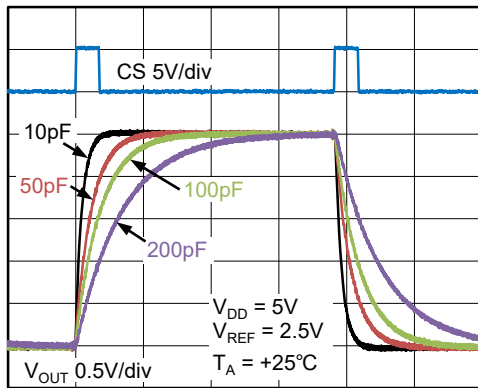
Time (2 $\mu s$ /div)

Digital-to-Analog Glitch Impulse



Time (0.5 $\mu s$ /div)

Large Signal Settling Time



Time (2 $\mu s$ /div)



FUNCTIONAL BLOCK DIAGRAM

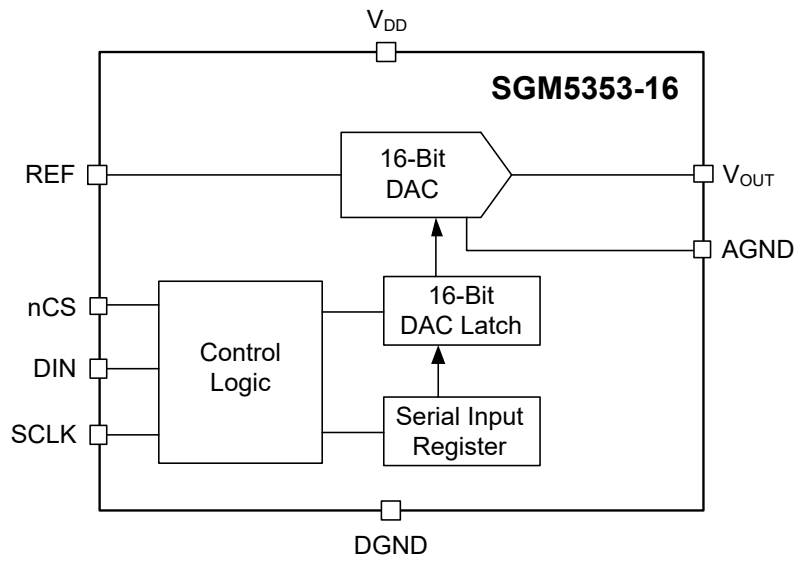


Figure 2. Block Diagram

**DETAILED DESCRIPTION**

The SGM5353-16 is a 16-bit, single channel, voltage-output DAC. It operates with a 3-wire SPI-compatible interface. And its output is power-on reset to 0V.

**DAC Section**

The SGM5353-16 is a voltage mode R-2R network DAC, and it doesn't have an output buffer. When operating with an external reference. An ideal output voltage is shown in the following equation:

$$V_{OUT} = \frac{V_{REF} \times D}{2^N} \tag{1}$$

Where:

D = Decimal equivalent of the data-word, which is loaded to the DAC register.

N = 16 now.

**Serial Interface**

The SGM5353-16 supports 3-wire SPI-compatible interface. Figure 1 shows a timing sequence. During the 16-bit word data is shifting in, the nCS keeps low. The data is locked into the input register on the rising edge of SCLK. A low-to-high transition of nCS loads the data of the input register to the DAC.

The data format is straight binary and MSB first.

**Output Operation**

The SGM5353-16 can output a voltage swing from 0V to a voltage reference (a 2.5V reference from the SGM4029-2.5 in Figure 3). The DAC is capable to drive a load of 60kΩ without a buffer. To improve the driving ability, a typical connection is shown in Figure 3.

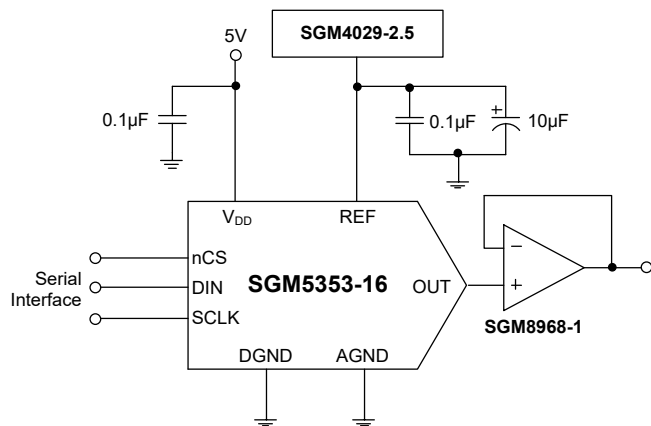


Figure 3. A Typical Connection

Table 1. Code Table

DAC Code	Analog Output
0xFFFF	$V_{REF} \times (65535/65536)$
0x8000	$V_{REF} \times (32768/65536) = \frac{1}{2}V_{REF}$
0x0001	$V_{REF} \times (1/65536)$
0x0000	0V

Don't consider the error of voltage reference, the worst case of output can be estimated by the following equation:

$$V_{OUT} = \frac{D}{2^{16}} \times (V_{REF} + V_{GE}) + V_{ZSE} + V_{INL} \tag{2}$$

Where:

$V_{OUT}$  = Worst case output.

D = Code that is loaded to DAC.

$V_{REF}$  = Reference voltage.

$V_{GE}$  = Gain error in volts.

$V_{ZSE}$  = Zero-code error in volts.

$V_{INL}$  = Integral nonlinearity in volts.

**Reference and Ground**

The SGM5353-16 needs an external voltage reference. The available reference voltage range is 2V to  $V_{DD}$ . In spite of the input impedance of voltage reference pin is code independent, the reference voltage pin should be driven from a low impedance source.

**Power-On Reset**

The SGM5353-16 has a power-on reset control circuit to reset output to 0V output when system is powered on. However, the serial input register is not reset to a defined code when system is powered up.

When operating to the SGM5353-16, at least a 16-bit data is required. If a more than 16-bit data is loaded, only the last 16 bits data is loaded to DAC.

**REVISION HISTORY**

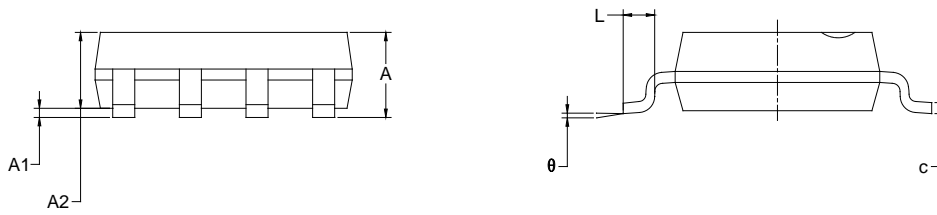
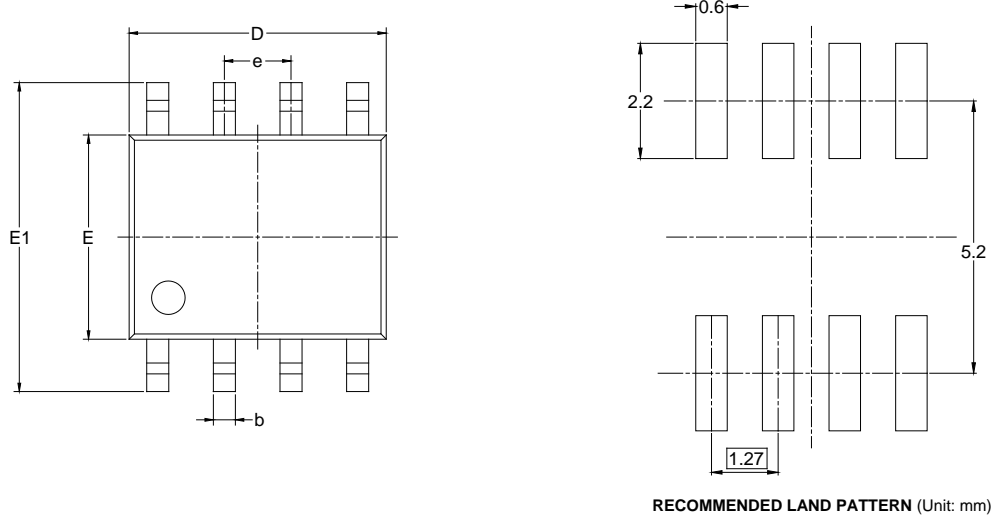
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Original (MARCH 2022) to REV.A</b>	<b>Page</b>
Changed from product preview to production data .....	All

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PACKAGE OUTLINE DIMENSIONS

SOIC-8



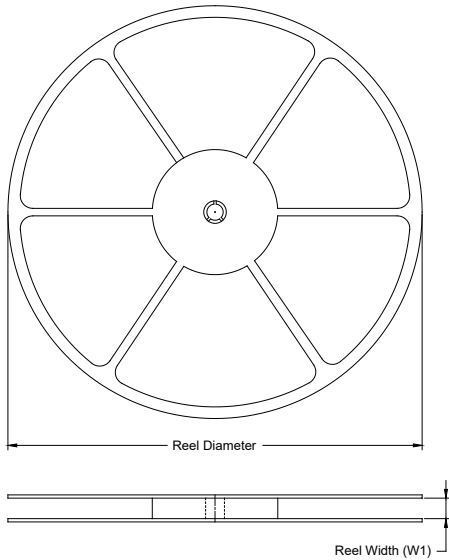
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

- NOTES:  
 1. Body dimensions do not include mode flash or protrusion.  
 2. This drawing is subject to change without notice.

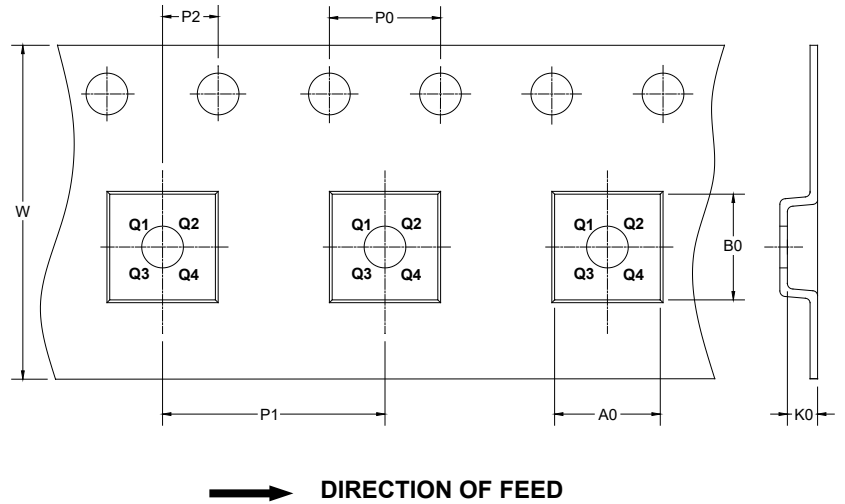
# PACKAGE INFORMATION

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



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
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1

DD0001

# PACKAGE INFORMATION

## 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
13"	386	280	370	5

DD0002