SGM5353-16
16-Bit, Serial Input, Voltage-Output Digital-to-Analog Converter

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 setting time output (setting to 0.5LSB of full-scale output within 1.5μs).

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

The SGM5353-16 is available in Green SOIC-8 and TDFN-3×3-8L packages. It operates over an ambient temperature range of -40℃ to +125℃.

FEATURES

- **16-Bit DAC, Monotonicity Guaranteed by Design**
- **Single-Supply Operation: 3V and 5V**
- **Settling Time: 1.5μs (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 Green SOIC-8 and TDFN-3×3-8L Packages**

APPLICATIONS

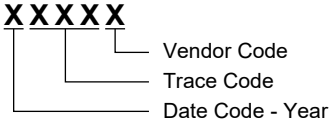
Process Control
Field Transducer
Automatic Test Equipment

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM5353-16	SOIC-8	-40℃ to +125℃	SGM5353-16XS8G/TR	SGM 535316XS8 XXXXX	Tape and Reel, 4000
			SGM5353-16XS8SG/TR	SGM 535316XS8 XXXXX	Tape and Reel, 500
	TDFN-3×3-8L	-40℃ to +125℃	SGM5353-16XTDB8G/TR	SGM 0IUDB XXXXX	Tape and Reel, 4000
			SGM5353-16XTDB8SG/TR	SGM 0IUDB XXXXX	Tape and Reel, 500

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace 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.

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.....±10mA
Package Thermal Resistance
SOIC-8, θ_{JA} ..... 116℃/W
SOIC-8, θ_{JC} ..... 55℃/W
TDFN-3×3-8L, θ_{JA} ..... 38℃/W
TDFN-3×3-8L, θ_{JC} ..... 48℃/W
Junction Temperature.....+150℃
Storage Temperature Range .....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃
ESD Susceptibility
HBM.....4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range.....-40℃ to +125℃

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

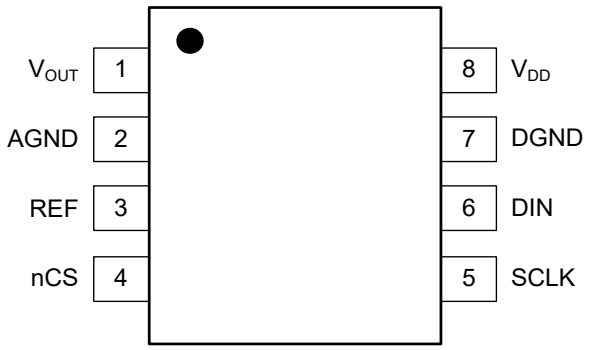
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

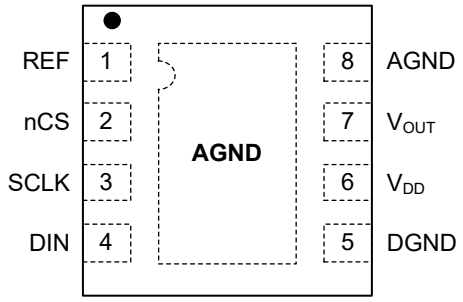
PIN CONFIGURATIONS

(TOP VIEW)



SOIC-8

(TOP VIEW)



TDFN-3×3-8L

PIN DESCRIPTION

PIN		NAME	TYPE (1)	FUNCTION
SOIC-8	TDFN-3×3-8L			
1	7	V_{OUT}	O	Analog Output.
2	8	AGND	G	Analog Ground.
3	1	REF	I	Reference Voltage Input Pin.
4	2	nCS	I	Chip Select Signal. Active low.
5	3	SCLK	I	Serial Clock Input Pin.
6	4	DIN	I	Serial Data Input Pin.
7	5	DGND	G	Digital Ground.
8	6	V_{DD}	P	Analog Power Supply Voltage.
—	Exposed Pad	AGND	—	Exposed Pad. Connect to AGND.

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

ELECTRICAL CHARACTERISTICS

(V_{DD} = 2.7V to 5.5V, 2V ≤ V_{REF} ≤ V_{DD}, AGND = DGND = 0V, T_A = -40℃ to +125℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Static Performance							
Resolution				16			Bits
Relative Accuracy	INL				0.15	1	LSB
Differential Nonlinearity	DNL	Guaranteed monotonic			0.3	1	LSB
Gain Error		SOIC-8	T_A = +25℃		0.8	1.7	LSB
			T_A = -40℃ to +125℃			2.2	
		TDFN-3×3-8L	T_A = +25℃		0.8	2	
			T_A = -40℃ to +125℃			3	
Gain Error Temperature Coefficient					0.04		ppm/℃
Unipolar Zero-Code Error		T_A = +25℃			0.4	1	LSB
		T_A = -40℃ to +125℃				1.8	
Unipolar Zero-Code Temperature Coefficient					0.04		ppm/℃
Output Characteristics							
Output Voltage Range				0		V_{REF} - 1LSB	V
Output Voltage Settling Time		To 1/2LSB of FS, C_L = 10pF			1.5		μs
Slew Rate		C_L = 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_{REF} = 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			1.3		μV_{PP}
Power Supply Rejection Ratio	PSRR	ΔV_{DD} ± 10%				0.6	LSB
DAC Reference Input							
Reference Input Range				2		V_{DD}	V
Reference Input Impedance				9.5			kΩ
Logic Inputs							
Input Current						1	μA
Input Low Voltage	V_{IL}					0.7	V
Input High Voltage	V_{IH}			2.1			V
Input Capacitance (1)					7		pF
Hysteresis Voltage (1)					0.1		V
Reference (1)							
Reference -3dB Bandwidth		All 1s loaded			3		MHz
Reference Feedthrough		All 0s loaded, V_{REF} = $1V_{PP}$ at 100kHz			1		mV_{PP}
Signal-to-Noise Ratio	SNR				92		dB
Reference Input Capacitance		Code 0x0000			45		pF
		Code 0xFFFF			45		
Power Requirements							
Supply Voltage	V_{DD}	Digital inputs at rails		2.7		5.5	V
Supply Current	I_{DD}				78	100	μA
Power Dissipation					0.39	0.55	mW

NOTE: 1. Guaranteed by design. Not production tested.

TIMING CHARACTERISTICS

(V_{DD} = 2.7V to 5.5V ±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℃ to +125℃, unless otherwise noted.) (1) (2)

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			
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.

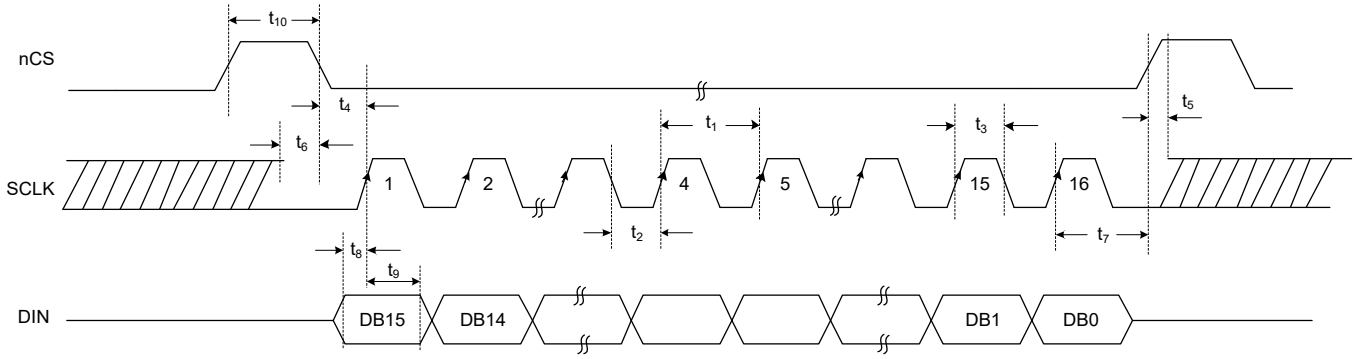
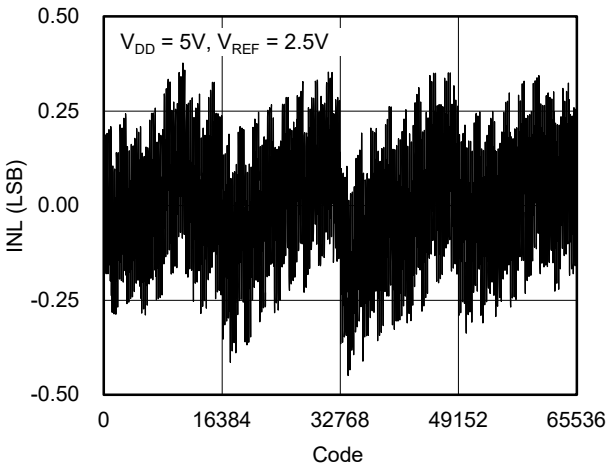


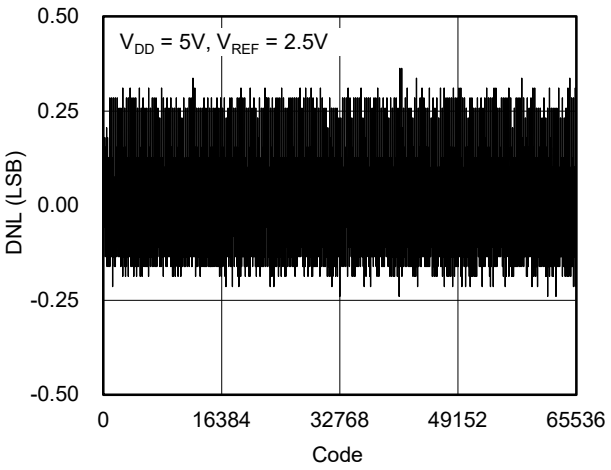
Figure 1. Timing Diagram

TYPICAL PERFORMANCE CHARACTERISTICS

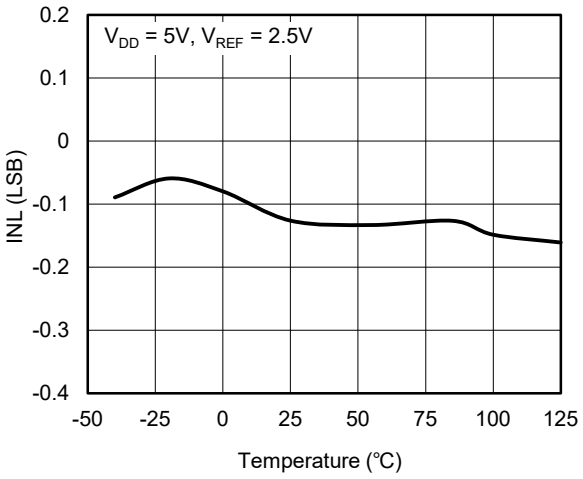
INL vs. Code



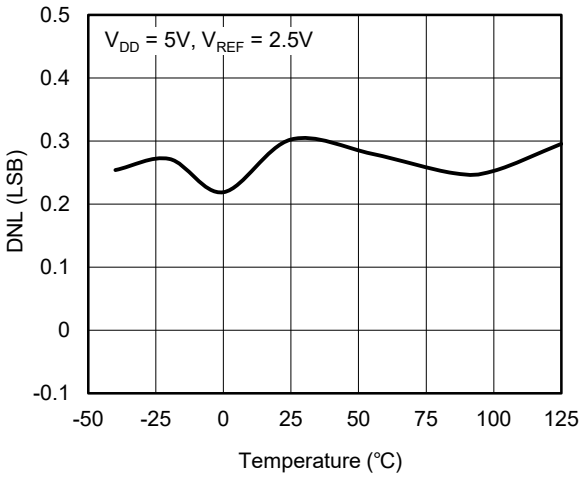
DNL vs. Code



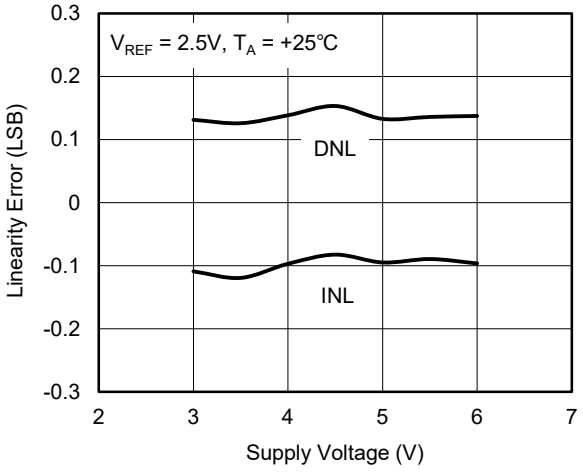
INL vs. Temperature



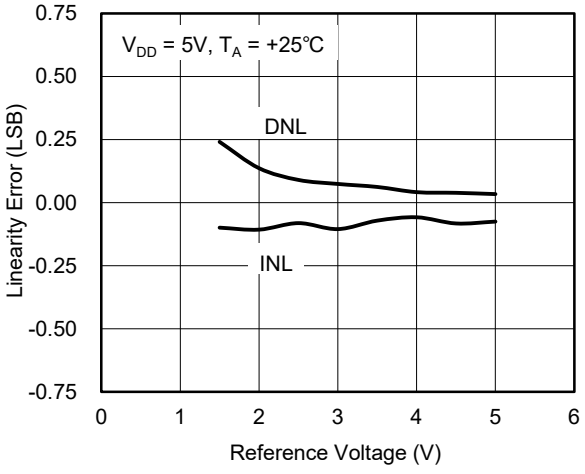
DNL vs. Temperature



Linearity Error vs. Supply Voltage

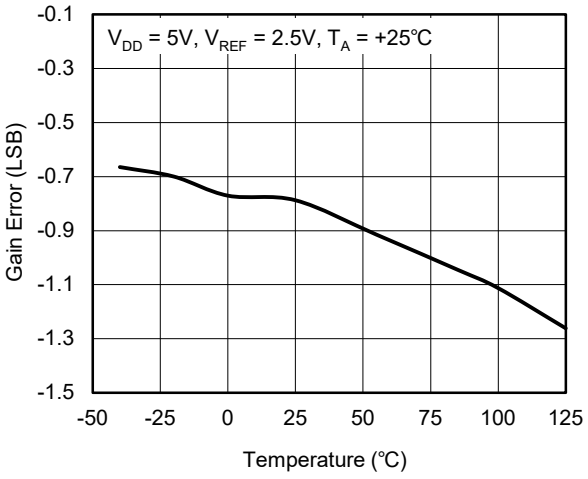


Linearity Error vs. Reference Voltage

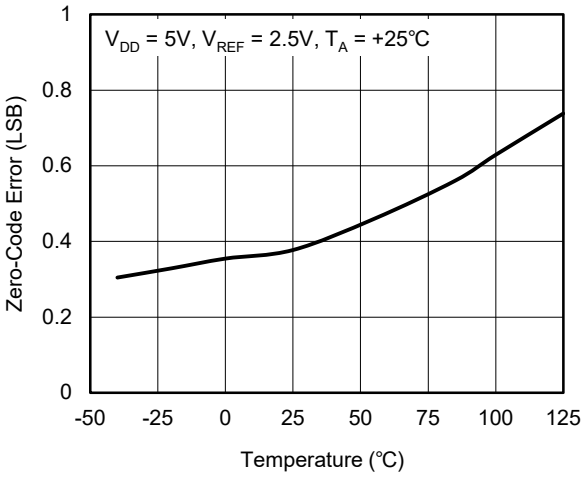


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

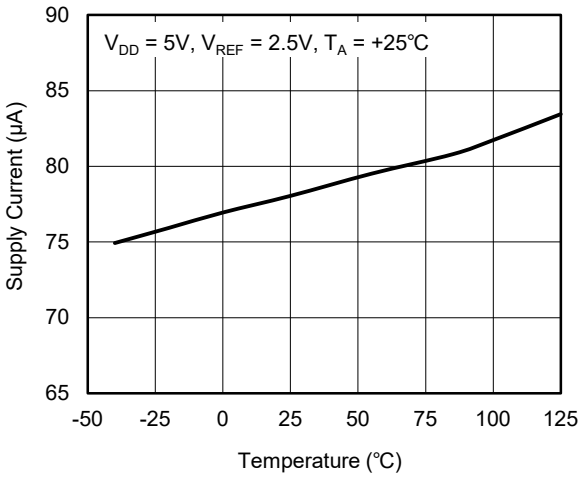
Gain Error vs. Temperature



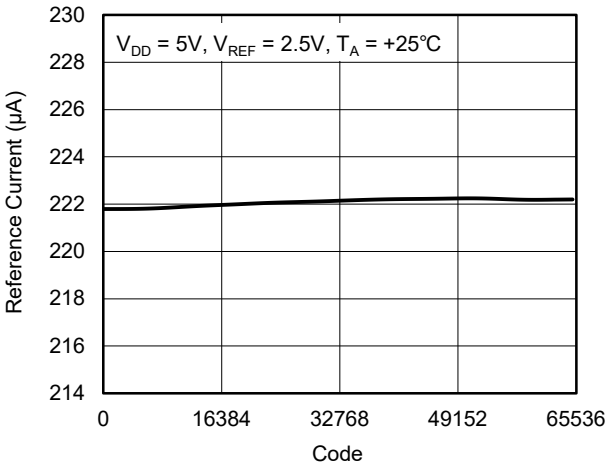
Zero-Code Error vs. Temperature



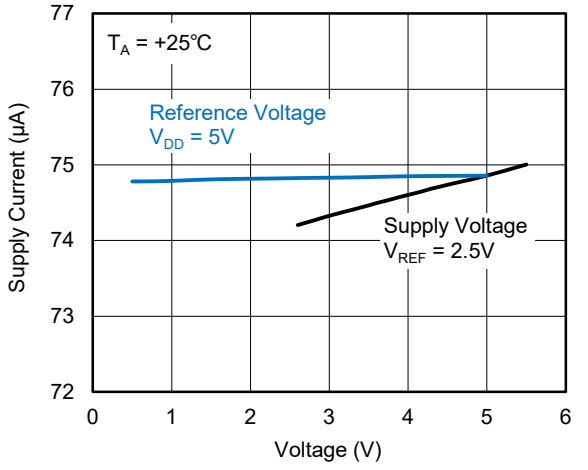
Supply Current vs. Temperature



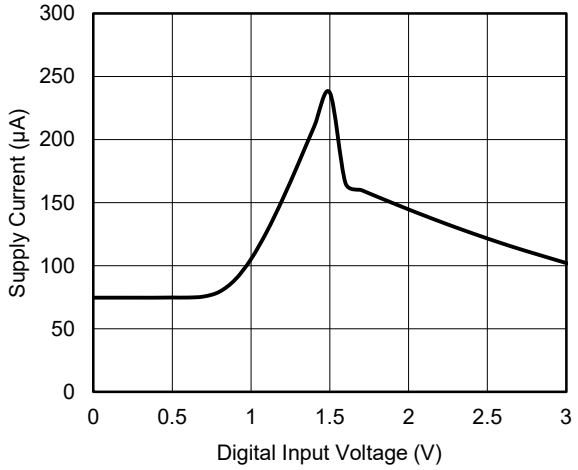
Reference Current vs. Code



Supply Current vs. Reference Voltage or Supply Voltage

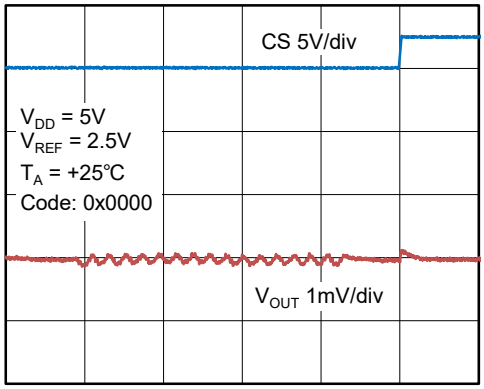


Supply Current vs. Digital Input Voltage



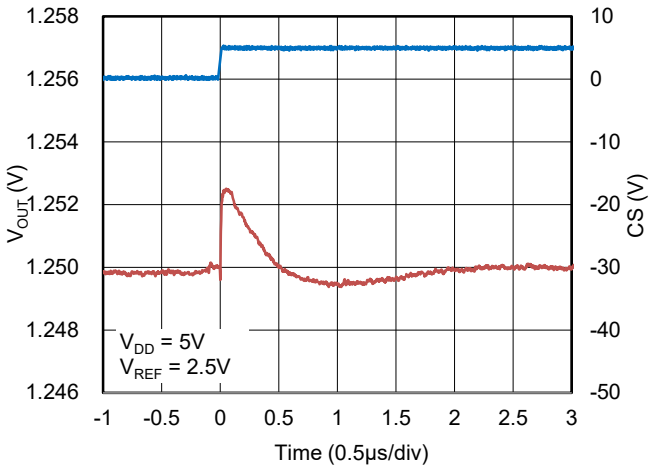
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Digital Feedthrough



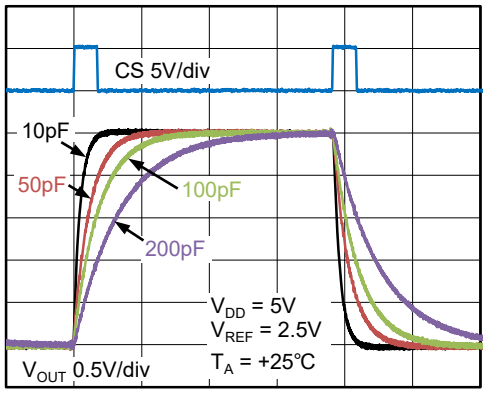
Time (2μs/div)

Digital-to-Analog Glitch Impulse



Time (0.5μs/div)

Large Signal Settling Time



Time (2μs/div)

FUNCTIONAL BLOCK DIAGRAM

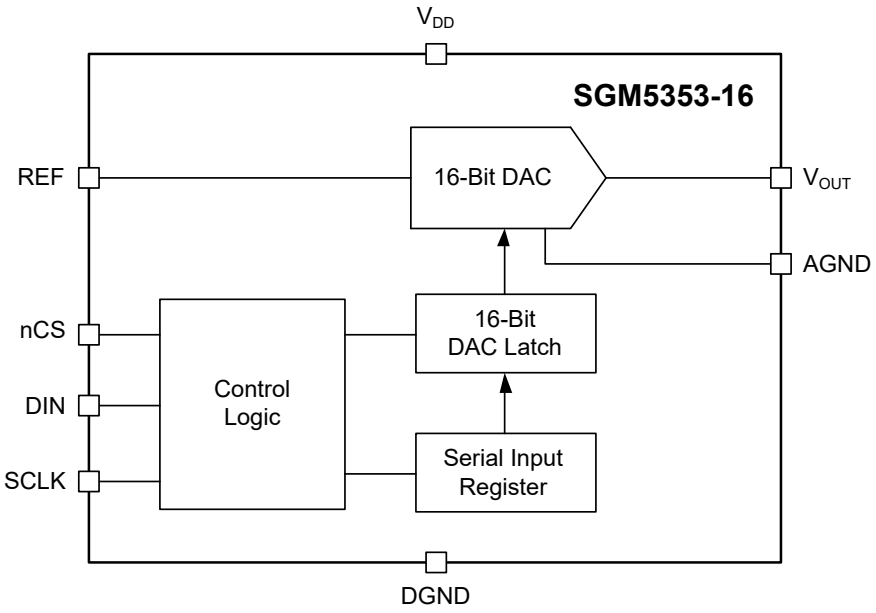


Figure 2. Block Diagram

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 does not have an output buffer. When operating with an external reference, an ideal output voltage is shown in the following equation:

$$V_{OUT} = \frac{V_{REF} \times D}{2^N} \quad (1)$$

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 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.

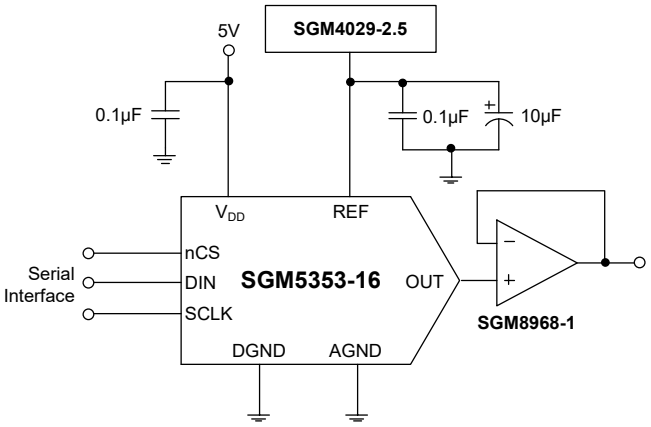


Figure 3. A Typical Connection

Table 1. Code Table

DAC Code	Analog Output
0xFFFF	V_{REF} × (65535/65536)
0x8000	V_{REF} × (32768/65536) = ½V_{REF}
0x0001	V_{REF} × (1/65536)
0x0000	0V

Do not consider the error of voltage reference, the worst case of output can be estimated by the following equation:

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

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

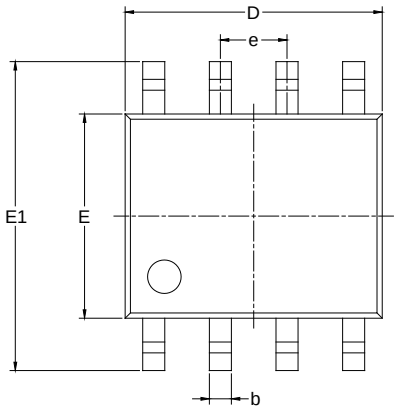
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

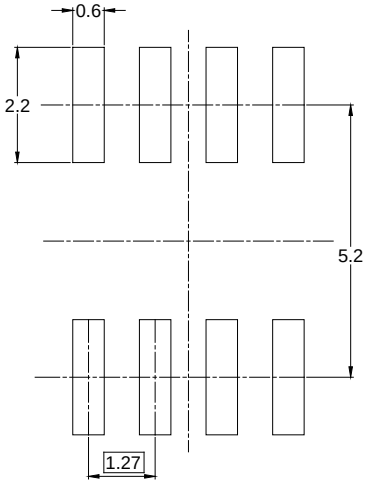
DECEMBER 2023 – REV.A to REV.A.1	Page
Added TDFN-3×3-8L Package	All
Updated Electrical Characteristics section	4

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

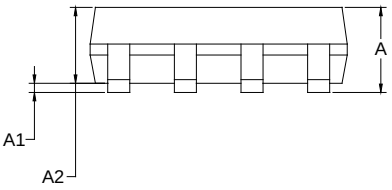
PACKAGE OUTLINE DIMENSIONS

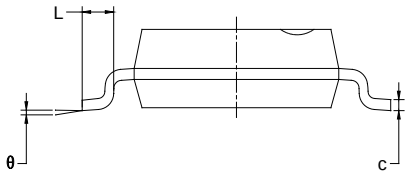
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)



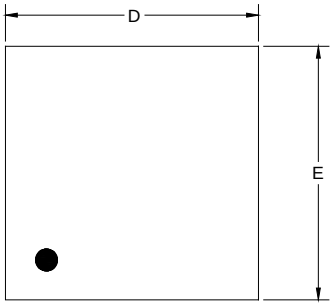


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

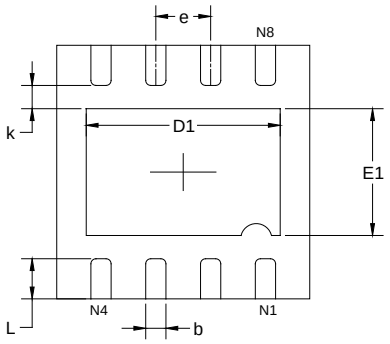
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

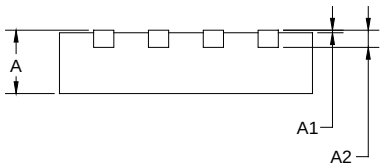
TDFN-3×3-8L



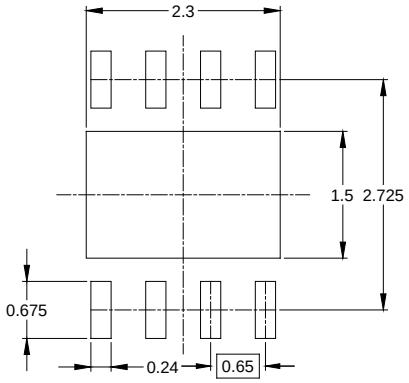
TOP VIEW



BOTTOM VIEW



SIDE VIEW



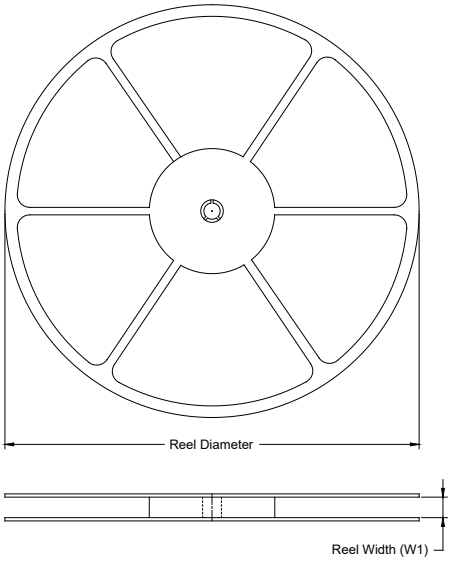
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.200	2.400	0.087	0.094
E	2.900	3.100	0.114	0.122
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.375	0.575	0.015	0.023

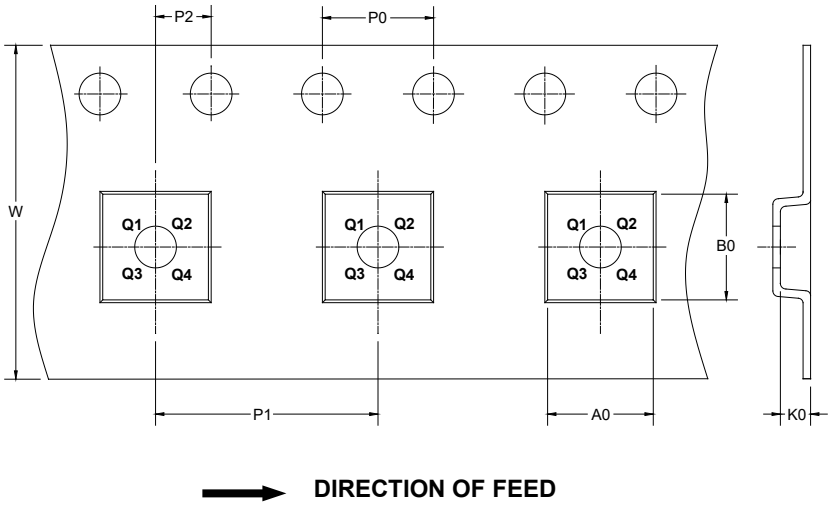
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



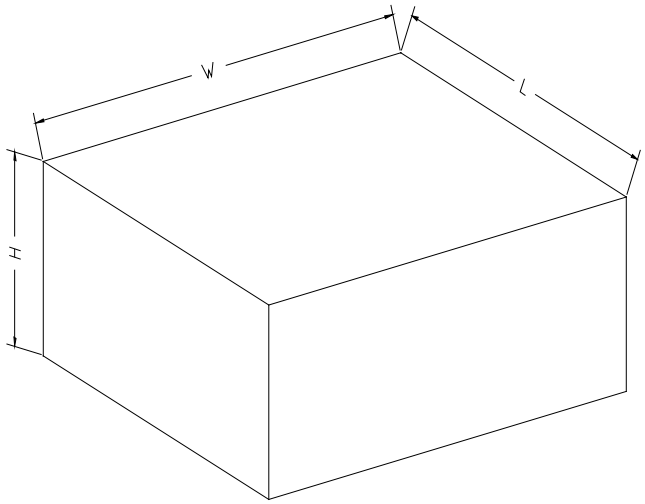
NOTE: The picture is only for reference. Please make the object as the standard.

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
TDFN-3×3-8L	13″	12.4	3.35	3.35	1.13	4.0	8.0	2.0	12.0	Q2

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
13″	386	280	370	5

DD0002