SGM8606
1.8V, Micro-Power, Precision, RRIO, CMOS Zero-Drift Operational Amplifier with Comparator and Voltage Reference

GENERAL DESCRIPTION

The SGM8606 is a high-precision and low power CMOS operational amplifier that provides very low offset voltage and zero-drift over time and temperature. One comparator and one low drift voltage reference are integrated with the amplifier.

The miniature, high-precision, low quiescent current amplifier offers high-impedance inputs that have a wide input common mode range 100mV beyond the rails and rail-to-rail output that swings within 14mV of the rails. Single or dual supplies as low as +1.8V (±0.9V) and up to +5.5V (±2.75V) may be used. It is optimized for low voltage, single-supply operation.

The amplifier offers excellent CMRR without the crossover associated with traditional complementary input stages. This design results in superior performance for driving analog-to-digital converters (ADCs) without degradation of differential linearity.

The comparator's input common mode range can be 200mV beyond the supply rails and the integrated voltage reference provides precise threshold in application.

The integrated 1.2V series voltage reference offers low 42μV/℃ drift. It is stable with up to 10nF capacitive load, and can source up to 2mA (TYP) of output current.

Designed to operate over a wide range of supply voltages, from 1.8V to 5.5V, with guaranteed operation at 1.8V and 5.0V, the SGM8606 is ideal for use in a variety of battery-powered applications. With rail-to-rail input common mode voltage range, the SGM8606 is well suited for single-supply operation. Its small package and low power make this device ideal for use in handheld electronics and mobile phone applications. The SGM8606 is available in Green TDFN-3×3-10L package. It is rated over the -40℃ to +85℃ temperature range.

FEATURES

- **Quiescent Current: 20μA (TYP)**
- **Supply Voltage Range: 1.8V to 5.5V**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in Green TDFN-3×3-10L Package**

AMPLIFIER

- **Low Offset Voltage: 50μV (MAX)**
- **Low 0.1Hz to 10Hz Noise: 2μV_{P-P}**
- **Integrated RFI Filter**
- **Single-Supply Operation**
- **Rail-to-Rail Input and Output**

COMPARATOR

- **Comparator Push-Pull Output Current Drive: 18mA (TYP) at V_S = 5V**
- **Comparator Rail-to-Rail Input**

VOLTAGE REFERENCE

- **1.2V Voltage Reference**
- **Low 42μV/℃ Drift**
- **2mA Output Drive Ability**

APPLICATIONS

Temperature Measurements
Medical Instrumentation
Battery-Powered Instrument
IR Receiver
Alarm and Monitoring Circuits

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8606	TDFN-3×3-10L	-40℃ to +85℃	SGM8606YTD10G/TR	SGM 8606D XXXXX	Tape and Reel, 4000

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.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage 6V
V_{IN} Differential ..... $\pm(+V_S - (-V_S))$
Voltage at I/O Pins ..... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V
Junction Temperature ..... 150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering 10sec) ..... 260℃
ESD Susceptibility
HBM 4000V
MM 400V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Specified Voltage Range ..... 1.8V to 5.5V
Operating Temperature Range ..... -40℃ to +85℃

OVERSTRESS CAUTION

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

ESD SENSITIVITY CAUTION

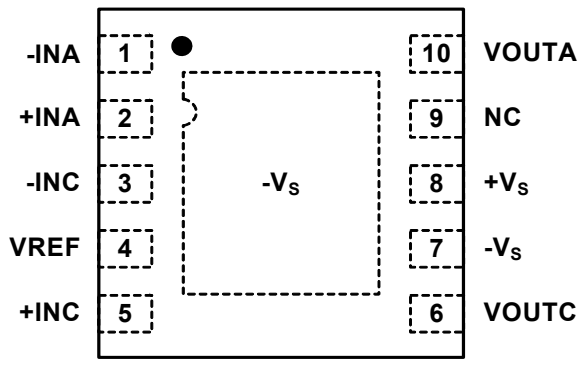
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

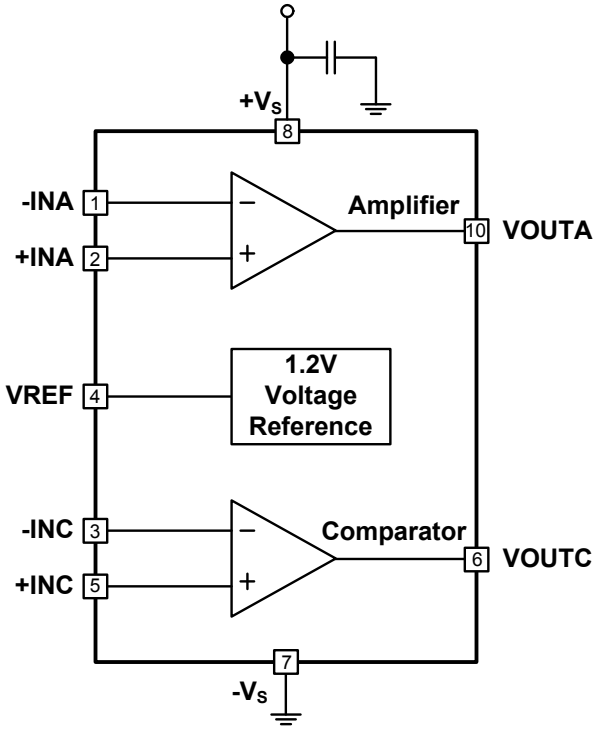
PIN CONFIGURATION

SGM8606 (TOP VIEW)



TDFN-3×3-10L

BLOCK DIAGRAM



PIN DESCRIPTION

PIN	NAME	FUNCTION
1	-INA	Negative Input of Amplifier.
2	+INA	Positive Input of Amplifier.
3	-INC	Negative Input of Comparator.
4	VREF	1.2V Voltage Reference Output.
5	+INC	Positive Input of Comparator.
6	VOUTC	Output of Comparator. Push-Pull output.
7	$-V_S$	Negative Supply. Always connect this pin to ground for single power supply Application.
8	$+V_S$	Positive Power Supply.
9	NC	No Connection.
10	VOUTA	Output of Amplifier.
Exposed Pad	—	Exposed Paddle. Must be connected to $-V_S$ or left floating.

ELECTRICAL CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Power Supply Range	V_S		1.8		5.5	V
Quiescent Current	I_Q	I_O = 0		20	37	μA
		-40℃ ≤ T_A ≤ +85℃			48	

Operational Amplifier Only

(At T_A = +25℃, V_S = 5V, V_{CM} = +V_S/2, V_{OUT} = +V_S/2, and R_L = 10kΩ to +V_S/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}	V_S = 5V		22	50	μV
		-40℃ ≤ T_A ≤ +85℃			83	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	-40℃ ≤ T_A ≤ +85℃		0.08		μV/℃
Input Bias Current	I_B			130		pA
Input Common Mode Voltage Range	V_{CM}		(-V_S) - 0.1		(+V_S) + 0.1	V
Common Mode Rejection Ratio	CMRR	(-V_S) - 0.1V < V_{CM} < (+V_S) + 0.1V	89	100		dB
		-40℃ ≤ T_A ≤ +85℃	85			
Open-Loop Voltage Gain	A_{OL}	(-V_S) + 0.1V < V_O < (+V_S) - 0.1V, R_L = 10kΩ	95	121		dB
		-40℃ ≤ T_A ≤ +85℃	94			
INPUT IMPEDANCE						
Differential				10^9		Ω
Common Mode				10^9		Ω
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail		R_L = 10kΩ		14	25	mV
		-40℃ ≤ T_A ≤ +85℃			27	
Short-Circuit Current	I_{SC}	V_S = 5V		60		mA
Open-Loop Output Impedance		f = 350kHz, I_O = 0		1		kΩ
POWER SUPPLY						
Specified Voltage Range	V_S		1.8		5.5	V
Power Supply Rejection Ratio	PSRR	V_S = 1.8V to 5.5V		4	20	μV/V
		-40℃ ≤ T_A ≤ +85℃			25	
Turn-On Time		V_S = 5V		220		μs
DYNAMIC PERFORMANCE						
Gain-Bandwidth Product	GBP	C_L = 100pF		350		kHz
Slew Rate	SR	G = +1		0.18		V/μs
NOISE						
Input Voltage Noise		f = 0.1Hz to 10Hz		2		μV_{P-P}

ELECTRICAL CHARACTERISTICS

Comparator and Voltage Reference (V_S = 1.8V)

(At T_A = +25℃, $+V_S$ = 1.8V, $-V_S$ = 0V, V_{CM} = $+V_S$/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	V_{CM} = 0V		0.5	3	mV
		V_{CM} = 1.8V		0.5	3	
Input Offset Average Drift				2		μV/℃
Common Mode Rejection Ratio	CMRR	V_{CM} = 0V to 1.8V	55	68		dB
Power Supply Rejection Ratio	PSRR	V_S = 1.8V to 5.5V, V_{CM} = 0V	74	102		dB
Power Supply Ramp-Up Rate (1)			5			V/s
Large Signal Voltage Gain	A_{VO}			100		dB
Output Swing High	V_{OH}	I_O = 1mA	1.412	1.525		V
		I_O = 1mA, -40℃ ≤ T_A ≤ +85℃	1.330			
Output Swing Low	V_{OL}	I_O = -1mA		173	249	mV
		I_O = -1mA, -40℃ ≤ T_A ≤ +85℃			347	
Output Current	I_{OUT}	Source	1.15	2		mA
		Source, -40℃ ≤ T_A ≤ +85℃	1.0			
		Sink		-3.5	-2.0	
		Sink, -40℃ ≤ T_A ≤ +85℃			-1.4	
Propagation Delay (High to Low)		Overdrive = 10mV		11.7		μs
		Overdrive = 100mV		5.6		
Propagation Delay (Low to High)		Overdrive = 10mV		24.2		μs
		Overdrive = 100mV		14.7		
Rise Time	t_{RISE}	Overdrive = 10mV, C_L = 30pF, R_L = 1MΩ		168		ns
		Overdrive = 100mV, C_L = 30pF, R_L = 1MΩ		174		
Fall Time	t_{FALL}	Overdrive = 10mV, C_L = 30pF, R_L = 1MΩ		75		ns
		Overdrive = 100mV, C_L = 30pF, R_L = 1MΩ		50		
Noise of V_{REF}		f = 0.1Hz to 10Hz		0.3		mV_{P-P}
VOLTAGE REFERENCE						
Reference Voltage	V_{REF}	I_{REF} = 0mA	1.176	1.200	1.224	V
Reference Voltage Drift				42		μV/℃
Reference Output Current (Source)				2		mA

ELECTRICAL CHARACTERISTICS

Comparator and Voltage Reference (V_S = 5V)

(At T_A = +25℃, $+V_S$ = 5V, $-V_S$ = 0V, V_{CM} = $+V_S$/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	V_{CM} = 0V		0.5	3	mV
		V_{CM} = 5V		0.5	3	
Input Offset Average Drift				2		μV/℃
Common Mode Rejection Ratio	CMRR	V_{CM} = 0V to 5V	63	76		dB
Power Supply Rejection Ratio	PSRR	V_S = 1.8V to 5.5V, V_{CM} = 0V	74	102		dB
Power Supply Ramp-Up Rate (1)			5			V/s
Large Signal Voltage Gain	A_{VO}			110		dB
Output Swing High	V_{OH}	I_O = 1mA	4.874	4.904		V
		I_O = 1mA, -40℃ ≤ T_A ≤ +85℃	4.855			
Output Swing Low	V_{OL}	I_O = -1mA		106	140	mV
		I_O = -1mA, -40℃ ≤ T_A ≤ +85℃			154	
Output Current	I_{OUT}	Source	14.0	18		mA
		Source, -40℃ ≤ T_A ≤ +85℃	10.5			
		Sink		-18	-15.5	
		Sink, -40℃ ≤ T_A ≤ +85℃			-12.5	
Propagation Delay (High to Low)		Overdrive = 10mV		12.7		μs
		Overdrive = 100mV		5.6		
Propagation Delay (Low to High)		Overdrive = 10mV		38.1		μs
		Overdrive = 100mV		29.5		
Rise Time	t_{RISE}	Overdrive = 10mV, C_L = 30pF, R_L = 1MΩ		39		ns
		Overdrive = 100mV, C_L = 30pF, R_L = 1MΩ		40		
Fall Time	t_{FALL}	Overdrive = 10mV, C_L = 30pF, R_L = 1MΩ		33		ns
		Overdrive = 100mV, C_L = 30pF, R_L = 1MΩ		30		
Noise of V_{REF}		f = 0.1Hz to 10Hz		0.32		mV_{P-P}
VOLTAGE REFERENCE						
Reference Voltage	V_{REF}	I_{REF} = 0mA	1.176	1.200	1.224	V
Reference Voltage Drift				41		μV/℃
Reference Output Current (Source)				2		mA

NOTE:

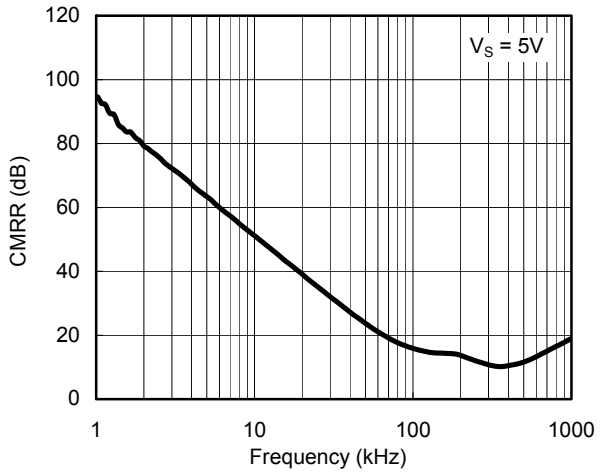
1. If the power supply ramp-up rate is lower than 5V/s, the reference voltage output is not guaranteed to start up.

TYPICAL PERFORMANCE CHARACTERISTICS

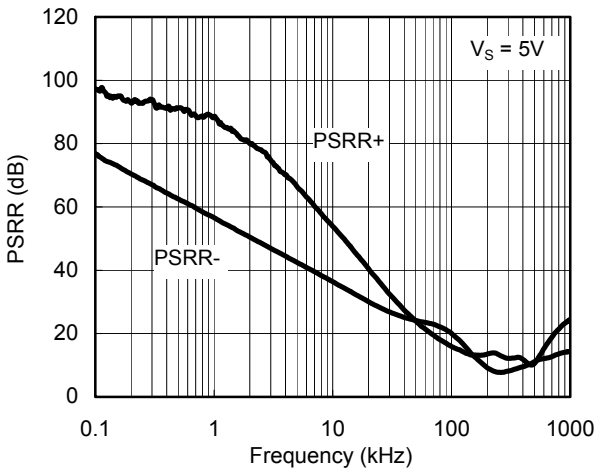
Operational Amplifier Only

At T_A = +25℃, V_S = 5V, and C_L = 0pF, unless otherwise noted.

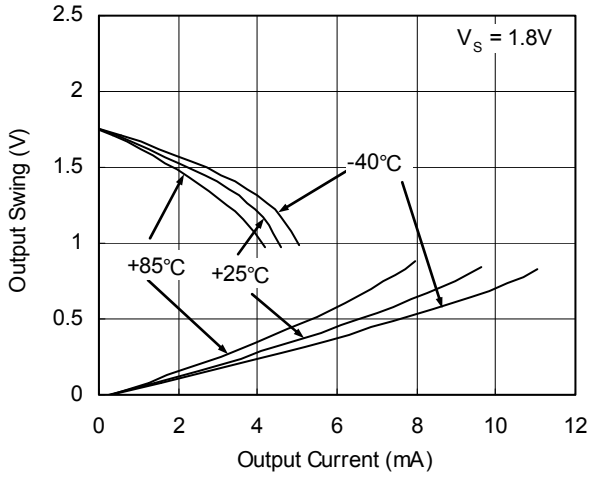
Common Mode Rejection Ratio vs. Frequency



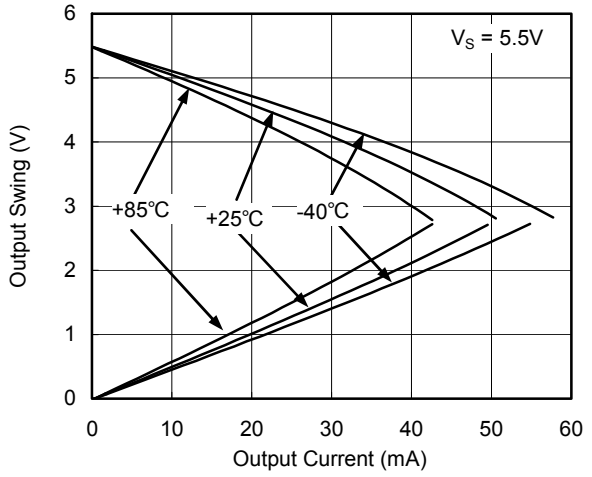
Power Supply Rejection Ratio vs. Frequency



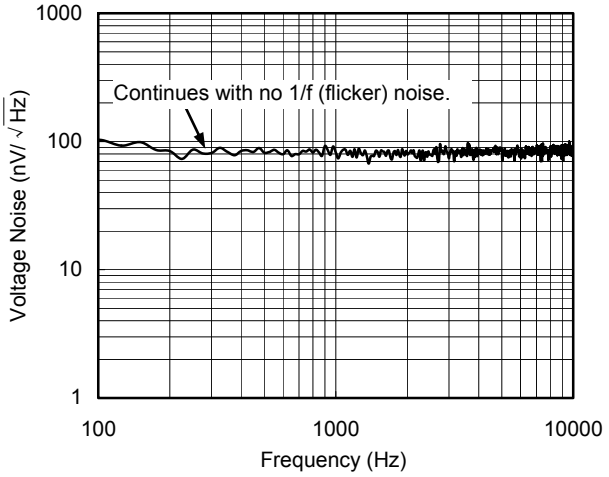
Output Voltage Swing vs. Output Current



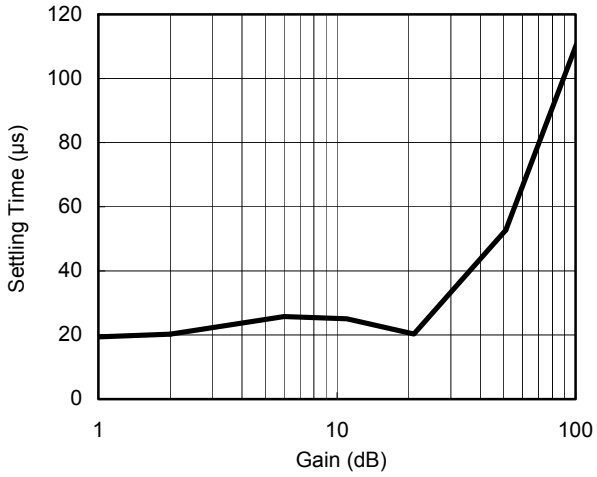
Output Voltage Swing vs. Output Current



Voltage Noise Spectral Density vs. Frequency



Settling Time vs. Closed-Loop Gain

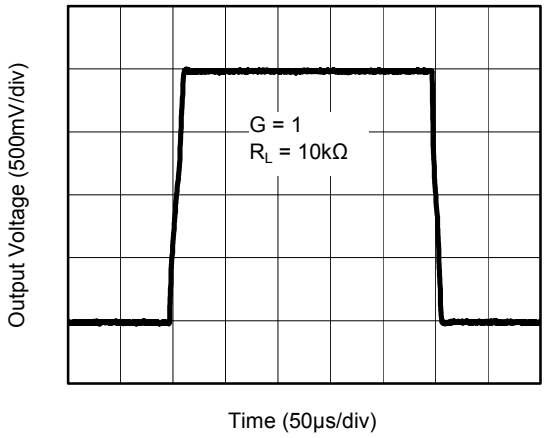


TYPICAL PERFORMANCE CHARACTERISTICS

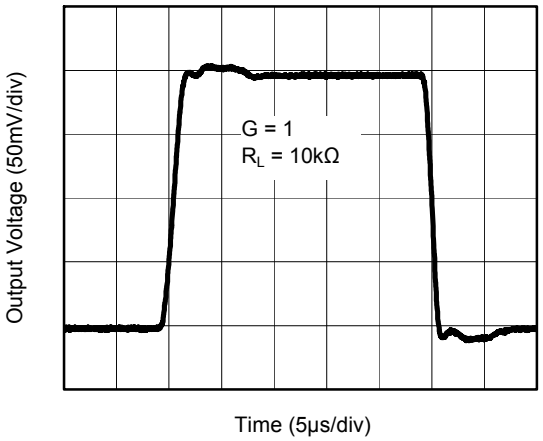
Operational Amplifier Only

At T_A = +25℃, V_S = 5V, and C_L = 0pF, unless otherwise noted.

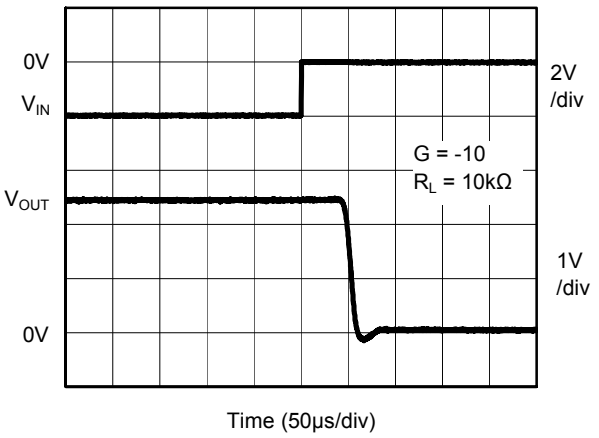
Large-Signal Step Response



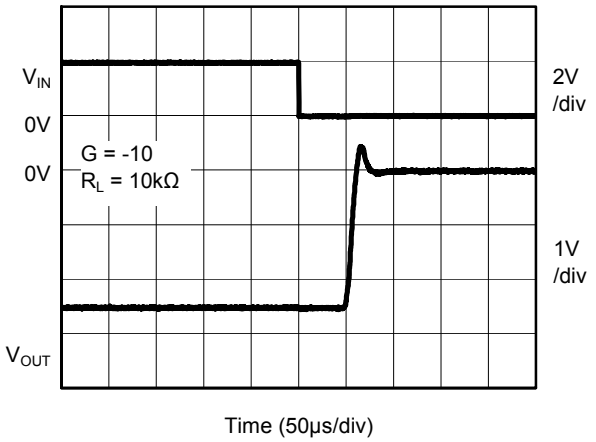
Small-Signal Step Response



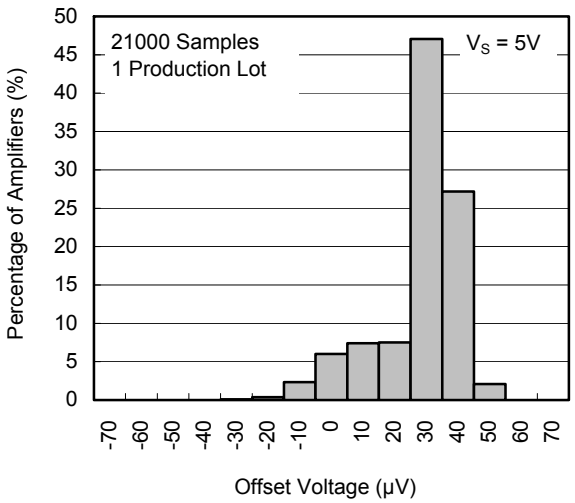
Positive Over-Voltage Recovery



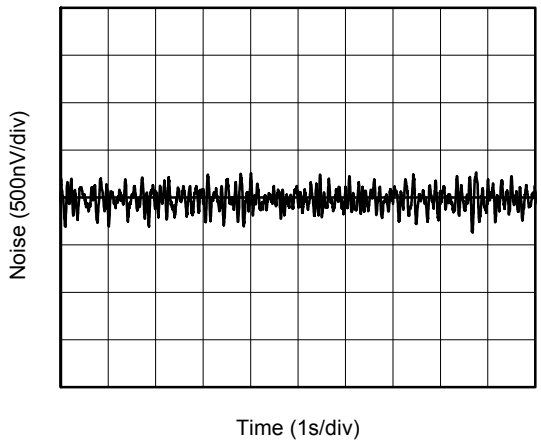
Negative Over-Voltage Recovery



Offset Voltage Production Distribution



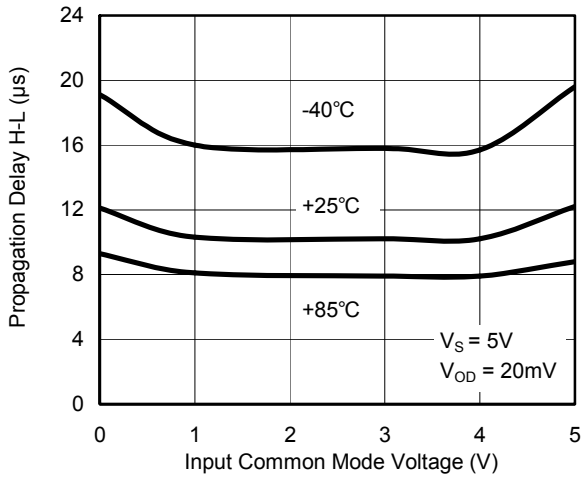
0.1Hz to 10Hz Noise



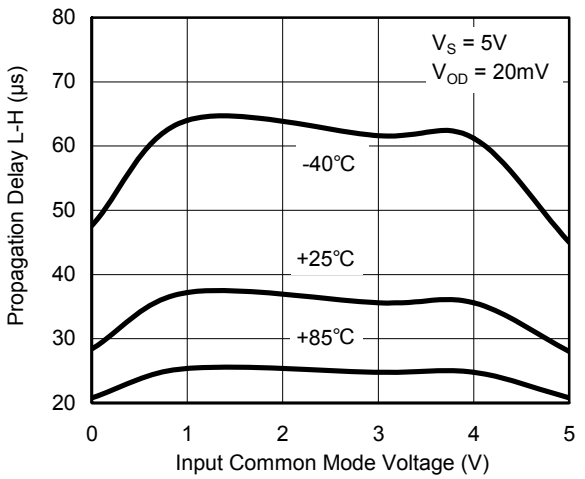
TYPICAL PERFORMANCE CHARACTERISTICS

Comparator Only

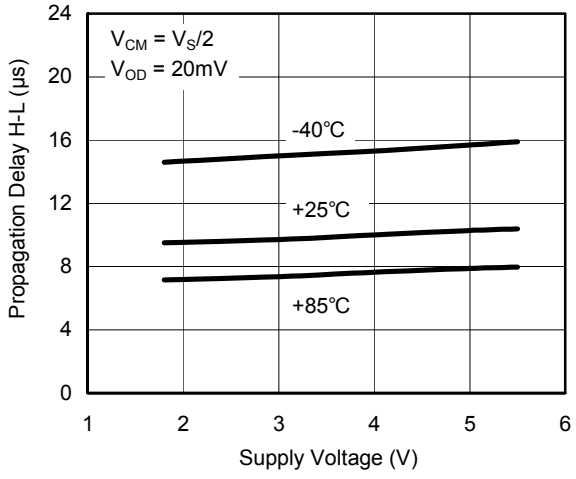
Propagation Delay vs. Input Common Mode Voltage



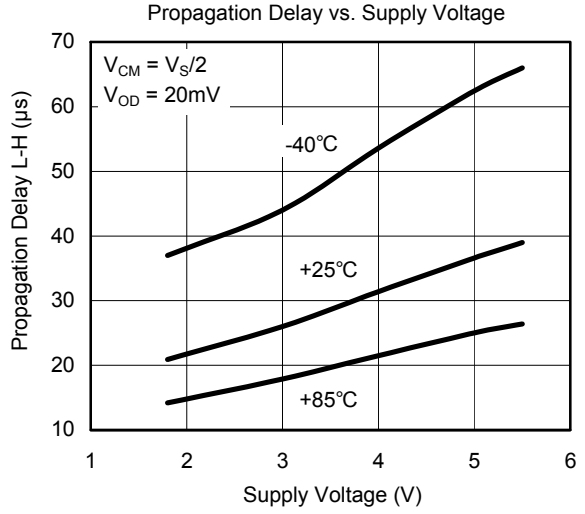
Propagation Delay vs. Input Common Mode Voltage



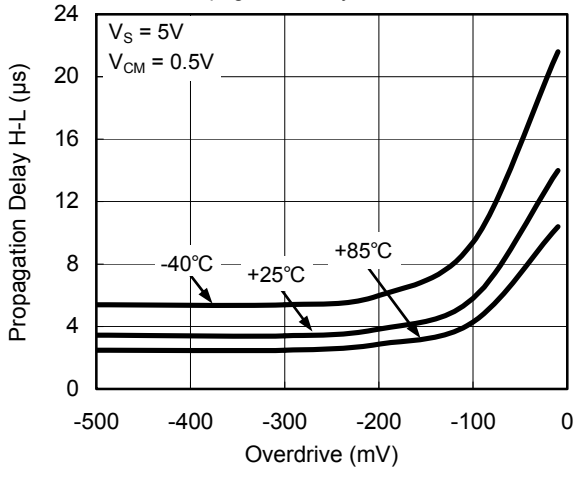
Propagation Delay vs. Supply Voltage



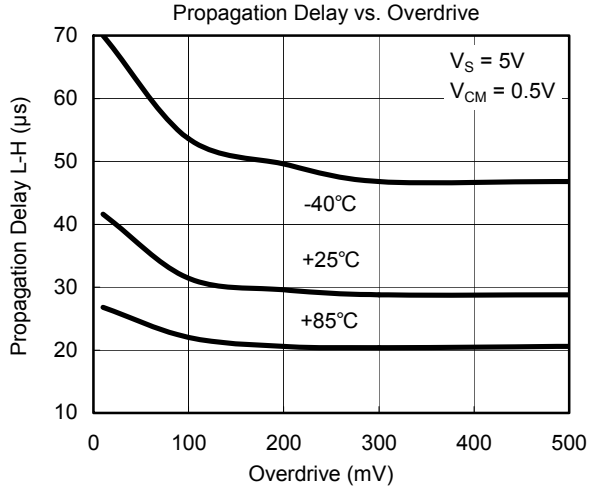
Propagation Delay vs. Supply Voltage



Propagation Delay vs. Overdrive

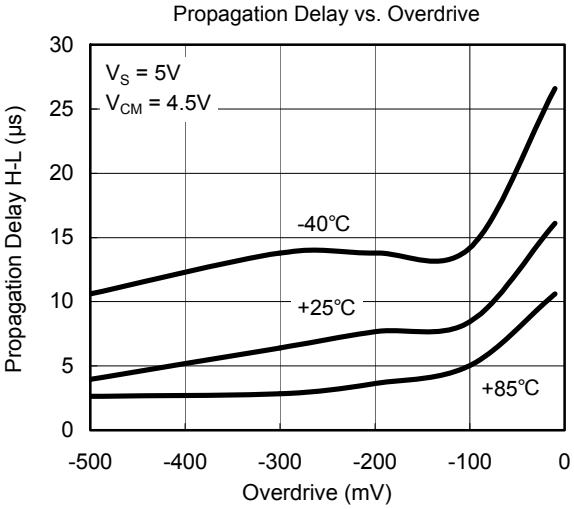


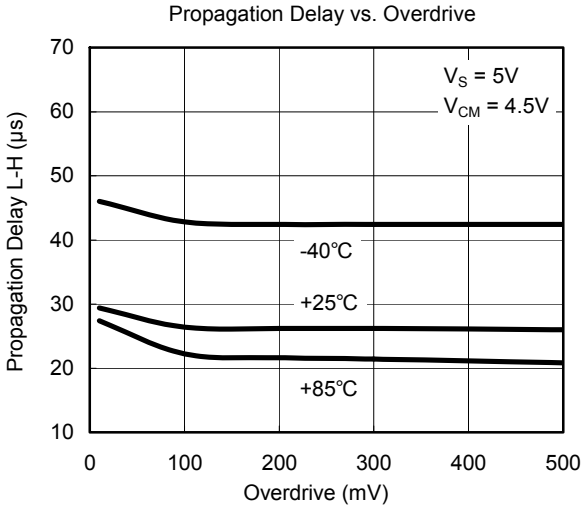
Propagation Delay vs. Overdrive

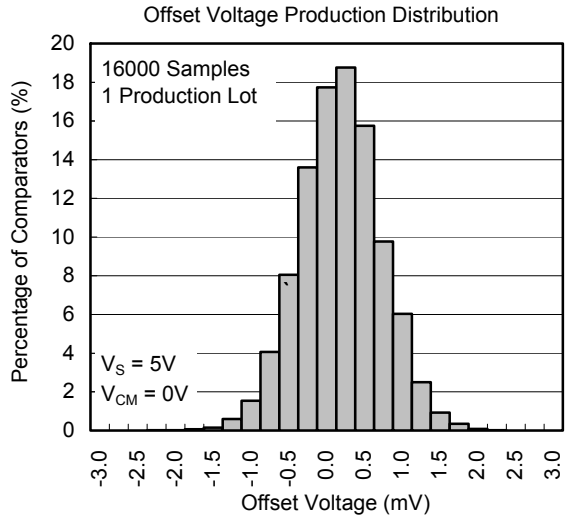


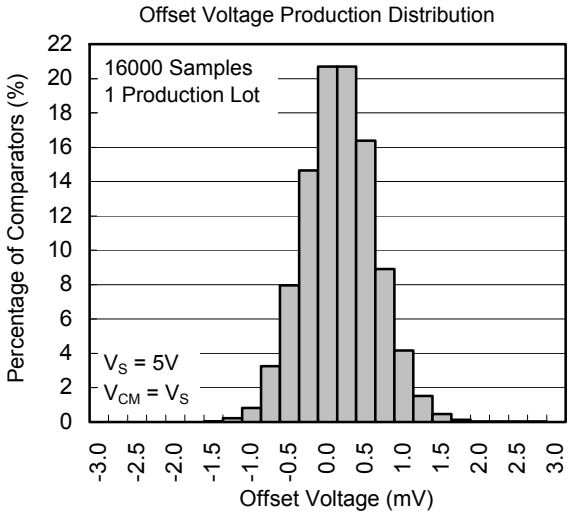
TYPICAL PERFORMANCE CHARACTERISTICS

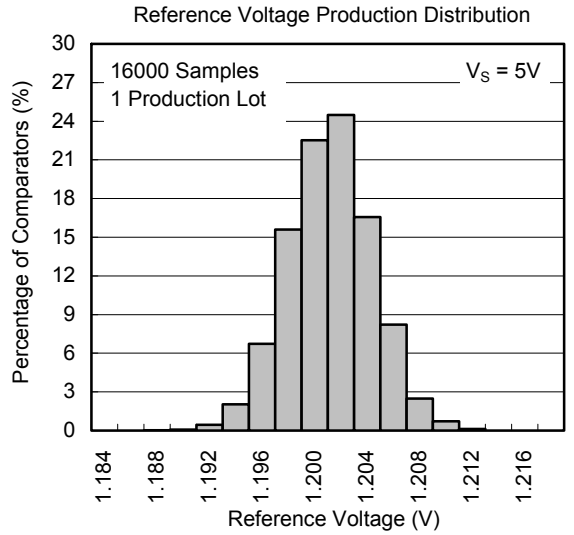
Comparator Only







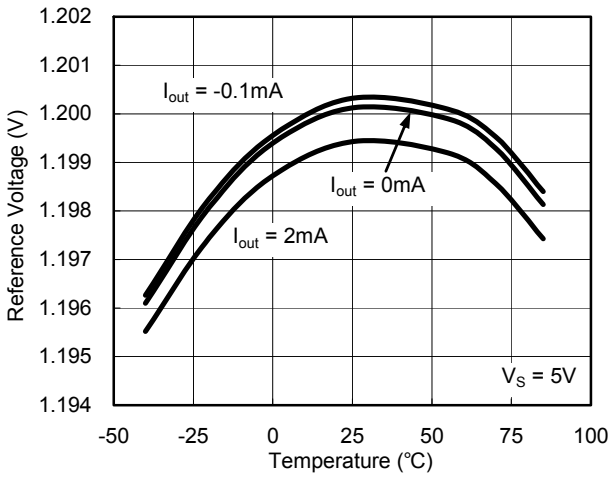




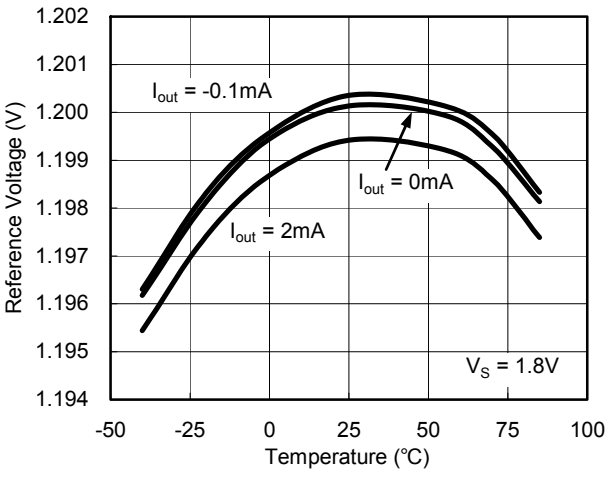
TYPICAL PERFORMANCE CHARACTERISTICS

Comparator Only

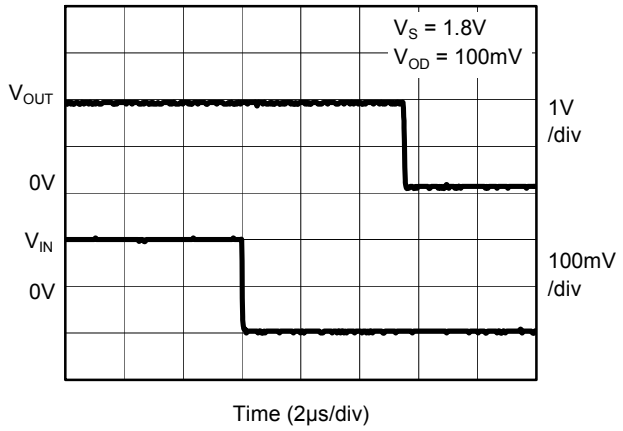
Reference Voltage vs. Temperature



Reference Voltage vs. Temperature

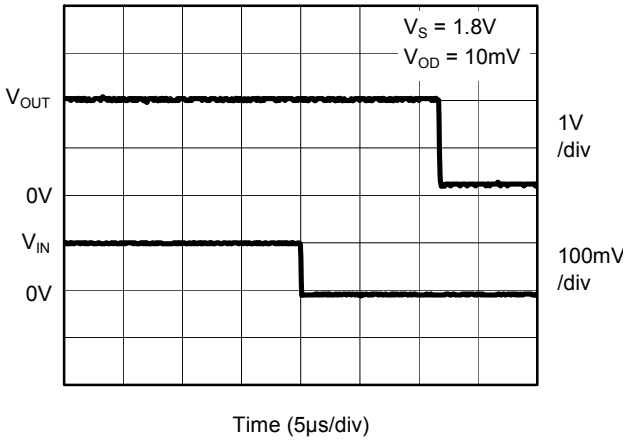


Propagation Delay (t_{PHL})



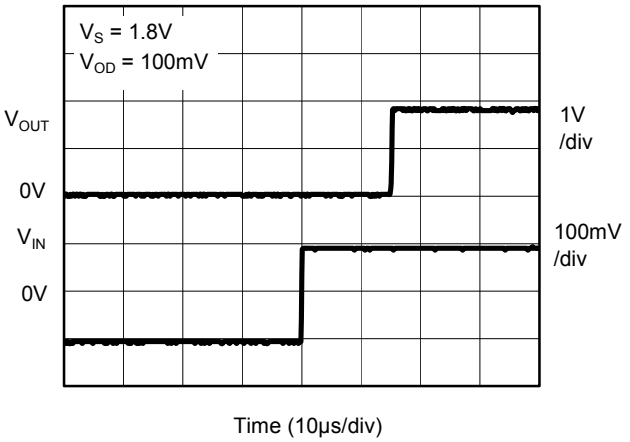
Time (2μs/div)

Propagation Delay (t_{PHL})



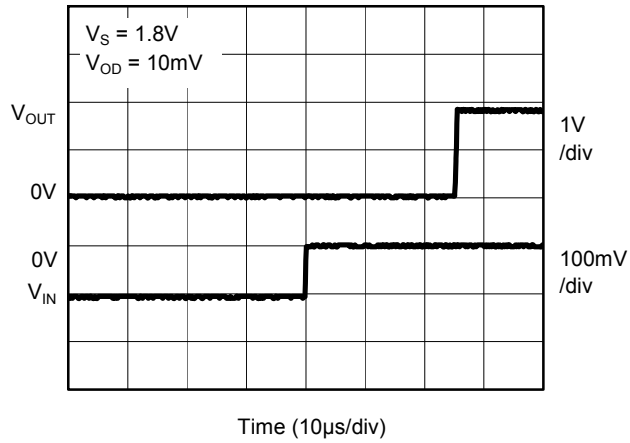
Time (5μs/div)

Propagation Delay (t_{PLH})



Time (10μs/div)

Propagation Delay (t_{PLH})

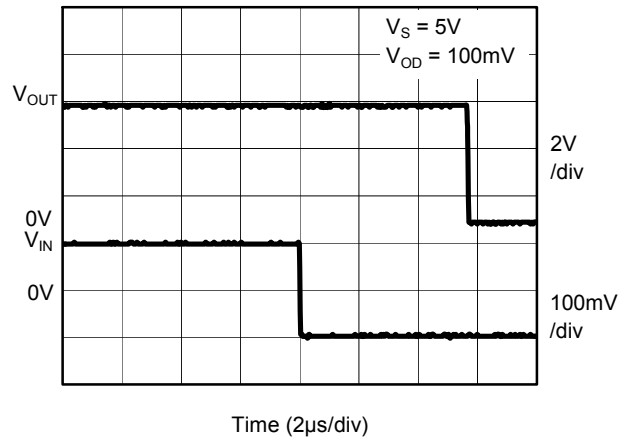


Time (10μs/div)

TYPICAL PERFORMANCE CHARACTERISTICS

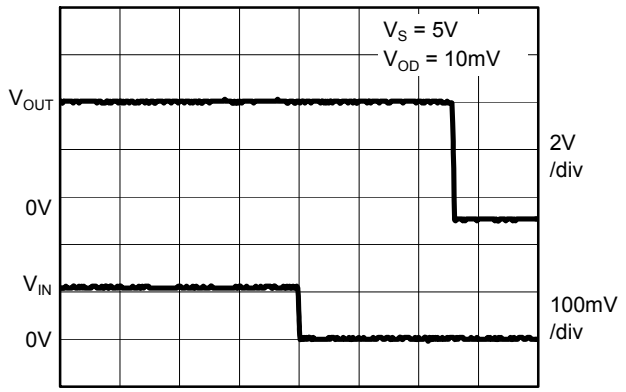
Comparator Only

Propagation Delay (t_{PHL})



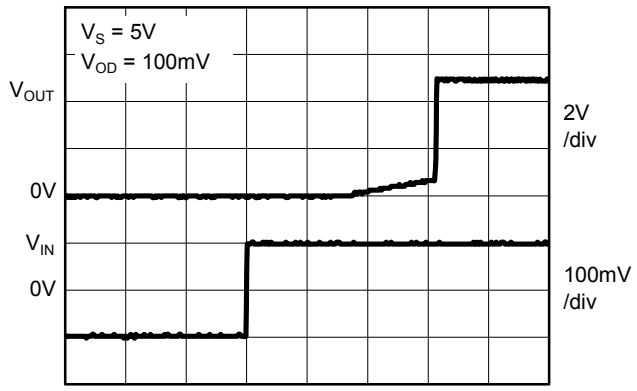
Time (2μs/div)

Propagation Delay (t_{PHL})



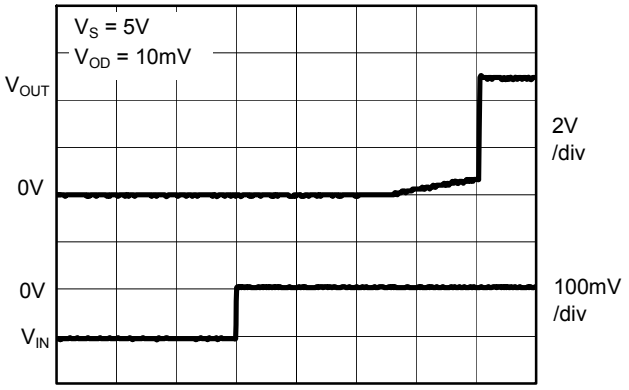
Time (5μs/div)

Propagation Delay (t_{PLH})



Time (10μs/div)

Propagation Delay (t_{PLH})



Time (10μs/div)

APPLICATION INFORMATION

In order to increase the efficiency of power system, current sensing resistors at mΩ level are always used. When current at mA level goes through the current sensing resistor, the sensing voltage will be very small, and a very low V_{OS} and V_{OS} drift amplifier must be used to amplify this voltage. The output signal of amplifier can be processed by ADC or a comparator. For example, the output of the comparator will be the wake-up signal of MCU in standby status, or the indication of over-current event and it also can be used to turn off the switch in the power trace.

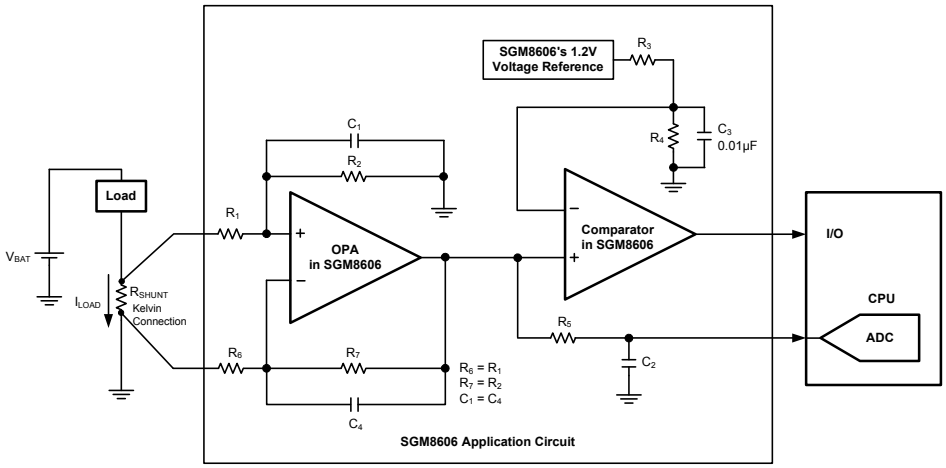
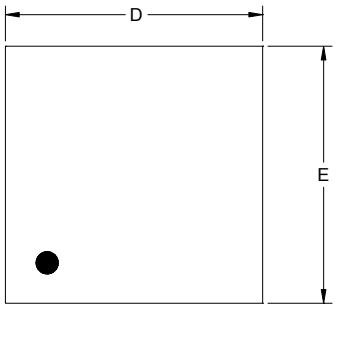


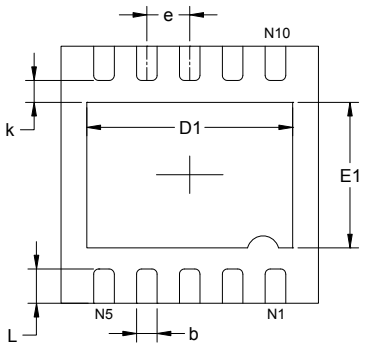
Figure 1. Low-side Current Monitor

PACKAGE OUTLINE DIMENSIONS

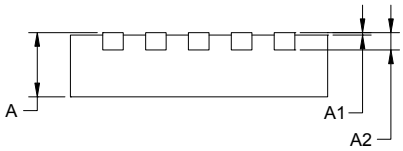
TDFN-3×3-10L



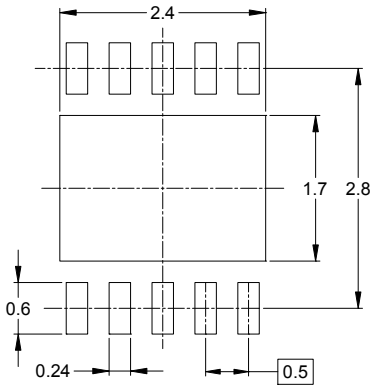
TOP VIEW



BOTTOM VIEW



SIDE VIEW

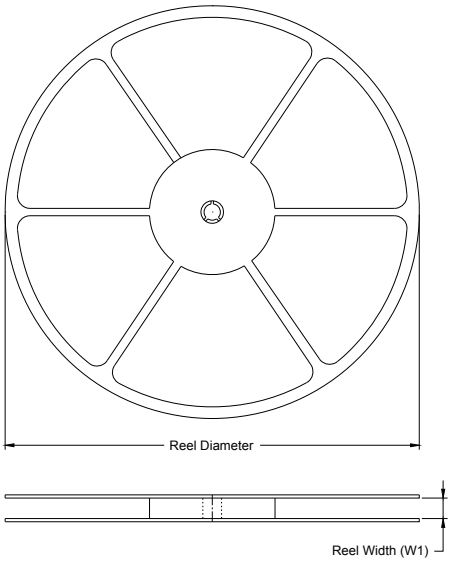


RECOMMENDED LAND PATTERN (Unit: mm)

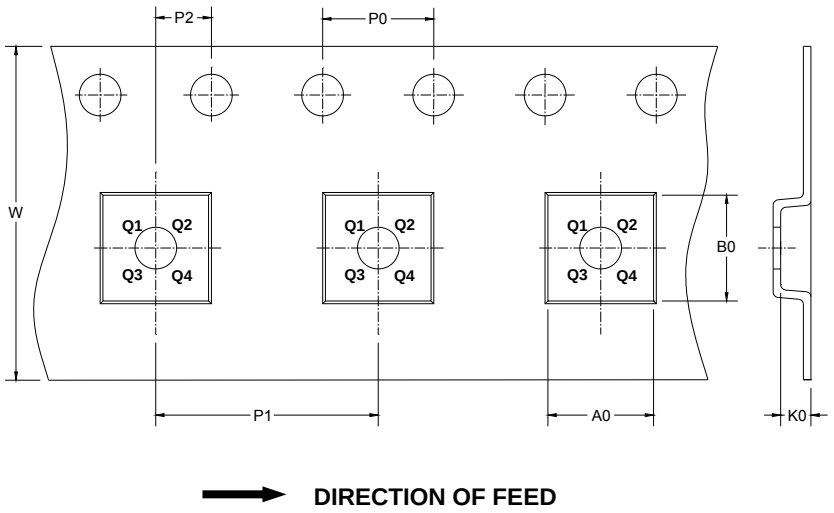
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.300	2.600	0.091	0.103
E	2.900	3.100	0.114	0.122
E1	1.500	1.800	0.059	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



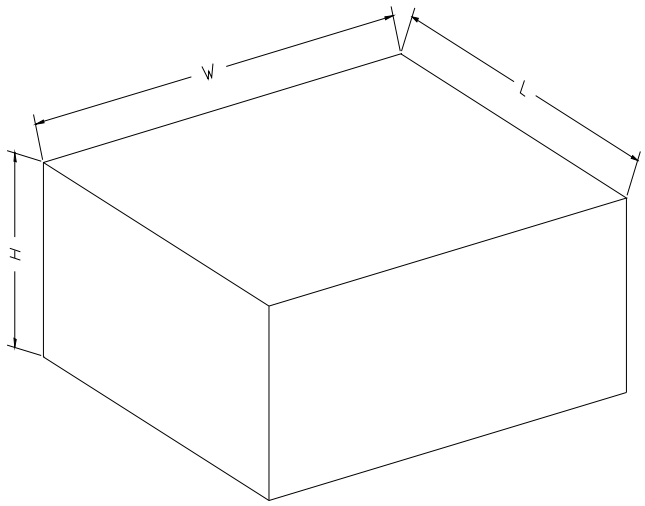
NOTE: The picture is only for reference. Please make the object as the standard.

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
TDFN-3×3-10L	13″	12.4	3.35	3.35	1.13	4.00	8.00	2.00	12.00	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
13″	386	280	370	5

DD0002