SGM4547
High Speed Piezo-Sounder and Ultra-Sound Transducer Driver

GENERAL DESCRIPTION

The SGM4547 is matched dual-channel high speed piezo-sounder and ultra-sound transducer driver which is integrated boost DC/DC to achieve high driven voltage. Unique circuit design provides very high speed driver capable of delivering peak currents of 2A into highly capacitive loads. Improved speed and drive capability are enhanced by matched rise and fall delay times. These matched delays maintain the integrity of input-to-output pulse-widths to reduce timing errors and clock skew problems. Dynamic switching losses are minimized with non-overlapped drive techniques.

In order to get higher volume sound from piezo-sounder and ultra-sound transducer, boost DC/DC is integrated to provide high driven voltage. Tiny TDFN package is provided to save PCB size in space limited application.

The SGM4547 is available in Green TDFN-4×3-14L package. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **Integrated Boost DC/DC to Achieve MAX. 26V Driven Voltage**
- **2A Peak Driven Current to Drive Capacitive Loads**
- **High Speed Driver and Very Short Rise and Fall Time**
- **Improved Response Times**
- **Matched Rise and Fall Times**
- **Independent Enable Function for Each Output**
- **Reduced Clock Skew between Dual Channels**
- **Low Output Impedance**
- **Output is at LOW under UVLO Protection, Enable Pin Floating or Disable Status**
- **High Noise Immunity**
- **Improved Clocking Rate**
- **Low Supply Current**
- **Wide Operating Voltage Range**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in Green TDFN-4×3-14L Package**

APPLICATIONS

Ultra-Sound Transducer Driver
Piezo-Sounder Driver

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PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM4547	TDFN-4×3-14L	-40℃ to +85℃			

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

VIN to GND (Boost DC/DC) .... -0.3V to 22V
Voltage on SW (Driver) .... -0.3V to 40V
Voltage on FB and COMP .... -0.3V to 3V
VCC to GND .... -0.3V to 28V
ENA, ENB, CTRL to GND .... -0.3V to 6V
INA, INB to GND ....-0.3V to V_{CC} + 0.3V
Combined Peak Output Current...4A
Junction Temperature ....150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s) ....260℃
ESD Susceptibility
HBM..4000V
MM..300V

RECOMMENDED OPERATING CONDITIONS

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.

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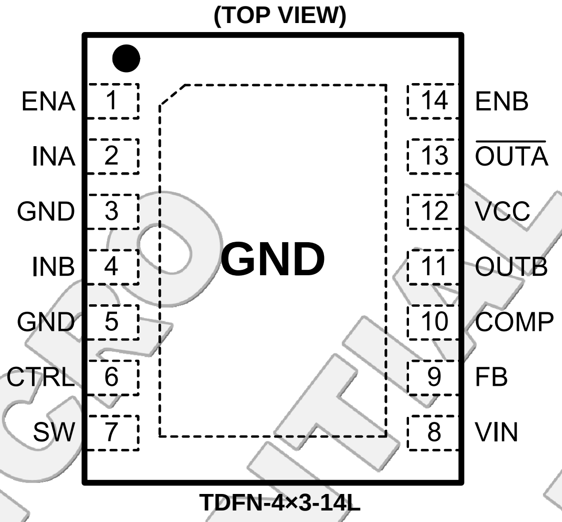
PIN CONFIGURATION



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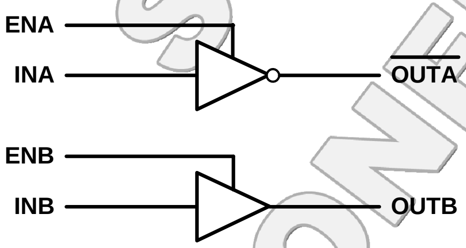
LOGIC SYMBOL



FUNCTION TABLE

ENA	ENB	INA	INB	$\overline{\text{OUTA}}$	OUTB
H	H	L	L	H	L
H	H	L	H	H	H
H	H	H	L	L	L
H	H	H	H	L	H
L	L	—	—	L	L
Floating	Floating	—	—	L	L

PIN DESCRIPTION

PIN	NAME	FUNCTION
1	ENA	Enable Input for Channel A. ENA biased LOW or floating disables channel A output regardless of INA state. ENA biased HIGH enables channel A output.
2	INA	Input for Channel A. Inverting channel input. $\overline{\text{OUTA}}$ is held LOW if INA is unbiased or floating.
3, 5	GND	Ground. All signals referenced to this pin.
4	INB	Input for Channel B. Non-inverting channel input. OUTB is held LOW if INB is unbiased or floating.
6	CTRL	Enable Control Pin of the Boost Regulator. Logic LOW disables the regulator. Logic HIGH enables the regulator.
7	SW	Switching Node of the Boost Regulator. Connect SW to the switched side of the inductor.
8	VIN	The Input Supply Pin for the Boost Regulator. Connect VIN to a supply voltage between 3V and 20V.
9	FB	Feedback Pin of Boost Regulator's Output Voltage. Connect to the center tap of a resistor divider to program the output voltage.
10	COMP	Output of the Transconductance Error Amplifier. Connect an external RC network to this pin to compensate the regulator.
11	OUTB	Output of Channel B.
12	VCC	Supply Input of Driver.
13	$\overline{\text{OUTA}}$	Output of Channel A.
14	ENB	Enable Input for Channel B. ENB biased LOW or floating disables channel B output regardless of INB state. ENB biased HIGH enables channel B output.
Exposed Pad	GND	Exposed pad should be soldered to PCB board and connected to GND.

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ELECTRICAL CHARACTERISTICS OF DRIVER

(V_{CC} = 24V, V_{ENA} = V_{ENB} = 3.3V, T_A = 25℃, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
INPUT					
Logic High Input Voltage (V_{IH})		1.8			V
Logic Low Input Voltage (V_{IL})				0.3	V
Input Hysteresis (V_{HYS})			0.3		V
Logic High Input Current (I_{IH})	Inverting Input Current, V_{INX} = 24V		6		μA
	Non-Inverting Input Current, V_{INX} = 24V		110		
Logic Low Input Current (I_{IL})	Inverting Input Current, V_{INX} = 0V		104		μA
	Non-Inverting Input Current, V_{INX} = 0V		0.1		
OUTPUT					
Pull-Up Resistance (R_{OH})	Source Current = 100mA		2.5		Ω
Pull-Down Resistance (R_{OL})	Sink Current = -100mA		1.8		Ω
Peak Output Current (I_{PK})	Source Current, f = 1kHz, C_L =0.1μF		2		A
	Sink Current, f = 1kHz, C_L =0.1μF		-2		
Continuous Output Current (I_{DC})	Source/Sink Current		±200		mA
POWER SUPPLY					
Power Supply Current (I_{CC})	Inputs Floating, V_{ENA} = V_{ENB} = 3.3V		1.27		mA
	Inputs Floating, V_{ENA} = V_{ENB} = 0V		0.19		
Supply Voltage Range (V_{CC})		4.5		26.5	V
Under-Voltage Lockout ON Threshold			3.6		V
Under-Voltage Lockout OFF Threshold			3.1		V
Under-Voltage Lockout Hysteresis			0.5		V
ENABLE LOGIC					
EN Signal High Threshold (V_{ENH})		2.5			V
EN Signal Low Threshold (V_{ENL})				0.4	
EN Hysteresis ($V_{EN\text{-}HYS}$)			0.8		
SWITCHING CHARACTERISTICS					
Rise Time (t_R)	C_L = 1000pF		12		ns
Fall Time (t_F)	C_L = 1000pF		13		ns
Turn-On Delay Time (t_{D1})	See Figure 1, Figure 2		22		ns
Turn-Off Delay Time (t_{D2})	See Figure 1, Figure 2		24		ns
EN to Output Propagation Delay (t_{D3})	See Figure 3, Figure 4		8		ms
EN to Output Propagation Delay (t_{D4})	See Figure 3, Figure 4		25		ns
OVER-TEMPERATURE PROTECTION					
Thermal Shutdown Threshold (T_{SHDN})			150		℃
Thermal Shutdown Threshold Hysteresis (T_{HYS})			15		℃

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ELECTRICAL CHARACTERISTICS OF BOOST REGULATOR

(V_{IN} = 3.6V, V_{CTRL} = V_{IN}, Full = -40℃ to +85℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
SUPPLY CURRENT						
Input Voltage Range (V_{IN})		+25℃	3		20	V
Operating Quiescent Current into VIN (I_Q)	Device PWM Switching No Load	+25℃		400	600	μA
Shutdown Current (I_{SHDN})	V_{CTRL} = GND, V_{IN} = 4.2V	+25℃			1	μA
Under-Voltage Lockout Threshold (UVLO)	V_{IN} Falling	+25℃		2.2	2.5	V
Under-Voltage Lockout Hysteresis (V_{HYS})		+25℃		70		mV
ENABLE AND REFERENCE CONTROL						
CTRL Logic High Voltage (V_{IH})	V_{IN} = 3V to 20V	Full	1.5			V
CTRL Logic Low Voltage (V_{IL})	V_{IN} = 3V to 20V	Full			0.4	V
CTRL Pull-Down Resistor (R_{CTRL})		+25℃	300	500	700	kΩ
VOLTAGE AND CURRENT CONTROL						
Voltage Feedback Regulation Voltage (V_{REF})		Full	1.186	1.211	1.236	V
Voltage Feedback Input Bias Current (I_{FB})	V_{FB} = 1.3V	Full			200	nA
Oscillator Frequency (f_{OSC})		Full	0.96	1.2	1.44	MHz
Maximum Duty Cycle (D)	V_{FB} = 1.1V	+25℃	90	94		%
Minimum ON Pulse Width (t_{MIN_ON})		+25℃		80		ns
COMP Pin Sink Current (I_{SINK})		+25℃		55		μA
COMP Pin Source Current (I_{SOURCE})		+25℃		55		μA
Error Amplifier Transconductance (G_{EA})		Full	220	300	440	μmho
POWER SWITCH						
N-Channel MOSFET On-Resistance ($R_{DS(ON)}$)	V_{IN} = 3.6V	+25℃		0.36	0.55	Ω
	V_{IN} = 3.0V	+25℃			0.6	
N-Channel Leakage Current (I_{LN_NFET})	V_{SW} = 35V, V_{CTRL} = 0V	+25℃			1	μA
OC AND SS						
N-Channel MOSFET Current Limit (I_{LIM})		+25℃	0.8	1.1	1.3	A
V_{REF} Ramp Up Time (t_r)		+25℃		2		ms
THERMAL SHUTDOWN						
Thermal Shutdown Threshold (T_{SHDN})				150		℃
Thermal Shutdown Threshold Hysteresis (T_{HYS})				15		℃

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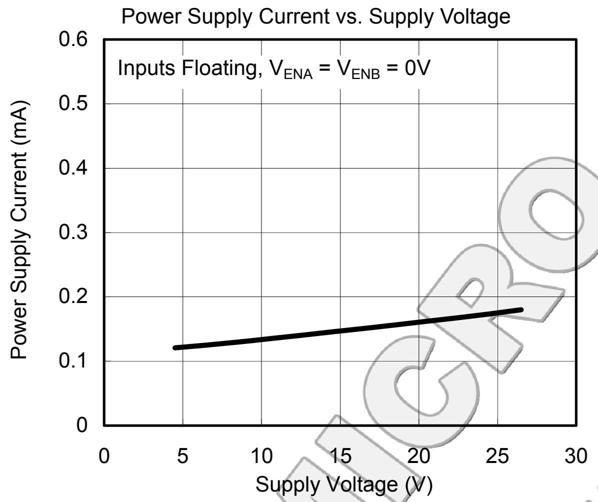
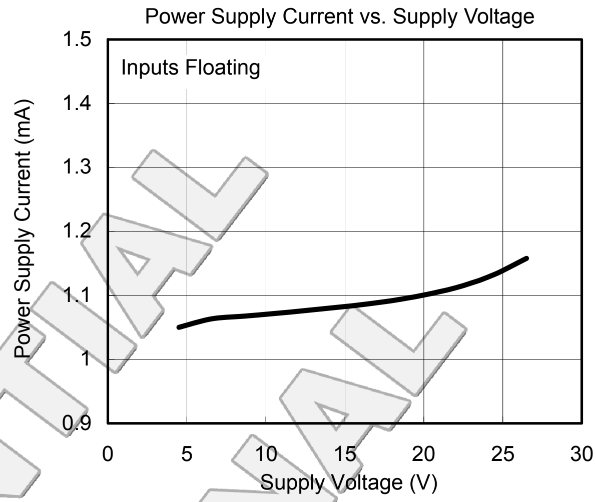
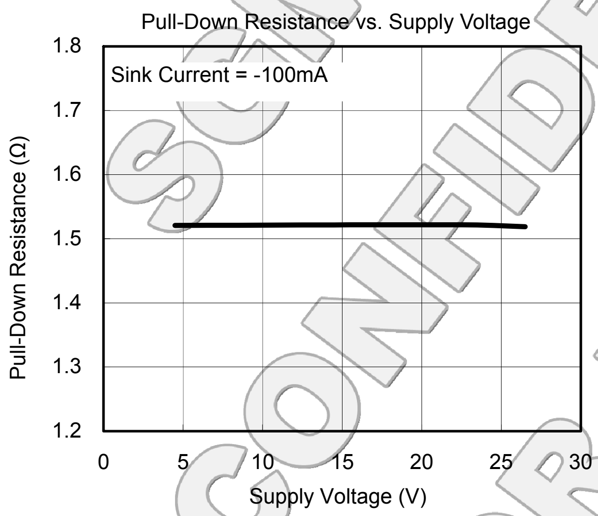
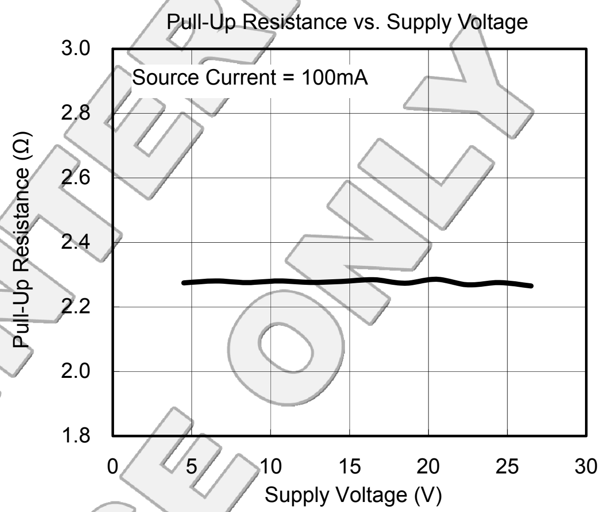
TYPICAL PERFORMANCE CHARACTERISTICS OF DRIVER

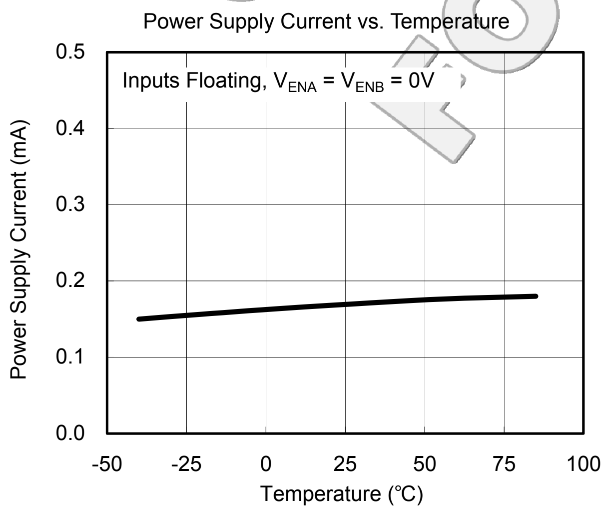
T_A = +25℃, V_{CC} = 24V, V_{ENA} = V_{ENB} = 5V, C_{IN} = 4.7μF, C_L = 1nF, unless otherwise noted.

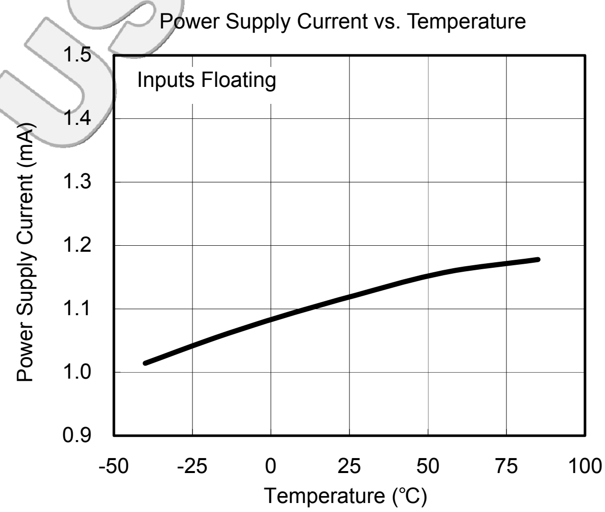












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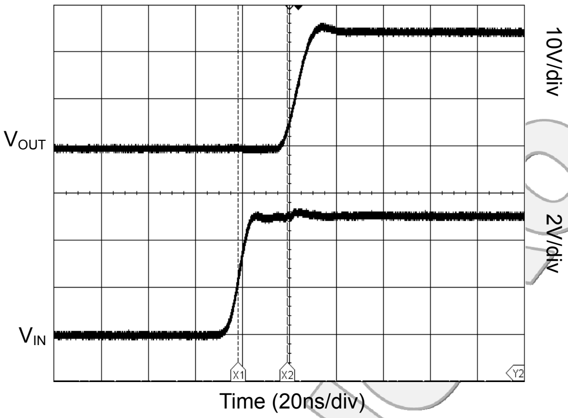
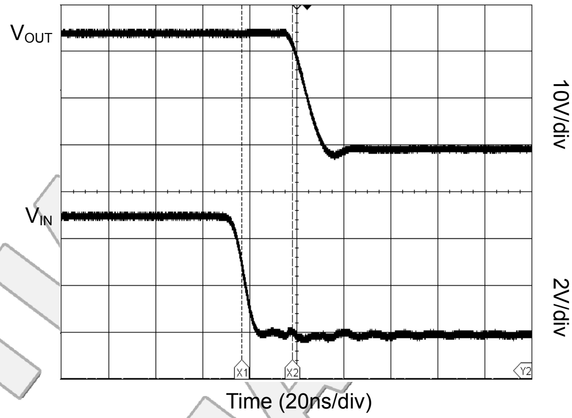
TYPICAL PERFORMANCE CHARACTERISTICS OF DRIVER

T_A = +25℃, V_{CC} = 24V, V_{ENA} = V_{ENB} = 5V, C_{IN} = 4.7μF, C_L = 1nF, unless otherwise noted.

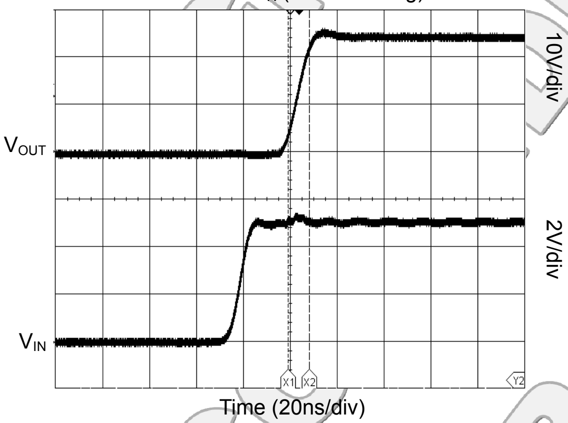
Turn-On Delay Time t_{D1} (Non-Inverting)



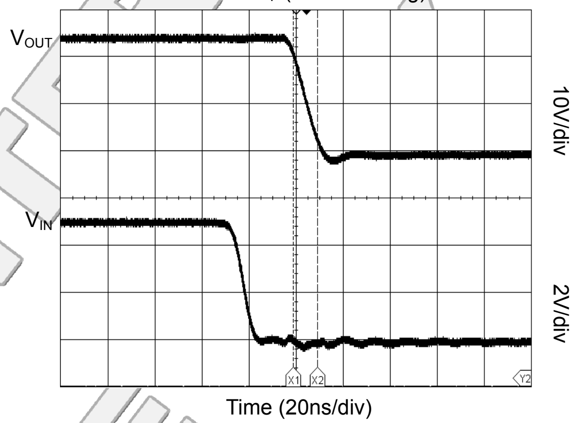
Turn-Off Delay Time t_{D2} (Non-Inverting)



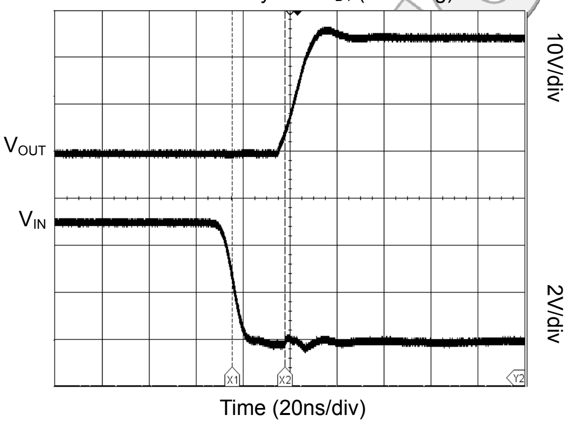
Rise Time t_R (Non-Inverting)



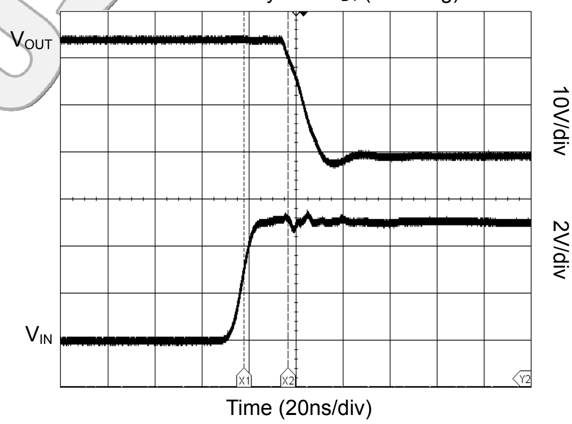
Fall Time t_F (Non-Inverting)



Turn-On Delay Time t_{D1} (Inverting)



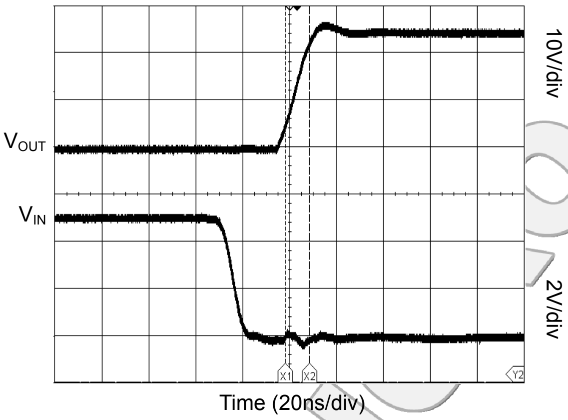
Turn-Off Delay Time t_{D1} (Inverting)



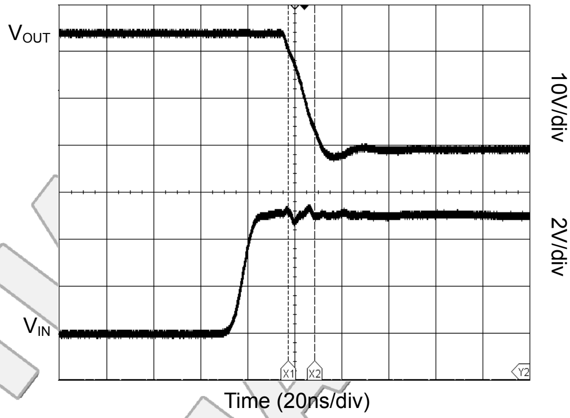
TYPICAL PERFORMANCE CHARACTERISTICS OF DRIVER

T_A = +25℃, V_{CC} = 24V, V_{ENA} = V_{ENB} = 5V, C_{IN} = 4.7μF, C_L = 1nF, unless otherwise noted.

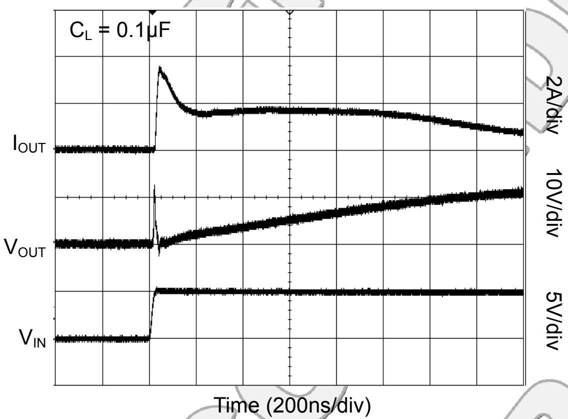
Rise Time t_R (Inverting)



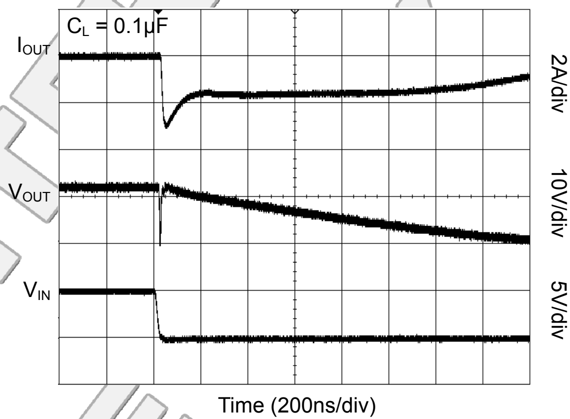
Fall Time t_F (Inverting)



Quasi-Static Source Current



Quasi-Static Sink Current



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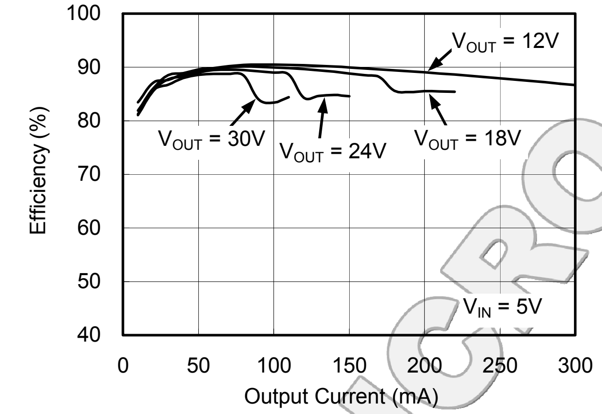
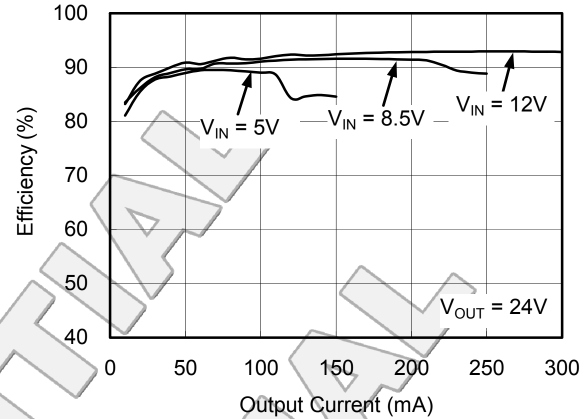
TYPICAL PERFORMANCE CHARACTERISTICS OF BOOST REGULATOR

T_A = +25℃, L = 10μH, D1 = On semi MBR0540T1, unless otherwise noted.

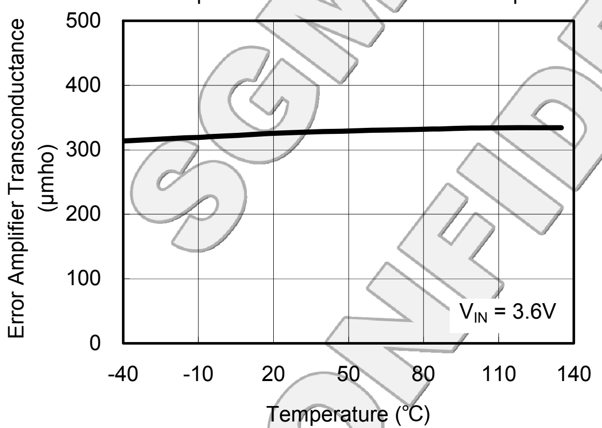
Efficiency vs. Output Current



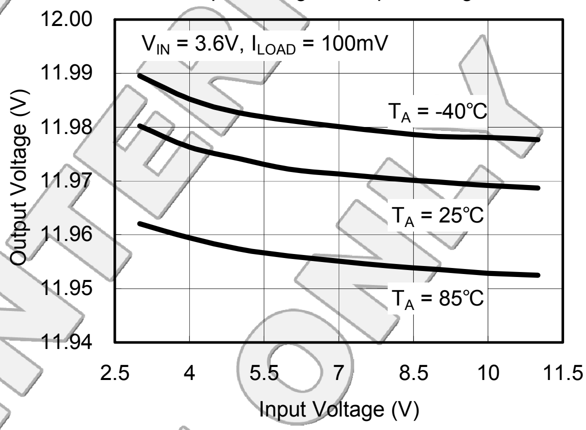
Efficiency vs. Output Current



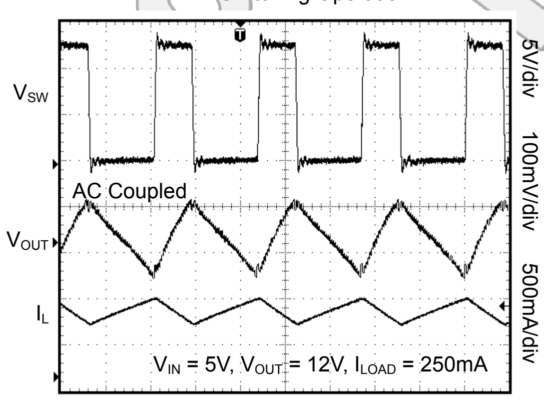
Error Amplifier Transconductance vs. Temperature



Output Voltage vs. Input Voltage

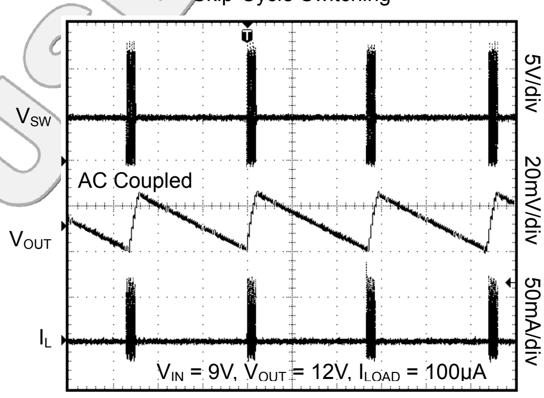


PWM Switching Operation



Time (400ns/div)

Skip-Cycle Switching



Time (200μs/div)

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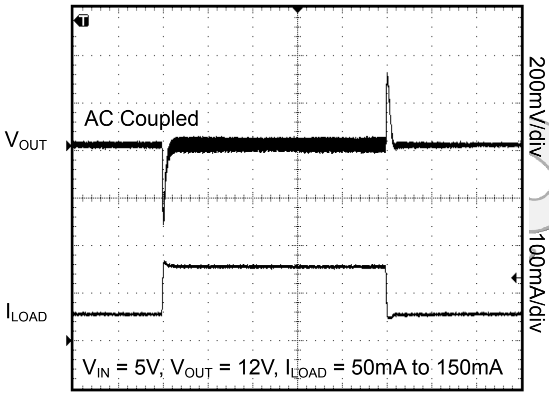
TYPICAL PERFORMANCE CHARACTERISTICS OF BOOST REGULATOR

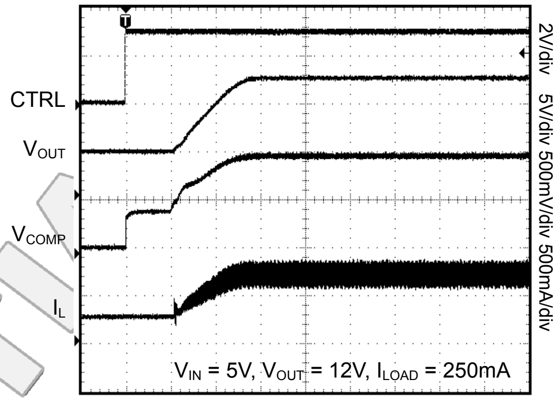
T_A = +25℃, L = 10μH, D1 = ONsemi MBR0540T1, unless otherwise noted.

Load Transient Response



Time (1ms/div)

Start-Up



Time (1ms/div)

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TIMING TABLE OF DRIVER

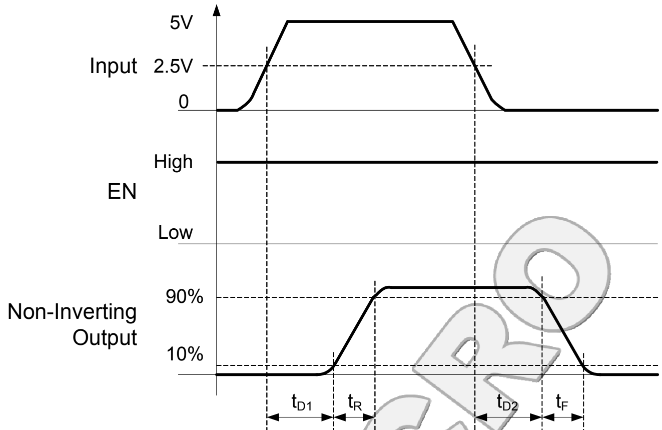

Figure 1. Non-Inverting Input Driver Operation

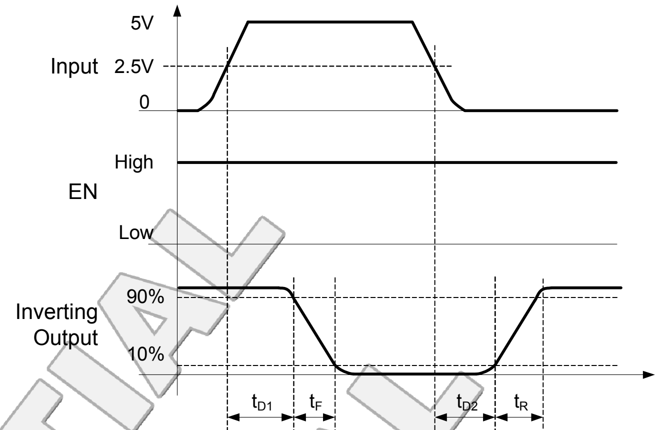

Figure 2. Inverting Input Driver Operation

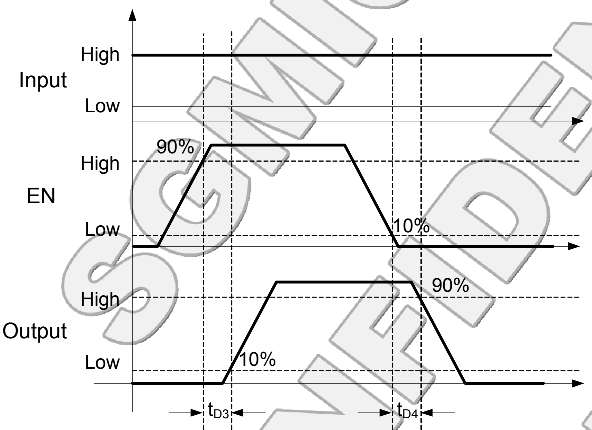

Figure 3. Enable Function
(For Non-Inverting Input Driver Operation)

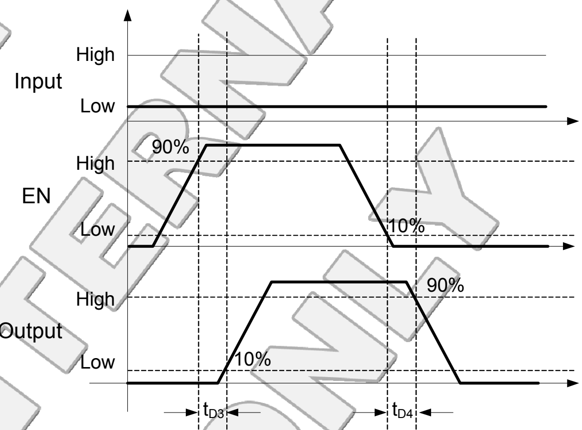

Figure 4. Enable Function
(For Inverting Input Driver Operation)

TEST CIRCUIT OF DRIVER

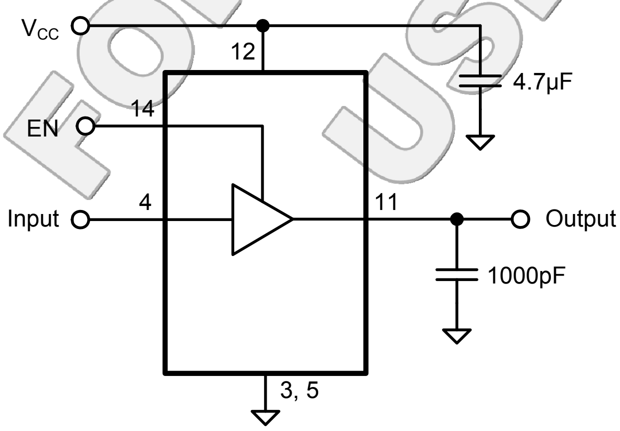

Figure 5. Standard Test Configuration

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FUNCTIONAL BLOCK DIAGRAM

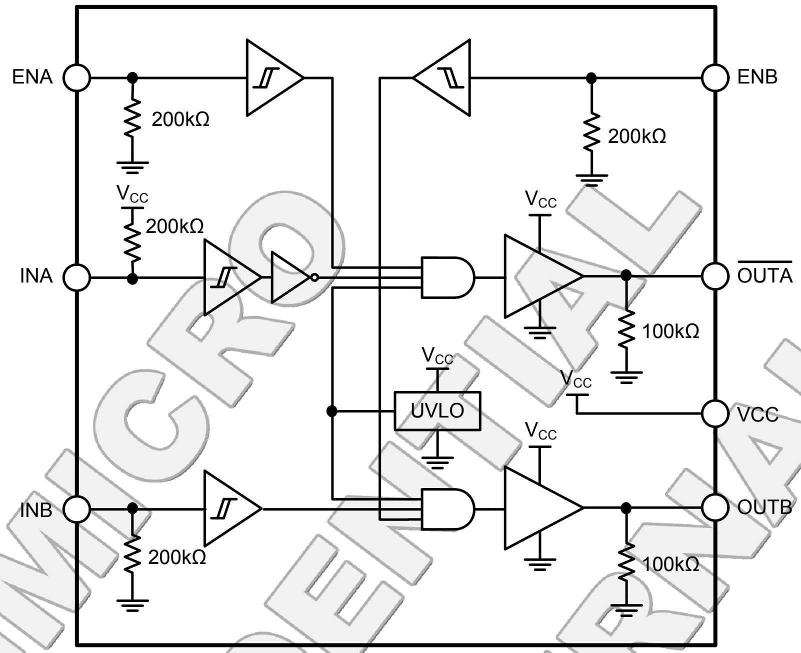

Figure 6. Block Diagram of Driver

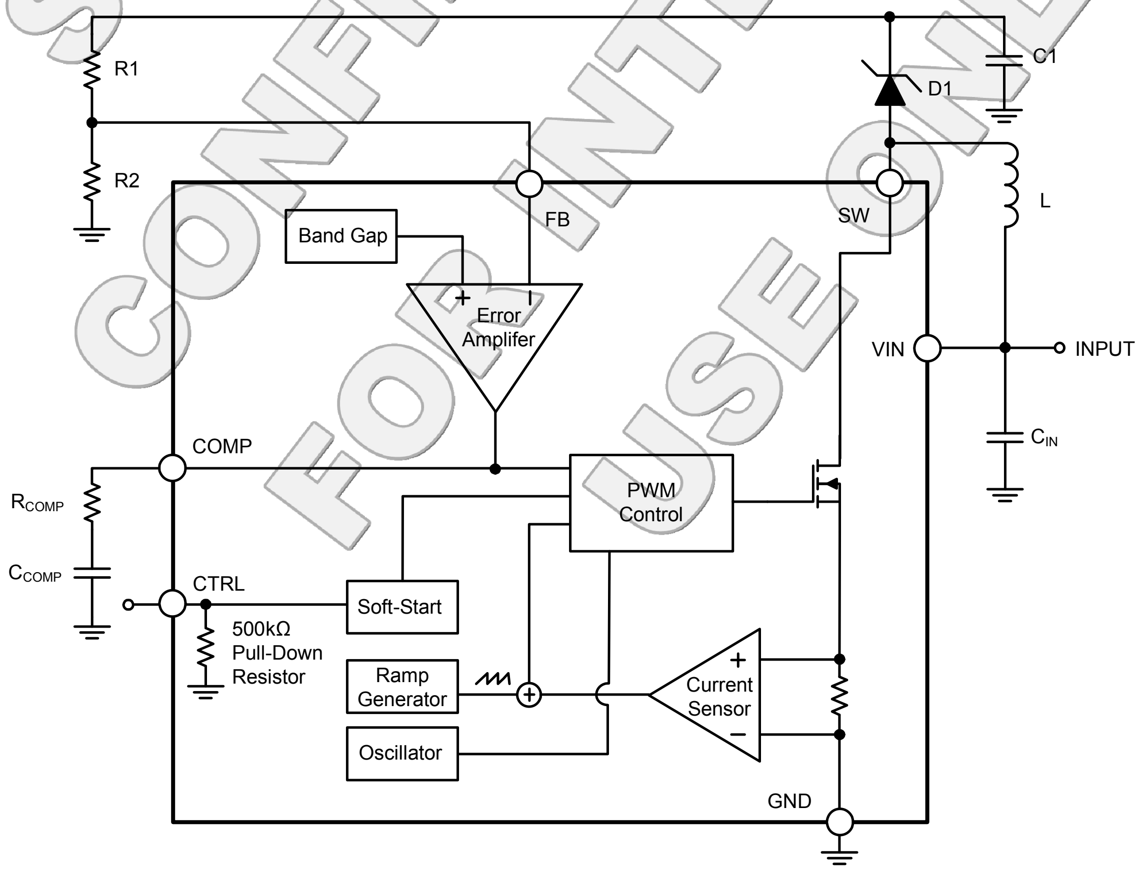

Figure 7. Block Diagram of Boost Regulator

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APPLICATION INFORMATION OF BOOST REGULATOR

Program Output Voltage

To program the output voltage, select the values of R_1 and R_2 (see Figure 8) according to Equation 1.

$$V_{OUT} = 1.211V \times \left(\frac{R_1}{R_2} + 1 \right)$$

$$R_1 = R_2 \times \left(\frac{V_{OUT}}{1.211V} - 1 \right) \quad (1)$$

Considering the leakage current through the resistor divider and noise decoupling to FB pin, an optimum value for R_2 is around 10kΩ. The output voltage tolerance depends on the V_{FB} accuracy and the tolerance of R_1 and R_2.c

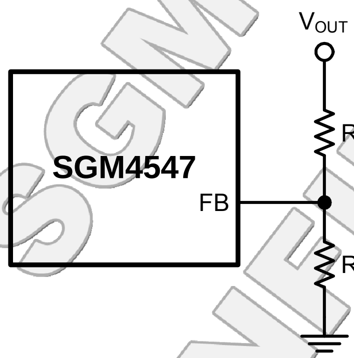

Figure 8. Program Output Voltage

Maximum Output Current

The over-current limit in a boost converter limits the maximum input current, and thus the maximum input power for a given input voltage. The maximum output power is less than the maximum input power due to power conversion losses. Therefore, the current-limit setting, input voltage, output voltage and efficiency can all affect the maximum output current. The current limit clamps the peak inductor current; therefore, the ripple must be subtracted to derive the maximum DC current. The ripple current is a function of the switching frequency, inductor value and duty cycle. The following equations take into account of all the above factors for maximum output current calculation.

$$I_P = \frac{1}{\left[L \times f_S \times \left(\frac{1}{V_{OUT} + V_F - V_{IN}} + \frac{1}{V_{IN}} \right) \right]} \quad (2)$$

Where:

I_P = Inductor peak to peak ripple

L = Inductor value

V_F = Schottky diode forward voltage

f_S = Switching frequency

V_{OUT} = Output voltage

$$I_{OUT\_MAX} = \frac{V_{IN} \times \left(I_{LIM} - \frac{I_P}{2} \right) \times \eta}{V_{OUT}} \quad (3)$$

Where:

I_{OUT_MAX} = Maximum output current of the boost converter

I_{LIM} = Over-current limit

η = Efficiency

For instance, when V_{IN} is 5V, V_{OUT} is 12V, the inductor is 10μH, the Schottky forward voltage is 0.2V; and then the maximum output current is 300mA in typical operation.

Switch Duty Cycle

The maximum switch duty cycle (D) of the SGM4547 is 94% (TYP). The duty cycle of a boost converter under continuous conduction mode (CCM) is given by:

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (4)$$

For a 5V to 12V application, the duty cycle is 58.3%, and for a 5V to 24V application, the duty cycle is 79.2%. The duty cycle must be lower than the maximum specification of 90% in the application; otherwise, the output voltage can not be regulated.

Once the PWM switch is turned on, the SGM4547 has minimum ON pulse width. This sets the limit of the minimum duty cycle. For operating low duty cycle, the SGM4547 enters pulse-skipping mode. In this mode, the device keeps the power switch off for several switching cycles to keep the output voltage in regulation. This operation typically occurs in light load condition when the PWM operates in discontinuous mode.

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APPLICATION INFORMATION OF BOOST REGULATOR

Inductor Selection

The selection of the inductor affects steady state operation as well as transient behavior and loop stability. These factors make it the most important component in power regulator design. There are three important inductor specifications, inductor value, DC resistance and saturation current. Considering inductor value alone is not enough.

The inductor's value determines the inductor ripple current. It is recommended that the peak-to-peak ripple current given by Equation 2 be set to 30% - 40% of the DC current. Also, the inductor value should not be beyond the range in the recommended operating conditions table. It is a good compromise of power losses and inductor size. Inductor DC current can be calculated as:

$$I_{IN\_DC} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta} \quad (5)$$

Inductor values can have ±20% tolerance with no current bias. When the inductor current approaches saturation level, its inductance can decrease 20% to 35% from the 0A value depending on how the inductor vendor defines saturation current. Using an inductor with a smaller inductance value forces discontinuous PWM where the inductor current ramps down to zero before the end of each switching cycle. This reduces the boost converter's maximum output current, causes large input voltage ripple and reduces efficiency. In general, large inductance value provides much more output and higher conversion efficiency. Small inductance value can give better the load transient response. For these reasons, a 6.8μH to 22μH inductor value range is recommended.

SGM4547 has built-in slope compensation to avoid sub-harmonic oscillation associated with current mode control. If the inductor value is lower than 6.8μH, the slope compensation may not be adequate, and the loop can be unstable. Therefore, customers need to verify the inductor in their application if it is different from the recommended values.

Compensation Capacitor Selection

The SGM4547 has an external compensation, COMP pin, which allows the loop response to be optimized for each application. The COMP pin is the output of the internal error amplifier. An external resistor R_{COMP} and ceramic capacitor C_{COMP} are connected to COMP pin to provide a pole and a zero. This pole and zero, along with the inherent pole an zero in a current mode control boost converter, determine the close loop frequency response. This is important to a converter stability and transient response.

The following equations summarize the poles, zeros and DC gain in SGM4547, as shown in the Functional Block Diagram. They include the dominant pole (f_{P1}), the output pole (f_{P2}) of a boost converter, the right-half-plane zero (f_{RHPZ}) of a boost converter, the zero (f_Z) generated by R_{COMP} and C_{COMP} and the DC gain (A).

$$f_{P1} = \frac{1}{2\pi \times 140M\Omega \times C_{COMP}} \quad (6)$$

$$f_{P2} = \frac{2}{2\pi \times R_{OUT} \times C_{OUT}} \quad (7)$$

$$f_{RHPZ} = \frac{R_{OUT}}{2\pi \times L} \times \left(\frac{V_{IN}}{V_{OUT}}\right)^2 \quad (8)$$

$$f_Z = \frac{1}{2\pi \times R_{COMP} \times C_{COMP}} \quad (9)$$

$$A = \frac{1.211V}{V_{OUT}} \times G_{EA} \times 140M\Omega \times \frac{V_{IN}}{V_{OUT} \times R_{SENSE}} \times R_{OUT} \times \frac{1}{2} \quad (10)$$

Where R_{OUT} is the load resistance, G_{EA} is the error amplifier transconductance located in the electrical characteristics table, R_{SENSE} (200mΩ) is a sense resistor in the current control loop. These equations helps generate a simple bode plot for SGM4547 loop analysis. Increasing R_{COMP} or reducing C_{COMP} increases the close loop bandwidth which improves the transient response. Adjusting R_{COMP} and C_{COMP} toward opposite direction increase the phase, and help loop stability. For most of the applications, the recommended value of 4.99kΩ and 10nF makes an ideal compromise between transient response and loop stability. To optimize the compensation, use C_{COMP} in the range of 1nF to 22nF, and R_{COMP} of 4.99kΩ.

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APPLICATION INFORMATION OF BOOST REGULATOR

Schottky Diode Selection

The high switching frequency of the SGM4547 demands a high-speed rectification for optimum efficiency. Ensure that the diode's average and peak current rating exceeds the average output current and peak inductor current. In addition, the diode's reverse breakdown voltage must exceed the switch FET rating voltage of 40V. However, Schottky diode of low rating voltage can be used for low output to save the solution size and cost. For example, 12V output with 20V diode is a good choice.

Input and Output Capacitor Selection

The output capacitor is mainly selected to meet the requirements for the output ripple and loop stability. This ripple voltage is related to the capacitor's capacitance and its equivalent series resistance (ESR). Assuming a capacitor with zero ESR, the minimum capacitance needed for a given ripple can be calculated using Equation 11.

$$C_{OUT} = \frac{(V_{OUT} - V_{IN}) \times I_{OUT}}{V_{OUT} \times f_S \times V_{RIPPLE}} \quad (11)$$

Where, V_{RIPPLE} = peak-to-peak output ripple. The additional output ripple component caused by ESR is calculated using:

$$V_{RIPPLE\_ESR} = I_{OUT} \times R_{ESR}$$

Due to its low ESR, V_{RIPPLE_ESR} can be neglected for ceramic capacitors, but must be considered if tantalum or electrolytic capacitors are used. Care must be taken when evaluating a ceramic capacitor's derating under DC bias, aging and AC signal. For example, larger form factor capacitors (in 1206 size) have a resonant frequency in the range of the switching frequency. So, the effective capacitance is significantly lower. The DC bias can also significantly reduce capacitance. Ceramic capacitors can loss as much as 50% of its capacitance at its rated voltage. Therefore, choose a ceramic capacitor with a voltage rating at least 1.5× its expected DC bias voltage.

The capacitor in the range of 1μF to 4.7μF is recommended for input side. The output requires a capacitor in the range of 1μF to 10μF. The output capacitor affects the loop stability of the boost regulator. If the output capacitor is below the range, the boost regulator can potentially become unstable.

Thermal Considerations

The maximum IC junction temperature should be restricted to 150℃ under normal operating conditions. This restriction limits the power dissipation of the SGM4547. Calculate the maximum allowable dissipation, $P_{D(MAX)}$, and keep the actual dissipation less than or equal to $P_{D(MAX)}$. The maximum-power-dissipation limit is determined using Equation 12:

$$P_{D(MAX)} = \frac{150℃ - T_A}{\theta_{JA}} \quad (12)$$

Where, T_A is the maximum ambient temperature for the application. θ_{JA} is the package thermal resistance.

The SGM4547 comes in TDFN package, this package includes a thermal pad that improves the thermal capabilities of the package. The θ_{JA} of the TDFN package greatly depends on the PCB layout and thermal pad connection. The thermal pad must be soldered to the analog ground on the PCB. Using thermal vias underneath the thermal pad as illustrated in the layout example.

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TYPICAL APPLICATION

In Piezo-sounder or ultra-sound transducer application, the typical circuit is shown in Figure 9.

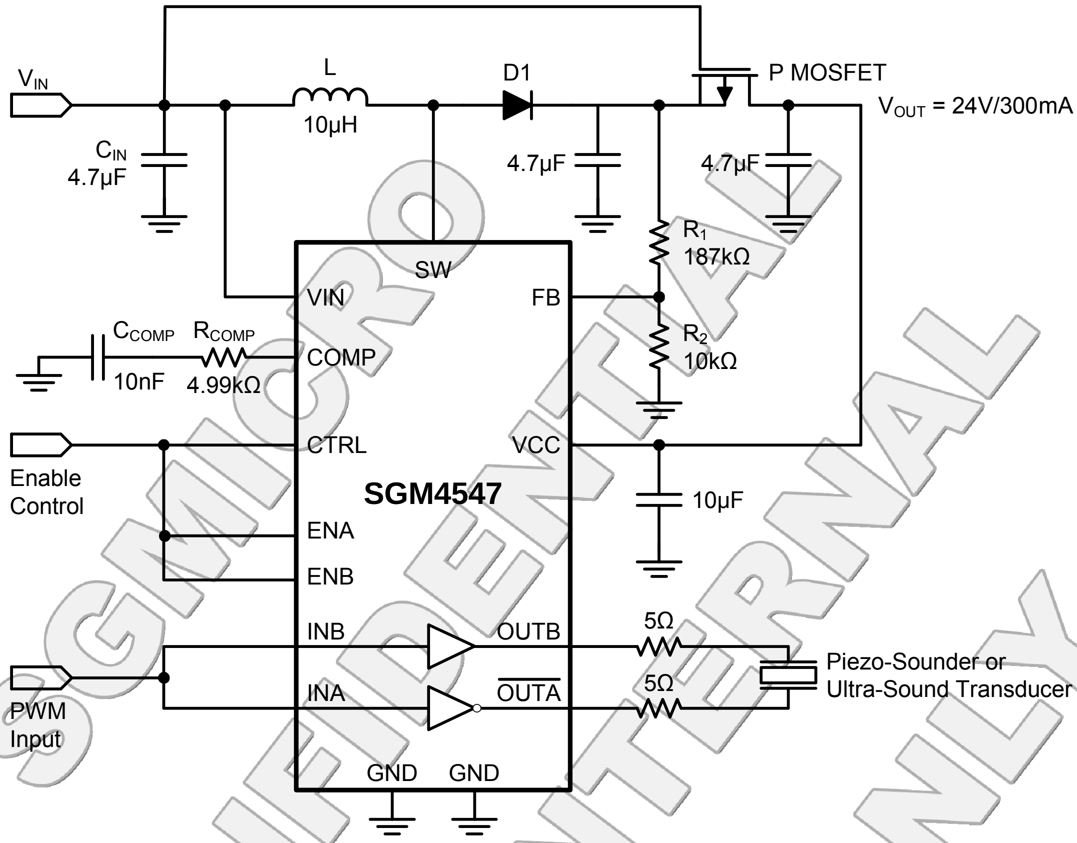
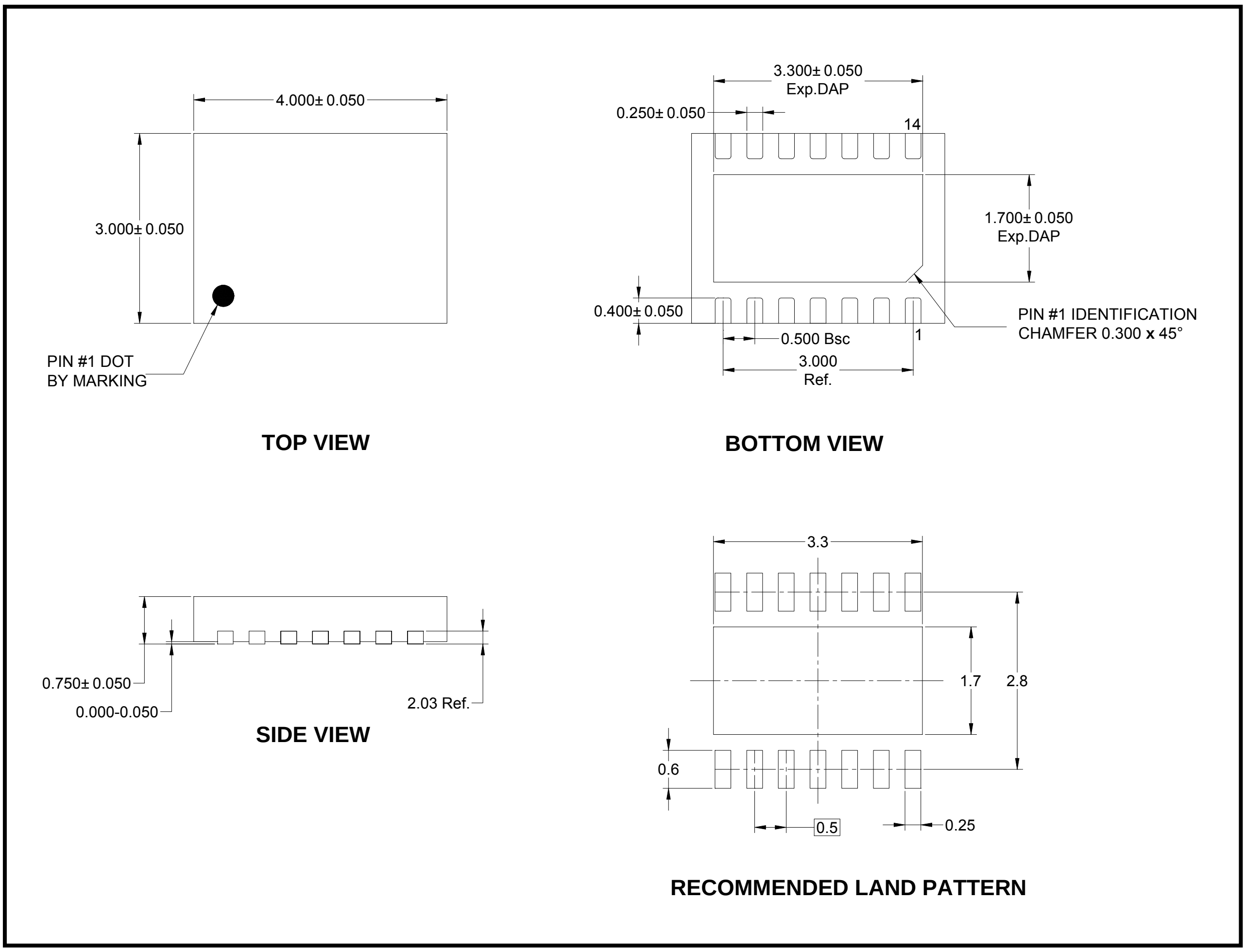


Figure 9. Typical Circuit to Drive Piezo-Sounder or Ultra-Sound Transducer

PACKAGE OUTLINE DIMENSIONS

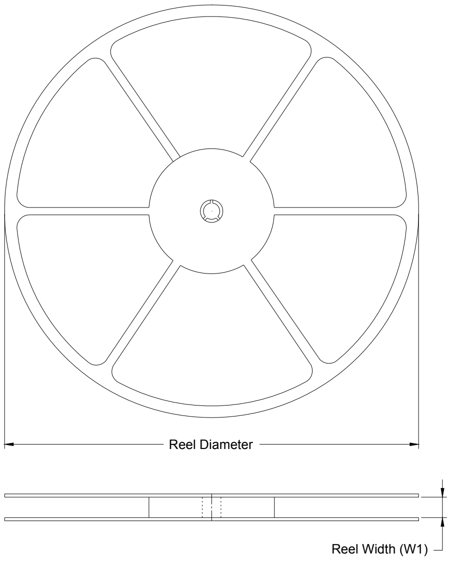
TDFN-4×3-14L



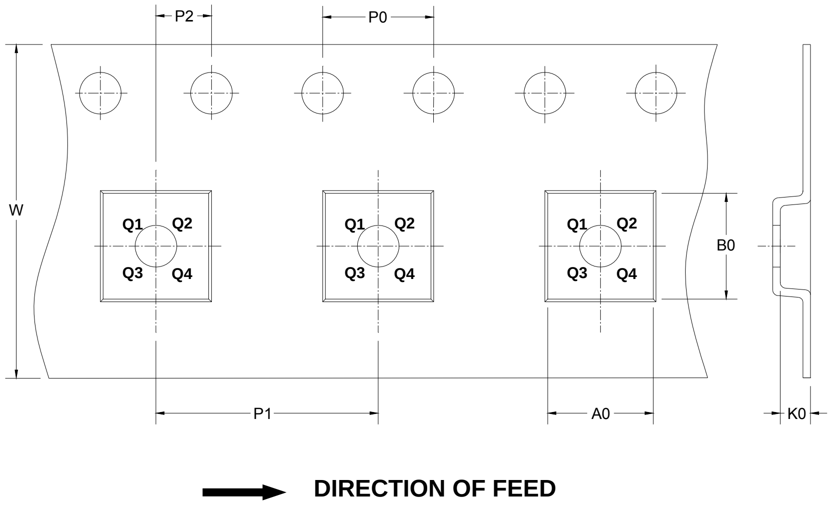
NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



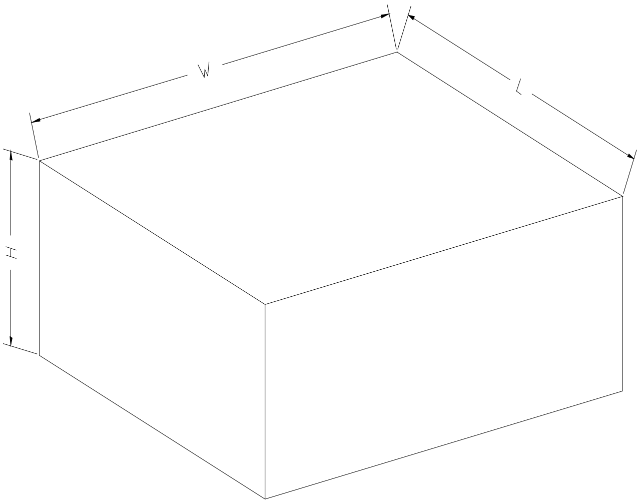
NOTE: The picture is only for reference. Please make the object as the standard.

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-4×3-14L	13″	12.4	3.4	4.4	1.1	4.0	4.0	2.0	12.0	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
13″	386	280	370	5

DD0002