SGM61013
10MHz, 1A Point-of-Load Step-Down Converter

GENERAL DESCRIPTION

The Micro-Point-of-Load (μPOL) SGM61013 is a family of very efficient and high frequency step-down DC/DC converter. Operating with a switching frequency up to 10MHz, it allows the use of small external components in both value and footprint. Different versions are available with a fixed output voltage between 1.2V and 3.3V, delivered from an input voltage supply of 2.3V to 5.5V.

A low quiescent current of only 20μA enables high efficiency even with very light loads.

At light current load condition, the converter will automatically enter pulse frequency modulation (PFM) mode for best possible efficiency over the entire range of load currents. If PFM mode is not desired, the MODE pin can be set high to forced pulse width modulation (FPWM) operation.

The SGM61013 is available in a Green WLCSP-0.9×1.2-6B package.

TYPICAL APPLICATION

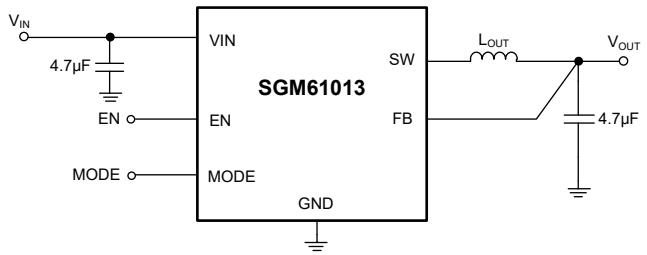


Figure 1. Typical Application Circuit

FEATURES

- **2.3V to 5.5V Input Voltage Range**
- **Fixed Output Voltage Options from 1.2V to 3.3V**
- **1A Output Current**
- **20μA (TYP) Quiescent Current**
- **Selectable PFM Light Load Operation**
- **Up to 95% Efficiency**
- **SGM61013A: 10MHz Switching Frequency**
- **SGM61013B: 6.5MHz/8MHz Switching Frequency**
- **Fast Load Transient Response**
- **100% Duty Cycle**
- **Logic Enable Input**
- **Soft-Start**
- **Input Under-Voltage Lockout**
- **Over-Current Protection**
- **Thermal Shutdown**
- **Active Output Discharge**
- **Available in a Green WLCSP-0.9×1.2-6B Package**

APPLICATIONS

Optical Modules
Cellular Phones
Tablets
Wireless Data Cards
Embedded Power Supply
Wearables
IoT
Security and Surveillance

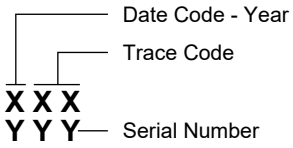
PACKAGE/ORDERING INFORMATION

MODEL	V_{OUT} (V)	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM61013A (10MHz)	1.8	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013A-1.8YG/TR	XXX G9S	Tape and Reel, 3000
	2.1	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013A-2.1YG/TR	XXX G9T	Tape and Reel, 3000
SGM61013B (6.5MHz)	1.2	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-1.2YG/TR	XXX G9U	Tape and Reel, 3000
	1.35	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-1.35YG/TR	XXX G9V	Tape and Reel, 3000
SGM61013B (8MHz)	1.5	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-1.5YG/TR	XXX G9W	Tape and Reel, 3000
	1.6	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-1.6YG/TR	XXX G9X	Tape and Reel, 3000
	1.8	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-1.8YG/TR	XXX G9Y	Tape and Reel, 3000
	2.1	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-2.1YG/TR	XXX G9Z	Tape and Reel, 3000
	2.4	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-2.4YG/TR	XXX GA5	Tape and Reel, 3000
	2.5	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-2.5YG/TR	XXX GAG	Tape and Reel, 3000
	3.3	WLCSP-0.9×1.2-6B	-40℃ to +85℃	SGM61013B-3.3YG/TR	XXX GAH	Tape and Reel, 3000

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.

MARKING INFORMATION

NOTE: XXX = Date Code and Trace Code.



ABSOLUTE MAXIMUM RATINGS

DC Supply Voltage ..... -0.3V to 6V
Voltage on Other Pins, MODE, SW, FB, EN
..... -0.3V to V_{IN} + 0.3V
Package Thermal Resistance
WLCSP-0.9×1.2-6B, θ_{JA} ..... TBD℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM ..... ±4000V
CDM ..... ±2000V

RECOMMENDED OPERATING CONDITIONS

Supply Voltage ..... 2.3V to 5.5V (1)
Output Current ..... 0A to 1.0A
Output Inductor ..... 220nH to 2200nH, 470nH (TYP)
Input Capacitor ..... 2.2μF to 4.7μF (TYP)
Output Capacitor ..... 2.2μF to 4.7μF (TYP)
Operating Ambient Temperature Range ..... -40℃ to +85℃
Operating Junction Temperature Range ..... -40℃ to +125℃

NOTE:
1. V_{IN} above 5.5V over extended periods may affect device reliability.

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

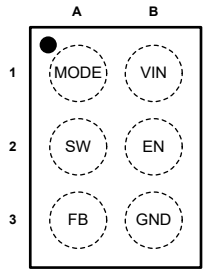
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

(TOP VIEW)



WLCSP-0.9×1.2-6B

PIN DESCRIPTION

PIN	NAME	DESCRIPTION
A1	MODE	Mode Selection. MODE pin = Low allows the converter to automatically switch between pulse frequency modulation (PFM) at light current loads and pulse width modulation (PWM) at heavy current loads. MODE pin = High forces the converter to stay in PWM mode.
B1	VIN	Power Supply Input. Connect to power source with a minimum 2.2μF ceramic capacitor.
A2	SW	Switching Node. Connect to the output inductor.
B2	EN	Enable Logic Input. Logic high level (V_{EN} > 1.2V) enables the device. Logic low level (V_{EN} < 1.07V) disables the device and turns it into shutdown mode. Do not leave this pin floating.
A3	FB	Feedback Input. Connect to output voltage.
B3	GND	Ground Pin.

ELECTRICAL CHARACTERISTICS

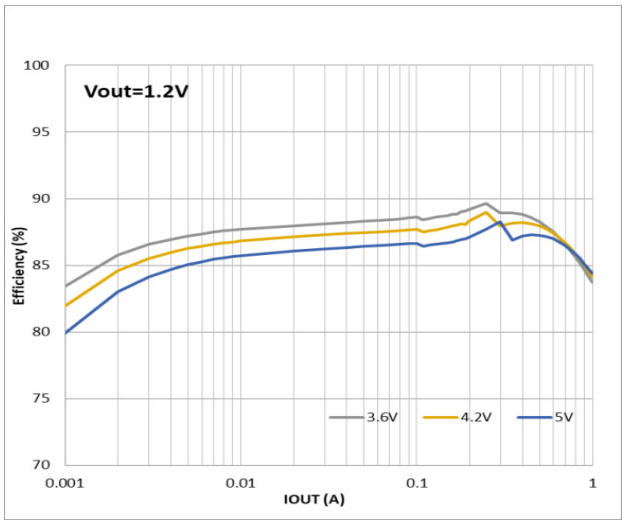
(Typical values are at V_{IN} = 3.6V, V_{OUT} = 1.8V, MODE = 0V, T_A = +25℃; maximum and minimum values are at V_{IN} = V_{EN} = 2.3V to 5.5V, T_A = -40℃ to +85℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC Characteristics						
Supply Voltage	V_{IN}		2.3		5.5	V
Quiescent Current	I_Q	PWM mode		6.5		mA
		No load, not switching		20		μA
Shutdown Current	I_{SHDN}	EN = GND		0.1	1	μA
Under-Voltage Lockout Threshold	V_{UVLO}	Rising V_{IN}		2.0	2.25	V
Under-Voltage Lockout Hysteresis	$V_{UVLOHYST}$			150		mV
Thermal Shutdown	T_{TSD}			135		℃
Thermal Shutdown Hysteresis	T_{HYST}			15		℃
Output Characteristics						
Switching Frequency	f_{SW}	SGM61013B-1.2, SGM61013B-1.35		6.5		MHz
		SGM61013B family		8		
		SGM61013A family		10		
Output Voltage Accuracy	V_{OUT}	I_{LOAD} = 0A to 1A, V_{IN} = 5.5V (MAX)	-2%	V_{OUT}	+2%	
		PWM Mode, V_{IN} = 5.5V (MAX)	-1.5%	V_{OUT}	+1.5%	
Soft-Start Time	t_{SS}			280		μs
Enable Turn-On Delay	t_{EN}			100		μs
PMOS On-resistance	R_{DSON_P}	V_{IN} = V_{GS} = 3.6V		148		mΩ
NMOS On-resistance	R_{DSON_N}	V_{IN} = V_{GS} = 3.6V		77		mΩ
PMOS Peak Current Limit	I_{LIM}	V_{IN} = 3.6V, open loop		1600		mA
Output Discharge Resistance	R_{DIS}	V_{EN} = 0V		17		Ω
Logic Inputs: EN and Mode						
Logic High Voltage	V_{IH}		1.2		V_{IN}	V
Logic Low Voltage	V_{IL}				1.07	V
Logic Pin Leakage Current	I_{LPIN}				1	μA
Logic Input Hysteresis	V_{LHYST}			130		mV

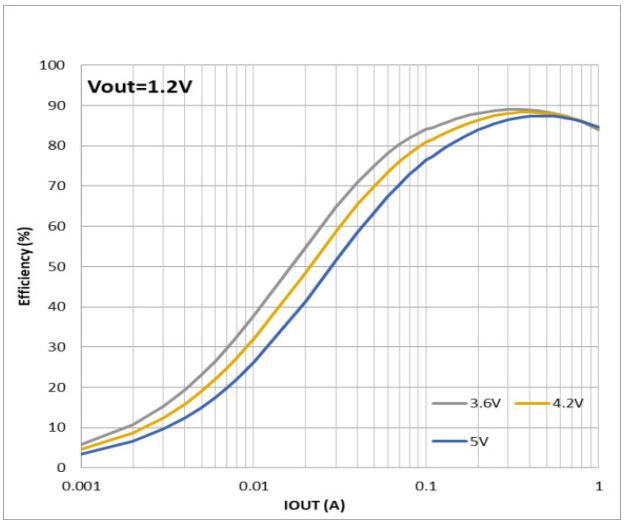
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

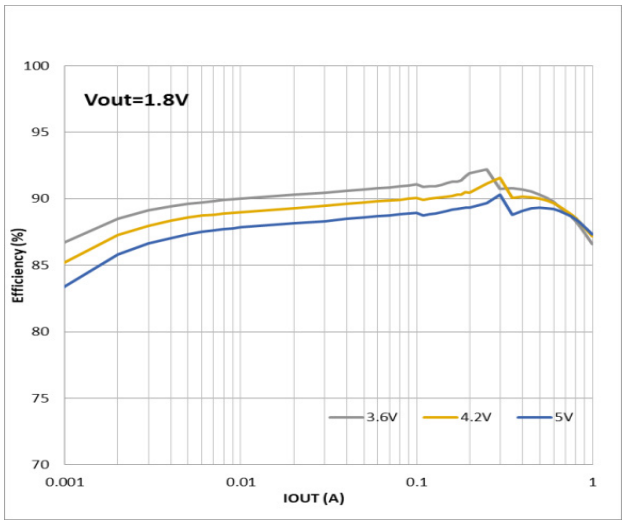
Efficiency, Mode = Low, V_{OUT} = 1.2V



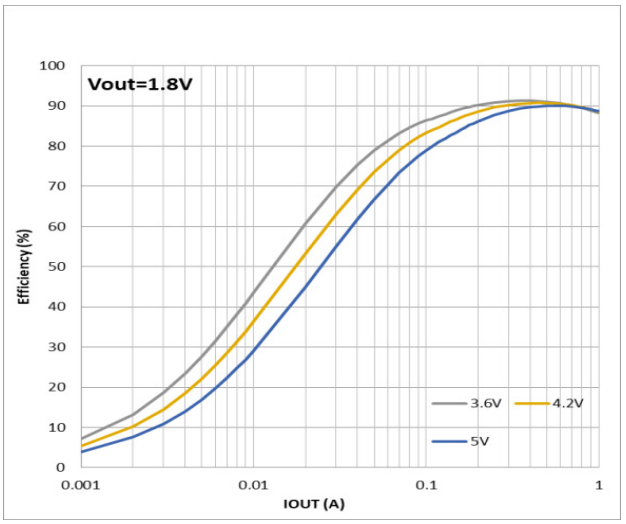
Efficiency, Mode = High, V_{OUT} = 1.2V



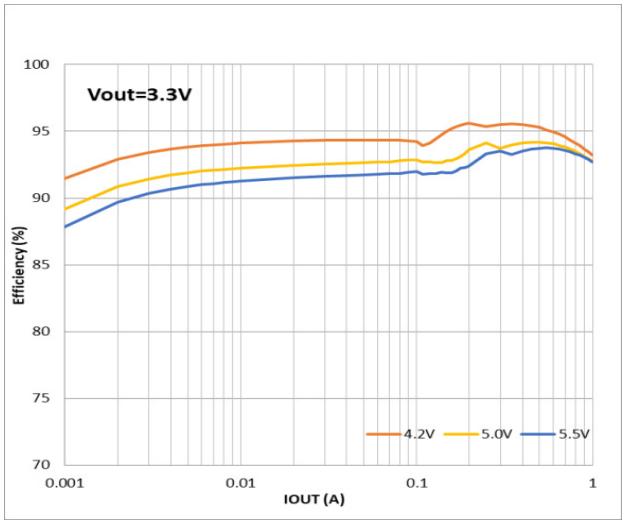
Efficiency, Mode = Low, V_{OUT} = 1.8V



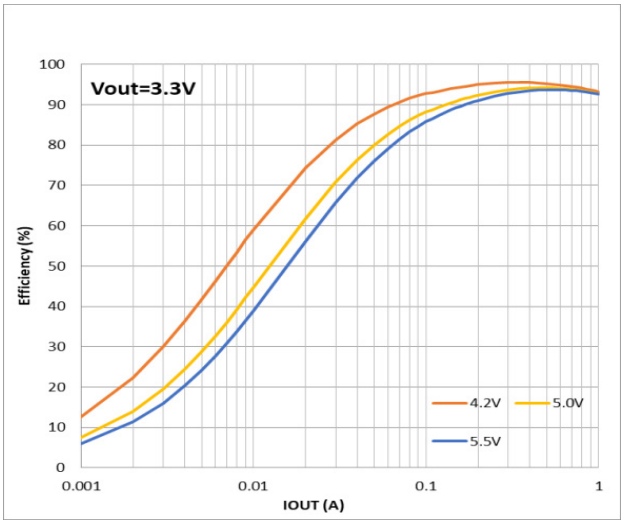
Efficiency, Mode = High, V_{OUT} = 1.8V



Efficiency, Mode = Low, V_{OUT} = 3.3V



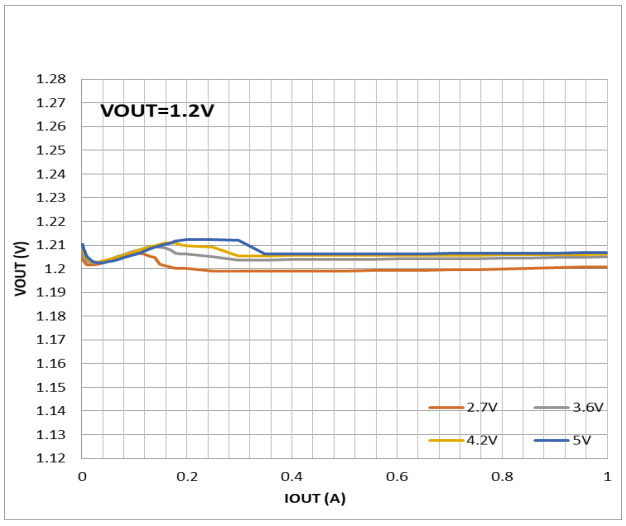
Efficiency, Mode = High, V_{OUT} = 3.3V



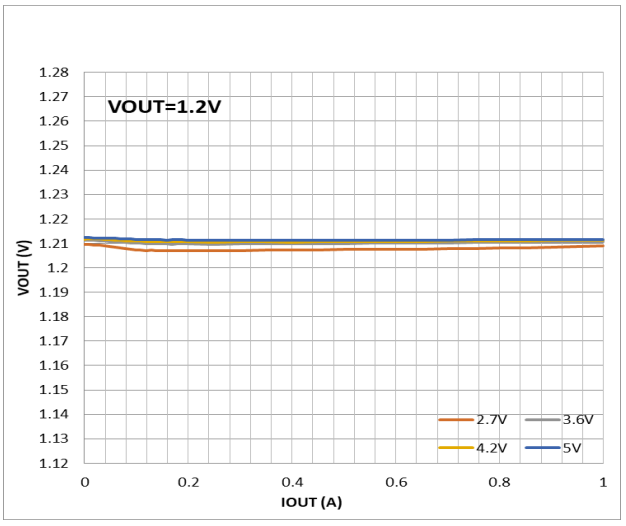
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

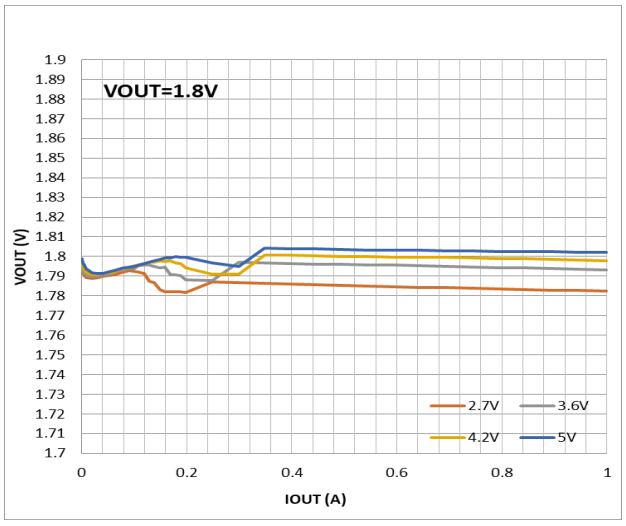
Load regulation, Mode = Low, V_{OUT} = 1.2V



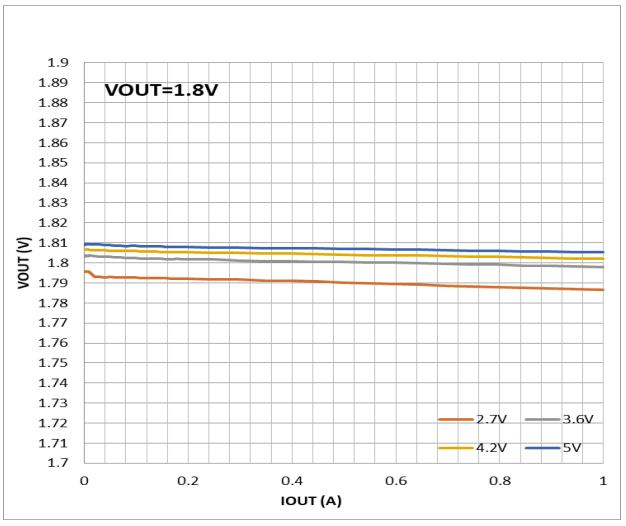
Load regulation, Mode = High, V_{OUT} = 1.2V



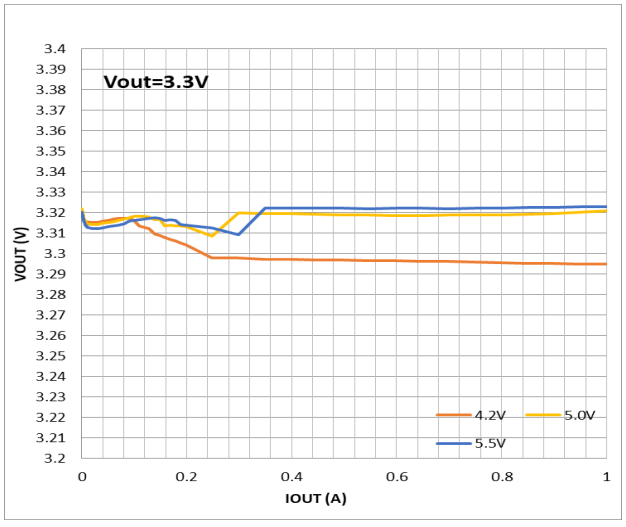
Load regulation, Mode = Low, V_{OUT} = 1.8V



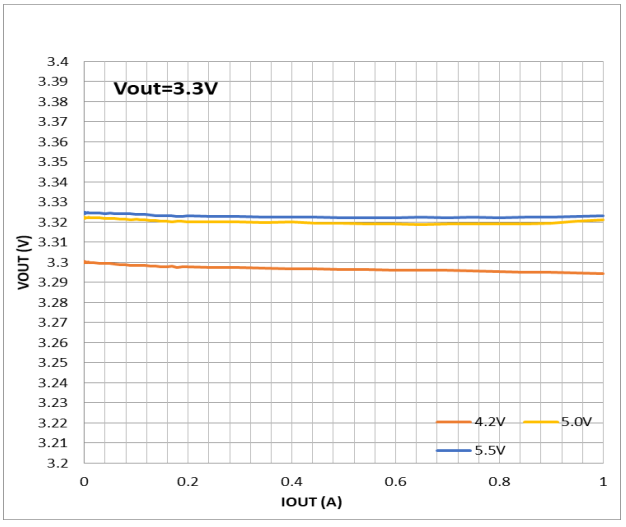
Load regulation, Mode = High, V_{OUT} = 1.8V



Load regulation, Mode = Low, V_{OUT} = 3.3V



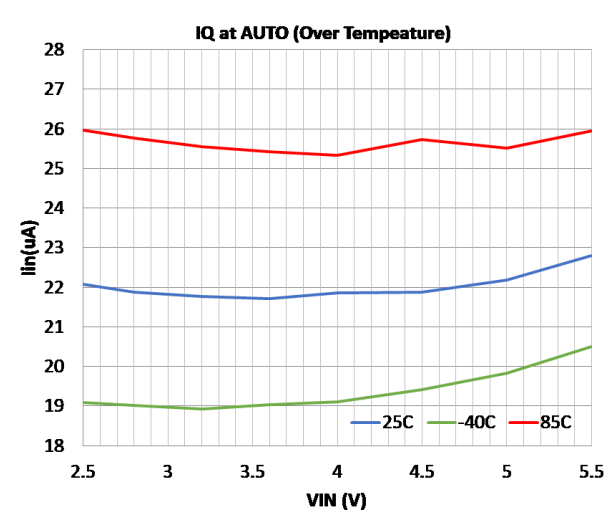
Load regulation, Mode = High, V_{OUT} = 3.3V



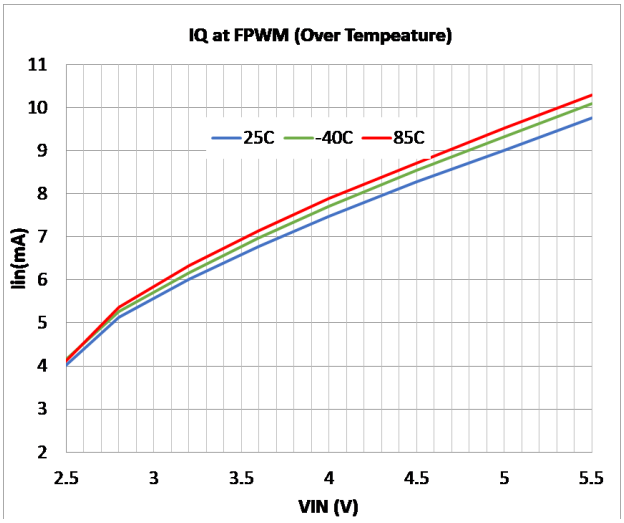
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

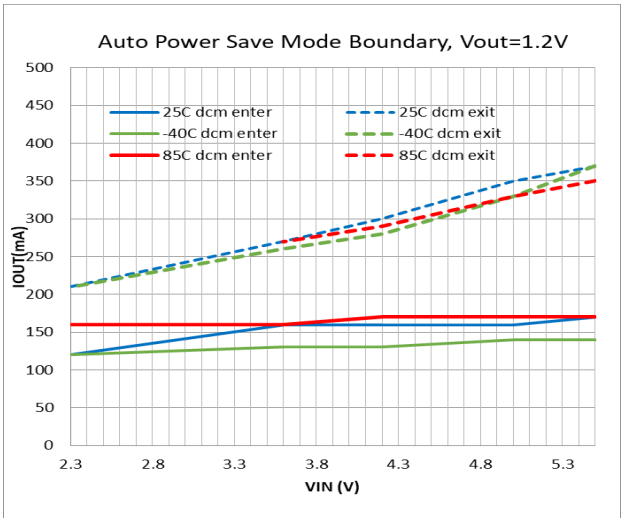
I_Q vs V_{IN} over Temperature, Mode = Low, V_{OUT} = 1.8V



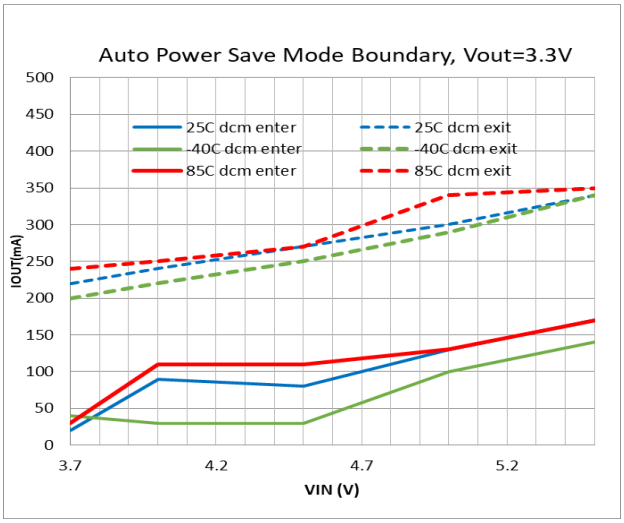
I_Q vs V_{IN} over Temperature, Mode = High, V_{OUT} = 1.8V



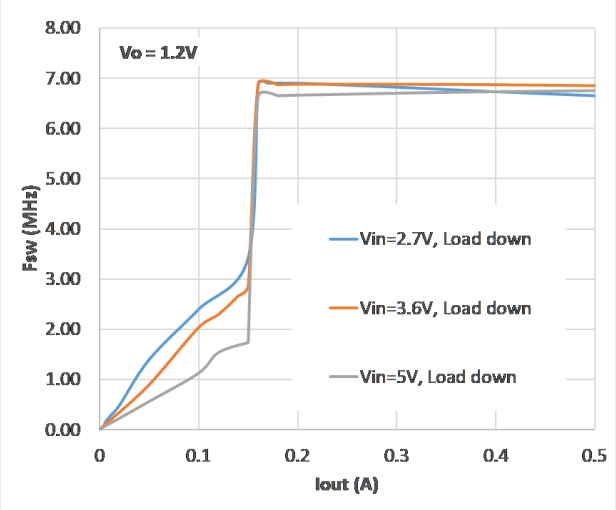
PFM/PWM Boundaries, Mode = Low, V_{OUT} = 1.2V



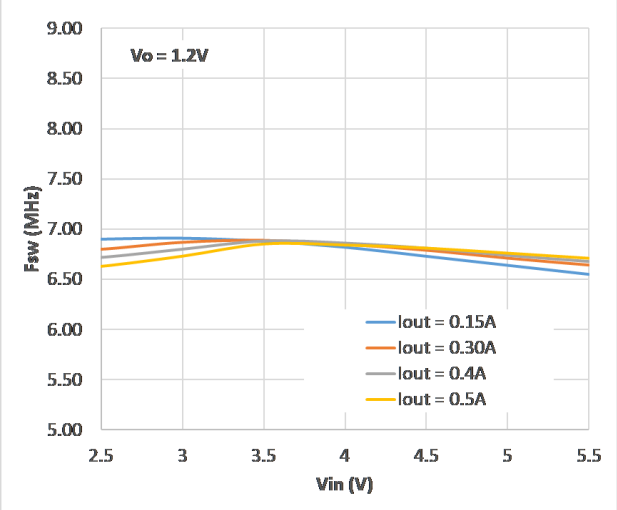
PFM/PWM Boundaries, Mode = Low, V_{OUT} = 3.3V



FSW, V_{OUT} = 1.2V, Mode = Low



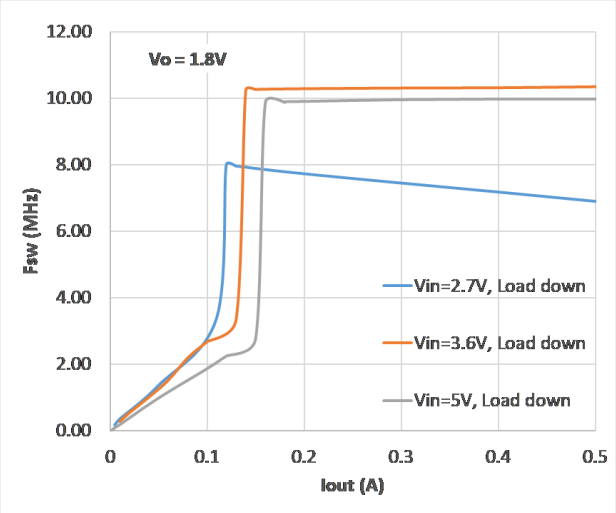
FSW, V_{OUT} = 1.2V, Mode = High



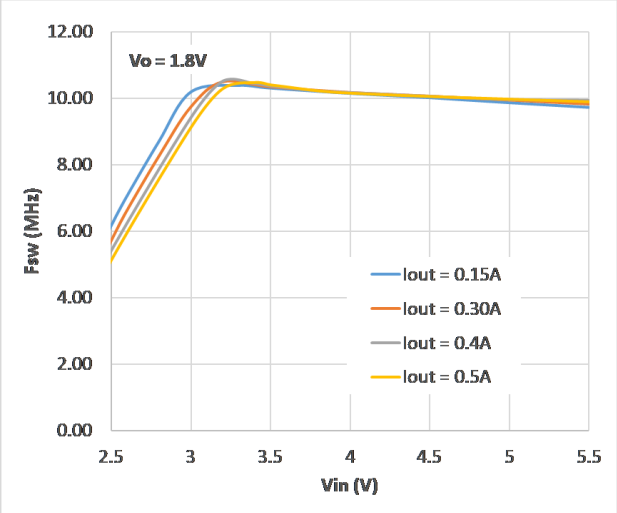
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

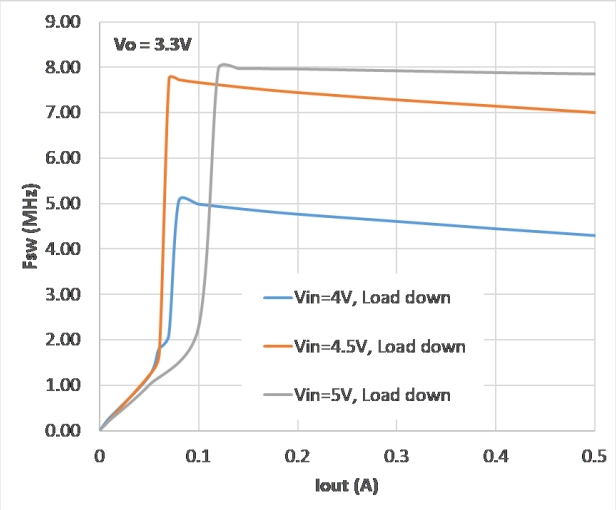
FSW, V_{OUT} = 1.8V, Mode = Low



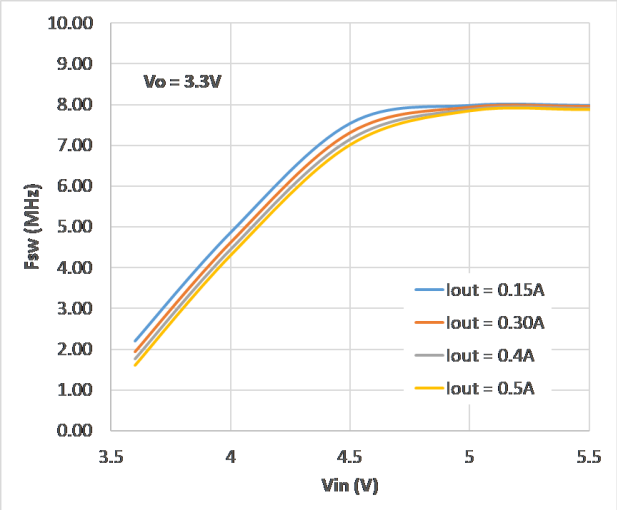
FSW, V_{OUT} = 1.8V, Mode = High



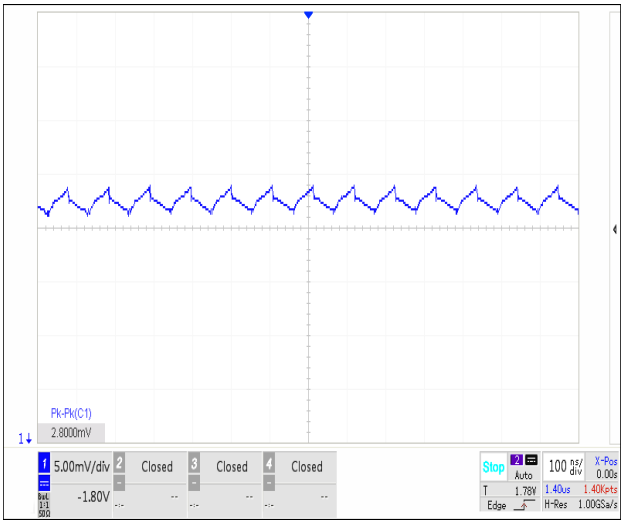
FSW, V_{OUT} = 3.3V, Mode = Low



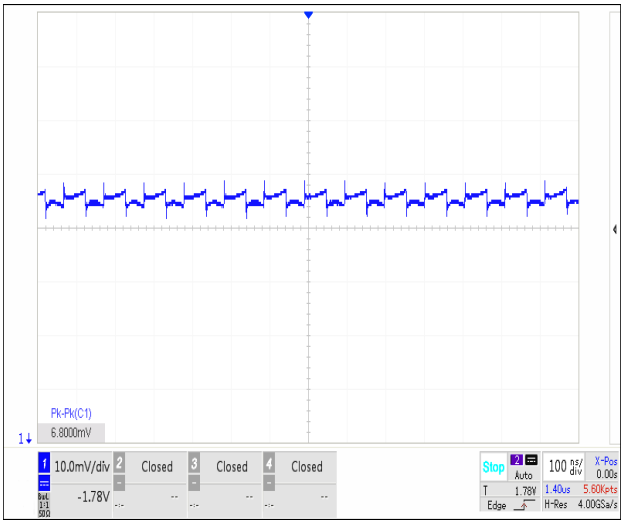
FSW, V_{OUT} = 3.3V, Mode = High



Output Voltage Ripple, V_{OUT} = 1.8V, Mode = High, I_{LOAD} = 0A



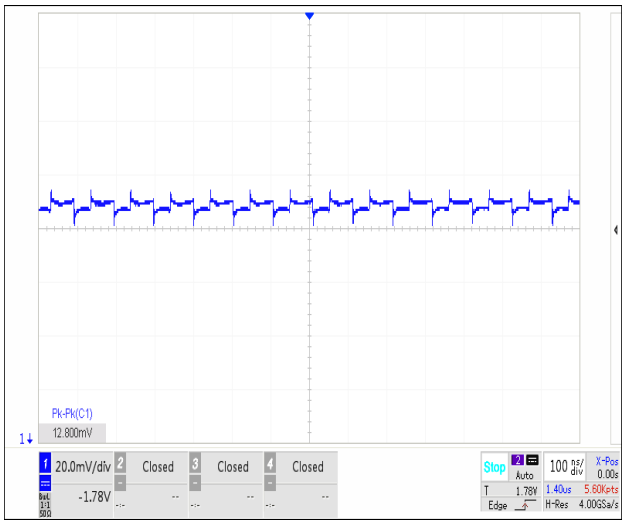
Output Voltage Ripple, V_{OUT} = 1.8V, Mode = High, I_{LOAD} = 500mA



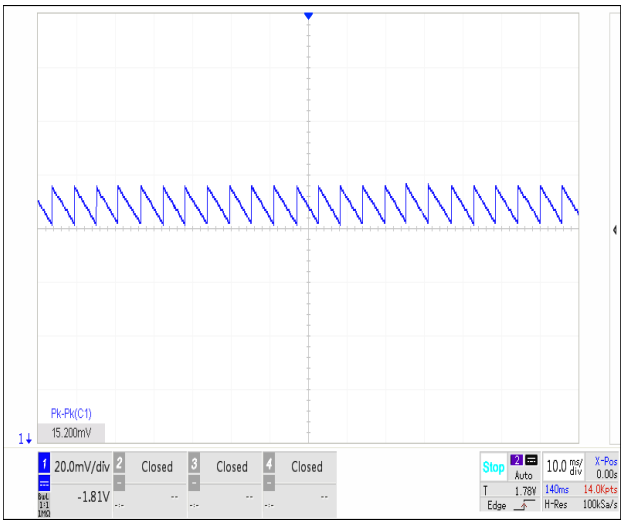
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

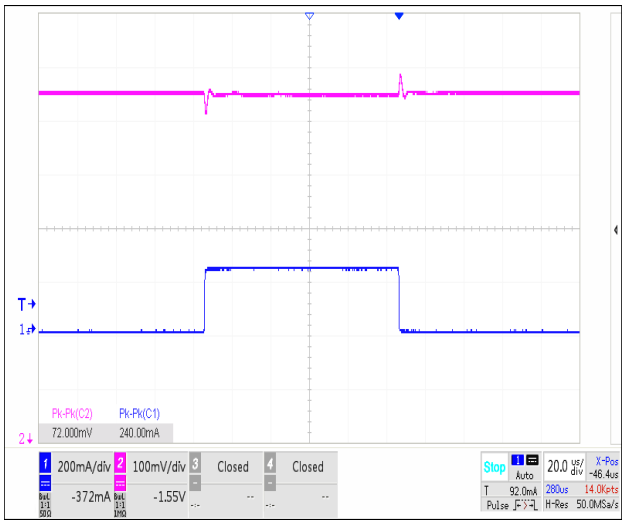
Output Voltage Ripple, V_{OUT} = 1.8V, Mode = High, I_{LOAD} = 1A



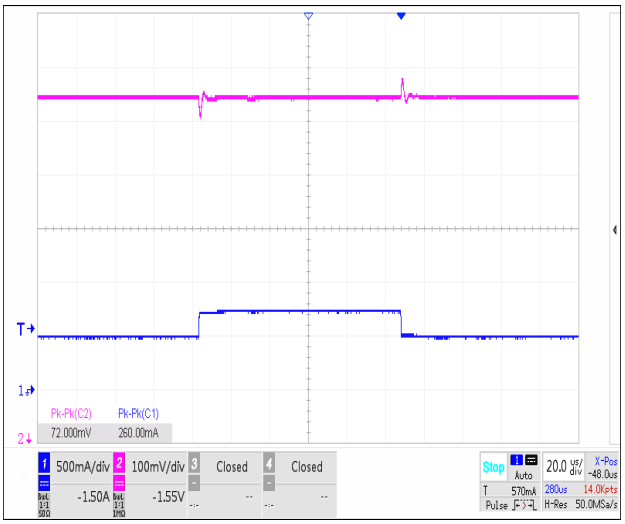
Output Voltage Ripple, V_{OUT} = 1.8V, Mode = Low, I_{LOAD} = 0A



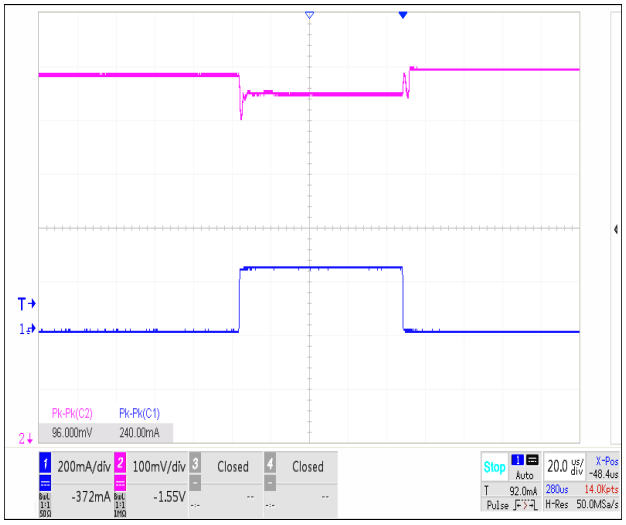
Load Transient, V_{OUT} = 1.8V, Mode = High, I_{LOAD} = 0A to 250mA



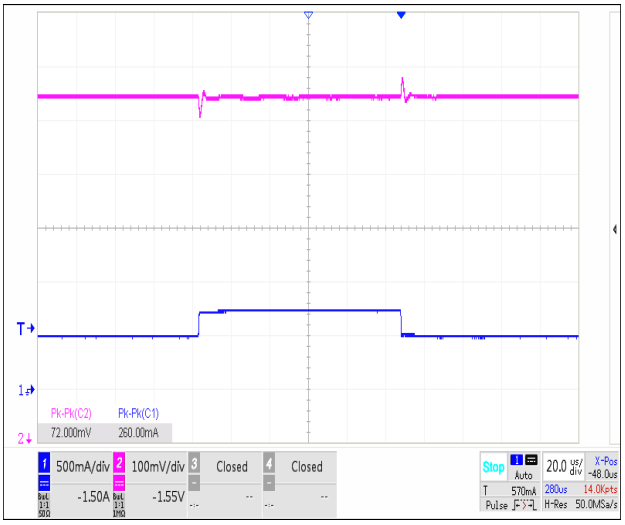
Load Transient, V_{OUT} = 1.8V, Mode = High, I_{LOAD} = 500mA to 750mA



Load Transient, V_{OUT} = 1.8V, Mode = Low, I_{LOAD} = 0A to 250mA



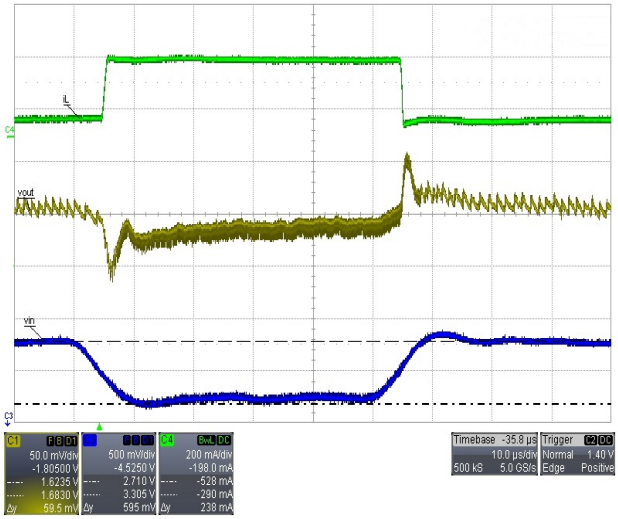
Load Transient, V_{OUT} = 1.8V, Mode = Low, I_{LOAD} = 500mA to 750mA



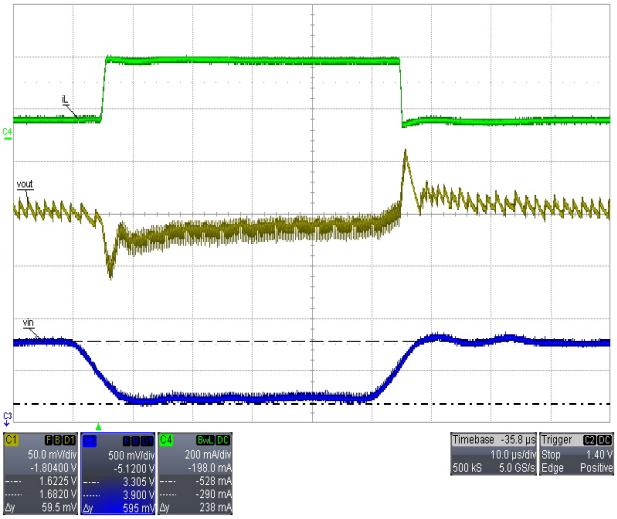
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

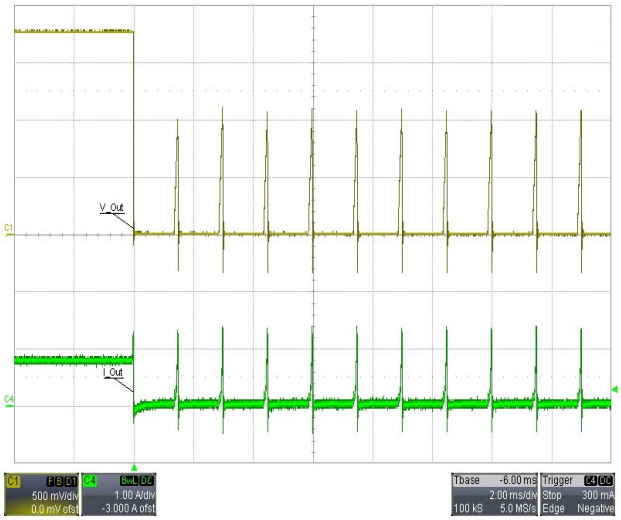
Combined Line/Load Transient, V_{IN} = 2.7V to 3.3V, I_{LOAD} = 30mA to 300mA



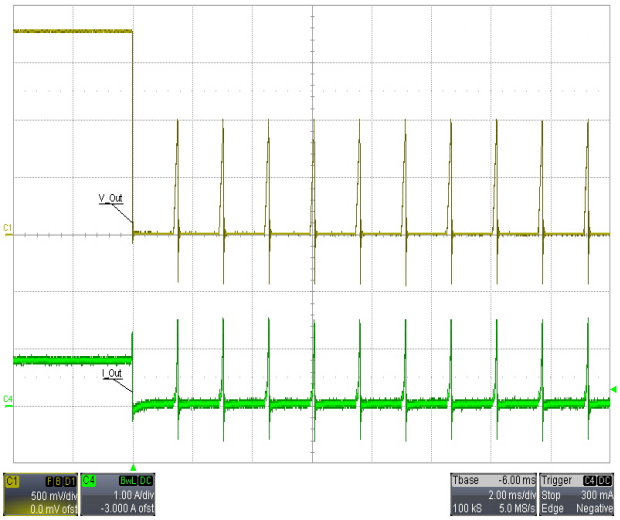
Combined Line/Load Transient, V_{IN} = 3.3V to 3.9V, I_{LOAD} = 30mA to 300mA



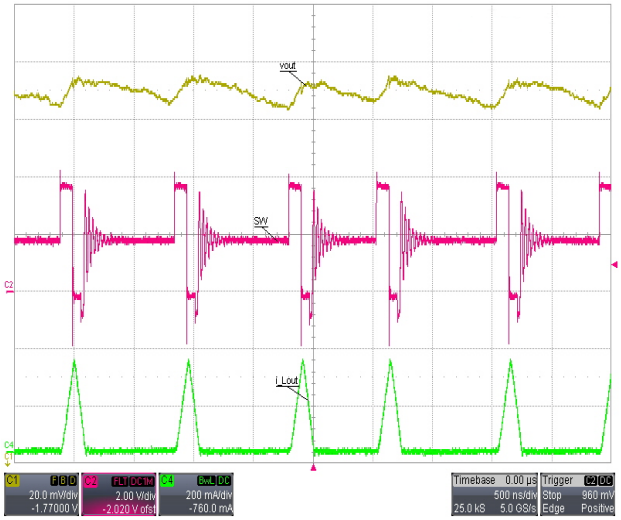
OCP Hiccup: V_{IN} = 3.6V, V_{OUT} = 1.8V



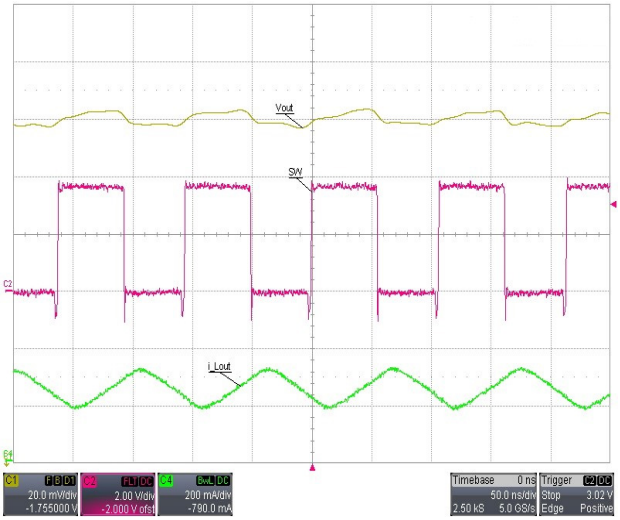
OCP Hiccup: V_{IN} = 5.5V, V_{OUT} = 1.8V



PFM Mode Operation: V_{IN} = 3.6V, V_{OUT} = 1.8V, I_{LOAD} = 40mA



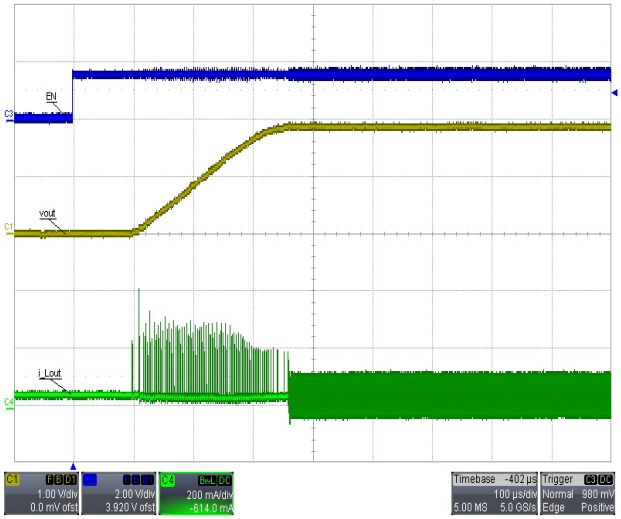
PWM Mode Operation: V_{IN} = 3.6V, V_{OUT} = 1.8V, I_{LOAD} = 300mA



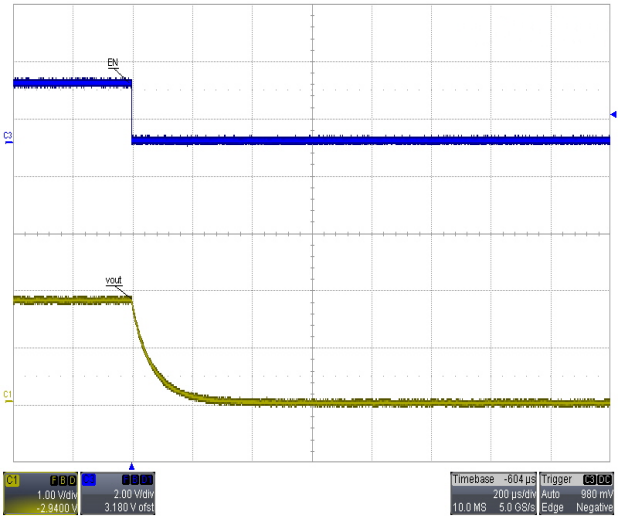
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = 3.6V, V_{OUT} = 1.8V. MODE = 0V, T_A = +25℃. f_{SW} = 10MHz for 1.8V device, f_{SW} = 6.5MHz for 1.2V and f_{SW} = 8MHz for 3.3V devices, unless otherwise noted.

Startup, V_{IN} = 3.6V, V_{OUT} = 1.8V, Mode = High, No load



Shutdown, V_{IN} = 3.6V, V_{OUT} = 1.8V, Mode = High, No load



FUNCTIONAL BLOCK DIAGRAM

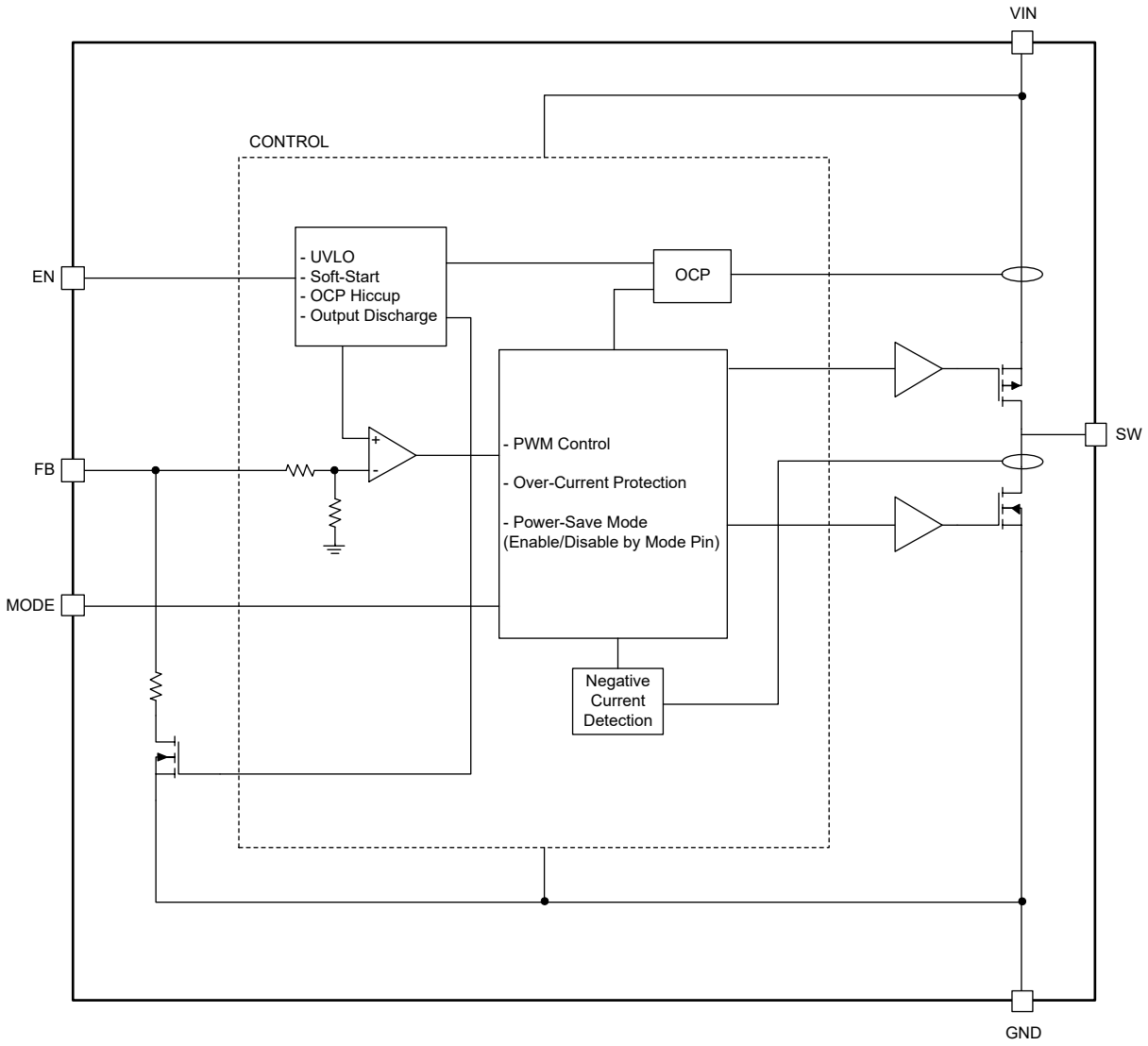


Figure 2. Block Diagram

DETAILED DESCRIPTION

The SGM61013 family is synchronous step-down DC/DC converter with switching frequency up to 10MHz. Operating from an input voltage between 2.3V and 5.5V, the converter can deliver up to 1A load current at a fixed output voltage.

Enable

Setting the EN voltage to logic high enables the device. Alternatively, the device is disabled when the EN voltage is set to logic low. In this state, the IC draws less than 1μA of current and the output is pulled down to ground through a resistive load (R_{DSON}). V_{OUT} starts to ramp up after 100μs delay.

Under-Voltage Lockout (UVLO)

The under-voltage lockout feature prevents the device from turning on if V_{IN} is below the UVLO level of 2.0V. If the device is enabled under UVLO conditions, the circuitry will not turn on until the input voltage is increased. Once active, the UVLO circuit has 150mV of hysteresis and the device will turn off if V_{IN} drops below 1.85V.

Soft-start

When the device is enabled, internal soft-start circuitry causes V_{OUT} to ramp up over a period of 280μs to limit inrush current. This feature protects a high impedance source from being pulled to a lower voltage as the device turns on.

Active Output Discharge

When the device is disabled through the EN pin, a discharge path for the output capacitor is created between V_{OUT} and ground through a 17Ω resistor (R_{DIS}).

Modes of Operation

The MODE pin selects the device's mode of operation. When connected to logic high, the converter always operates in pulse width modulation (PWM) mode regardless of load current. The PWM mode is a continuous switching mode where the duty cycle is modulated to achieve the required output power.

When connected to logic low, the converter automatically switches to pulse frequency modulation (PFM) mode at light current loads. In PFM mode the frequency of pulses is varied to deliver the best possible efficiency. The device switches between PFM and PWM as the load current changes and thus optimizes performance.

If the input voltage ever gets too close to the target output voltage, such that regulation can no longer be maintained, the converter will enter 100% duty cycle mode. In this mode the high-side switch is on, connecting the input and output together to deliver a voltage as close to the target as possible.

Over-Current Protection

The device has an over-current protection to prevent damage to the device and inductor during over-current conditions.

Over-current protection occurs at 1.6A. After hitting 16 consecutive cycles of peak current limit, the output will be disabled. After being disabled for 1.5ms, the device will be re-enabled, and a new soft-start cycle will begin.

Thermal Shutdown

The device thermal shutdown protection is enabled if the chip temperature exceeds +135℃. Once the temperature drops below +120℃, the device will be re-enabled, and a new soft-start cycle will begin.

APPLICATION INFORMATION

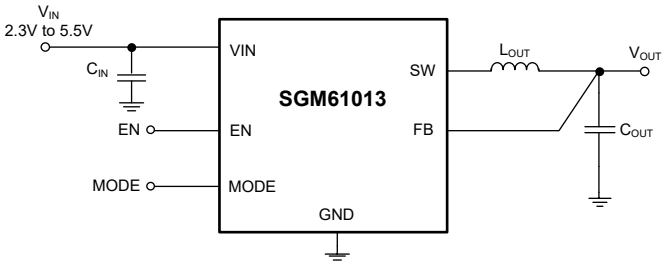


Figure 3. Application Circuit

Table 1 .Recommended Components

Part	Value	Package	Manufacturer	Part Number
C_{IN}	4.7μF, 10V	0402	AVX	0402ZD475MATA2A
	2.2μF, 10V	0402	AVX	0402ZD225MATA2A
C_{OUT}	4.7μF, 10V	0402	AVX	0402ZD475MATA2A
	2.2μF, 10V	0402	AVX	0402ZD225MATA2A
L_{OUT}	470nH, DCR 54mΩ	1.6mm × 1.0mm × 0.8mm	Murata	DFE18SANR47MG0L
	470nH, DCR 32mΩ	2.0mm × 1.6mm × 1.0mm	Murata	DFE201610ER47M
	470nH, DCR 40mΩ	2.0mm × 1.6mm × 1.0mm	FDK	MIPSZ2016DR47FR
	470nH, DCR 125mΩ	1.6mm × 0.8mm × 0.6mm	Cyntec	16010F100E
	470nH, DCR 80mΩ	2.0mm × 1.2mm × 1.0mm	Sunlord	MPH201210QR47MT

Layout Guidelines and Example

A well-designed and manufactured PCB is important for all switching power supplies, especially for those operate at high switching frequency.

If the layout is not fulfilled carefully, not only the converter performance could be degraded but also the stability or EMI issue may be introduced. Hence, care must be taken in board layout to achieve the specified performance.

Please use the following guidelines when designing PCBs:

- Keep components placement as compact as possible.
- Place a low-ESR input capacitor as close to VIN and GND as possible.
- Minimize the area between SW pin trace and inductor to limit high frequency radiation.
- Keep FB trace away from noisy components and traces (e.g. SW and inductor).
- Use wide and short traces for the main current paths.
- Ground pins of converter must be strongly connected to PCB ground with low inductance and impedance.
- Place common and unbroken ground for C_{IN} and C_{OUT}.
- Reduce excessive thermal relief vias and keep them away from SW and inductor.

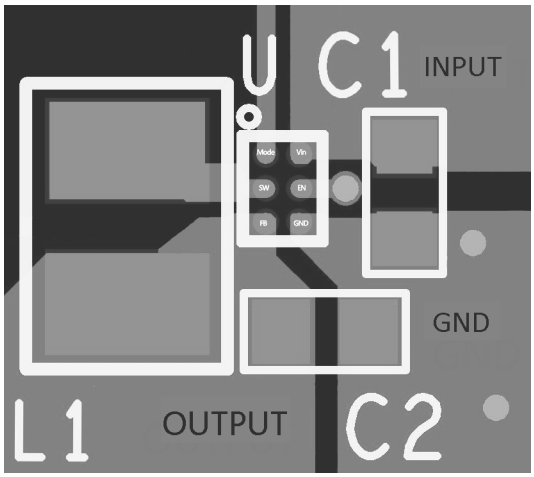
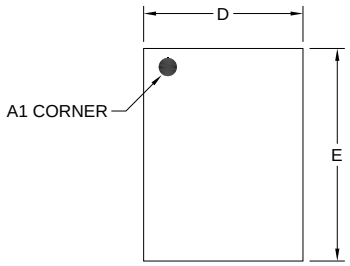


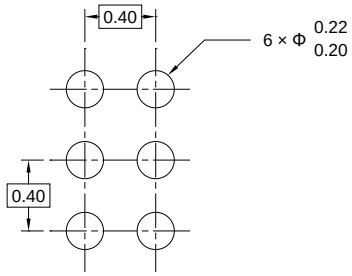
Figure 4. Layout Top Layer

PACKAGE OUTLINE DIMENSIONS

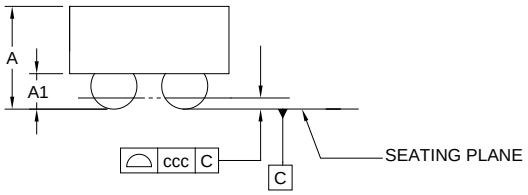
WLCSP-0.9×1.2-6B



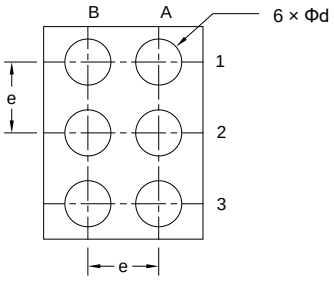
TOP VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



SIDE VIEW



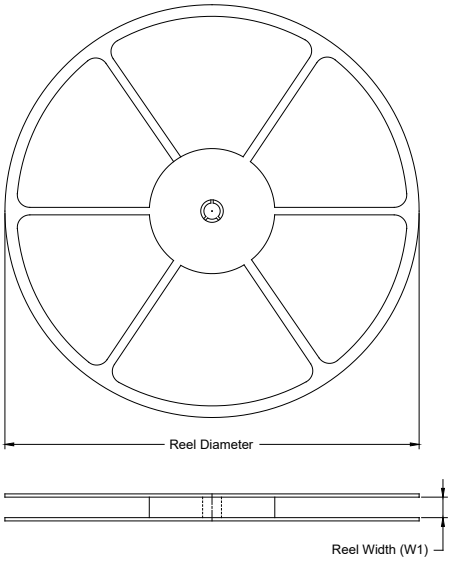
BOTTOM VIEW

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.536	0.582	0.628
A1	0.182	0.202	0.222
D	0.860	0.900	0.940
E	1.160	1.200	1.240
d	0.223	0.262	0.301
e	0.400 BSC		
ccc	0.030		

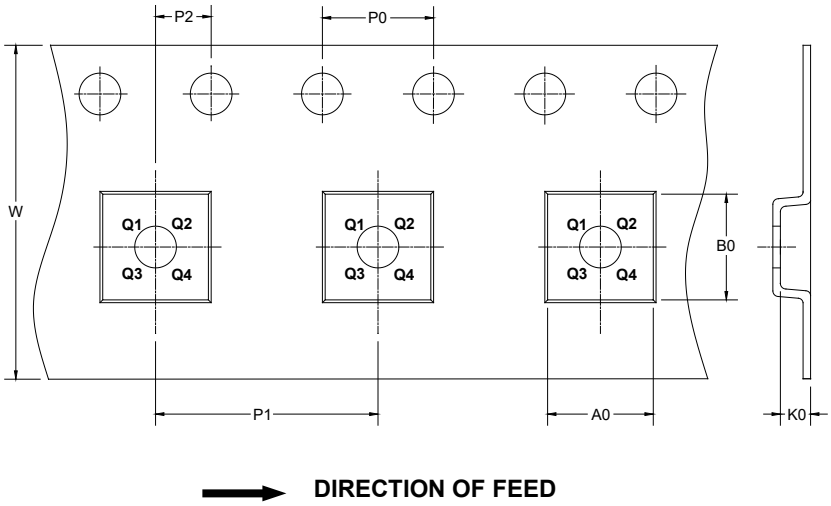
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



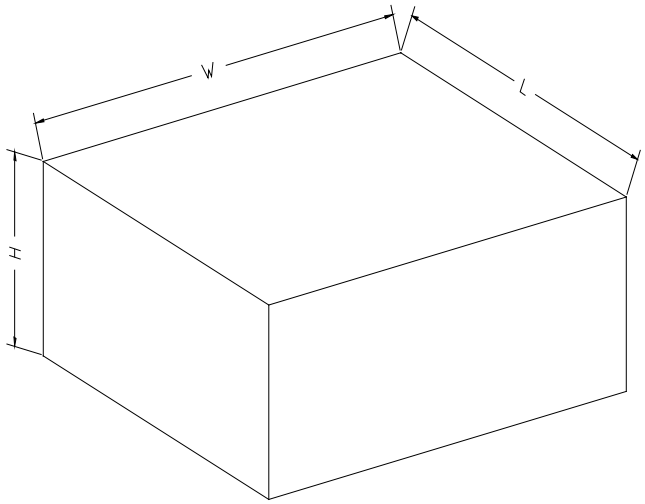
NOTE: The picture is only for reference. Please make the object as the standard.

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
WLCSP-0.9×1.2-6B	7"	9.5	0.99	1.38	0.69	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