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The Future of Analog IC Technology

MP1603

3A,2.5V-5.5V Synchronous Step-Down Converterwith 25µA I_Q in SOT563 Package

DESCRIPTION

The MP1603 is a monolithic, step-down, switch-mode converter with built-in internal power MOSFETs. The MP1603 achieves 3A of continuous output current from a 2.5V to 5.5V input voltage with excellent load and line regulation. The output voltage can be regulated to as low as 0.6V.

The constant-on-time (COT) control scheme provides fast transient response and eases loop stabilization. Fault protections include cycle-by-cycle current limiting and thermal shutdown.

The MP1603 is ideal for a wide range of applications, including high-performance DSPs, wireless power, portable and mobile devices, and other low-power systems.

The MP1603 requires a minimal number of readily available, standard, external components and is available in an ultra-small SOT563 package.

FEATURES

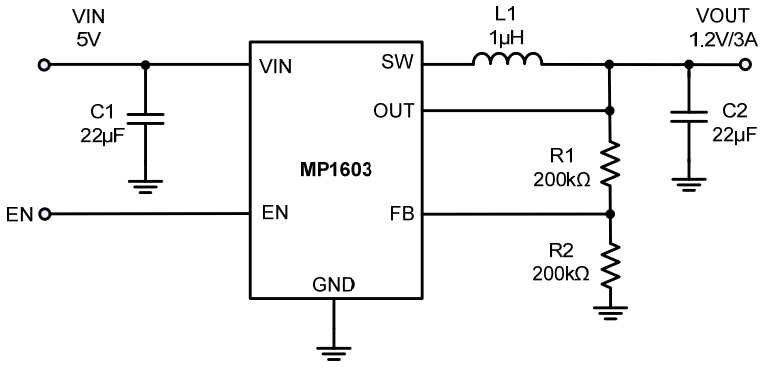
- Low I_Q: 25µA
- 1.1MHz Switching Frequency
- EN for Power Sequencing
- 1% FB Accuracy
- Wide 2.5V to 5.5V Operating Input Range
- Output Adjustable from 0.6V
- Up to 3A Output Current
- 65mΩ and 35mΩ Internal Power MOSFET Switches
- 100% Duty On
- Output Discharge
- V_{OUT} Over-Voltage Protection (OVP)
- Short-Circuit Protection (SCP) with Hiccup Mode
- Power Good (PG) Only for Fixed Output Version
- Available in a SOT563 Package

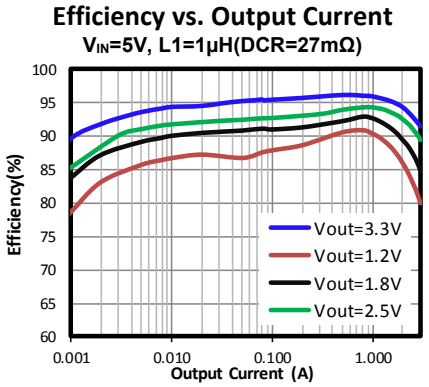
APPLICATIONS

- Wireless/Networking Cards
- Portable Instruments
- Battery-Powered Devices
- Low-Voltage I/O System Power
- Multi-Function Printer

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TYPICAL APPLICATION





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ORDERING INFORMATION

Part Number*	Package	Top Marking	V_{OUT} Range
MP1603GTF	SOT563	*See Below*	Adjustable
MP1603GTF-12		*See Below*	Fixed 1.2V
MP1603GTF-15		*See Below*	Fixed 1.5V
MP1603GTF-18		*See Below*	Fixed 1.8V
MP1603GTF-25		*See Below*	Fixed 2.5V
MP1603GTF-33		*See Below*	Fixed 3.3V

* For Tape & Reel, add suffix –Z (e.g. MP1603GTF–Z)

TOP MARKING (MP1603GTF)

AVBY
LLL

AVB: Product code of MP1603GTF
Y: Year code
LLL: Lot number

TOP MARKING (MP1603GTF-12)

AZRY
LLL

AZR: Product code of MP1603GTF-12
Y: Year code
LLL: Lot number

TOP MARKING (MP1603GTF-15)

BAJY
LLL

BAJ: Product code of MP1603GTF-15
Y: Year code
LLL: Lot number

TOP MARKING (MP1603GTF-18)

BAGY
LLL

BAG: Product code of MP1603GTF-18
Y: Year code
LLL: Lot number

TOP MARKING (MP1603GTF-25)

BAEY
LLL

BAE: Product code of MP1603GTF-25
Y: Year code
LLL: Lot number

TOP MARKING (MP1603GTF-33)

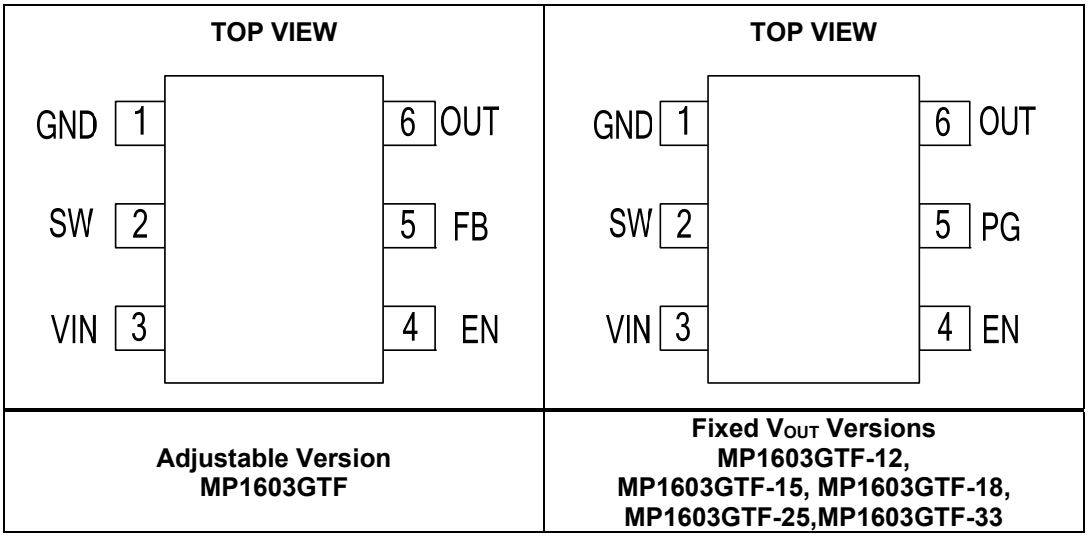
BAFY
LLL

BAF: Product code of MP1603GTF-33
Y: Year code
LLL: Lot number

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PACKAGE REFERENCE



Adjustable Version MP1603GTF	Fixed V_{OUT} Versions MP1603GTF-12, MP1603GTF-15, MP1603GTF-18, MP1603GTF-25,MP1603GTF-33

ABSOLUTE MAXIMUM RATINGS(1)

Supply voltage (VIN) 6.5V
V_{SW} ..... -0.3V(-5V for <10ns)to 6.5V (10V for <10ns)
All other pins ..... -0.3V to 6.5 V
Junction temperature ..... 150°C
Lead temperature..... 260°C
Continuous power dissipation(T_A = +25°C) (2)(4) 1.5W
Storage temperature .....-65°C to +150°C

Recommended Operating Conditions (3)

Supply voltage (VIN) ..... 2.5V to 5.5V
Operating junction temp. (T_J)....-40°C to +125°C

Thermal Resistance	θ_{JA}	θ_{JC}	
EV1603-TF-00A (4)	80	50	°C/W
JESD51-7 (5)	130	60	°C/W

NOTES:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation produces an excessive die temperature, causing the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured onEV1603-TF-00A, 2-layer PCB, 63mm×63mm.
5) Measured on JESD51-7, 4-layer PCB.
note 5) The value of θ_{JA} given in this table is only valid for comparison with other packages and cannot be used for design purposes. These values are calculated in accordance with JESD51-7, and simulated on a specified JEDEC board. They do not represent the performance obtained in an actual application.

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ELECTRICAL CHARACTERISTICS

VIN = 3.6V, T_J = -40°C to +125°C(6), typical value is tested at T_J = +25°C. The limit over temperature is guaranteed by characterization, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
VIN range			2.5		5.5	V
UVLO threshold rising				2.3	2.45	V
UVLO threshold hysteresis				200		mV
Feedback voltage	V_{FB}	2.5V ≤ VIN ≤ 5.5V	594	600	606	mV
		T_J=-40°C to +125°C	591	600	609	
Feedback current	I_{FB}	V_{FB}= 0.63V		50	100	nA
OUT voltage (MP1603GTF-12)	V_{OUT}	T_J=25ºC	1188	1200	1212	mV
		T_J=-40°C to +125°C	1182	1200	1218	mV
OUT voltage (MP1603GTF-15)	V_{OUT}	T_J=25ºC	1485	1500	1515	mV
		T_J=-40°C to +125°C	1478	1500	1522	mV
OUT voltage (MP1603GTF-18)	V_{OUT}	T_J=25ºC	1782	1800	1818	mV
		T_J=-40°C to +125°C	1773	1800	1827	mV
OUT voltage (MP1603GTF-25)	V_{OUT}	T_J=25ºC	2475	2500	2525	mV
		T_J=-40°C to +125°C	2463	2500	2537	mV
OUT voltage (MP1603GTF-33)	V_{OUT}	T_J=25ºC	3267	3300	3333	mV
		T_J=-40°C to +125°C	3251	3300	3349	mV
P-FET switch on resistance	R_{DSON_P}	VIN=5V		65		mΩ
N-FET switch on resistance	R_{DSON_N}	VIN=5V		35		mΩ
Switch leakage		V_{EN} = 0V, VIN = 6V,V_{SW}= 0V and 6V, T_J = +25°C		0	1	µA
P-FET peak current limit			4		6	A
N-FET valley current limit				3.5		A
ZCD				50		mA
On time	T_{ON}	VIN=5V, V_{OUT}=1.2V	180	220	260	ns
		VIN=3.6V, V_{OUT}=1.2V	240	300	360	
Switching frequency	f_S	V_{OUT}=1.2V		1100		kHz
Minimum off time	$T_{MIN-OFF}$			100		ns
Minimum on time(7)	T_{MIN-ON}			60		ns
Soft-start time	T_{SS-ON}	V_{OUT} rise from 10% to 90%		0.5		ms
Maximum duty cycle			100			%
Power good rising threshold UV		Fixed V_{OUT} Version, V_{OUT} rising edge		90		%
Power good falling threshold UV		Fixed V_{OUT} Version, V_{OUT} falling edge		85		%
Power good rising threshold OV		Fixed V_{OUT} Version, V_{OUT} rising edge		115		%
Power good falling threshold OV		Fixed V_{OUT} version, V_{OUT} falling edge		105		%
Power good delay	PGD	Fixed V_{OUT} version, PG rising/falling edge		150		µs

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ELECTRICAL CHARACTERISTICS *(continued)*

VIN = 3.6V, T_J = -40°C to +125°C[6], typical value is tested at T_J = +25°C. The limit over temperature is guaranteed by characterization, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Power good sink current capability	VPG-L	Fixed V_{OUT} Version, sink 1mA			0.4	V
Power good logic high voltage	VPG-H	Fixed V_{OUT} Version, V_{IN}=5V, V_{OUT} =Fixed OUT	4.9			V
EN turn-on delay		EN on to SW active		150		µs
EN input logic low voltage					0.4	V
EN input logic high voltage			1.2			V
Output discharge resistor	R_{DIS}	V_{EN}=0V, V_{OUT}=1.2V		200		Ω
EN input current		V_{EN}=2V		1.2		µA
		V_{EN}=0V		0		µA
Supply current (shutdown)		V_{EN}=0V, T_J = +25°C		0	1	µA
Supply current (quiescent) Adjustable version		V_{EN}=2V, V_{FB}=0.63V, VIN=5V, T_J = +25°C		25	30	µA
Supply current (quiescent) Fixed V_{OUT} version		V_{EN}=2V, No switching, VIN=5V, T_J = +25°C		30	35	µA
Output over-voltage threshold	V_{OVP}		110%	115%	120%	V_{FB}
V_{OUT} OVP hysteresis	V_{OVP_HYS}			10%		V_{FB}
OVP delay				12		µs
Low-side current		Current flow from SW to GND		1.5		A
Absolute VIN OVP		After V_{OUT} OVP enable		6.1		V
Absolute VIN OVP hysteresis				400		mV
Thermal shutdown[7]				160		°C
Thermal hysteresis[7]				30		°C

NOTES:

6) Not tested in production. Guaranteed by over-temperature correlation.

7) Guaranteed by engineering sample characterization.

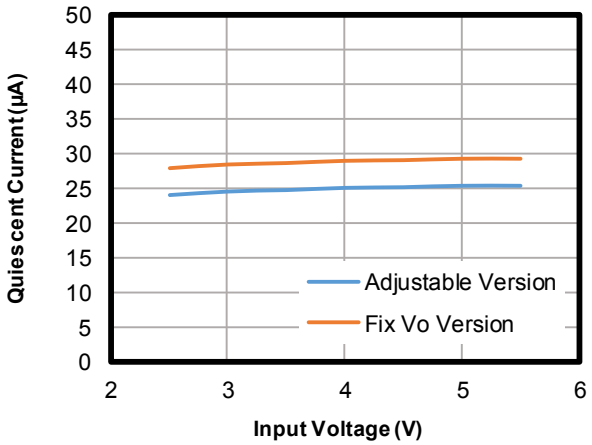
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TYPICAL CHARACTERISTICS

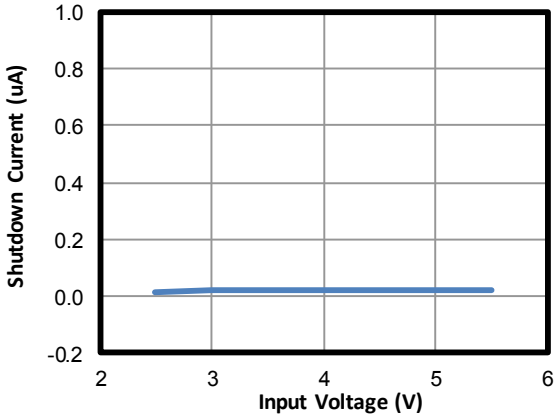
VIN = 3.6V, V_{OUT} = 1.2V, L =1µH, C_{OUT}=22µF, T_A = +25°C, unless otherwise noted.

Quiescent Current vs. Input Voltage

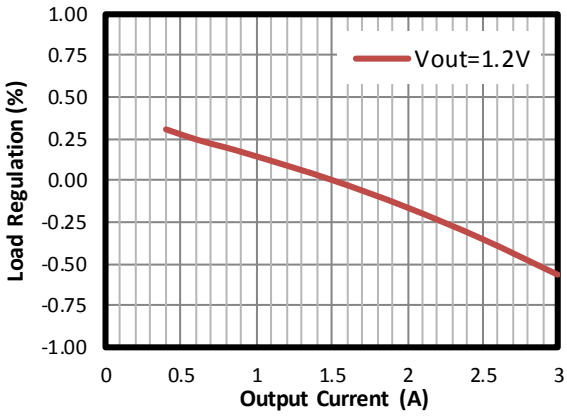


Shutdown Current vs. Input Voltage

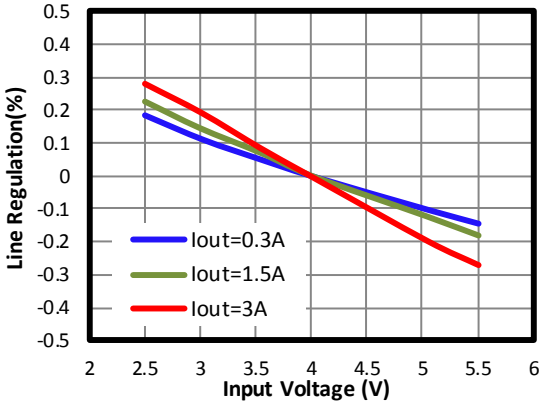
V_{EN}=0V



Load Regulation

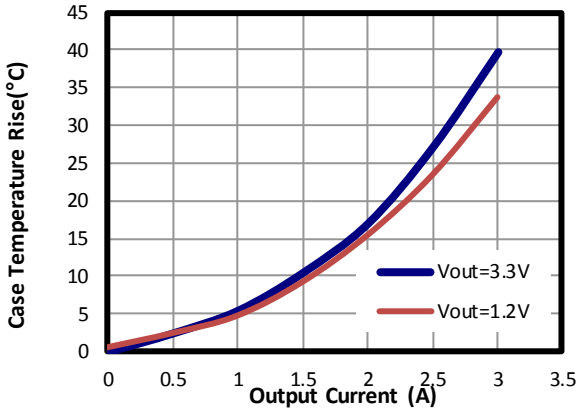


Line Regulation



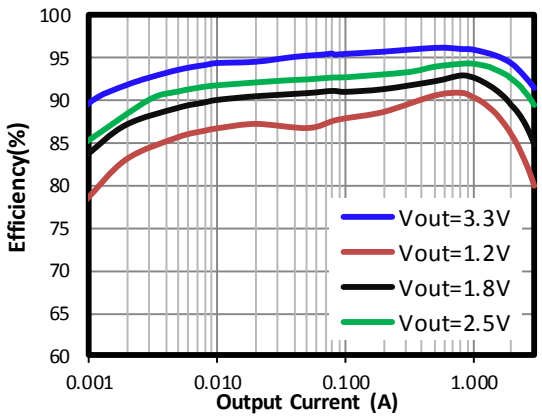
Case Temperature Rise vs. Output Current

VIN=5V



Efficiency vs. Output Current

VIN=5V



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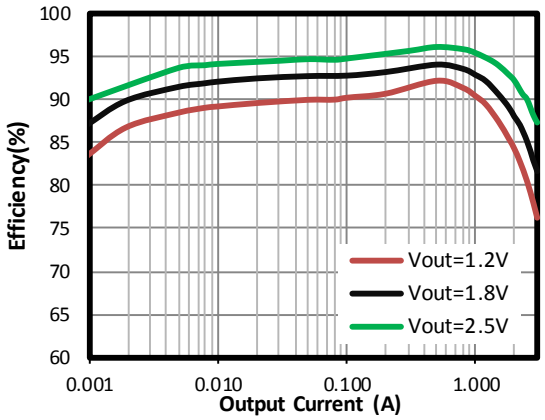
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TYPICAL CHARACTERISTICS*(continued)*

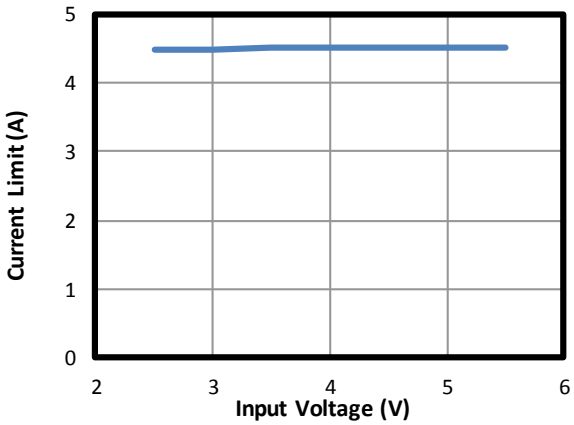
VIN = 3.6V, V_{OUT} = 1.2V, L =1µH, C_{OUT}=22µF, T_A = +25°C, unless otherwise noted.

Efficiency vs. Output Current

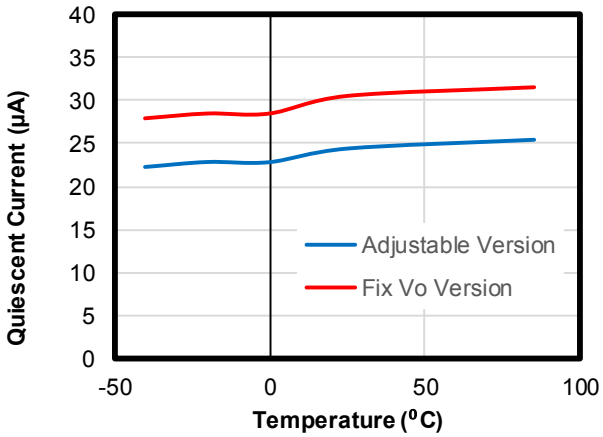
VIN=3.6V



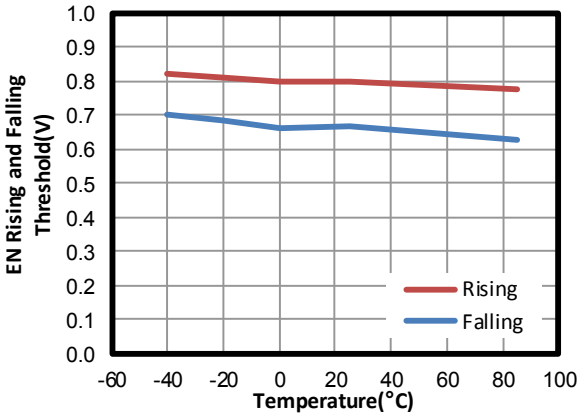
Peak Current Limit vs. VIN



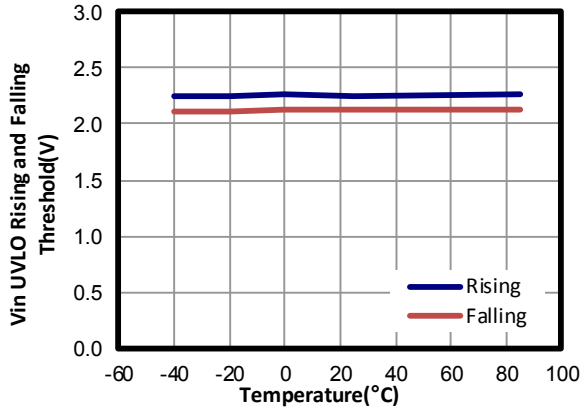
Quiescent Current vs. Temperature



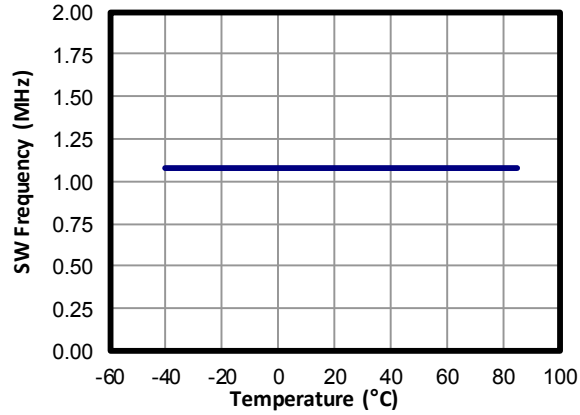
EN Rising and Falling Threshold vs. Temperature



VIN Rising and Falling Threshold vs. Temperature



Switch Frequency vs. Temperature



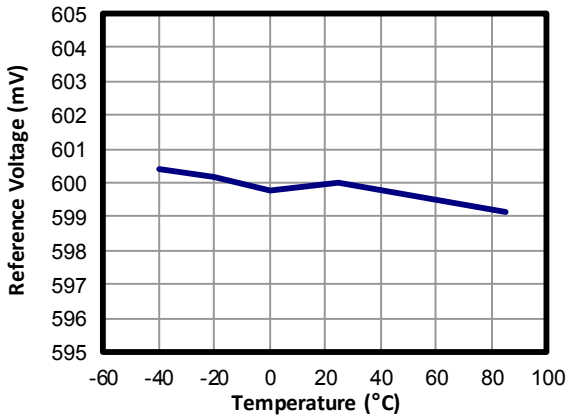
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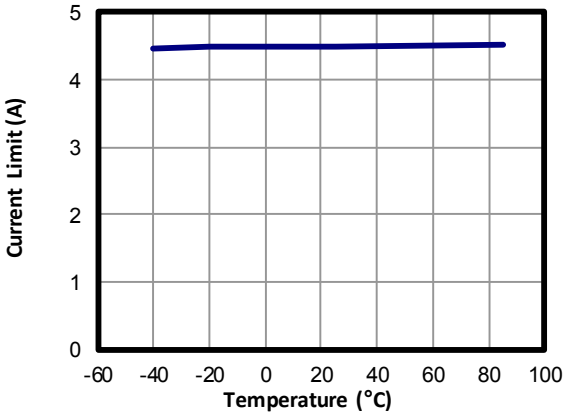
TYPICAL CHARACTERISTICS*(continued)*

VIN = 3.6V, V_{OUT} = 1.2V, L =1µH, C_{OUT}=22µF, T_A = +25°C, unless otherwise noted.

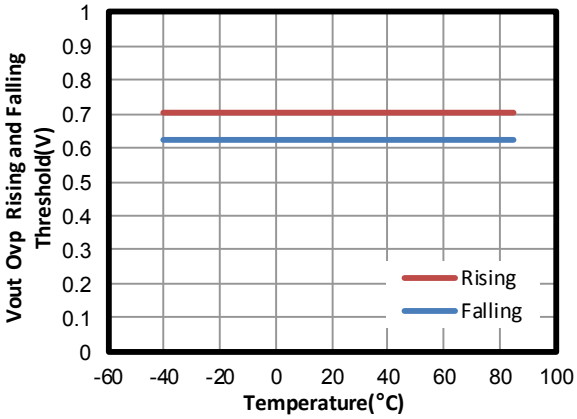
Reference Voltage vs. Temperature



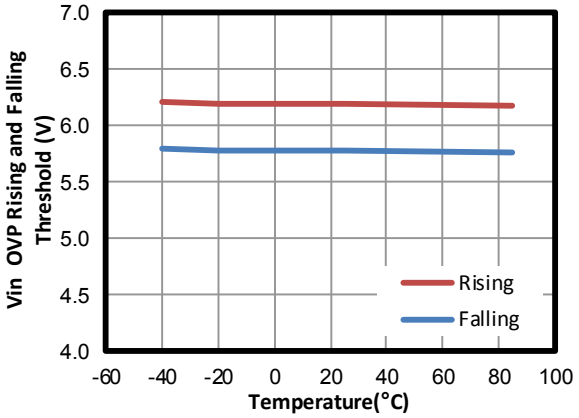
Peak Current Limit vs. Temperature



V_{OUT} OVP Rising and Falling Threshold vs. Temperature

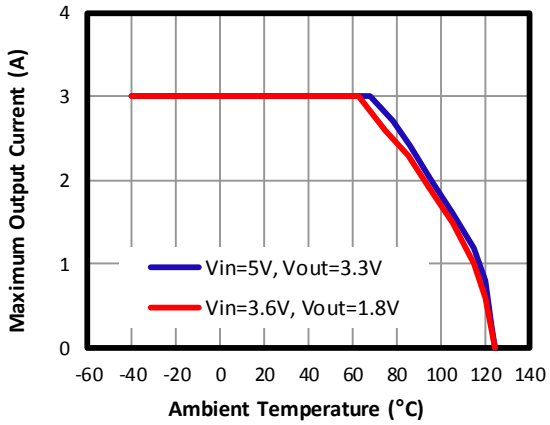


VIN OVP Rising and Falling Threshold vs. Temperature



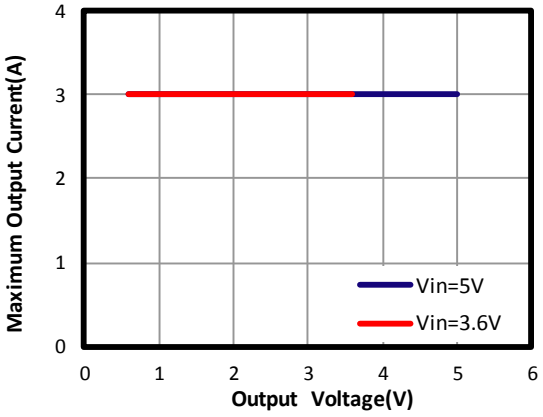
Output Current Derating vs. Ambient Temperature

T_J≤ 125°C



Output Current Derating vs. Output Voltage

T_J≤ 125°C



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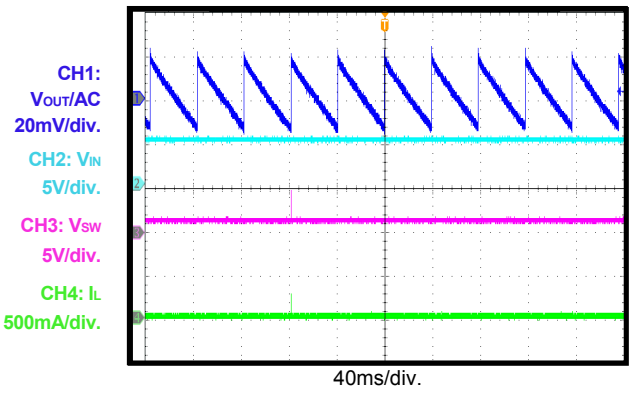
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TYPICAL PERFORMANCE CHARACTERISTICS

VIN = 5V, V_{OUT} = 1.2V, L =1µH, C_{OUT}=22µF, T_A = +25°C, unless otherwise noted.

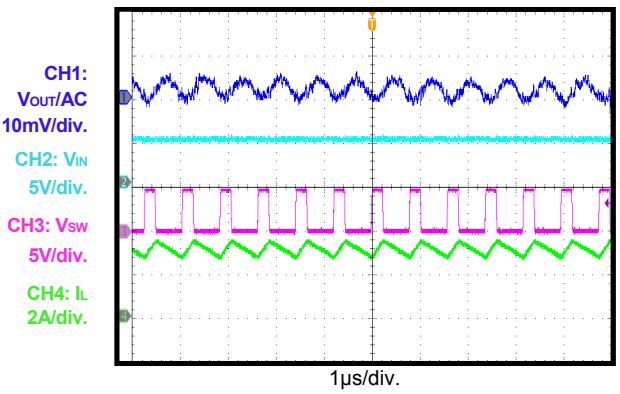
Steady State

I_{OUT}=0A



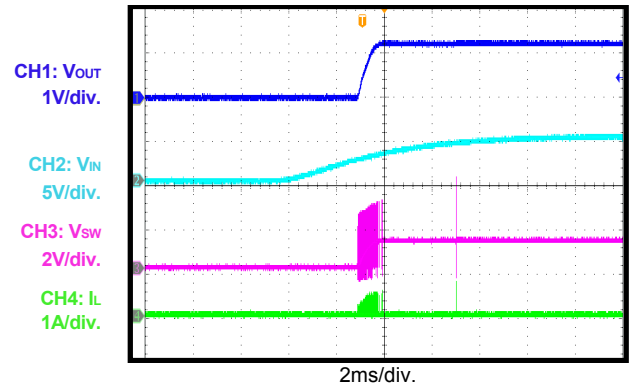
Steady State

I_{OUT}=3A



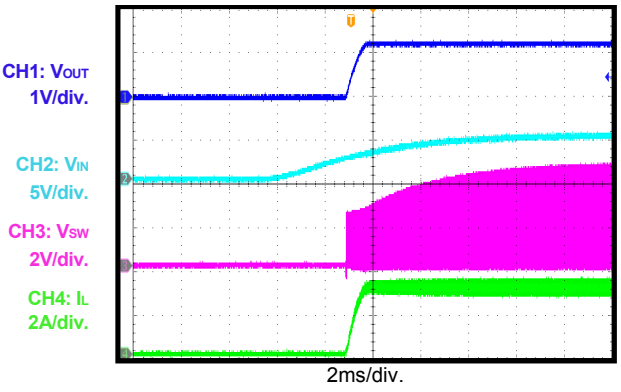
VIN Power-Up

I_{OUT}=0A



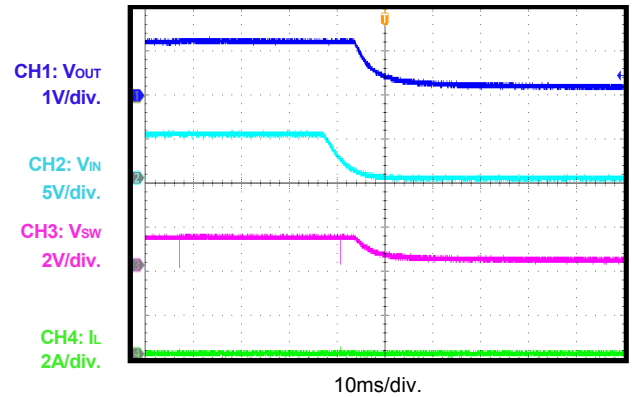
VIN Power-Up

I_{OUT}=3A



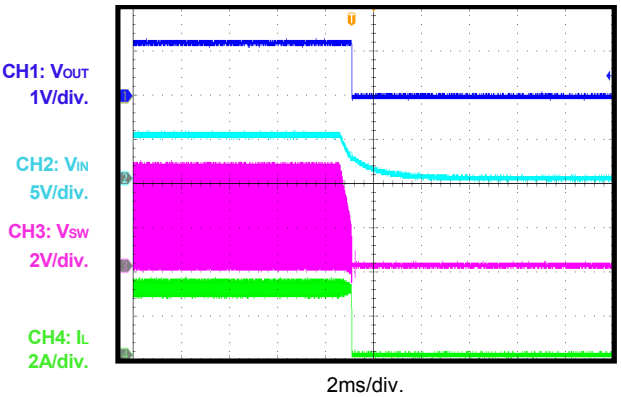
VIN Shutdown

I_{OUT}=0A



VIN Shutdown

I_{OUT}=3A



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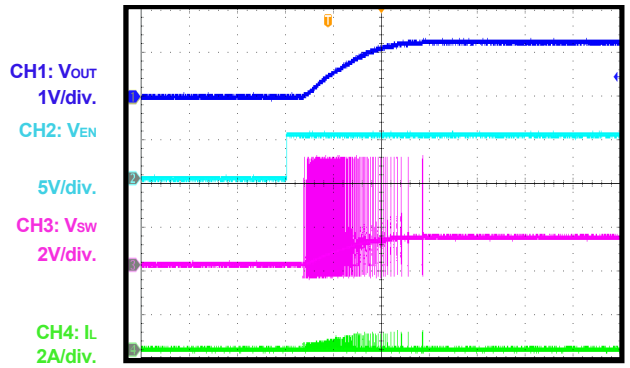
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TYPICAL PERFORMANCE CHARACTERISTICS*(continued)*

VIN=5V, V_{OUT}=1.2V, L=1µH, C_{OUT}=22µF, T_A = +25°C, unless otherwise noted.

EN Power-Up

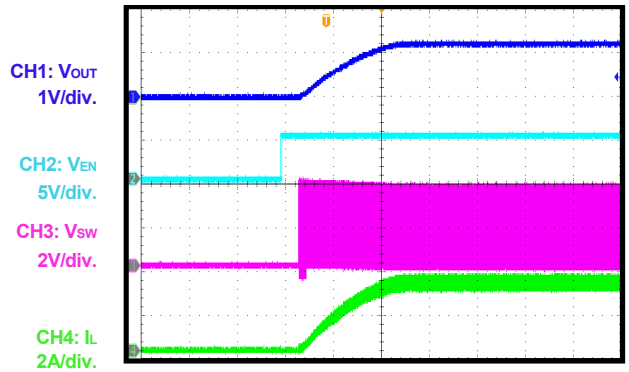
I_{OUT}=0A



400µs/div.

EN Power-Up

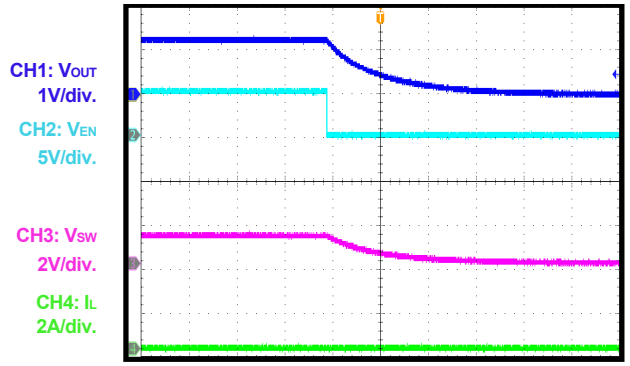
I_{OUT}=3A



400µs/div.

EN Shutdown

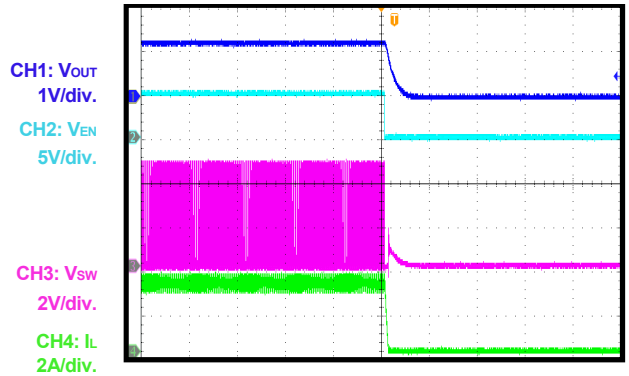
I_{OUT}=0A



4ms/div.

EN Shutdown

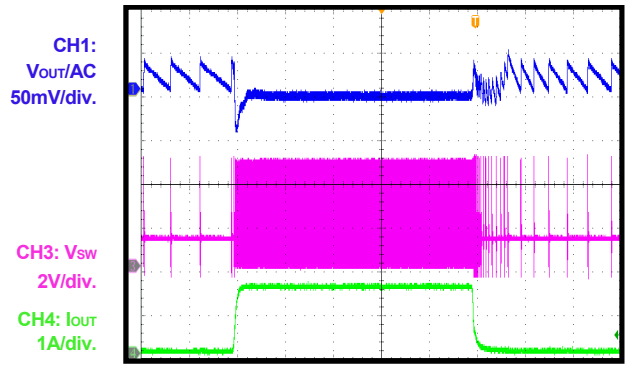
I_{OUT}=3A



40µs/div.

Load Transient

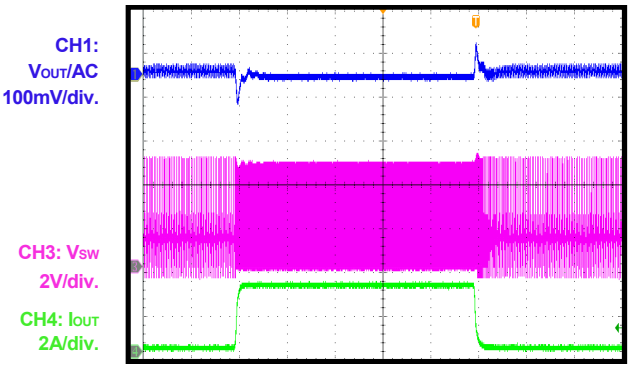
I_{OUT}=0-1.5A, 1A/µs



100µs/div.

Load Transient

I_{OUT}=0.1-3A, 1A/µs



100µs/div.

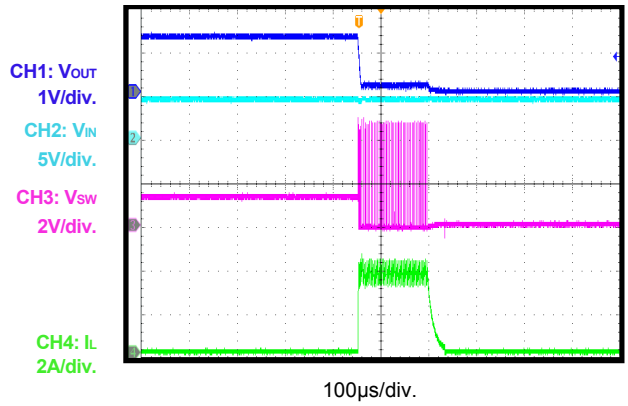
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TYPICAL PERFORMANCE CHARACTERISTICS*(continued)*

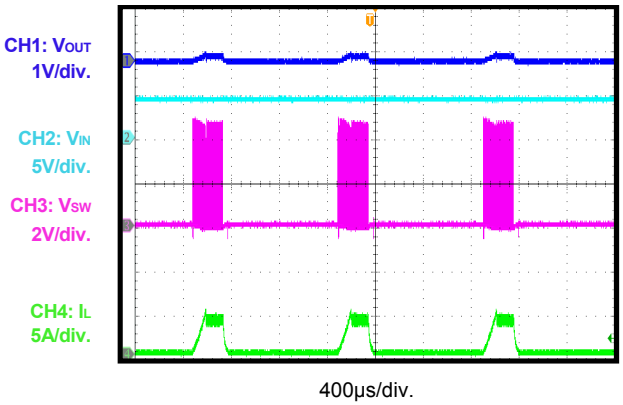
VIN=5V, V_{OUT}=1.2V, L=1µH, C_{OUT}=22µF, T_A = +25°C, unless otherwise noted.

Short-Circuit Entry



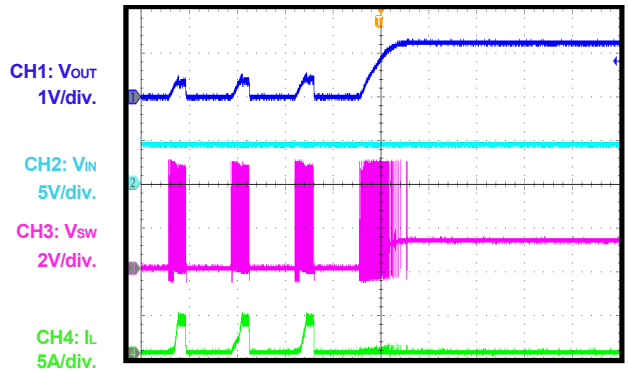
100µs/div.

Short-Circuit State



400µs/div.

Short-Circuit Recovery



1ms/div.

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PIN FUNCTIONS

Pin #	Name		Description
	SOT563 Adj Rev	SOT563 Fix Rev	
1	GND	GND	**Power ground.**
2	SW	SW	**Output switching node.** SW is the drain of the internal high-side P-channel MOSFET. Connect an inductor to SW to complete the converter.
3	VIN	VIN	**Supply voltage.** The MP1603 operates from a 2.5V to 5.5V unregulated input. A decoupling capacitor is needed to prevent large voltage spikes from appearing at the input.
4	EN	EN	**On/off control.**
5	FB	-	**Feedback.** An external resistor divider from the output to GND tapped to FB sets the output voltage.
	-	PG	**Power good indicator.** The output of PG is an open drain with an external pull-up resistor to VIN.
6	OUT	OUT	**Output sense.** OUT is the voltage power rail and input sense for the output voltage. An output capacitor is needed to decrease the output voltage ripple.

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BLOCK DIAGRAM

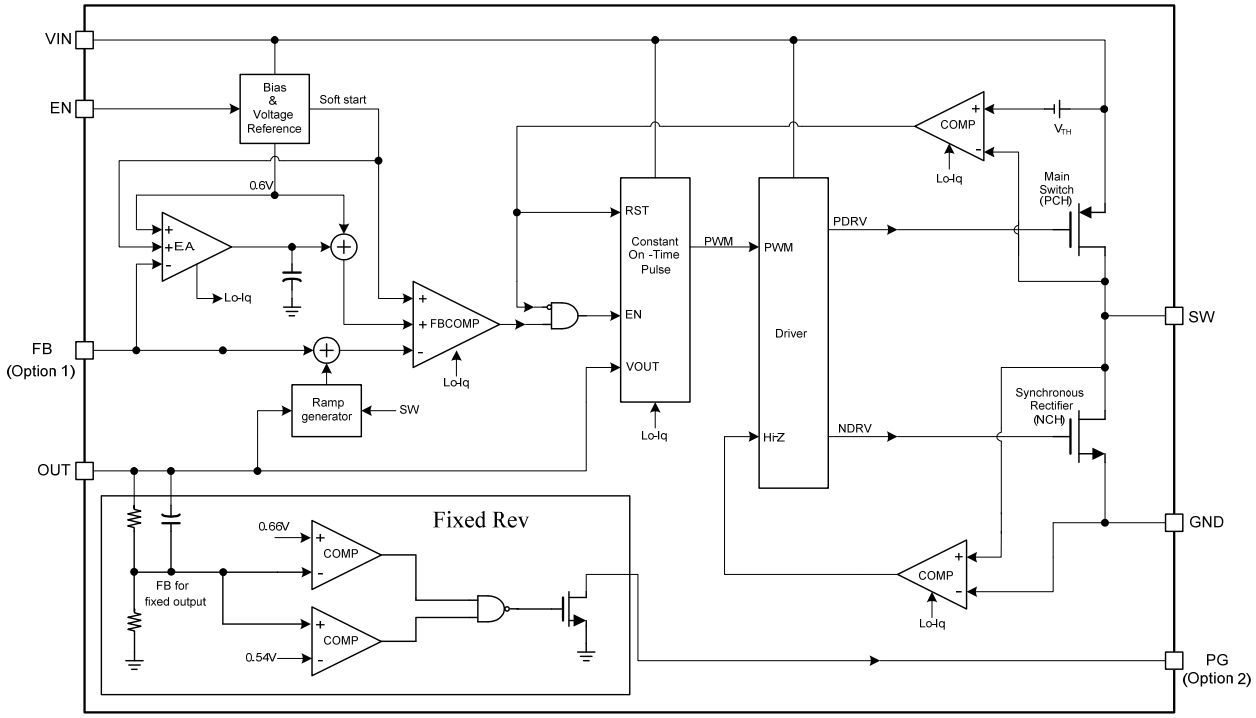


Figure 1: Functional Block Diagram

Option 1: FB is only for MP1603GTF
Option 2: PG is only for MP1603GTF-XX

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OPERATION

The MP1603 uses constant-on-time control (COT) with input voltage feed-forward to stabilize the switching frequency over the entire input range. The MP1603 achieves 3A of continuous output current from a 2.5V to 5.5V input voltage with excellent load and line regulation. The output voltage can be regulated to as low as 0.6V.

Constant-On-Time (COT) Control

Compare to the fixed-frequency pulse-width modulation (PWM) control, constant-on-time (COT) control offers a simpler control loop and a faster transient response. By using input voltage feed-forward, the MP1603 maintains a fairly constant s witching frequency across the input and output voltage ranges. The switching pulse on time can be estimated with Equation (1):

$$T_{ON} = \frac{V_{OUT}}{V_{IN}} \cdot 0.91\mu s \quad (1)$$

To prevent inductor current run away during the load transient, the MP1603 has a fixed minimum off time of 100ns.

Sleep Mode Operation

The MP1603 features sleep mode to achieve high efficiency at extremely light loads. In sleep mode, most of the circuit blocks are turned off except for the error amplifier (EA) and PWM comparator, reducing the operation current to a minimal value(see Figure 2).

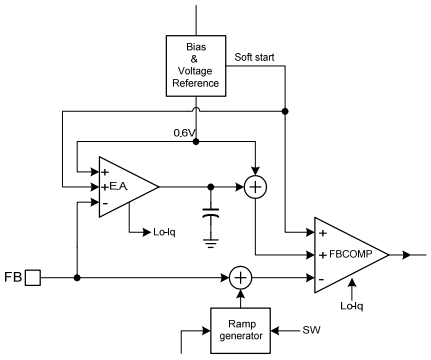


Figure2: Operation Blocks at Sleep Mode

When the loading becomes lighter, the ripple of the output voltage becomes larger and drives the error amplifier output (EAO) lower. When the EAO reaches the internal low threshold, it is clamped at that level, and the MP1603 enters sleep mode. During sleep mode, the valley of the FB voltage is regulated to the internal reference voltage. Therefore, the average output voltage is slightly higher than the output voltage at discontinuous conduction mode (DCM) or continuous conduction mode (CCM). The on-time pulse at sleep mode is a little larger than that in DCM or CCM. Figure 3 shows the average FB voltage relationship with the internal reference at sleep mode.

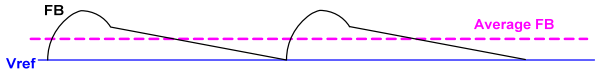


Figure 3: FB Average Voltage at Sleep Mode

When the MP1603 is in sleep mode, the average output voltage is higher than the internal reference voltage. The EAO is kept low and clamped in sleep mode. When the load increases, the PWM switching period decreases to keep the output voltage regulated, and the output voltage ripple decreases relatively. Once the EAO is greater than the internal low threshold, the MP1603 exits sleep mode and enters either DCM or CCM depending on the load. In DCM or CCM, the EA regulates the average output voltage to the internal reference (see Figure 4).

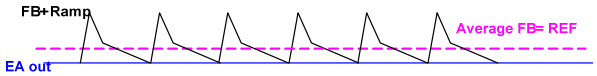


Figure 4: DCM Control

There is always a loading hysteresis when entering or exiting sleep mode due to the error amplifier clamping response time.

AAM Operation at Light-Load Operation

The MP1603 uses advanced asynchronous mode (AAM) power-save mode together with a zero-current cross detection (ZCD) circuit for light-load operation.

The MP1603 uses AAM power-save mode for light load (see Figure 5). The AAM current (I_{AAM}) is set internally. The SW on-pulse time is determined by the on-time generator and AAM comparator. At light-load condition, the SW on-pulse time is the longer pulse. If the AAM comparator pulse is longer than the on-time generator, the operation mode is as shown in Figure 6.

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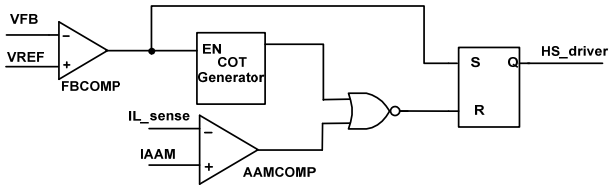


Figure 5: Simplified AAM Control Logic

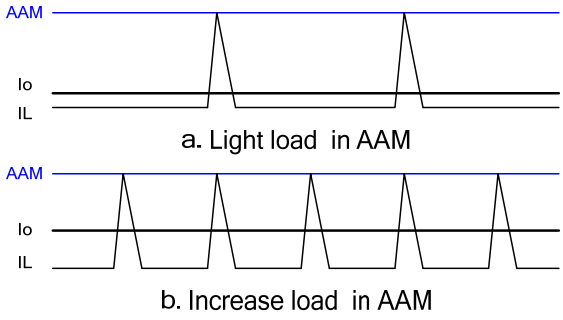


Figure 6: AAM Comparator Control T_{ON}

If the AAM comparator pulse is shorter than the on-time generator, the operation mode is as shown in Figure 7.

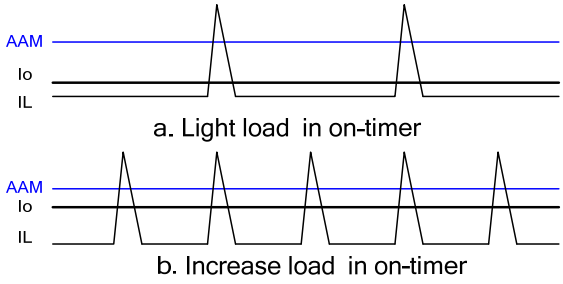


Figure 7: On-Timer Control T_{ON}

Figure 8 shows the AAM threshold decreasing as T_{ON} increases gradually. For CCM, Io needs more than at least half of the AAM threshold. Generally, the AAM threshold is lower than the inductor current at a normal duty cycle.

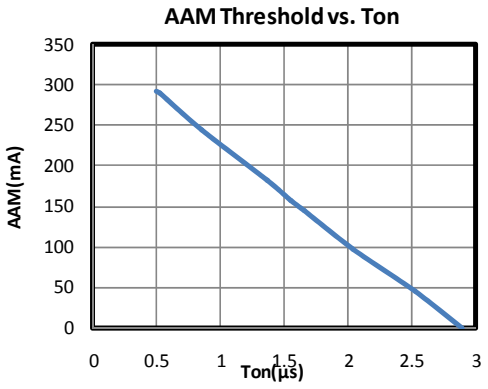


Figure8: AAM Threshold Decreases as T_{ON} Increases

The MP1603 has a ZCD to determine if the inductor current has started reversing. When the inductor current reaches the ZCD threshold, the low-side switch turns off.

AAM with a ZCD circuit makes the MP1603 always work in DCM at light load, even if V_{OUT} is close to VIN.

Enable (EN)

If the input voltage is greater than the under-voltage lockout (UVLO) threshold (typically 2.3V), the MP1603 can be enabled by pulling EN above 1.2V. Leave EN floating or pull EN down to ground to disable the MP1603. There is an internal 1MΩ resistor from EN to ground.

When the device is disabled, the part enters output discharge mode automatically. Its internal discharge MOSFET provides a resistive discharge path for the output capacitor.

Soft Start (SS)

The MP1603 has a built-in soft start that ramps up the output voltage at a controlled slew rate to avoid overshooting at start-up. The soft-start time is about 0.5ms, typically.

Current Limit

The MP1603 has a typical 6A (max value) high-side switch current limit. When the high-side switch reaches its current limit, the MP1603 remains in hiccup mode until the current drops. This prevents the inductor current from continuing to rise and damaging components.

Short Circuit and Recovery

The MP1603 enters short-circuit protection (SCP) mode when it reaches its current limit and attempts to recover with hiccup mode. The MP1603 disables the output power stage, discharges the soft-start capacitor, and attempts soft-start again automatically. If the short-circuit condition remains after the soft-start ends, the MP1603 repeats this cycle until the short circuit is removed and the output rises back to the regulation level.

Over-Voltage Protection (V_{OUT} OVP)

The MP1603 monitors the feedback voltage to detect over-voltage. When the feedback voltage becomes higher than 115% of the target voltage, the controller enters a dynamic regulation period. During this period, the low-side is on until the low-side current drops

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-1.5A.This discharges the output to keep it within the normal range. If the over-voltage condition still remains, the low-side turns on again after a 1µs time delay. The MP1603 exits this regulation period when the feedback voltage is decreased below 105% of the reference voltage. If the dynamic regulation cannot limit the increasing V_{OUT}, once the input detects the 6.1V input OVP, the MP1603 stops switching until the input voltage drops below 5.7V. Then the MP1603 resumes operation.

Power Good Indicator (only for MP1603GTF-XX)

The MP1603GTF-XX has an open-drain output and requires an external pull-up resistor (100~500k Ω) for the power good indicator. When V_{FB} is within -10%/+15% of the regulation voltage, V_{PG} is pulled up to V_{OUT}/VIN by the external resistor. If V_{FB} exceeds this window, the internal MOSFET pulls PG to ground. The MOSFET has a maximum $R_{DS(ON)}$ of less than 400 Ω .

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APPLICATION INFORMATION

Setting the Output Voltage

The external resistor divider sets the output voltage (see the Typical Application Circuit on page 18). Select a feedback resistor (R1) that reduces the V_{OUT} leakage current, typically between 100- 200kΩ. There is no strict requirement on the feedback resistor. Select R1 to be greater than 10kΩ. R2 can then be calculated with Equation (2):

$$R2 = \frac{R1}{\frac{V_{out}}{0.6} - 1} \quad (2)$$

Figure 9 shows the feedback circuit.

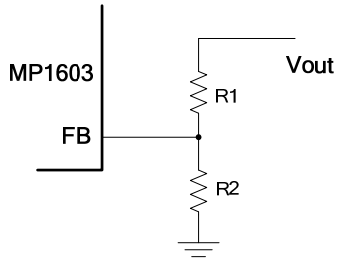


Figure 9: Feedback Network

Table 1 lists recommended resistor values for common output voltages.

Table1: Resistor Values for Common Output Voltages

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
1.0	200(1%)	300(1%)
1.2	200(1%)	200(1%)
1.8	200(1%)	100(1%)
2.5	200(1%)	63.2(1%)
3.3	200(1%)	44.2(1%)

Selecting the Inductor

Most applications work best with a 1- 2.2µH inductor. Select an inductor with a DC resistance less than 50mΩ to optimize efficiency.

A high-frequency switch-mode power supply with a magnetic device has strong electronic magnetic inference. Any unshielded power inductors should be avoided. Metal alloy or multiplayer chip power inductors are ideal shielded inductors for the application since they can decrease the influence effectively.

Table2 lists some recommended inductors.

Table2: Suggested Inductor List

Manufacturer P/N	Inductance(µH)	Manufacturer
PIFE25201B-1R0MS	1.0	CYNTEC CO. LTD.
74437324010	1.0	Wurth

For most designs, estimate the inductance value with Equation (3):

$$L_1 = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}} \quad (3)$$

Where ΔI_L is the inductor ripple current.

Choose the inductor current to be approximately 30% of the maximum load current. The maximum inductor peak current can be calculated with Equation (4):

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2} \quad (4)$$

Selecting the Input Capacitor

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 22µF capacitor is sufficient. Higher output voltages may require a 44µF capacitor to increase system stability.

The input capacitor requires an adequate ripple current rating since it absorbs the input switching current. Estimate the RMS current in the input capacitor with Equation (5):

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \quad (5)$$

The worst-case occurs at VIN = $2V_{OUT}$, shown in Equation (6):

$$I_{C1} = \frac{I_{LOAD}}{2} \quad (6)$$

For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current.

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The input capacitor can be electrolytic, tantalum, or ceramic. When using electrolytic or tantalum capacitors, add a small, high-quality, 0.1µF ceramic capacitor as close to the IC as possible. When using ceramic capacitors, ensure that they have enough capacitance to provide a sufficient charge to prevent excessive voltage ripple at the input. The input voltage ripple caused by the capacitance can be estimated with Equation (7):

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_S \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (7)$$

Selecting the Output Capacitor

The output capacitor (C2) stabilizes the DC output voltage. Low ESR ceramic capacitors are recommended to limit the output voltage ripple. Estimate the output voltage ripple with Equation (8):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right) \quad (8)$$

Where L_1 is the inductor value, and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

When using ceramic capacitors, the capacitance dominates the impedance at the switching frequency and causes most of the output voltage ripple. For simplification, the output voltage ripple can be estimated with Equation (9):

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^2 \times L_1 \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (9)$$

For tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated with Equation (10):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR} \quad (10)$$

The characteristics of the output capacitor also affect the stability of the regulation system.

PCB Layout Guidelines

Efficient PCB layout of the switching power supplies is critical for stable operation. For the high-frequency switching converter, a poor layout design can result in poor line or load regulation and stability issues. For best results, refer to Figure 10 and follow the guidelines below.

1. Place the high-current paths (GND, VIN, and SW) very close to the device with short, direct, and wide traces.
2. Place the input capacitor as close to VIN and GND as possible.
3. Place the external feedback resistors next to FB.
4. Keep the switching node (SW) short and away from the feedback network.
5. Keep the V_{OUT} sense line as short as possible and away from the power inductor, especially the surrounding inductor.

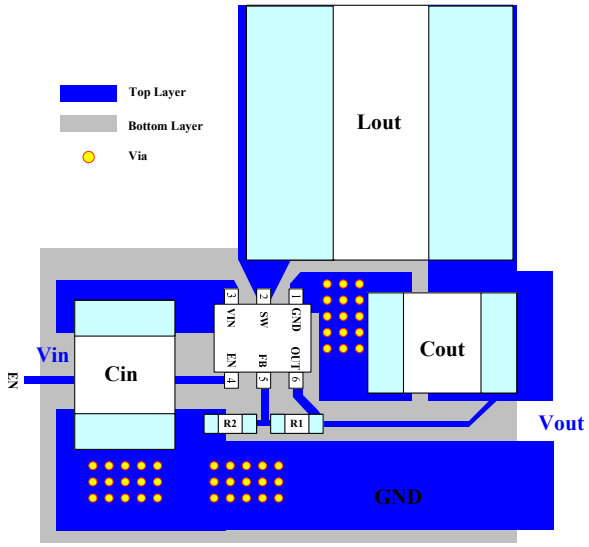


Figure 10: Recommended Layout

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TYPICAL APPLICATION CIRCUITS

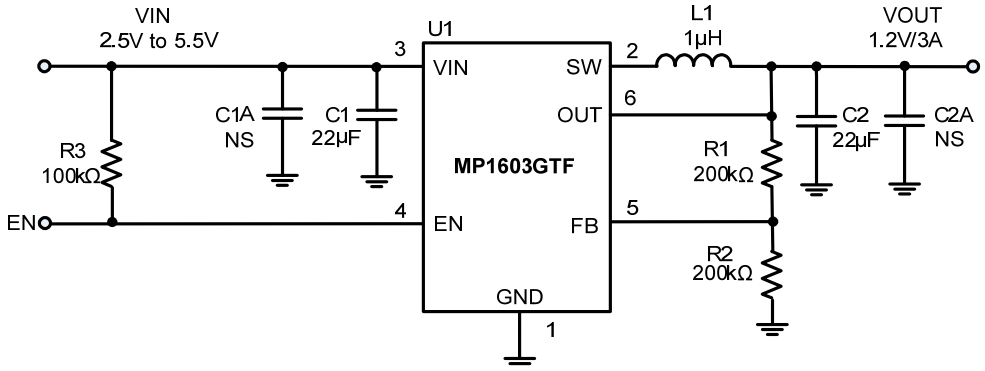


Figure 11: Typical Application Circuit for MP1603GTF

NOTE: VIN < 3.3V may require more input capacitors.

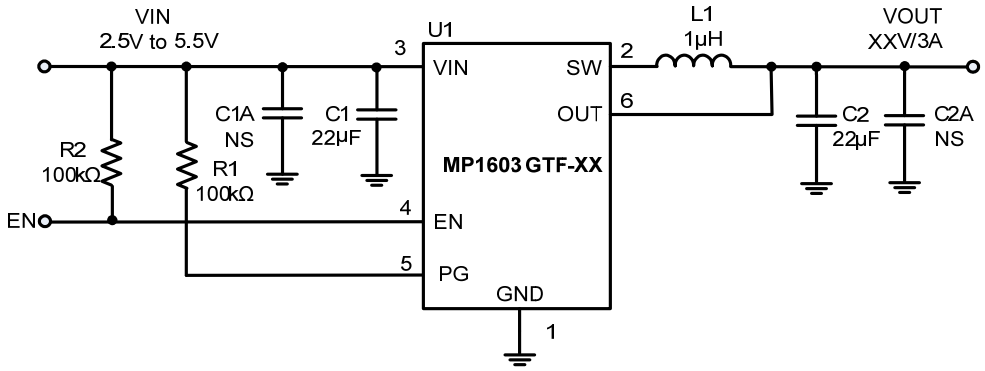


Figure 12: Typical Application Circuit for MP1603GTF-XX

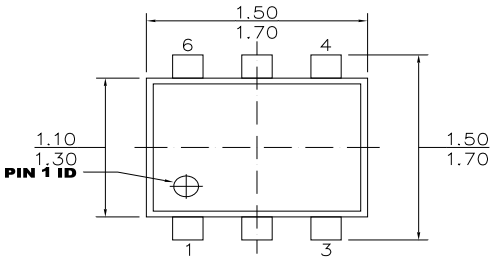
NOTE: VIN<3.3V may require more input capacitors.

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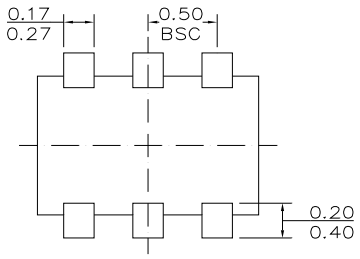
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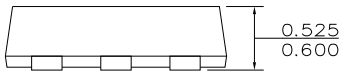
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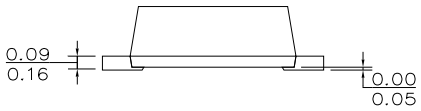
TOP VIEW



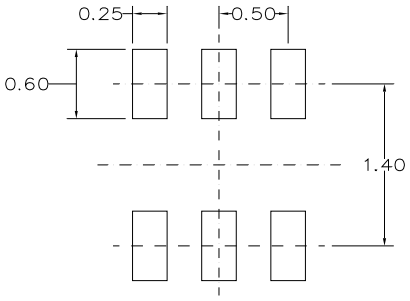
BOTTOM VIEW



FRONT VIEW



SIDE VIEW



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3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.10 MILLIMETERS MAX.
5) DRAWING IS NOT TO SCALE.

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