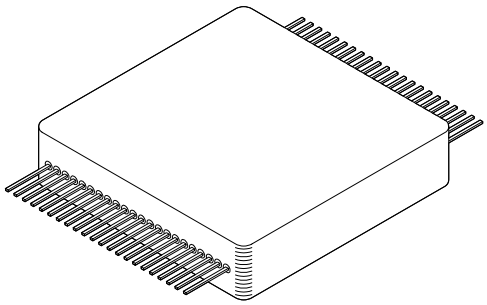
MIL-PRF-38534 & 38535 CERTIFIED FACILITY

RADIATION HARDENED HIGH EFFICIENCY, 5 AMP SWITCHING REGULATORS

5046RH SERIES

FEATURES:

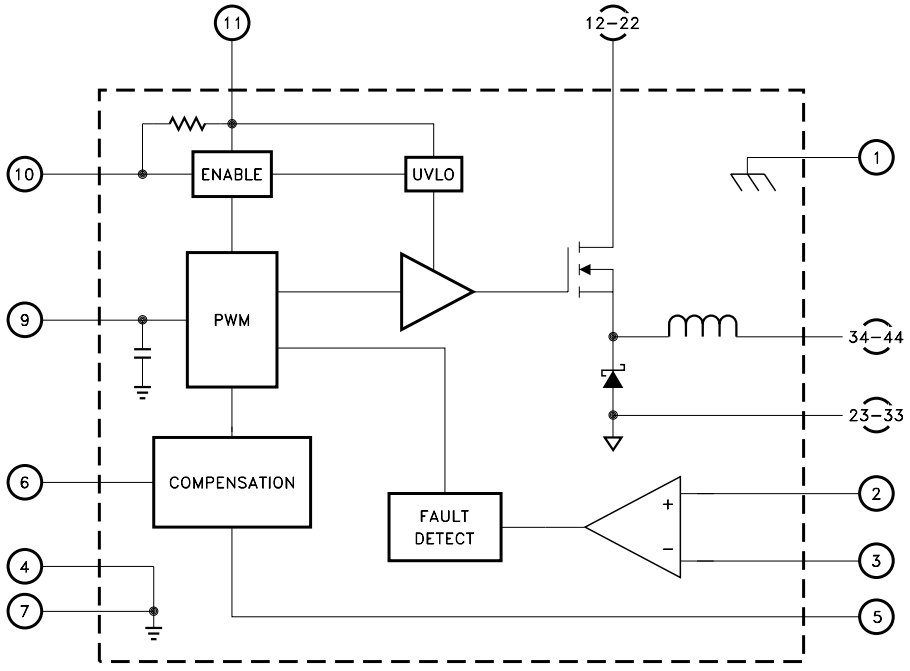
- Up To 92% Conversion Efficiency For 5V Version
- 5 Amp Output Current
- 3.1V to 18V Input Range with Separate Bias
- 12V to 18V Input Range with UVLO (VBIAS=VIN)
- Preset 1.5V,1.7V,1.8V,1.9V,2.0V,2.5V,3.0V,3.3V,3.4V or 5.0V Output Versions
- User Programmable Current Limit
- Output Trim Capability
- Custom Compensation & Outputs Available
- 350KHz Switching Frequency
- Surface Mountable Hermetic Package
- -40°C to +125°C Operating Temperature Range
- Total Dose Hardened to 300 Krads(Si) (Method 1019.7 Condition A)
- Available with Gull Wing Leads



DESCRIPTION:

The MSK5046RH series are high efficiency, 5 amp, radiation hardened switching regulators. The output voltage is configured for 1.5V,1.7V,1.8V,1.9V,2.0V,2.5V,3.0V,3.3V,3.4V or 5.0V internally with a tolerance of 1%.The very low output impedance allows the MSK5046RH to drive the start up surge current required by many CPU's and FPGA's with little or no decrease in the output voltage. The operating frequency of the MSK5046RH is 350KHz. A low quiescent current and very good operating efficiency keep the total internal power dissipation of the MSK5046RH down to an absolute minimum. The device is packaged in a hermetic surface mountable package for high reliability applications.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- POL Applications
- Satellite System Power Supply
- Step-down Switching Regulator
- Microprocessor, FPGA Power Source
- High Efficiency Low Voltage Subsystem Power Supply

PIN-OUT INFORMATION

1	CASE	8	NC
2	CS+	9	SOFT START
3	CS-	10	ENABLE
4	SIGNAL GROUND	11	VBIAS
5	SENSE	12-22	VIN
6	ADJUST	23-33	POWER GROUND
7	SIGNAL GROUND	34-44	VOUT

ABSOLUTE MAXIMUM RATINGS ⑪

Input Voltage ..... -0.3V, +20V
VBIAS Voltage ..... -0.3V, 18V
Enable ..... -0.3V, VBIAS
Output Current ..... 5.0 Amps
Thermal Resistance MOSFET(@ 125°C) 6.0°C/W
Diode(@ 125°C) ..... 7.5°C/W

T_{ST} Storage Temperature Range ⑬ ..... -65°C to +150°C
T_{LD} Lead Temperature Range
(10 Seconds) ..... 300°C
T_C Case Operating Temperature
MSK5046RH KE/HE Series ..... -40°C to +125°C
MSK5046RH Series ..... -40°C to +85°C
T_J Junction Temperature ..... +150°C
ESD Rating ..... Class 1C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ①⑫	Group A Subgroup	MSK5046RHKE/HE Min.	Typ.	Max.	MSK5046RH Min.	Typ.	Max.	Units
VIN Input Supply Range ② ⑦ ⑧		1,2,3	NOTE 8	–	18	3.1	–	18	V
VBIAS Input Supply Range ②		1,2,3	12	–	16	12	–	16	V
IBIAS		1	–	35	60	–	35	65	mA
		2,3	–	40	68	–	–	–	mA
Under Voltage Lockout Rising VBIAS		1	8.4	10.5	12.0	8.4	10.5	12.0	V
Output Voltage Tolerance		1	–	±0.3	±1	–	±0.3	±1.5	%
		2,3	–	–	±2.5	–	–	–	%
Output Current ②	Within SOA	1	5.0	5.2	–	5.0	5.2	–	A
Load Regulation	0.50A≤IOUT≤4.0A	1	–	±0.1	±1.0	–	±0.1	±1.5	%
		2,3	–	±0.1	±1.5	–	–	–	%
Line Regulation	VBias=12V VIN Step=VOUT + 2V to 18V	1	–	±0.1	±1.0	–	±0.1	±1.5	%
		2,3	–	±0.1	±1.5	–	–	–	%
Oscillator Frequency		4	320	350	380	320	350	380	KHz
Enable Input Voltage	Open Circuit Voltage, Enabled	1,2,3	–	–	VBIAS	–	–	VBIAS	V
	Logic Low Disabled	1,2,3	–	–	0.8	–	–	0.8	V
Enable Input Current ② ⑩	VEN=0V	1	–	−1.2	−2.0	–	−1.2	−2.5	mA
Disabled Quiescent Current ⑩	VEN=0V	1,2,3	–	2.6	4.8	–	2.6	4.8	mA
Efficiency ⑨ 5046−1.5RH	VIN=3.3V IOUT=3.0A	4	70	75	–	68	75	–	%
5046−1.7RH	VIN=3.3V IOUT=3.0A	4	72	77	–	70	77	–	%
5046−1.8RH	VIN=3.3V IOUT=3.0A	4	73	78	–	71	78	–	%
5046−1.9RH	VIN=3.3V IOUT=3.0A	4	75	80	–	73	80	–	%
5046−2.0RH	VIN=3.3V IOUT=3.0A	4	77	82	–	75	82	–	%
5046−2.5RH	VIN=5.0V IOUT=3.0A	4	79	84	–	77	84	–	%
5046−3.0RH	VIN=5.0V IOUT=3.0A	4	81	86	–	79	86	–	%
5046−3.3RH	VIN=5.0V IOUT=3.0A	4	83	88	–	81	88	–	%
5046−3.4RH	VIN=5.0V IOUT=3.0A	4	83	88	–	81	88	–	%
5046−5.0RH	VIN=7.0V IOUT=3.0A	4	86	92	–	84	92	–	%

NOTES:

① VIN=12V, VBIAS=12V, I_{OUT}=4.0A, R_{SENSE}=15mΩ, C_{OUT}=3x100µF Low ESR tantalum (AVX P/N TAZH107M015L) + 1.0µF ceramic, SOFT START=NC, ENABLE=NC, ADJUST=NC, unless otherwise specified.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ All output parameters are tested using a low duty cycle pulse to maintain T_J = T_C.
④ Industrial grade devices shall be tested to subgroup 1 and 4 unless otherwise specified.
⑤ Military grade devices ('HE' and 'KE' suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑥ subgroup 1,4 T_A=T_C=+25°C
Subgroup 2 T_A=T_C=+125°C
Subgroup 3 T_A=T_C=-40°C
⑦ The device can operate with input voltages as high as 18V, but efficiency is best at lower inputs.
⑧ With VBIAS connected to a separate source, VIN Min. is VOUT + $V_{DROPOUT}$; see typical dropout curves.
⑨ Sense resistor losses and VBIAS power not included. See typical performance curves.
⑩ The disabled bias current is the sum of the enable pin sink current (approximately VBIAS/10KΩ) and the internal bias current.
⑪ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑫ Pre and post irradiation limits, up to 300Krad TID, are identical unless otherwise specified.
⑬ Internal solder reflow temperature is 180°C, do not exceed.

APPLICATION NOTES

INPUT BIAS AND UVLO:

The VBIAS pin of the MSK5046RH provides bias to the control circuitry. The VBIAS pin can be connected directly to the input bus for 12V to 18V operation or it can be biased separately with a 12V to 18V source to extend the input range of the device. Refer to the paragraph titled "INPUT VOLTAGE RANGE". For bias voltages greater than 16V series diodes or resistors are recommended to bring VBIAS below 16V. The MSK5046RH's built-in under voltage lockout feature prevents damage to downstream devices in the event of a drop in bias voltage. Under voltage lockout occurs at bias voltages of approximately 10.3V rising and 9.5V falling. The internal bias draws approximately 40mA under normal operation.

INPUT VOLTAGE RANGE

The MSK5046RH's input range of 12V to 18V can be further extended down to 3.1V by using a separate bias supply. In this configuration very efficient low V to low V conversion can be achieved.

POWER CIRCUIT LAYOUT CONSIDERATIONS:

Layout of the power circuitry will affect the overall performance of the MSK5046RH. Input power should be tied as close to VIN (pins 12-22) as possible. Create a single point ground as close to the MSK5046RH power ground pins (23-33) as possible. The input power return should be tied between the MSK5046RH power ground pins and the load. Keeping the input power return connection as close to the MSK5046RH power ground pins as possible and keeping the distance between the MSK5046RH power ground pins and the load to a minimum will maximize the performance. Tie the signal ground pins (4 and 7) to the single point ground with a short low impedance connection. See remaining notes for more layout and application performance.

INPUT CAPACITOR SELECTION:

The MSK5046RH should have an external high frequency ceramic capacitor (0.1uF) between VIN and power ground. Connect a low-ESR bulk capacitor directly to the input pin of the MSK5046RH. Select the bulk input filter capacitor according to input ripple-current requirements and voltage rating, rather than capacitor value. Electrolytic capacitors that have low enough ESR to meet the ripple-current requirement invariably have more than adequate capacitance values. Aluminum-electrolytic capacitors are preferred over tantalum types, which could cause power-up surge-current failure when connecting to robust AC adapters or low-impedance batteries.

OUTPUT CAPACITOR SELECTION:

The MSK5046RH has no internal output capacitance. Use between 200 and 400µF of low ESR bulk capacitance for optimum performance. For optimal performance use three AVX part number TAZH107M015L (MIL part number CWR29H-107M). See typical gain and phase response curves. Less capacitance will increase the gain; more capacitance will decrease the gain. For loads with large excursions use surge rated capacitors. Additional 0.1µF ceramic capacitors close to the load will help suppress high frequency switching noise. Custom compensation to maximize performance with a variety of capacitive loads is available; consult the factory.

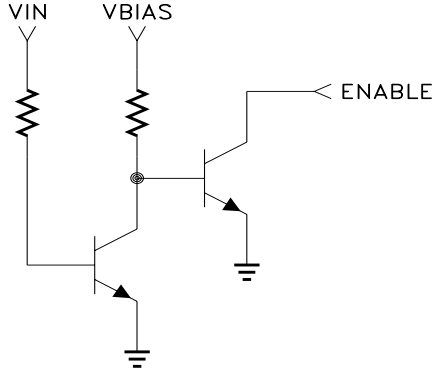
SOFT START:

The internal 0.1µF soft start capacitor charges from a 12µA (nominal) current source. Connect additional capacitance to the soft start pin to slow the output rise further. The output rise time is dependant on the input to ouput voltage ratio as well as the soft start capacitance. The output rise time at 50% load may be approximated with the following equation:

$$T_{RISE} = \frac{(V_{OUT} + 0.6V)\ 2\ C_{ss}}{(V_{IN} + 0.3V)\ 14}$$

Where VOUT = the output voltage in volts.
VIN = the input bus voltage in volts.
Css = 0.1 + external soft start capacitance in µF.

The soft start will begin as soon as the bias voltage exceeds the under voltage lockout threshold or the inhibit pin is released; whichever comes last. If bias voltage is applied and the inhibit pin is released before the input voltage is applied, the soft start will have risen early and the output will rise at approximately the same rate as VIN and may overshoot. Any circuit that holds the enable pin low until VIN rises will ensure soft start when VBIAS must rise before VIN. The circuit below may be adapted to suit a variety of applications.



SENSE:

It is very important that the DC voltage returned to the SENSE pin from the output be as noise and oscillation free as possible. This voltage helps to determine the final output and therefore must be a clean voltage. Excessive noise or oscillation can cause the device to have an incorrect output voltage. Proper PC board layout techniques can help to achieve a noise free voltage at the SENSE pin.

CURRENT LIMIT:

The MSK5046RH current limit is user programmable by means of an external low value sense resistor. The current limit trips at approximately 100mV, ±20% across the sense resistor. The output voltage will decrease when the current limit is reached. In the case of a sudden and severe overload, the MSK5046RH will reset and attempt a restart cycle. In noisy systems, the use of a twisted pair helps reduce noise succeptability of the sense circuit. The voltage present on the sense resistor will have an AC component at the switching frequency. The peak of the AC plus DC voltage will trip the current fault. If current limit is not desired, simply connect CS+ to ground and CS- to VOUT to disable the current sense. Reference the MSK5046RH radiation test report for typical current limit response to radiation dose. See total dose radiation test performance paragraph at the end of this section for a link to the radiation test report.

ENABLE FUNCTION:

The ENABLE pin of the MSK5046RH is designed for open collector drive. Leaving the pin open will allow for normal operation. Pulling the pin low will shut the device down. The enable pin will source up to 3mA when pulled low with high line voltage.

TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing have been generated for all radiation testing performed by MSK. These curves show performance trends throughout the TID test process and can be located in the MSK5046RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.

http://www.mskennedy.com/store.asp?pid=9951&catid=19680

ADJUST:

The output voltage of the MSK5046RH may be adjusted up or down to accomodate a variety of system requirements. Connecting a resistor between the adjust pin and the sense pin will decrease the output voltage. Connecting a resistor between the adjust pin and ground will increase the output voltage.

APPROXIMATE RESISTOR VALUES FOR OUTPUT VOLTAGE TRIM

PART #	KΩ ADJUST TO GROUND		KΩ ADJUST TO VOUT (SENSE)	
	+5.0%	+10%	-5.0%	-10%
5046-1.5RH	163	81.1	SEE BELOW	
5046-1.7RH	146	72.4		
5046-1.8RH	103	51.2		
5046-1.9RH	97.4	48.2		
5046-2.0RH	95.6	47.3		
5046-2.5RH	75.1	37.1		
5046-3.0RH	61.9	30.5	8.41	1.8
5046-3.3RH	75.1	37.1	19.8	6.84
5046-3.4RH	75.1	37.1	19.8	6.84
5046-5.0RH	149	74.0	134	59

Devices configured for ouput voltages less than 2.5V are trimmed in the negative direction by placing a resistor in series with the sense connection. 2.5V devices can not be trimmed in the negative direction. The table below gives approximate resistor values to trim the devices -5% and -10%. Variable resistors may be used but high quality fixed resistors are recommended. Keep extermal trim to a minimum to limit the effect of temperature coeficient mismatch between the external trim resistor and the internal components. Trim beyond 5 or 10% is not recommended.

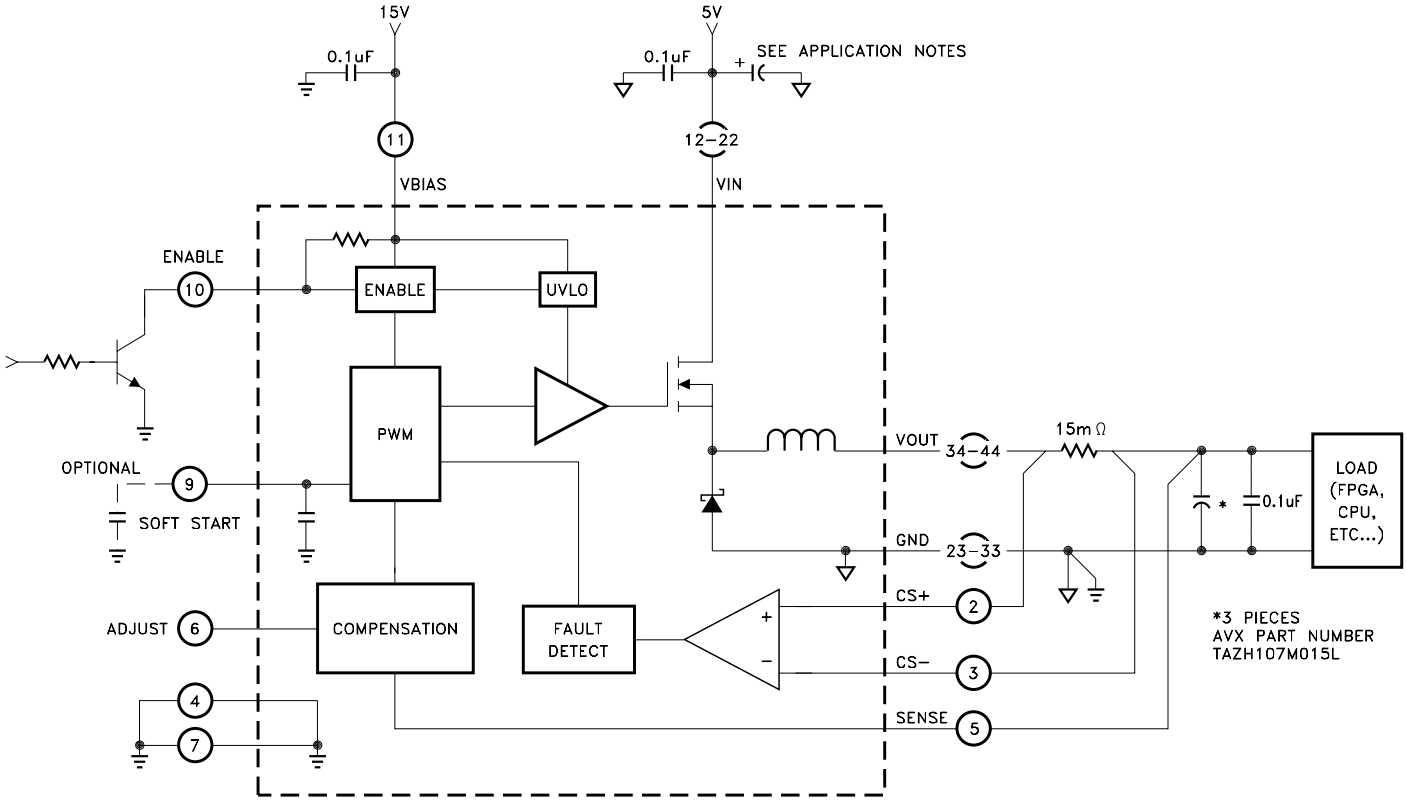
APPROXIMATE RESISTOR VALUES FOR OUTPUT VOLTAGE TRIM

PART #	SERIES SENSE RESISTOR (KΩ)	
	-5%	-10%
5046-1.5RH	0.425	0.850
5046-1.7RH	0.585	1.17
5046-1.8RH	0.515	1.03
5046-1.9RH	0.651	1.30
5046-2.0RH	0.825	1.65

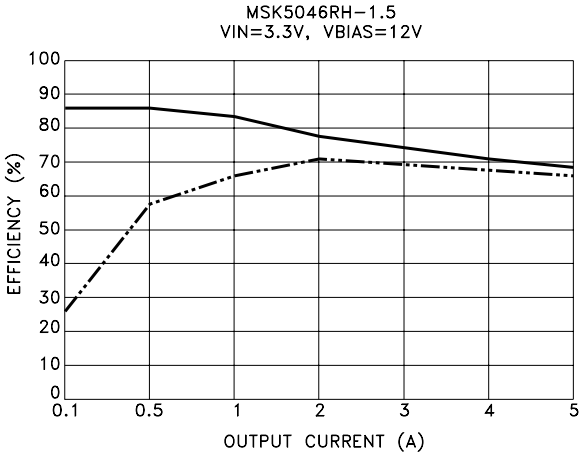
MINIMUM LOAD:

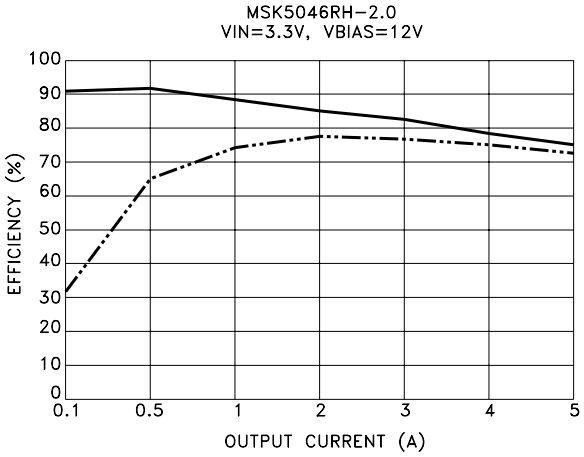
The MSK5046RH requires less than 2mA minimum load to maintain regulation. Minimum loads greater than 200mA at low line voltage and 400mA at high line voltage provide faster load response.

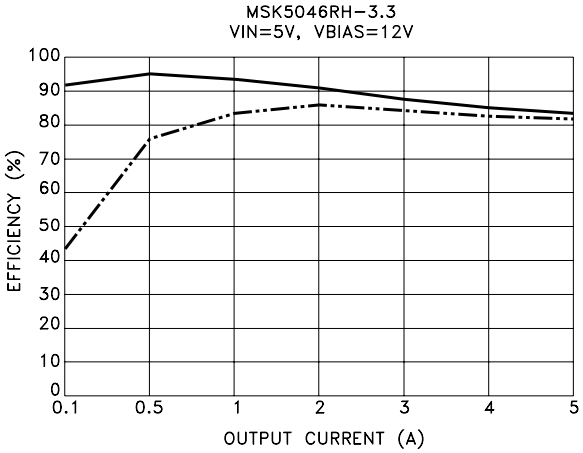
TYPICAL LOW VOLTAGE APPLICATION

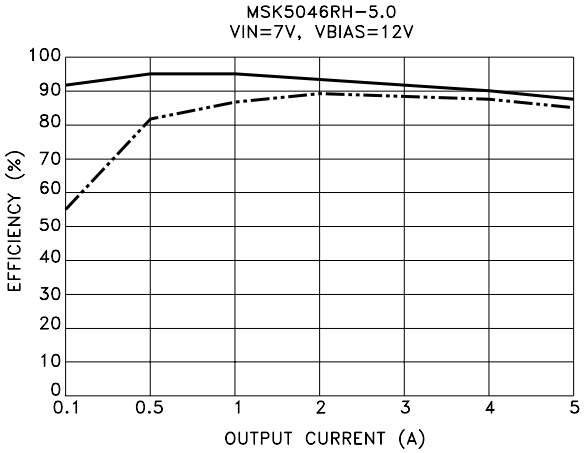


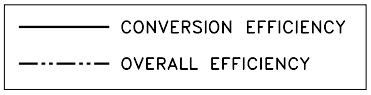
TYPICAL PERFORMANCE CURVES

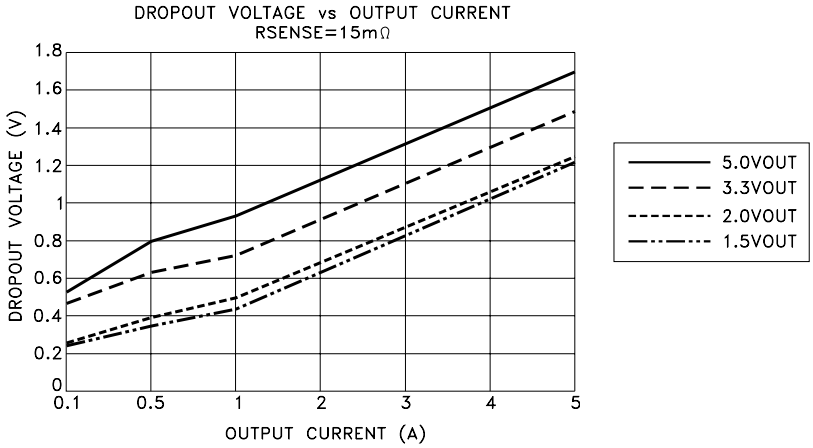








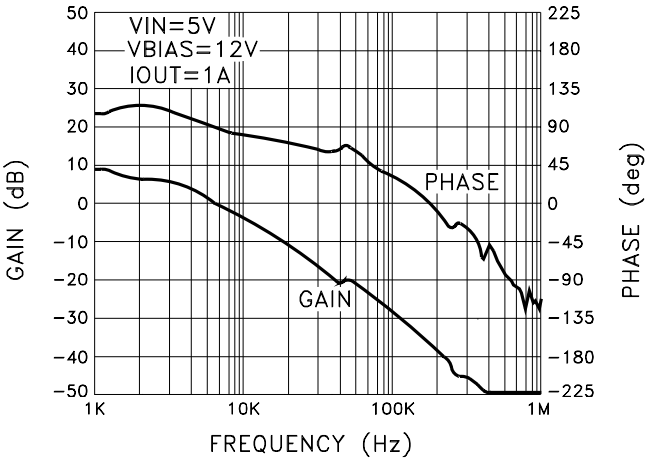




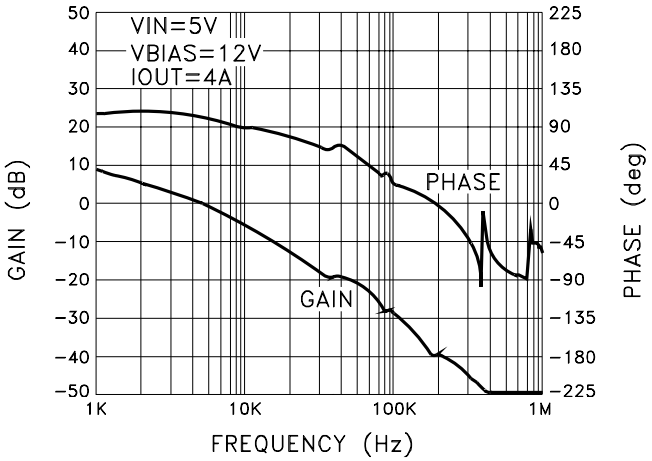
NOTE: Overall efficiency curves include VBias power consumption.

GAIN AND PHASE RESPONSE
(SEE TYPICAL APPLICATION CIRCUIT)

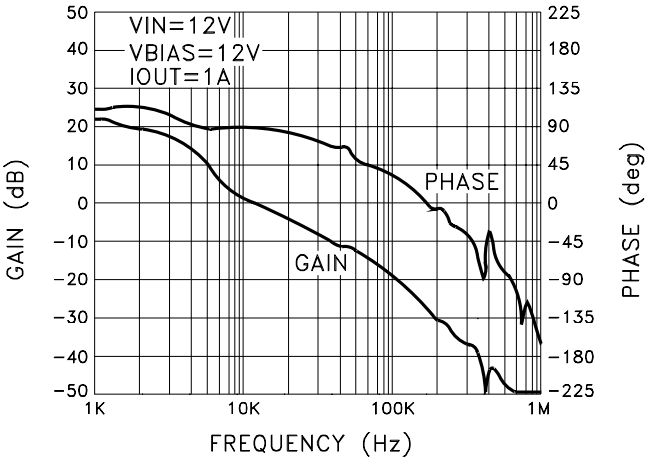
MSK5046–2.5RH GAIN AND PHASE vs. FREQUENCY



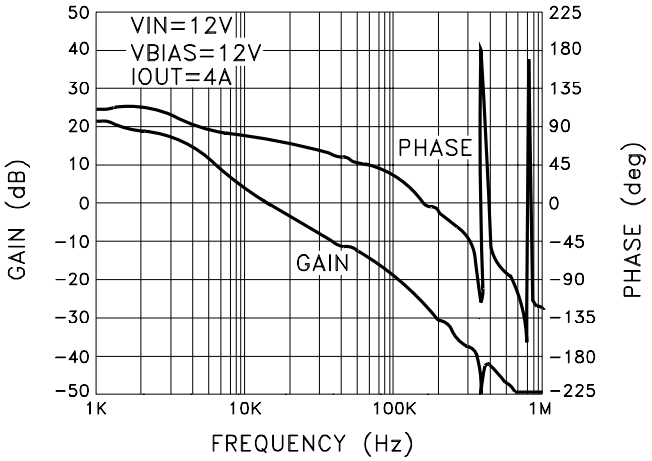
MSK5046–2.5RH GAIN AND PHASE vs. FREQUENCY



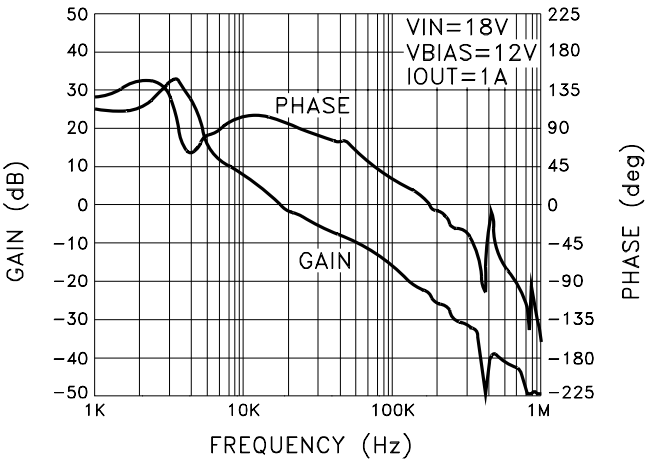
MSK5046–2.5RH GAIN AND PHASE vs. FREQUENCY



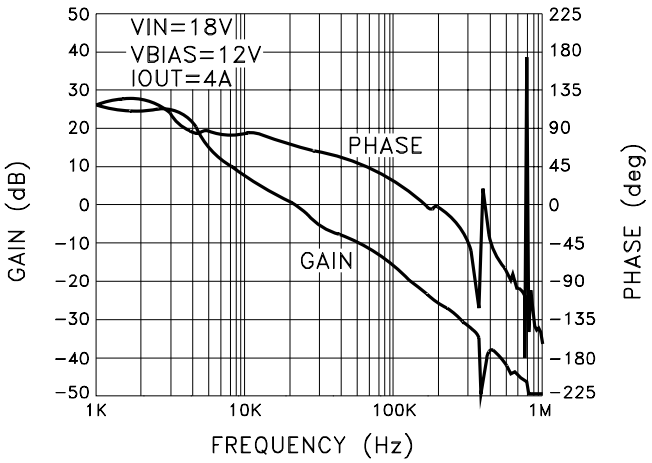
MSK5046–2.5RH GAIN AND PHASE vs. FREQUENCY



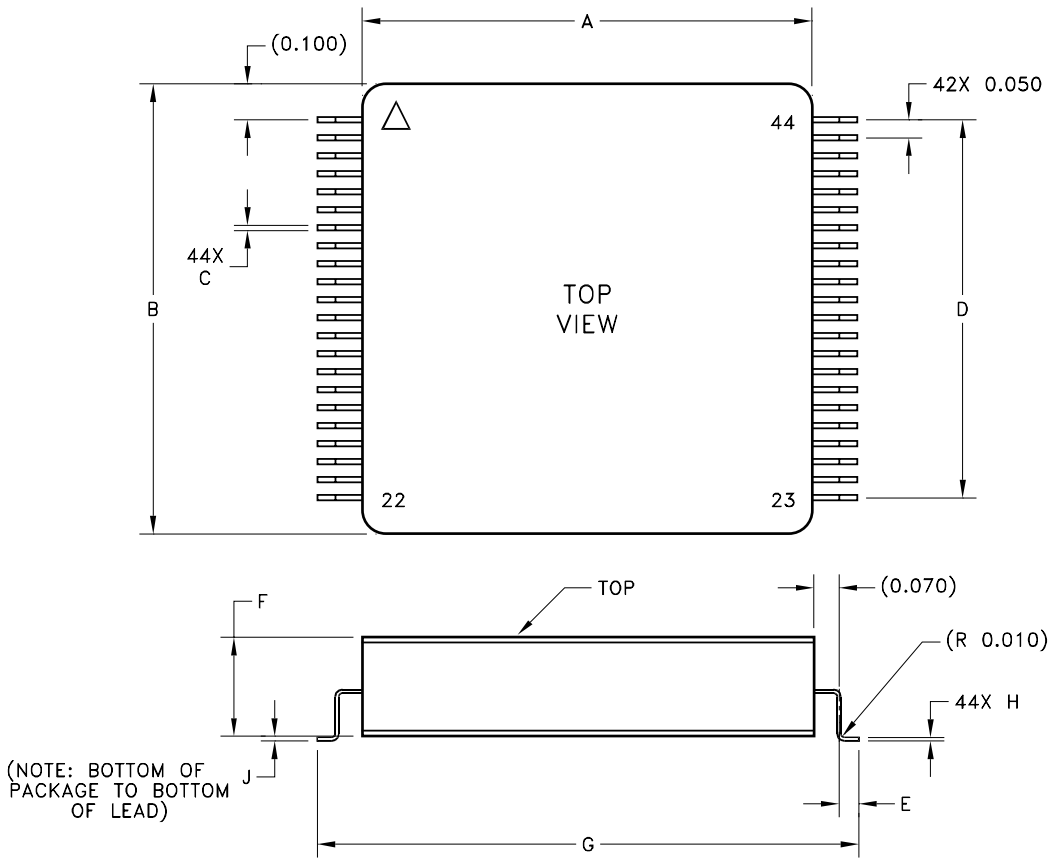
MSK5046–2.5RH GAIN AND PHASE vs. FREQUENCY



MSK5046–2.5RH GAIN AND PHASE vs. FREQUENCY



MECHANICAL SPECIFICATIONS



REF	MIN	MAX
A	1.240	1.260
B	1.240	1.260
C	0.013	0.020
D	1.045	1.055
E	0.045	0.065
F	———	0.275
G	1.490	1.510
H	0.008	0.014
J	0.008	0.018

ESD TRIANGLE INDICATES PIN 1
WEIGHT=17 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK5046-3.3 H RH G

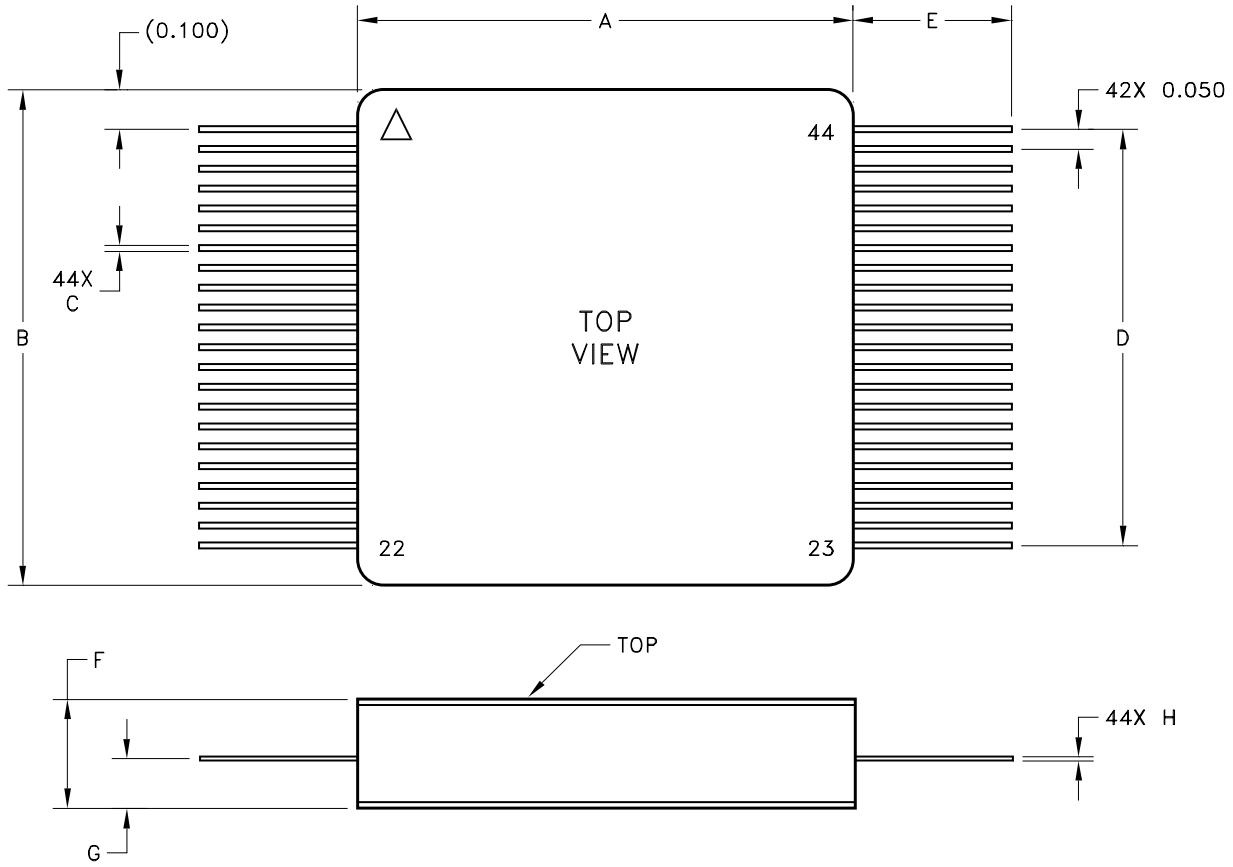
LEAD FORM OPTIONS
BLANK=STRAIGHT; G=GULL WING

RADIATION HARDENED

SCREENING
BLANK= INDUSTRIAL; HE=MIL-PRF-38534 CLASS H (REDUCED TEMP);
KE= MIL-PRF-38534 CLASS K (REDUCED TEMP)

OUTPUT VOLTAGE
1.5=+1.5V; 1.7=+1.7V; 1.8=+1.8V; 1.9=+1.9V; 2.0=+2.0V;
2.5=+2.5V; 3.0=+3.0V; 3.3=+3.3V; 3.4=+3.4V; 5.0=+5.0V

The above example is a +3.3V, Class H screened regulator with gull wing leads.



REF	MIN	MAX
A	1.240	1.260
B	1.240	1.260
C	0.013	0.020
D	1.045	1.055
E	0.350	———
F	———	0.275
G	0.115	0.135
H	0.008	0.014

ESD TRIANGLE INDICATES PIN 1
WEIGHT=17 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK5046-3.3 H RH

LEAD FORM OPTIONS
BLANK=STRAIGHT; G=GULL WING

RADIATION HARDENED

SCREENING
BLANK= INDUSTRIAL; HE=MIL-PRF-38534 CLASS H (REDUCED TEMP);
KE= MIL-PRF-38534 CLASS K (REDUCED TEMP)

OUTPUT VOLTAGE
1.5=+1.5V; 1.7=+1.7V; 1.8=+1.8V; 1.9=+1.9V; 2.0=+2.0V;
2.5=+2.5V; 3.0=+3.0V; 3.3=+3.3V; 3.4=+3.4V; 5.0=+5.0V

The above example is a +3.3V, Class H screened regulator.

REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
L	Released	02/15	Add ESD rating, internal note and clarify mechanical specifications.
M	Released	02/17	Change minimum operating temperature to -40°C

MSK
www.anaren.com/msk