MIL-PRF-38534 CERTIFIED

RAD HARD 3.5A SWITCHING REGULATOR 5044RH

M.S.KENNEDY CORP.

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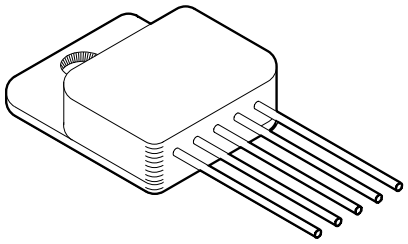
(315) 701-6751

FEATURES:

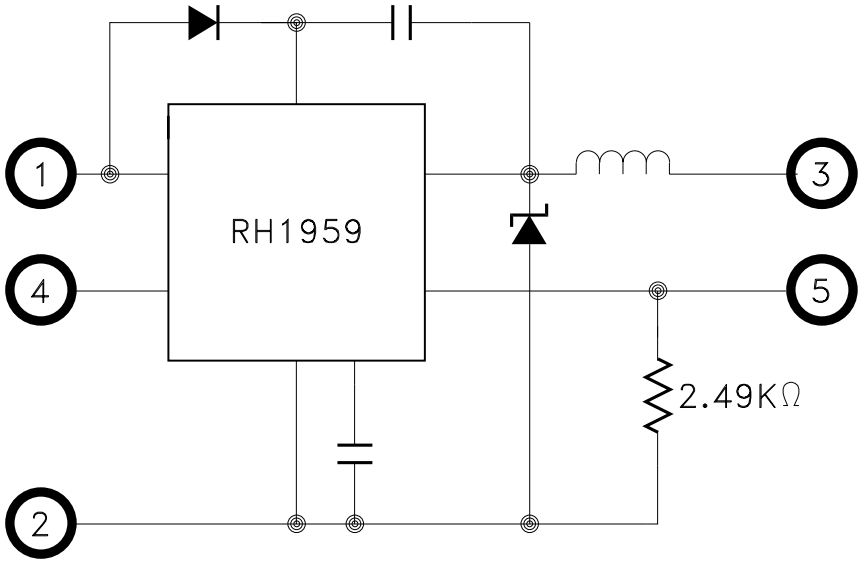
- Manufactured using LINEAR TECHNOLOGY Rad Hard RH1959MILDICE
- Total Dose Tested to TBD Krad(Si) (Method 1019.7 Condition A)
- Improved Replacement for Satcon SAT8565A
- Adjustable Output Voltage from 1.21 to 5V
- Input Voltage Range from 4.3V to 16V
- Constant 500KHz Switching Frequency
- Shutdown Pin
- Short Circuit and Thermal Limit Protection
- Available in 3 Lead Form Options: Straight, Up and Down
- Contact MSK for MIL-PRF-38534 Qualification Status



DESCRIPTION:

The MSK 5044RH is a radiation hardened adjustable output voltage switching regulator. A wide input and output voltage range with 3.5A output current capability make these regulators suitable for many applications. Excellent efficiency and a reduced output capacitance requirement are the results of a constant 500KHz switching frequency. The regulator output can be turned on and off remotely with low current logic levels via the shutdown pin for meeting power sequencing requirements. Short circuit current limit and thermal shutdown features provide fault protection. The MSK 5044RH is hermetically sealed in a space saving 5 pin power package and specifically designed for space/satellite applications.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

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

PIN-OUT INFORMATION

1 VIN
2 GND
3 VOUT
4 $\overline{\text{SHDN}}$
5 FB

ABSOLUTE MAXIMUM RATINGS ⑦

V_{IN}	Input Voltage 16V	T_{ST}	Storage Temperature Range . . . . -65°C to +150°C
I_{OUT}	Output Current 4A	T_{LD}	Lead Temperature Range
	$\overline{SHDN}$ Pin Voltage . . . . . 7.0 V		(10 Seconds) . . . . . 300°C
		T_J	Junction Temperature . . . . . 150°C
		T_C	Case Operating Temperature Range
			MSK 5044K/H/E RH . . . . . -55°C to +125°C
			MSK 5044RH . . . . . -40°C to +85°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ①		Group A Subgroup	MSK 5044K/H/E RH Min.	MSK 5044K/H/E RH Typ.	MSK 5044K/H/E RH Max.	MSK 5044RH Min.	MSK 5044RH Typ.	MSK 5044RH Max.	Units
Feedback Voltage(V_{FB})			1,2,3	1.19	1.21	1.23	1.19	1.21	1.23	V
		Post Radiation	1	TBD	TBD	TBD	TBD	TBD	TBD	V
Line Regulation	4.3V≤VIN≤15V		1,2,3	-0.5	-	0.5	-0.5	-	0.5	%
		Post Radiation	1	TBD	-	TBD	TBD	-	TBD	%
Load Regulation	1A≤I_{OUT}≤3A		1,2,3	-1.0	-	1.0	-1.0	-	1.0	%
		Post Radiation	1	TBD	-	TBD	-1.0	-	1.0	%
VIN Input Supply Range ② ⑨			1,2,3	4.3	-	15.0	4.3	-	15.0	V
Output Voltage Range	VIN = 10.0V		1,2,3	V_{FB}	-	TBD	V_{FB}	-	TBD	V
Efficiency			1	TBD	TBD	-	TBD	TBD	-	%
		Post Radiation	1	TBD	TBD	-	TBD	TBD	-	%
Output Voltage Ripple			4	-	TBD	TBD	-	TBD	TBD	mVpp
		Post Radiation	4	-	TBD	TBD	-	TBD	TBD	mVpp
Switching Frequency			4	460	500	540	460	500	540	KHz
Current Limit			1,2,3	3.5	-	-	3.5	-	-	A
		Post Radiation	1	TBD	-	-	TBD	-	-	A
VIN Supply Current @ Shutdown (low power state)	$V_{\overline{SHDN}}$ = 0V		1,2,3	-	TBD	75	-	TBD	75	uA
		Post Radiation	1	-	-	TBD	-	-	TBD	uA
Shutdown Threshold Voltage (low power state)			1,2,3	0.13	TBD	0.60	0.13	-	0.60	V
		Post Radiation	1	TBD	-	TBD	TBD	-	TBD	V
Thermal Resistance ②	Junction to Case @125°C Forward Switch		-	-	13.4	14.0	-	13.4	14.0	°C/W
Thermal Resistance ②	Junction to Case @125°C Catch Diode		-	-	18.7	20	-	18.7	20	°C/W

NOTES:

① Unless otherwise specified VIN = 5.0V, VOUT = 2.5V and I_{OUT} = 1.0A. See Figure 1 for typical application circuit.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade and "E" suffix devices shall be tested to subgroup 1 and 4 unless otherwise specified.
④ Military grade devices ("H" Suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤ Subgroup 5 & 6 testing available on request.
⑥ Subgroup 1,4 TA = TC = +25°C
2,5 TA = TC = +125°C
3,6 TA = TC = -55°C
⑦ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑧ Pre and Post irradiation limits at 25°C, up to TBD Krad(Si) TID, are identical unless otherwise specified.
⑨ Verified during line regulation test.

APPLICATION NOTES

PIN FUNCTIONS

VIN - VIN connects to the collector of the internal power switch and provides power to the internal control circuitry and internal regulator. Very high di/dt is seen at VIN during switch on and off transitions. High frequency decoupling capacitors are recommended to minimize voltage spikes. VIN should be connected to a low impedence source for best operation.

FB - The FB (feedback) pin's primary function is to set the output voltage to the desired level. Use a single resistor between VOUT and FB to form a feedback divider network with the internal 2.49K resistor. Select the external resistor value to set the voltage at the FB pin to 1.21V when the output is at the desired level, see **"Setting The Output Voltage."**The FB pin provides two additional functions. If the voltage at the FB pin drops below 0.8V the switch current limit is reduced. When the voltage at the FB pin drops below 0.7V the switching frequency is reduced. The switching frequency reduces to approximately 100KHz at $V_{FB} <= 0.4V$.

GND - The GND pin provides a return path for all internal control current and acts as a reference to the error amplifier. It is important that it is at the same voltage potential as the load return to ensure proper regulation. Keep current on the ground between the load and the MSK 5044RH to a minimum and use heavy copper traces to minimize voltage drops and regulation error.

$\overline{\text{SHDN}}$ - The $\overline{\text{SHDN}}$ (shutdown) pin has two shutdown functions. The first function disables switching when the voltage on the pin drops below 2.38V (nominal). The second forces a complete shutdown minimizing power consumption when the voltage drops below 0.4V (nominal). Pull this pin high or leave open for normal operation. The 2.38V threshold can be used for UVLO functions by configuring a resistive divider to VIN and GND that holds the pin voltage below 2.38V until VIN rises to the minimum desired voltage.

VOUT - VOUT is the output of the regulator. External capacitance between the VOUT pin and GND is required to maintain stability and minimize output ripple voltage, see **"Selecting The Output Capacitor."** Provide a low impedance path between VOUT and the load to minimize voltage drops.

SETTING THE OUTPUT VOLTAGE

The output voltage of the MSK 5044RH is set with a single resistor, see Figure 1 (Typical Application Circuit). Select the value of R_{FB} using the formulas below.

$V_{OUT} = V_{FB} * (1 + R_{FB}/2490)$

$R_{FB} = 2490 * ((V_{OUT}/V_{FB}) - 1)$

Given $V_{FB} = 1.21V$ Nominal

TYPICAL APPLICATION CIRCUIT

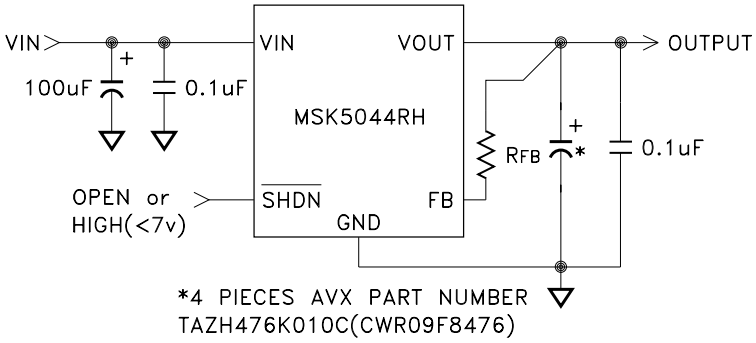


FIGURE 1

SELECTING THE OUTPUT CAPACITOR

The output capacitor filters the ripple current from the internal inductor to an acceptable ripple voltage seen by the load. The primary factor in determining voltage ripple is the ESR of the output capacitor. The voltage ripple can be approximated as follows:

$V_{P-P} = I_{P-P} * ESR$
Where $I_{P-P} = V_{OUT} * (V_{IN} - V_{OUT}) / (1.65 * V_{IN})$

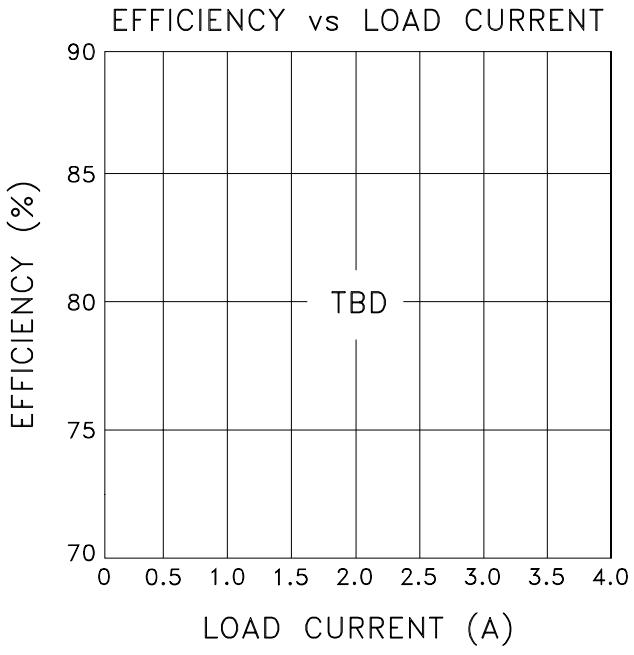
The typical ESR range for an MSK 5044RH application is between 0.05 and 0.20 ohm. Capacitors within these ESR ranges typically have enough capacitance value to make the capacitive term of the ripple equation insignificant. The capacitive term of the output voltage ripple lags the ESR term by 90° and can be calculated as follows:

$V_{P-P(CAP)} = I_{P-P}/(8 * F * C)$

Where:
C = output capacitance in Farads
F = Switching Frequency in Hertz

Select a capacitor or combination of capacitors that can tolerate the worst-case ripple current with sufficient de-rating. When using multiple capacitors in parallel to achieve ESR and/or total capacitance, sharing of ripple current between capacitors will be approximately equal if all of the capacitors are the same type and preferably from the same lot. Low ESR tantalum capacitors are recommended over aluminum electrolytic. The zero created by the ESR of the capacitor is necessary for loop stabilty. A small amount of ceramic capacitance close to the load to decouple high frequency is acceptable but it should not cancel the ESR zero.

TYPICAL EFFICIENCY



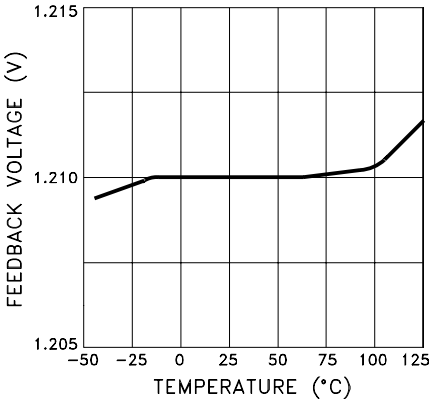
TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing will be generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout the TID test process and are located in the MSK 5044RH radiation test report. The complete radiation test report will be available in the RAD HARD PRODUCTS section on the MSK website.

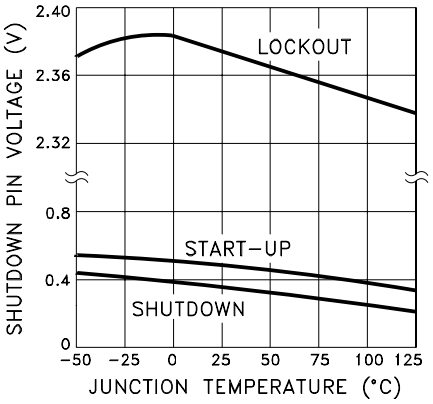
http://www.mskennedy.com/store.asp?pid=9951&catid=19680

TYPICAL PERFORMANCE CURVES

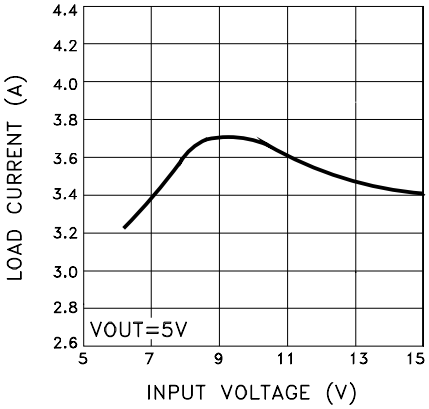
FEEDBACK PIN VOLTAGE
vs CASE TEMPERATURE



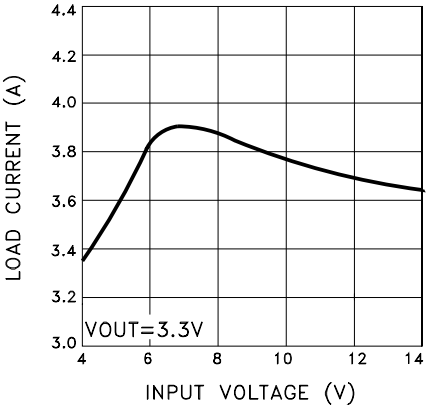
LOCKOUT AND SHUTDOWN THRESHOLDS
vs JUNCTION TEMPERATURE



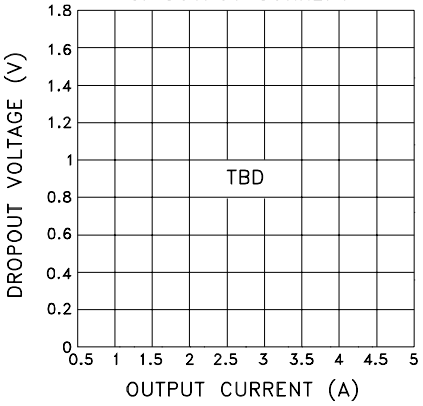
MAXIMUM LOAD CURRENT
vs INPUT VOLTAGE



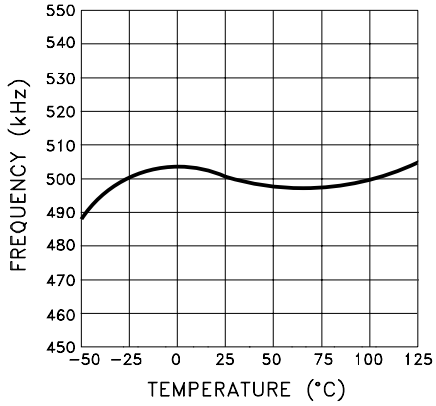
MAXIMUM LOAD CURRENT
vs INPUT VOLTAGE



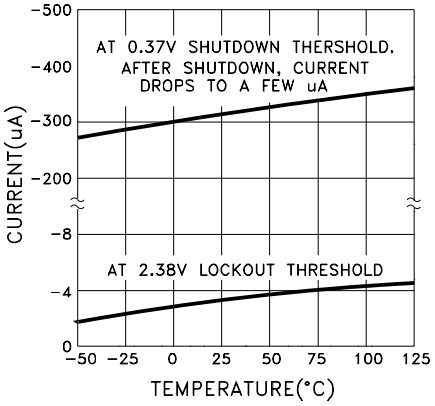
DROPOUT VOLTAGE
vs. OUTPUT CURRENT



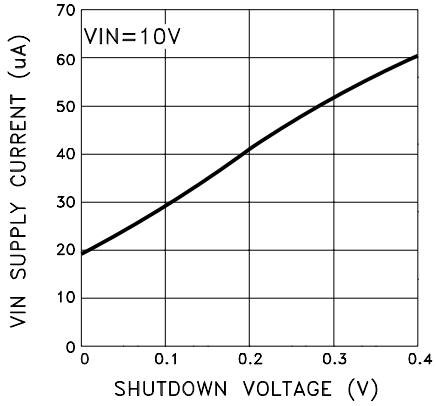
SWITCHING FREQUENCY



SHUTDOWN PIN BIAS CURRENT

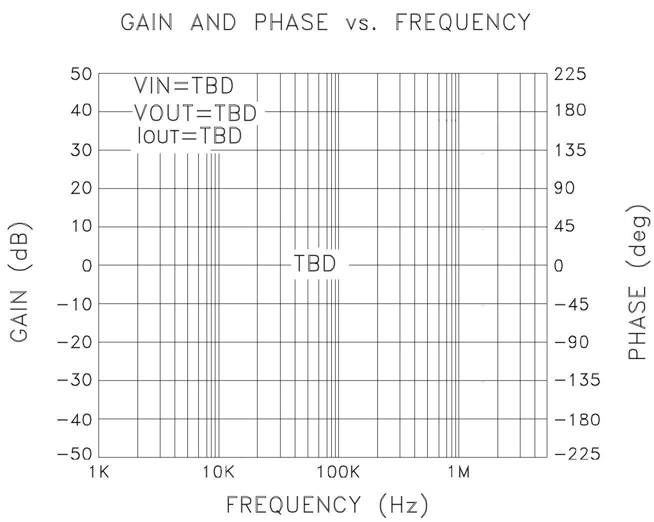


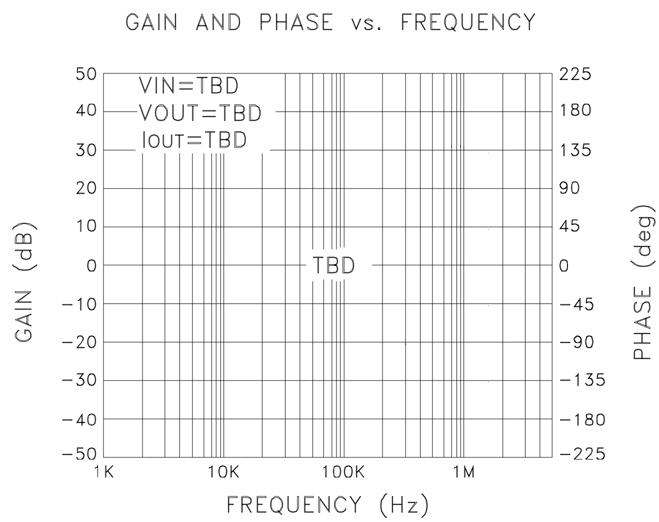
SHUTDOWN VIN SUPPLY CURRENT

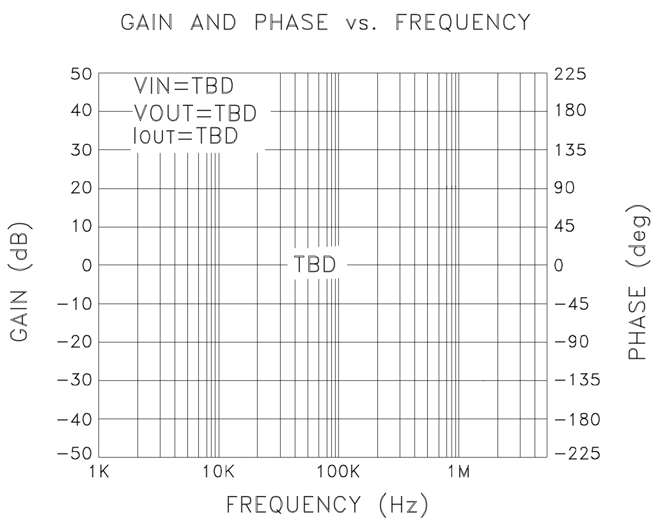


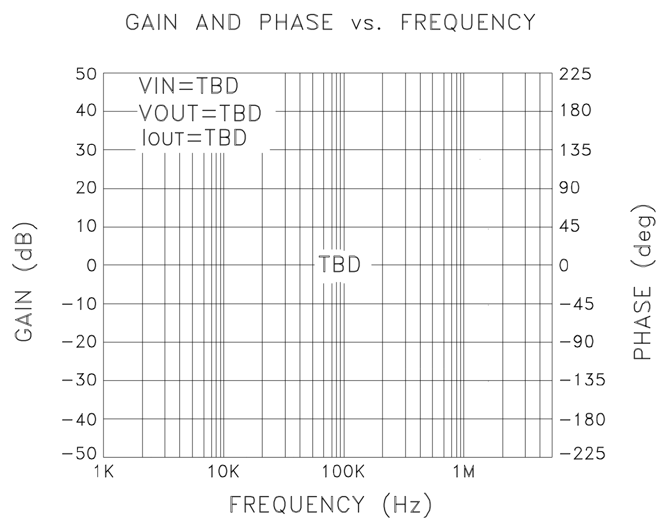
GAIN AND PHASE RESPONSE

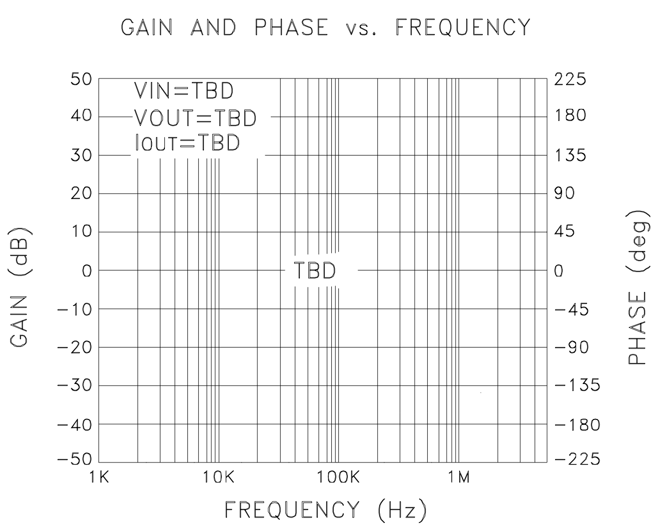
The gain and phase response curves are for the MSK typical application circuit and are representative of typical device performance, but are for reference only. The performance should be analyzed for each application to insure individual program requirements are met. External factors such as temperature, input and output voltages, capacitors, etc. all can be major contributors. Please consult factory for additional details.

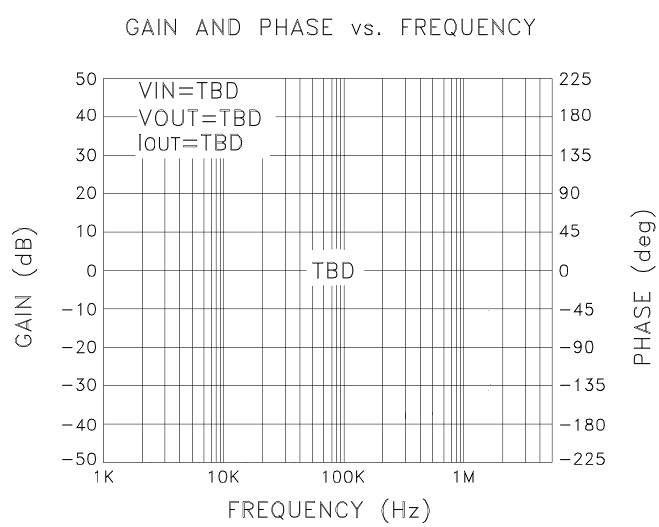




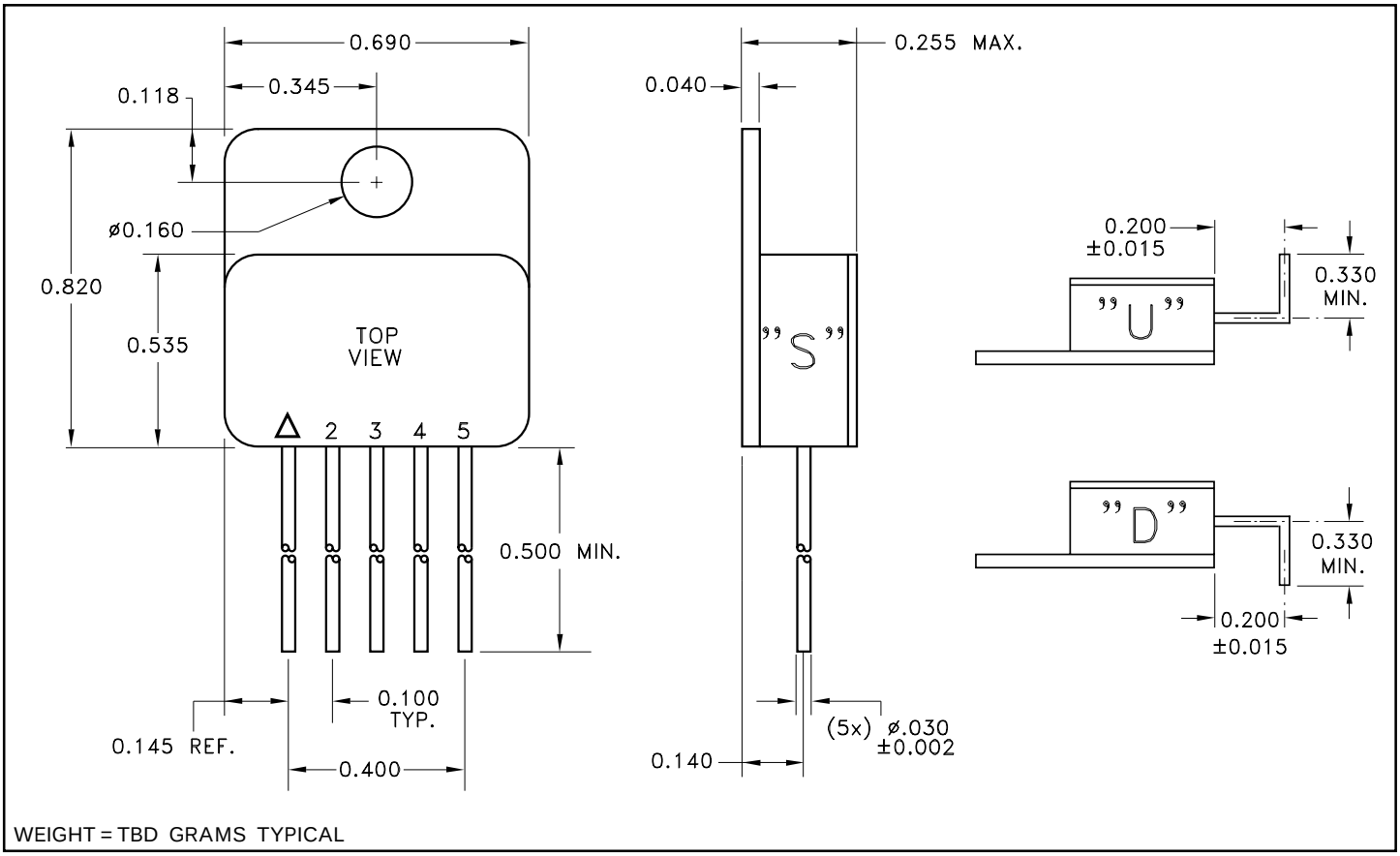








MECHANICAL SPECIFICATIONS



WEIGHT = TBD GRAMS TYPICAL

ALL DIMENSIONS ARE ± 0.010 INCHES UNLESS OTHERWISE LABELED.
ESD Triangle indicates pin 1.

ORDERING INFORMATION

MSK5044 K RH U

LEAD CONFIGURATIONS
S = STRAIGHT; U = BENT UP; D = BENT DOWN
RADIATION HARDENED
SCREENING
BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY
H = MIL-PRF-38534 CLASS H; K = MIL-PRF-38534 CLASS K
GENERAL PART NUMBER

The above example is a Class K switching regulator with leads bent up.

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