# RAD HARD ULTRA LOW DROPOUT POSITIVE LINEAR REGULATOR

# 5823RH SERIES

M.S.KENNEDY CORP.

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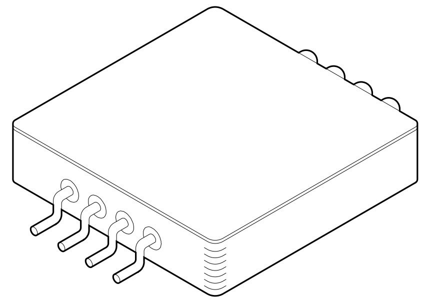
## FEATURES:

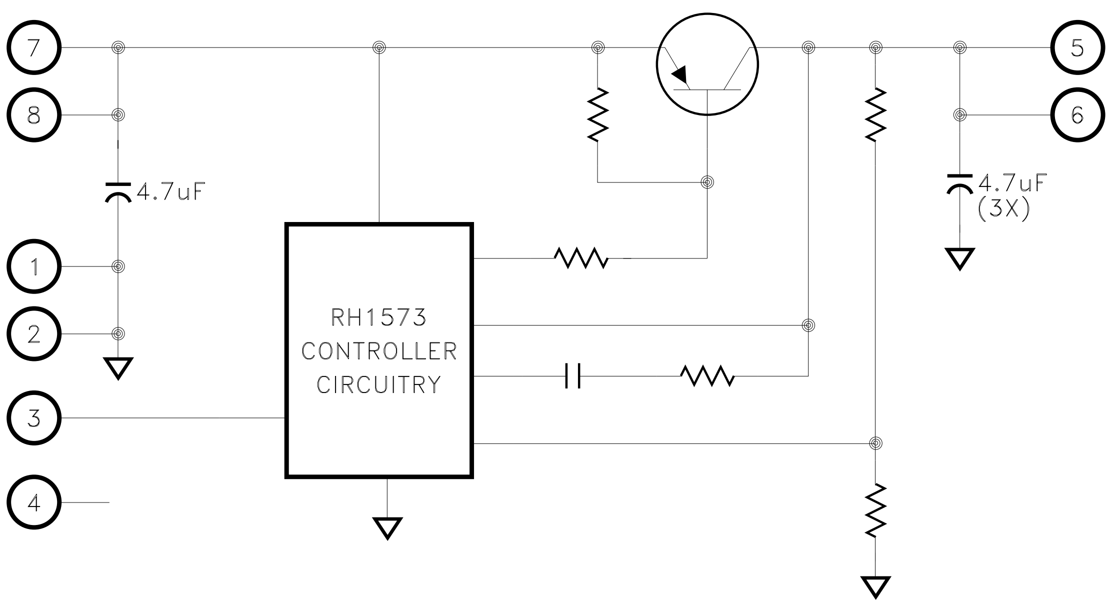
- Manufactured using LINEAR TECHNOLOGY Space Qualified RH1573 Die
- Replaces IR OMR9600, OMR9601 and IRUH33PXX3A
- Total Dose Tested to 450K RAD (Method 1019.7 Condition A)
- Ultra Low Dropout for Reduced Power Consumption
- External Shutdown Function
- Latching Overload Protection
- Available in 1.8V and 2.5V Output Voltages
- Alternate Output Voltages Available
- Output Current Limit
- Available in 2 Lead Form Options: Straight and Gullwing
- Optimized for 3.3V Input
- Contact MSK for MIL-PRF-38534 Qualification Status and Appendix G (Radiation) Status



## DESCRIPTION:

The MSK 5823RH is a rad hard fixed linear regulator capable of delivering 3.0 amps of output current. Typical dropout is only 0.30 volts with a 3 amp load. An external shutdown function is ideal for power supply sequencing. This device also has internal latching overload protection. The MSK 5823RH is radiation hard and specifically designed for space/satellite applications. The device is packaged in a hermetically sealed space efficient 8 pin flatpack that is electrically isolated from the internal circuitry allowing for direct heat sinking.

## EQUIVALENT SCHEMATIC




## TYPICAL APPLICATIONS

- Satellite System Power Supplies
- Switching Power Supply Post Regulators
- Constant Voltage/Current Regulators
- Microprocessor Power Supplies

## PIN-OUT INFORMATION

| | |
|---|---|
| 1 GND | 8 VIN |
| 2 GND | 7 VIN |
| 3 SHUTDOWN | 6 VOUT |
| 4 N/C | 5 VOUT |

## ABSOLUTE MAXIMUM RATINGS ⑨

| | | |
|---|---|---|
| $+V_{IN}$ | Supply Voltage | +7V |
| $I_{OUT}$ | Output Current ⑦ | 3.5A |
| $T_C$ | Case Operating Temperature Range | |
| | MSK5823K/H/E RH | -55°C to +125°C |
| | MSK5823RH | -40°C to +85°C |
| $T_{ST}$ | Storage Temperature Range | -65°C to +150°C |
| $T_{LD}$ | Lead Temperature Range (10 Seconds) | 300°C |
| $P_D$ | Power Dissipation | See SOA Curve |
| $T_C$ | Junction Temperature | 150°C |

## ELECTRICAL SPECIFICATIONS

| Parameter | Test Conditions ① ⑩ | Group A Subgroup | MSK 5823-1.8 K/H/E RH Min. | Typ. | Max. | MSK 5823-1.8RH Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|---|---|
| Output Voltage | VIN=3.3V, IO=1.5A | 1 | 1.782 | 1.8 | 1.818 | 1.782 | 1.8 | 1.818 | V |
| | VIN=3.3V, IO=1.5A | 2,3 | 1.71 | 1.8 | 1.89 | 1.71 | 1.8 | 1.89 | V |
| | VIN=2.97V, IO=50mA | 1,2,3 | 1.71 | - | 1.89 | 1.71 | - | 1.89 | V |
| | VIN=2.97V, IO=3.0A | 1,2,3 | 1.71 | - | 1.89 | 1.71 | - | 1.89 | V |
| | VIN=3.63V, IO=50mA | 1,2,3 | 1.71 | - | 1.89 | 1.71 | - | 1.89 | V |
| | VIN=3.63V, IO=3.0A | 1,2,3 | 1.71 | - | 1.89 | 1.71 | - | 1.89 | V |
| | 2.97V≤VIN≤3.63V 50mA≤IOUT≤3.0A Post 300KRAD(Si) | 1 | 1.71 | 1.8 | 1.89 | 1.71 | 1.8 | 1.89 | V |
| Input Voltage Range-Operating ② | IO=3.0A | 1,2,3 | 2.9 | - | 6.5 | 2.9 | - | 6.5 | V |
| Dropout Voltage ⑤ | IO=3.0A | 1,2,3 | - | - | 1.1 | - | - | 1.1 | V |
| Current Limit ⑦ | VIN=3.3V, Overcurrent Latchup | 1,2,3 | 3.0 | - | - | 3.0 | - | - | A |
| Ripple Rejection ② | F=120Hz, IO=50mA | 4 | 65 | - | - | 65 | - | - | dB |
| | Post 300KRAD(Si) | 4 | 40 | - | - | 40 | - | - | dB |
| Shutdown Source Current ⑧ | VSHDN=5.0V | - | - | 200 | - | - | 200 | - | uA |
| Shutdown Pin Threshold ⑧ | VIN=3.3V | 1,2,3 | 1.0 | - | 1.6 | 1.0 | - | 1.6 | V |
| Output Voltage at Shutdown | VIN=3.3V, IO=50mA VSHDN=+5.0V | 1,2,3 | -0.1 | - | +0.1 | -0.1 | - | +0.1 | V |
| Thermal Resistance ② | Junction to Case @ 125°C Output Device | - | - | 5.0 | 6.5 | - | 5.0 | 6.5 | °C/W |

| Parameter | Test Conditions ① ⑩ | Group A Subgroup | MSK 5823-2.5 K/H/E RH Min. | Typ. | Max. | MSK 5823-2.5RH Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|---|---|
| Output Voltage | VIN=3.3V, IO=1.5A | 1 | 2.475 | 2.5 | 2.525 | 2.475 | 2.5 | 2.525 | V |
| | VIN=3.3V, IO=1.5A | 2,3 | 2.375 | 2.5 | 2.625 | 2.375 | 2.5 | 2.625 | V |
| | VIN=2.97V, IO=50mA | 1,2,3 | 2.375 | - | 2.625 | 2.375 | - | 2.625 | V |
| | VIN=2.97V, IO=3.0A | 1,2,3 | 2.375 | - | 2.625 | 2.375 | - | 2.625 | V |
| | VIN=3.63V, IO=50mA | 1,2,3 | 2.375 | - | 2.625 | 2.375 | - | 2.625 | V |
| | VIN=3.63V, IO=3.0A | 1,2,3 | 2.375 | - | 2.625 | 2.375 | - | 2.625 | V |
| | 2.97V≤VIN≤3.63V 50mA≤IOUT≤3.0A Post 300KRAD(Si) | 1 | 2.375 | - | 2.625 | 2.375 | - | 2.625 | V |
| Input Voltage Range-Operating ② | IO=3.0A | 1,2,3 | 2.9 | - | 6.5 | 2.9 | - | 6.5 | V |
| Dropout Voltage | IO=3.0A | 1,2,3 | - | - | 0.4 | - | - | 0.4 | V |
| Current Limit ⑦ | VIN=3.3V, Overcurrent Latchup | 1,2,3 | 3.0 | - | - | 3.0 | - | - | A |
| Ripple Rejection ② | F=120Hz, IO=50mA | 4 | 65 | - | - | 65 | - | - | dB |
| | Post 300KRAD(Si) | 4 | 40 | - | - | 40 | - | - | dB |
| Shutdown Source Current ⑧ | VSHDN=5.0V | - | - | 200 | - | - | 200 | - | uA |
| Shutdown Pin Threshold ⑧ | VIN=3.3V | 1,2,3 | 1.0 | - | 1.6 | 1.0 | - | 1.6 | V |
| Output Voltage at Shutdown | VIN=3.3V, IO=50mA VSHDN=+5.0V | 1,2,3 | -0.1 | - | +0.1 | -0.1 | - | +0.1 | V |
| Thermal Resistance ② | Junction to Case @ 125°C Output Device | - | - | 5.0 | 6.5 | - | 5.0 | 6.5 | °C/W |

## NOTES:

① Unless otherwise specified, $V_{IN}$=3.3V, $V_{SHUTDOWN}$=0V and $I_{OUT}$=50mA. See figure 2 for typical test 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 subgroups 1 and 4 unless otherwise requested.
④ Military grade devices ("H" and "K" suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤ Dropout limited by minimum value of VIN.
⑥ Subgroup 1,4 $T_C$=+25°C
Subgroup 2 $T_C$=+125°C
Subgroup 3 $T_A$=-55°C
⑦ Output current limit is dependent upon the values of $V_{IN}$ and $V_{OUT}$. See Figure 1 and typical performance curves.
⑧ Refer to typical performance curves.
⑨ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑩ Pre and post irradiation limits at 25°C, up to 300Krad TID, are identical unless otherwise specified.

## PIN FUNCTIONS

$V_{IN}$ - These pins provide power to all internal circuitry including bias, start-up, thermal limit and overcurrent latch. Input voltage range is 2.9V to 6.5V but the MSK 5823RH is optimized for 3.3V input. See MSK 5825RH for 5V input version.

GND - Internally connected to ground, these pins should be connected externally by the user to the circuit ground.

SHUTDOWN - There are two functions to the SHUTDOWN pin. It may be used to disable the output voltage or to reset a current latch condition. To activate the shutdown/reset functions the user must apply a voltage greater than 1.6V to the SHUTDOWN pin. The output voltage will turn on when the SHUTDOWN pin is pulled below the threshold voltage. If the SHUTDOWN pin is not used, it should be connected to ground. It should be noted that with the shutdown pin tied to ground, a current latch condition can only be reset by cycling power off, then on.

$V_{OUT}$ - These are the output pins for the device.

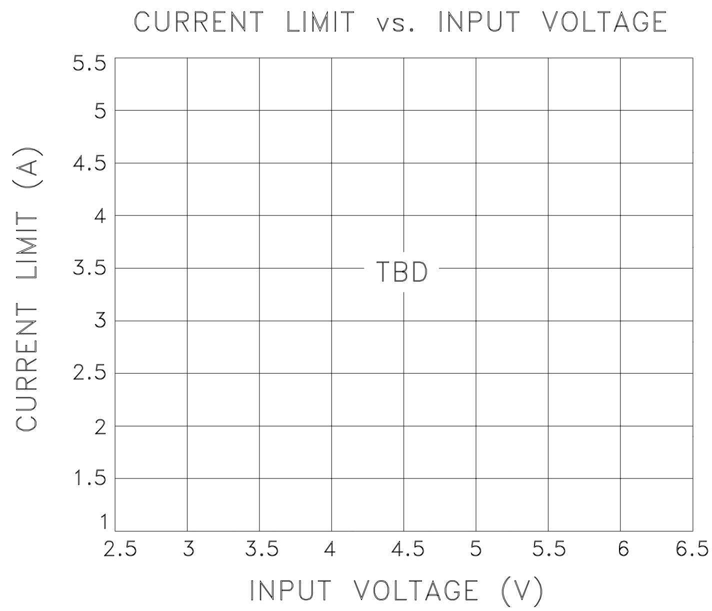



FIGURE 1

## OVERCURRENT LATCH

Overcurrent protection is provided by the MSK 5823RH series through the use of a timed latch off circuit. The internal latch timeout is triggered by an overcurrent condition. To allow for start up surge currents, the timeout is approximately TBDmS at 25°C. If the overcurrent condition remains at the end of the timeout cycle, the regulator will latch off until the latch is reset. Reset the latch by pulling the shutdown pin high or cycling $V_{IN}$ off then back on. A thermal limit condition will trigger the latch with no time out delay.

## INPUT POWER SUPPLY BYPASSING

The MSK 5823RH contains an internal 4.7µF tantalum input capacitor. To maximize transient response and minimize power supply transients it is recommended that a 100µF tantalum capacitor is connected between $V_{IN}$ and ground. A 0.1µF ceramic capacitor should also be used for high frequency bypassing.

## OUTPUT CAPACITOR SELECTION

The MSK 5823RH contains three internal 4.7µF tantalum output capacitors. Output capacitors are required to maintain regulation and stability. A 220µF surface mount tantalum capacitor from the output to ground should suffice under most conditions. Ceramic output capacitors (0.1µF typical) should be placed directly across the load power connections as close to the load as possible. If the user finds that tighter voltage regulation is needed during output transients, more capacitance may be added. If more capacitance is added to the output, the bandwidth may suffer.

## CURRENT LIMIT AND SOA

The MSK 5823RH current limit function is directly affected by the input and output voltages. Figure 1 illustrates the relationship between $V_{IN}$ and $I_{CL}$ for various output voltages. It is very important for the user to consult the SOA curve when using input voltages which result in current limit conditions beyond 3.5 Amps. When using input voltages which result in current limit above 3.5 Amps, the user must maintain output current within the SOA curve to avoid damage to the device. The current limit is adjusted internally for an input voltage of 3.3V.

## APPLICATION NOTES CONT.

### THERMAL LIMITING

The MSK 5823RH control circuitry has a thermal shutdown temperature of approximately 150°C. This thermal shutdown can be used as a protection feature, but for continuous operation, the junction temperature of the pass transistor must be maintained below 150°C. Proper heat sink selection is essential to maintain these conditions. Exceeding the thermal limit activates the latch feature of the MSK 5823RH. Toggle the shutdown pin high them low or cycle power to reset the latch. See shutdown pin description and overcurrent latch description for more information.

### HEAT SINK SELECTION

To select a heat sink for the MSK 5823RH, the following formula for convective heat flow may be used.

### Governing Equation:

$$T_J = P_D \times (R_{\theta JC} + R_{\theta CS} + R_{\theta SA}) + T_A$$

Where

- $T_J$ = Junction Temperature
- $P_D$ = Total Power Dissipation
- $R_{\theta JC}$ = Junction to Case Thermal Resistance
- $R_{\theta CS}$ = Case to Heat Sink Thermal Resistance
- $R_{\theta SA}$ = Heat Sink to Ambient Thermal Resistance
- $T_A$ = Ambient Temperature

$$\text{Power Dissipation} = (V_{IN} - V_{OUT}) \times I_{OUT}$$

Next, the user must select a maximum junction temperature. The absolute maximum allowable junction temperature is 150°C. The equation may now be rearranged to solve for the required heat sink to ambient thermal resistance ($R_{\theta SA}$).

### Example:

An MSK 5823-2.5RH is connected for $V_{IN}$ = +3.3V and $V_{OUT}$ = +2.5V. $I_{OUT}$ is a continuous 3A DC level. The ambient temperature is +25°C. The maximum desired junction temperature is +125°C.

$R_{\theta JC}$ = 6.5°C/W and $R_{\theta CS}$ = 0.15°C/W for most thermal greases

$$\text{Power Dissipation} = (3.3V - 2.5V) \times (3A) = 2.4 \text{ Watts}$$

Solve for $R_{\theta SA}$:

$$R_{\theta SA} = \left[\frac{125°C - 25°C}{2.4W}\right] - 6.5°C/W - 0.15°C/W$$

$$= 35.0°C/W$$

In this example, a heat sink with a thermal resistance of no more than 35.0°C/W must be used to maintain a junction temperature of no more than 125°C.

### TYPICAL APPLICATIONS CIRCUIT

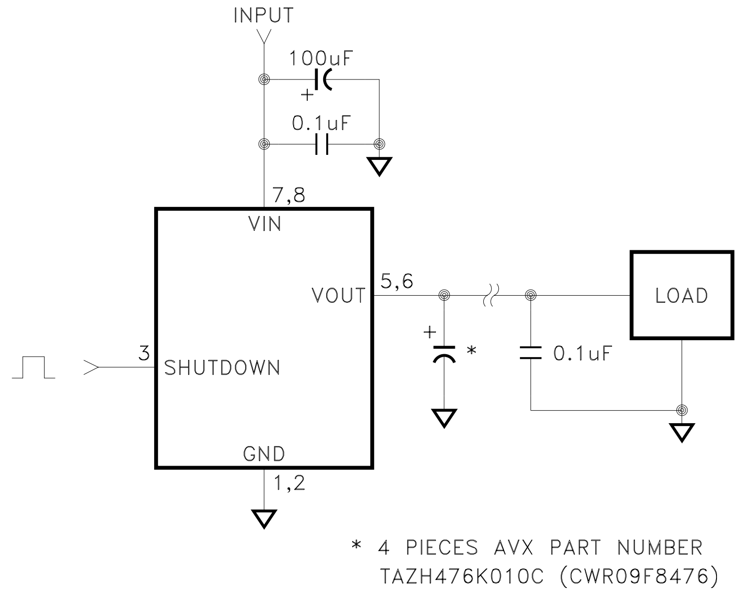


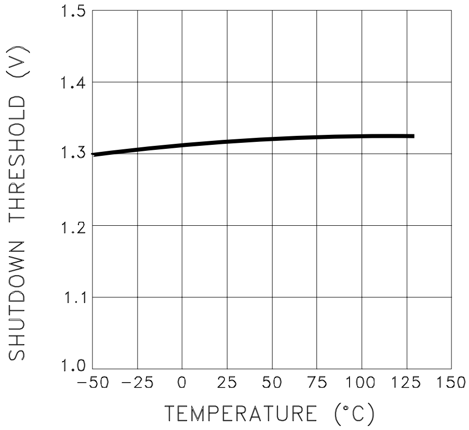

FIGURE 2

### TOTAL DOSE RADIATION TEST PERFORMANCE

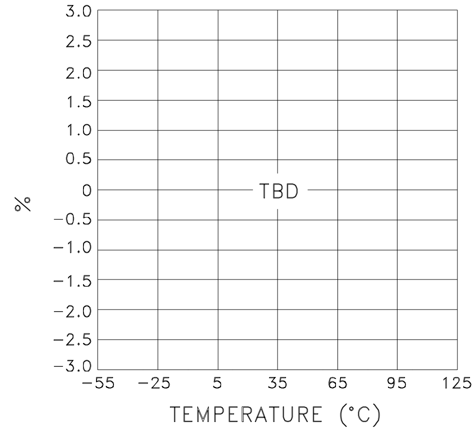
Radiation performance curves for TID testing will be generated for all radiation testing performed by MS Kennedy. These curves will show performance trends throughout the TID test process and will be located in the MSK 5823RH radiation test report. The complete radiation test report will be available in the RAD HARD PRODUCTS section on the MSK website.

# TYPICAL PERFORMANCE CURVES

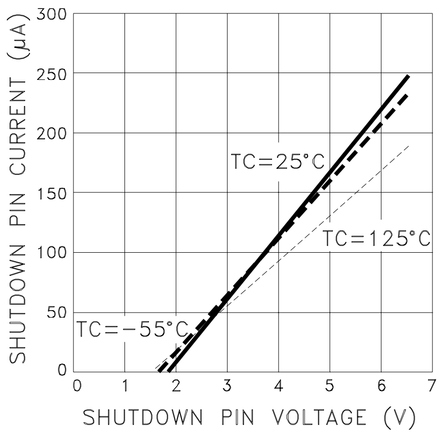
SHUTDOWN VOLTAGE THRESHOLD vs. TEMPERATURE



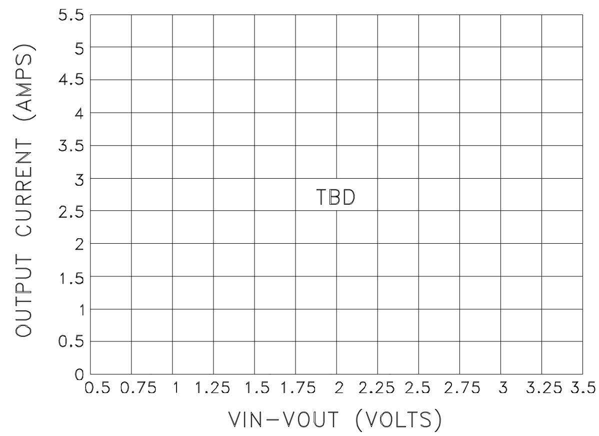

NORMALIZED LOAD REGULATION vs. TEMPERATURE



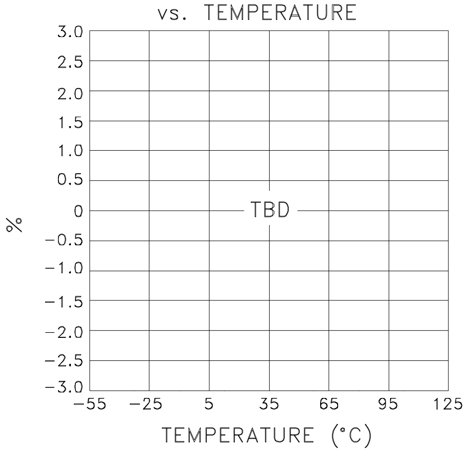

SHUTDOWN PIN CURRENT vs. SHUTDOWN PIN VOLTAGE



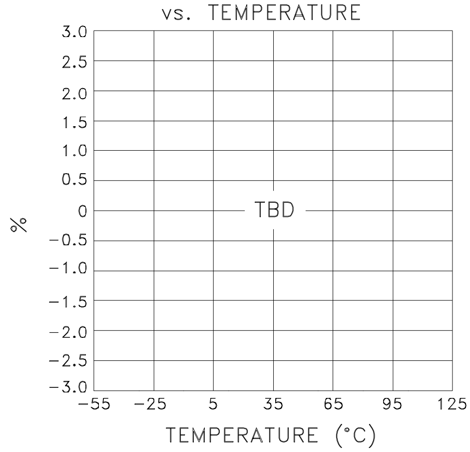

SOA OUTPUT CURRENT vs. VOLTAGE DROP



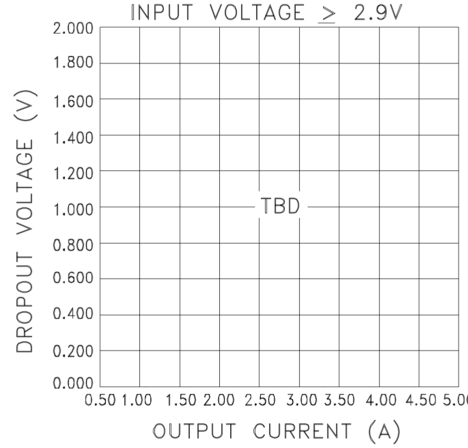

NORMALIZED OUTPUT VOLTAGE vs. TEMPERATURE




NORMALIZED LINE REGULATION vs. TEMPERATURE

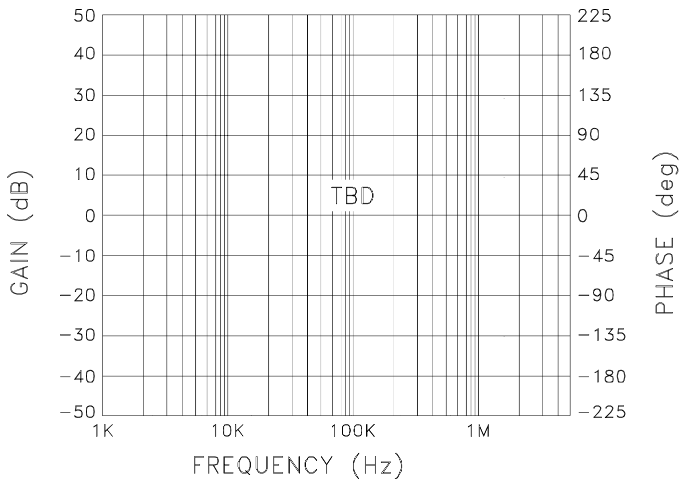



DROPOUT VOLTAGE vs. OUTPUT CURRENT INPUT VOLTAGE ≥ 2.9V

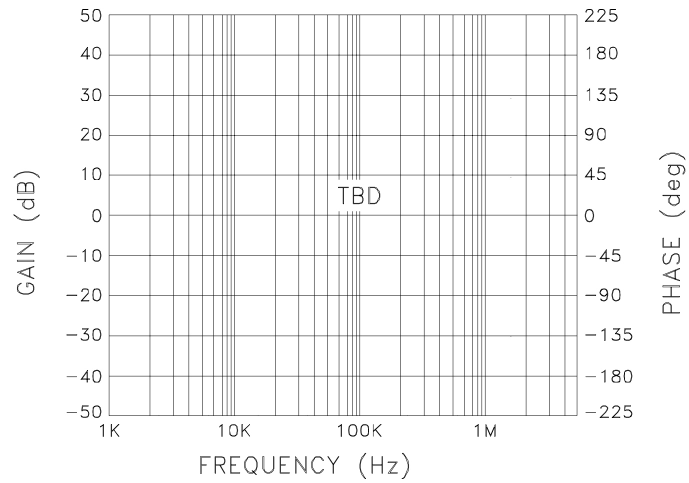


# TYPICAL PERFORMANCE CURVES

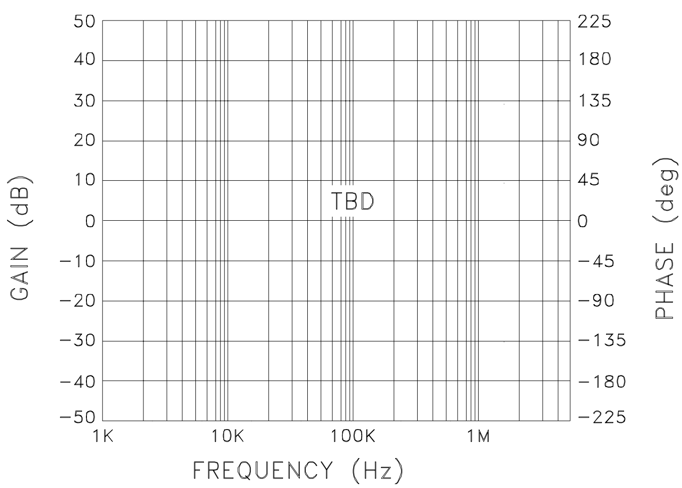
MSK5823−2.5RH GAIN AND PHASE vs. FREQUENCY



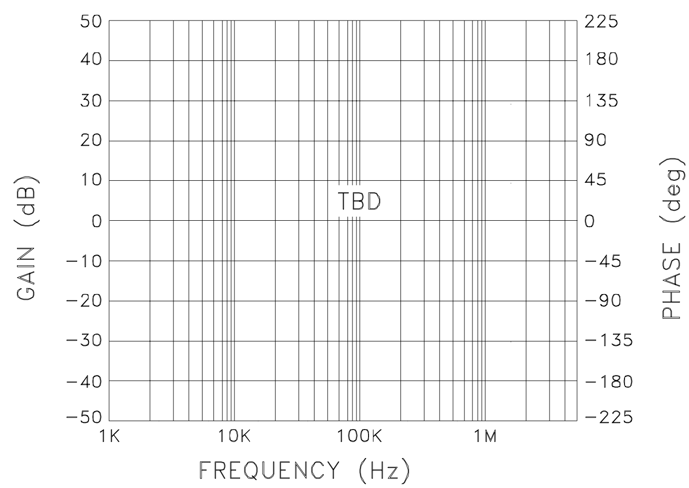

MSK5823−2.5RH GAIN AND PHASE vs. FREQUENCY



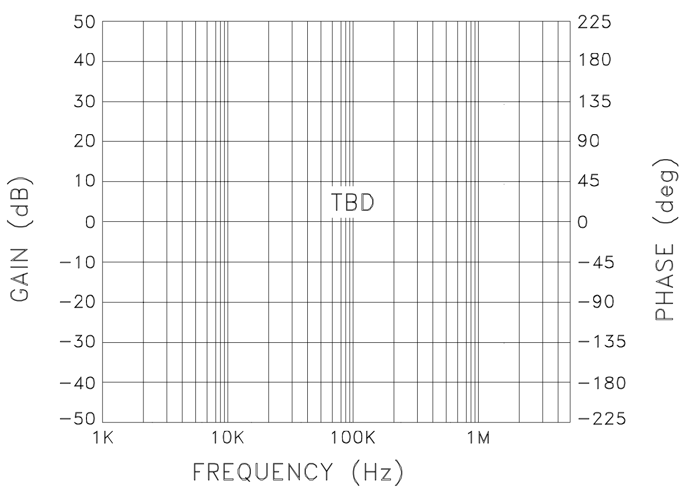

MSK5823−2.5RH GAIN AND PHASE vs. FREQUENCY



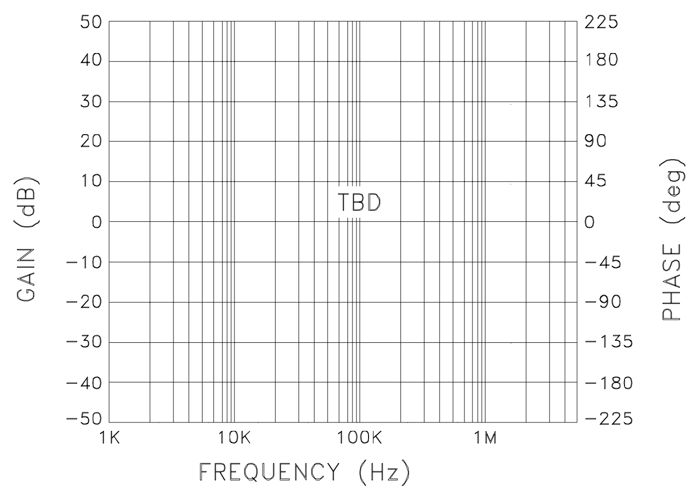

MSK5823−2.5RH GAIN AND PHASE vs. FREQUENCY



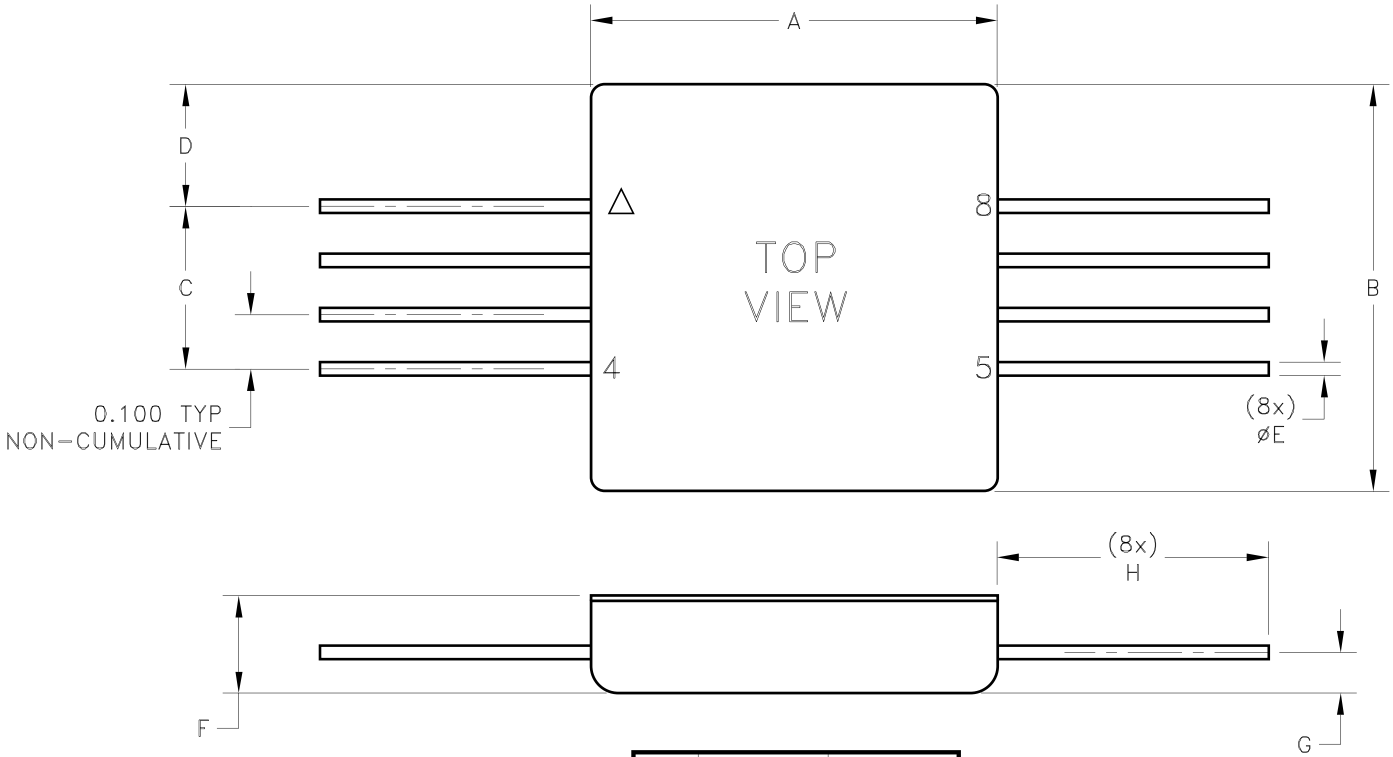

MSK5823−2.5RH GAIN AND PHASE vs. FREQUENCY




MSK5823−2.5RH GAIN AND PHASE vs. FREQUENCY



## MECHANICAL SPECIFICATIONS




| REF | MIN | MAX |
|---|---|---|
| A | 0.745 | 0.755 |
| B | 0.745 | 0.755 |
| C | 0.295 | 0.305 |
| D | 0.205 | 0.245 |
| E | 0.023 | 0.027 |
| F | ———— | 0.180 |
| G | 0.070 | 0.080 |
| H | 0.400 | ———— |

WEIGHT = TBD GRAMS TYPICAL
ESD TRIANGLE INDICATES PIN 1

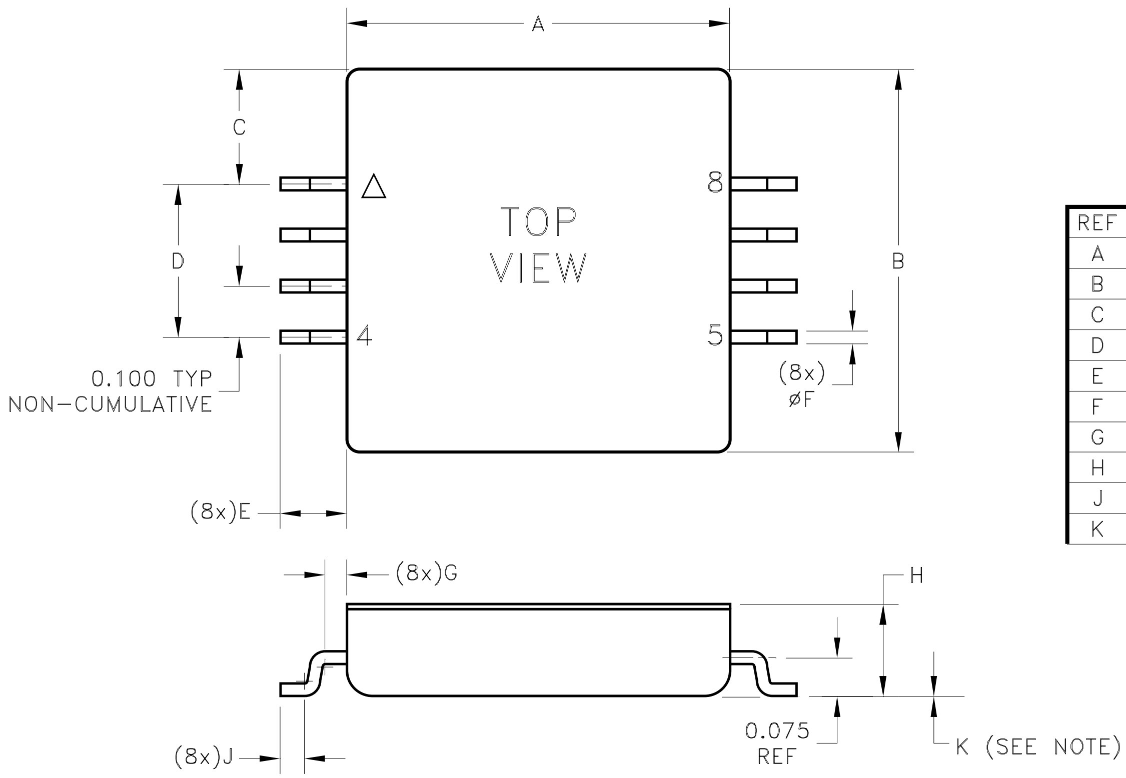
# ORDERING INFORMATION

MSK5823-1.8 K RH

- LEAD CONFIGURATIONS
  - BLANK = STRAIGHT
- RADIATION HARDENED
- SCREENING
  - BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY
  - H = MIL-PRF-38534 CLASS H; K = MIL-PRF-38534 CLASS K
- OUTPUT VOLTAGE
  - 1.8 = +1.8V; 2.5 = +2.5V
- GENERAL PART NUMBER

The above example is a +1.8V, Class K regulator with straight leads.

MECHANICAL SPECIFICATIONS




| REF | MIN | MAX |
|---|---|---|
| A | 0.745 | 0.755 |
| B | 0.745 | 0.755 |
| C | 0.205 | 0.245 |
| D | 0.295 | 0.305 |
| E | 0.110 | 0.150 |
| F | 0.023 | 0.027 |
| G | 0.040 | 0.065 |
| H | ——— | 0.180 |
| J | 0.040 | 0.065 |
| K | −0.010 | 0.010 |

**NOTE: 'K' IS MEASURED FROM THE BOTTOM OF THE PIN TO THE BOTTOM OF THE CASE**

WEIGHT = TBD GRAMS TYPICAL
ESD TRIANGLE INDICATES PIN 1

# ORDERING INFORMATION

MSK5823-1.8 K RH G

- LEAD CONFIGURATIONS
  - G = GULL WING
- RADIATION HARDENED
- SCREENING
  - BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY
  - H = MIL-PRF-38534 CLASS H; K = MIL-PRF-38534 CLASS K
- OUTPUT VOLTAGE
  - 1.8 = +1.8V; 2.5 = +2.5V
- GENERAL PART NUMBER

The above example is a +1.8V, Class K regulator with gull wing formed leads.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