



M.S.KENNEDY CORP.

# DUAL RAD TOLERANT +/- VOLTAGE REGULATOR

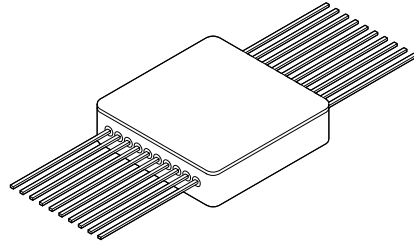
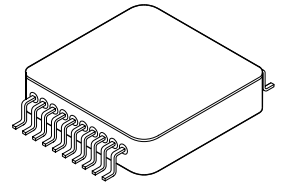
# 5901RH SERIES

4707 Dey Road Liverpool, N.Y. 13088

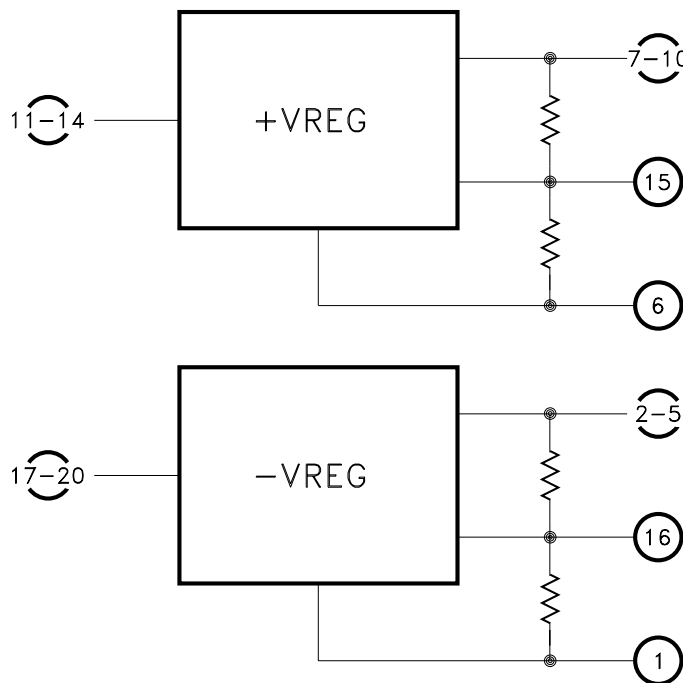
(315) 701-6751

**FEATURES:**

- 25KRAD(SI) Total Dose Performance
- Internal Thermal Overload Protection
- Output Current to 1.5 Amps
- Output Voltage Internally Trimmed to  $\pm 1\%$  Accuracy
- Available to DSCC SMD #TBD
- Lead Form Options: Straight and Gull Wing
- Alternate Voltage Combinations Available

**MIL-PRF-38534 CERTIFIED****MSK590XRH****MSK590XRHG****DESCRIPTION:**

The MSK 5901RH series are dual Radiation Tolerant +/- voltage regulators offering low dropout and output accuracy to  $\pm 1\%$  maximum. Excellent line and load regulation characteristics ensure highly accurate performance. In radiation environments, a total dose rating of 25KRAD(SI) provides highly reliable performance. The MSK 5901RH series regulators are equipped with internal thermal overload protection. The devices are packaged in a space efficient 20 pin flatpack with two lead form options, straight and gull wing.

**EQUIVALENT SCHEMATIC****TYPICAL APPLICATIONS**

- Switching Power Supply Post Regulators
- Constant Voltage/Current Regulators
- High Efficiency Linear Regulators

**PIN-OUT INFORMATION**

|          |           |
|----------|-----------|
| 1 -VRTN  | 20 -VIN   |
| 2 -VOUT  | 19 -VIN   |
| 3 -VOUT  | 18 -VIN   |
| 4 -VOUT  | 17 -VIN   |
| 5 -VOUT  | 16 -Ccomp |
| 6 +VRTN  | 15 +Ccomp |
| 7 +VOUT  | 14 +VIN   |
| 8 +VOUT  | 13 +VIN   |
| 9 +VOUT  | 12 +VIN   |
| 10 +VOUT | 11 +VIN   |

## ABSOLUTE MAXIMUM RATINGS

⑧

|            |  |                    |
|------------|--|--------------------|
| $+V_{IN}$  | + Input Voltage ( $V_{IN}-V_{OUT}$ ) . . . . . | +40VDC             |
| $-V_{IN}$  | -Input Voltage ( $V_{IN}-V_{OUT}$ ) . . . . .  | -40VDC             |
| $P_D$      | Power Dissipation . . . . .                    | Internally Limited |
| $+I_{OUT}$ | + Output Current . . . . .                     | 1.5A               |
| $-I_{OUT}$ | -Output Current . . . . .                      | 1.5A               |
| $T_J$      | Junction Temperature . . . . .                 | +150°C             |

|          |                                     |                       |
|----------|-------------------------------------|-----------------------|
| $T_{ST}$ | Storage Temperature Range . . . . . | -65°C to +150°C       |
| $T_{LD}$ | Lead Temperature Range . . . . .    | 300°C<br>(10 Seconds) |
| $T_C$    | Case Operating Temperature          |                       |
|          | MSK 5901RH-5909RH . . . . .         | -40°C to +85°C        |
|          | MSK 5901RH-5909RH(K/H/E) . . . . .  | -55°C to +125°C       |

## ELECTRICAL SPECIFICATIONS

| Parameter                          | Test Conditions ⑦  | Group A Subgroup ④ | MSK 590XRH K/H/E ③ | Min.      | Typ.      | Max. | MSK 590XRH ② | Min.      | Typ. | Max. | Units |
|------------------------------------|--|--------------------|--------------------|-----------|-----------|------|--------------|-----------|------|------|-------|
| <b>POSITIVE OUTPUT REGULATORS:</b> |  |                    |                    |           |           |      |              |           |      |      |       |
| Output Voltage Tolerance           | $I_{OUT} = 10mA$ ; $V_{IN} = V_{OUT} + 3V$               | 1                  | -                  | $\pm 0.2$ | $\pm 1.0$ | -    | $\pm 0.2$    | $\pm 1.5$ |      |      | %     |
|                                    |  | 2,3                | -                  | $\pm 0.8$ | $\pm 3.0$ | -    | -            | -         |      |      | %     |
| Dropout Voltage                    | $I_{OUT} = 0.5A$ ; $\Delta V_{OUT} = 1\%$                | 1                  | -                  | 1.6       | 3.0       | -    | 1.6          | 3.5       |      |      | V     |
|                                    |  | 2,3                | -                  | 1.9       | 3.0       | -    | -            | -         |      |      | V     |
| Load Regulation                    | $10mA \leq I_{OUT} \leq 0.5A$<br>$V_{IN} = V_{OUT} + 3V$ | 1                  | -                  | $\pm 0.2$ | $\pm 2.0$ | -    | $\pm 0.2$    | $\pm 2.5$ |      |      | %     |
|                                    |  | 2,3                | -                  | $\pm 0.4$ | $\pm 2.5$ | -    | -            | -         |      |      | %     |
| Line Regulation                    | $I_{OUT} = 10mA$<br>$V_{OUT} + 3V \leq V_{IN} \leq 35V$  | 1                  | -                  | $\pm 0.6$ | $\pm 1.5$ | -    | $\pm 0.6$    | $\pm 2.0$ |      |      | %     |
|                                    |  | 2,3                | -                  | $\pm 1.0$ | $\pm 2.5$ | -    | -            | -         |      |      | %     |
| Thermal Resistance ①               | JUNCTION TO CASE @ 125°C                                 | -                  | -                  | 9.5       | 10.5      | -    | 9.5          | 11.0      |      |      | °C/W  |
|                                    |  |                    |                    |           |           |      |              |           |      |      |       |
|                                    |  |                    |                    |           |           |      |              |           |      |      |       |
| <b>NEGATIVE OUTPUT REGULATORS:</b> |  |                    |                    |           |           |      |              |           |      |      |       |
| Output Voltage Tolerance           | $I_{OUT} = 10mA$ ; $V_{IN} = V_{OUT} - 3V$               | 1                  | -                  | $\pm 0.2$ | $\pm 1.0$ | -    | $\pm 0.2$    | $\pm 1.5$ |      |      | %     |
|                                    |  | 2,3                | -                  | $\pm 0.8$ | $\pm 3.0$ | -    | -            | -         |      |      | %     |
| Dropout Voltage                    | $I_{OUT} = 0.5A$ ; $\Delta V_{OUT} = 1\%$                | 1                  | -                  | 1.9       | 3.0       | -    | 1.9          | 3.0       |      |      | V     |
|                                    |  | 2,3                | -                  | 1.5       | 3.0       | -    | -            | -         |      |      | V     |
| Load Regulation                    | $10mA \leq I_{OUT} \leq 0.5A$<br>$V_{IN} = V_{OUT} - 3V$ | 1                  | -                  | $\pm 0.2$ | $\pm 2.0$ | -    | $\pm 0.2$    | $\pm 2.5$ |      |      | %     |
|                                    |  | 2,3                | -                  | $\pm 0.4$ | $\pm 2.5$ | -    | -            | -         |      |      | %     |
| Line Regulation                    | $I_{OUT} = 10mA$<br>$-30V \leq V_{IN} \leq V_{OUT} - 3V$ | 1                  | -                  | $\pm 0.1$ | $\pm 1.5$ | -    | $\pm 0.1$    | $\pm 2.0$ |      |      | %     |
|                                    |  | 2,3                | -                  | $\pm 0.2$ | $\pm 2.5$ | -    | -            | -         |      |      | %     |
| Thermal Resistance ①               | JUNCTION TO CASE @ 125°C                                 | -                  | -                  | 11.5      | 12.5      | -    | 11.5         | 13.0      |      |      | °C/W  |

### NOTES:

- ① Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
- ② Industrial grade and "E" suffix devices shall be tested to subgroup 1 unless otherwise specified.
- ③ Military grade devices shall be 100% tested to subgroups 1,2 and 3.
- ④ Subgroup 1  $T_A = T_C = +25^\circ C$   
Subgroup 2  $T_A = T_C = +125^\circ C$   
Subgroup 3  $T_A = T_C = -55^\circ C$
- ⑤ Please consult the factory if alternate output voltages are required.
- ⑥ For positive regulator, output decoupled to ground using 1 $\mu F$  minimum tantalum capacitor unless otherwise specified. For negative regulator, output decoupled to ground using 1 $\mu F$  minimum tantalum capacitor.
- ⑦ For complete radiation test data, consult "MSK 5901RH Total Dose Test Report".
- ⑧ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.

| PART NUMBER ⑤ | OUTPUT VOLTAGES |          |
|---------------|-----------------|----------|
|               | POSITIVE        | NEGATIVE |
| MSK5901       | 5.0             | 5.0      |
| MSK5902       | 5.0             | 5.2      |
| MSK5903       | 12.0            | 5.0      |
| MSK5904       | 12.0            | 12.0     |
| MSK5905       | 15.0            | 15.0     |
| MSK5906       | 15.0            | 5.0      |
| MSK5907       | 5.0             | 12.0     |
| MSK5908       | 5.0             | 15.0     |
| MSK5909       | 10.0            | 10.0     |

## CAPACITOR SELECTION

## POSITIVE REGULATOR

## INPUT CAPACITOR:

An input bypass capacitor is recommended when using the MSK 5901 series regulators. This is especially true if the regulator is located farther than 6 inches from the power supply filter capacitors. For most applications a 1 $\mu$ F solid tantalum capacitor will be suitable.

## OUTPUT CAPACITOR:

A minimum of a 1 $\mu$ F solid tantalum capacitor should also be used at the output to insure stability. Any increase of this output capacitor larger than 10 $\mu$ F will only improve output impedance.

## + CCOMP CAPACITOR:

For improved ripple rejection, +Ccomp can be bypassed to ground with a 10 $\mu$ F tantalum capacitor. This bypass capacitor will provide 80dB ripple rejection. Increased capacitance above 10 $\mu$ F does not improve the ripple rejection at frequencies above 120Hz. If the Ccomp bypass capacitor is used, it may be necessary to add a protection diode to protect the regulator from capacitor discharge damage. See Typical Applications Circuit for clarification. If the bypass capacitor is not used, it should be left open since it is internally connected to the regulator.

## NEGATIVE REGULATOR

## INPUT CAPACITOR:

Once again, if the regulator will be farther than 6 inches from power supply filter capacitors, then an input capacitor will be required on the negative regulator. It is recommended that a 1 $\mu$ F solid tantalum capacitor be used.

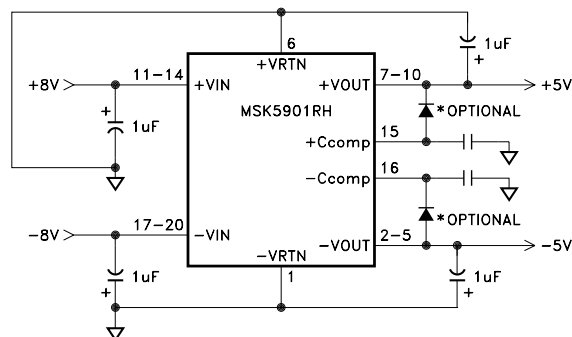
## OUTPUT CAPACITOR:

A minimum of a 1 $\mu$ F solid tantalum capacitor should also be used at the output to insure stability. Any increase of this output capacitor larger than 10 $\mu$ F will only improve output impedance.

## -CCOMP CAPACITOR:

For improved ripple rejection, -Ccomp can be bypassed to ground with a 10 $\mu$ F tantalum capacitor. This bypass capacitor will provide 80dB ripple rejection. Increased capacitance above 10 $\mu$ F does not improve the ripple rejection at frequencies above 120Hz. If the Ccomp bypass capacitor is used, it may be necessary to add a protection diode to protect the regulator from capacitor discharge damage. See Typical Applications Circuit for clarification. If the bypass capacitor is not used, it should be left open since it is internally connected to the regulator.

## TYPICAL APPLICATION CIRCUIT



## LOAD REGULATION

It is important to keep the output connection between the regulator and the load as short as possible since this directly affects the load regulation. For example, if 20 gauge wire were used which has a resistance of about 0.008 ohms per foot, this would result in a drop of 8mV/ft at 1Amp of load current. It is also important to follow the capacitor selection guidelines to achieve best performance.

## HEAT SINKING

To determine if a heat sink is required for your application and if so, what type, refer to the thermal model and governing equation below.

$$\text{Governing Equation: } T_j = P_d \times (R_{\theta jc} + R_{\theta cs} + R_{\theta sa}) + T_a$$

## 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
- $T_c$  = Case Temperature
- $T_a$  = Ambient Temperature
- $T_s$  = Heat Sink Temperature

## EXAMPLE:

This example demonstrates an analysis where the output currents are at 0.5 amp each and both inputs are 8V.

Conditions for MSK 5901RH:

$$+V_{in} = +8.0V; I_{out} = 0.5A \text{ Positive Regulator}$$

- 1.) Assume 45° heat spreading model.
- 2.) Find positive regulator power dissipation:

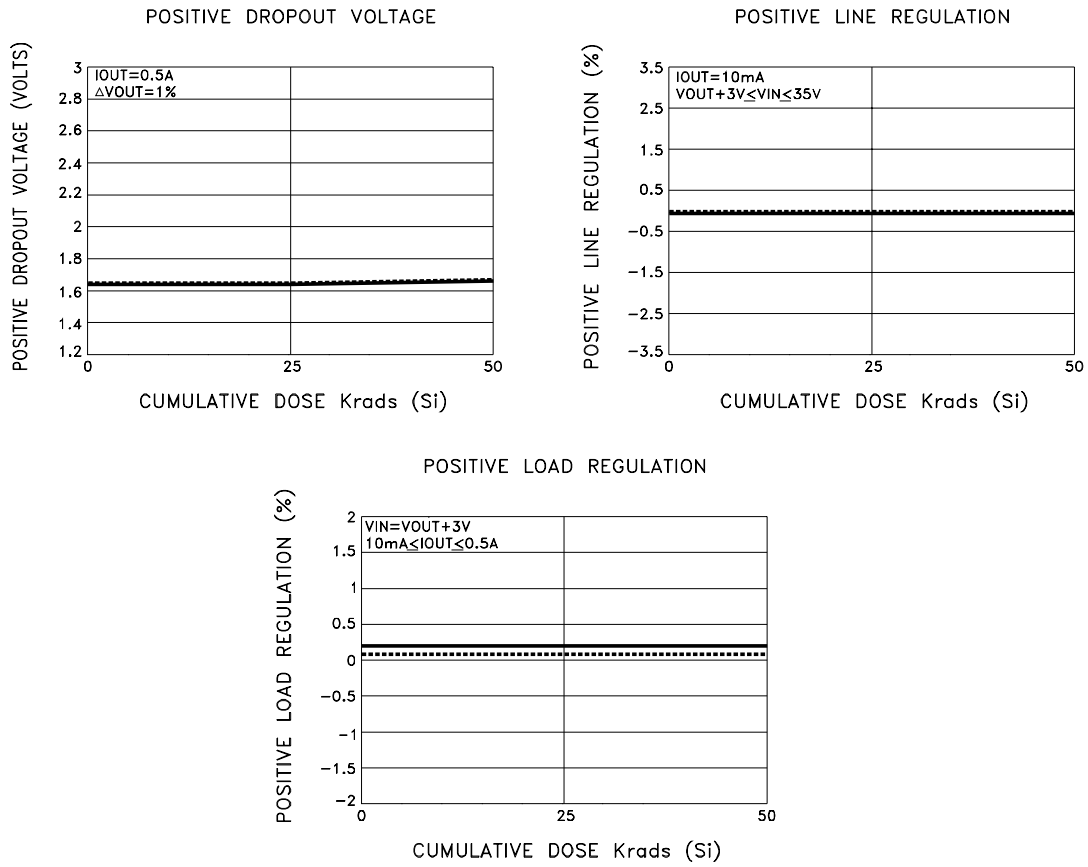
$$\begin{aligned} P_d &= (V_{in} - V_{out})(I_{out}) \\ P_d &= (+8V - 5V)(0.5A) \\ P_d &= 1.5W \end{aligned}$$

- 3.) For conservative design, set  $T_j = +125^\circ\text{C Max.}$
- 4.) For this example, worst case  $T_a = +90^\circ\text{C.}$
- 5.)  $R_{\theta jc} = 10.5^\circ\text{C/W}$  from the Electrical Specification Table.
- 6.)  $R_{\theta cs} = 0.15^\circ\text{C/W}$  for most thermal greases.
- 7.) Rearrange governing equation to solve for  $R_{\theta sa}$ :
 
$$\begin{aligned} R_{\theta sa} &= ((T_j - T_a)/P_d) - (R_{\theta jc}) - (R_{\theta cs}) \\ &= (125^\circ\text{C} - 90^\circ\text{C})/1.5W - 10.5^\circ\text{C/W} - 0.15^\circ\text{C/W} \\ &= 12.7^\circ\text{C/W} \end{aligned}$$

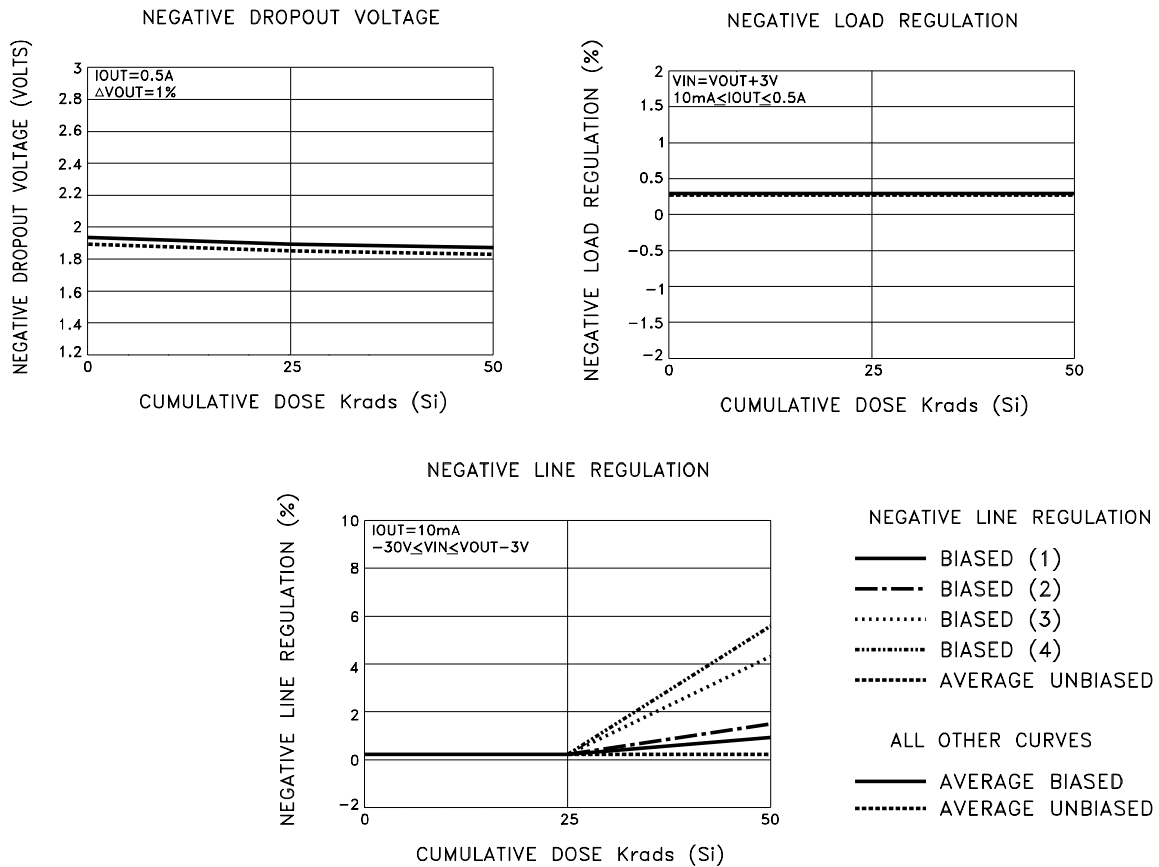
The same exercise must be performed for the negative regulator.

# TYPICAL PERFORMANCE CURVES

## POSITIVE

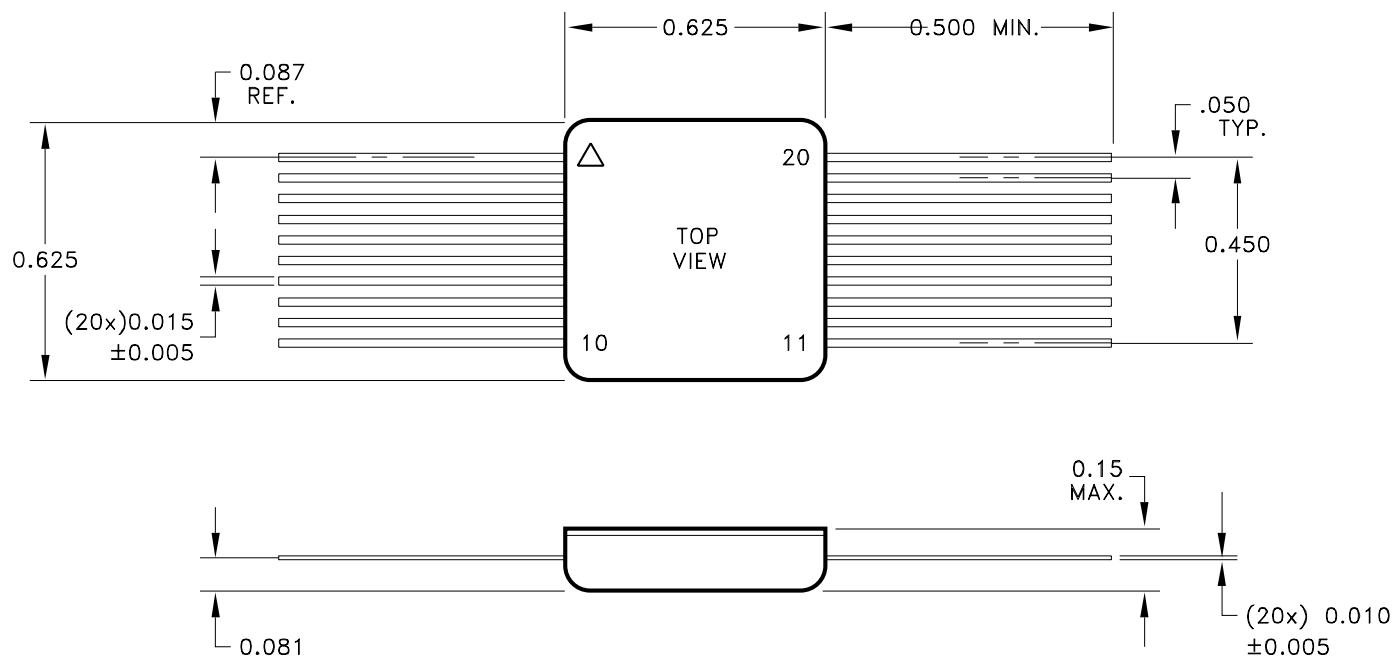


## NEGATIVE



## MECHANICAL SPECIFICATIONS

### MSK590XRH



WEIGHT = 3.3 GRAMS TYPICAL

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

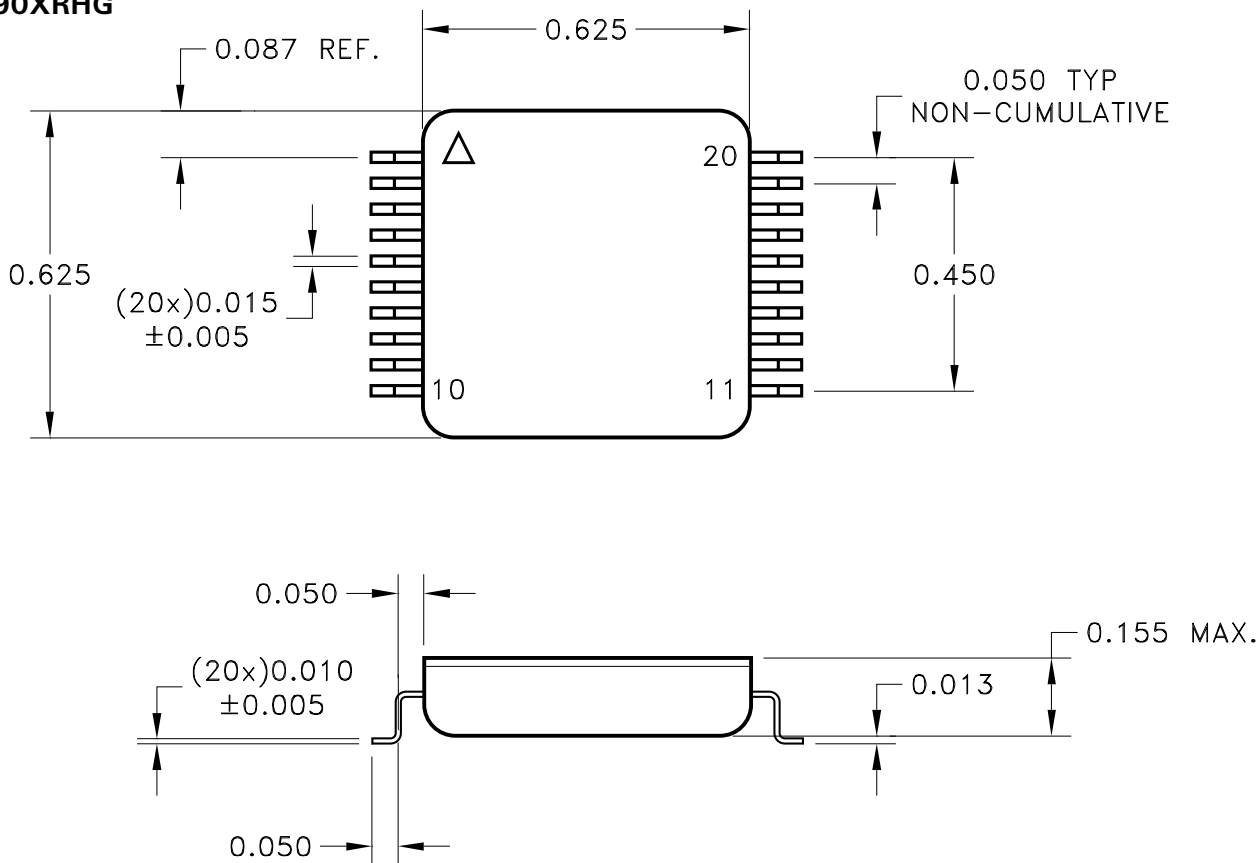
## ORDERING INFORMATION

| Part Number  | Screening Level       |
|--------------|-----------------------|
| MSK590XRH    | Industrial            |
| MSK590XHRH   | MIL-PRF-38534 CLASS H |
| MSK590XKRH   | MIL-PRF-38534 CLASS K |
| MSK590XERH   | EXTENDED RELIABILITY  |
| DSCC SMD TBD | TBD                   |

X - Designates voltage selection (MSK 5901-5909)

## MECHANICAL SPECIFICATIONS CONTINUED

### MSK590XRHG



WEIGHT = 3.3 GRAMS TYPICAL

NOTE: ALL DIMENSIONS ARE  $\pm 0.010$  INCHES UNLESS OTHERWISE LABELED.  
ESD Triangle indicates pin 1.

## ORDERING INFORMATION

| Part Number  | Screening Level       |
|--------------|-----------------------|
| MSK590XRHG   | Industrial            |
| MSK590XHRHG  | MIL-PRF-38534 CLASS H |
| MSK590XKRHG  | MIL-PRF-38534 CLASS K |
| MSK590XERHG  | EXTENDED RELIABILITY  |
| DSCC SMD TBD | TBD                   |

X - Designates voltage selection (MSK 5901-5909)

**M.S. Kennedy Corp.**  
4707 Dey Road, Liverpool, New York 13088  
Phone (315) 701-6751  
Fax (315) 701-6752  
[www.mskennedy.com](http://www.mskennedy.com)

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Contact MSK for MIL-PRF-38534 Class H, Class K and Appendix G (radiation) status.