MIL-PRF-38534 CERTIFIED

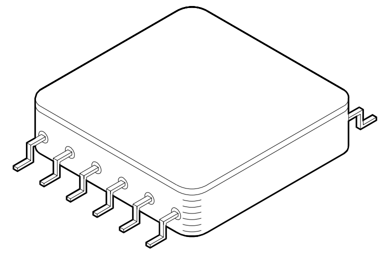
M.S.KENNEDY CORP.

RAD HARD DUAL POSITIVE LDO ADJ VOLTAGE REGULATOR 5953RH

4707 Dey Road Liverpool, N.Y. 13088 (315) 701-6751

FEATURES:

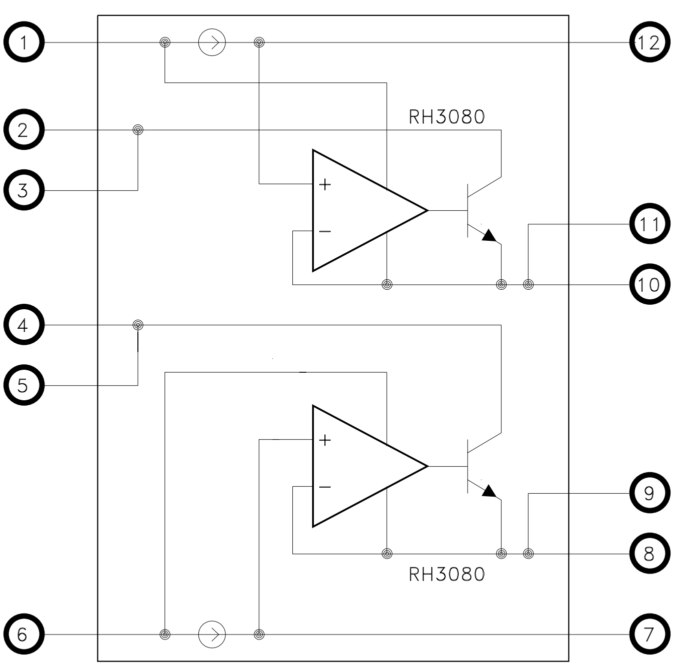
- Manufactured using LINEAR TECHNOLOGY Space Qualified RH3080 Die
- Total Dose Tested to TBD Krads(Si) (Method 1019.7 Condition A)
- Low Dropout Voltage
- Wide Input Voltage Range
- Output Adjustable to Zero Volts
- Output Current to 1.0A Each Output
- Outputs May Easily be Paralleled for Increased Output Current
- Internal Thermal Overload and Current Limit Protection
- Contact MSK for MIL-PRF-38534 Qualification and Radiation Status



DESCRIPTION:

The MSK 5953RH is a radiation hardened, low dropout, dual linear regulator. Each regulator is capable of up to 1.0Amps output current and can easily be paralleled for increased current capability and increased heat spreading. The output voltage is selected through the use of a single resistor and may be adjusted as low as 0 Volts. The MSK 5953RH regulators also have internal current limit and thermal protection. These features combined with low Øjc, make the MSK 5953RH regulator an excellent choice for many space applications. The MSK 5953RH is packaged in a hermetically sealed 12 pin flatpack that is lead formed for surface mount applications.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- Post Regulator for Switching Supplies
- Low Output Voltage Power Supplies
- High Efficiency Linear Regulator
- Satellite System Power Supply
- FPGA and Microprocessor Power Supply
- Coincident Output Tracking

PIN-OUT INFORMATION

1	CTL A	12	SET A
2	VIN A	11	VOUT A
3	VIN A	10	VOUT A
4	VIN B	9	VOUT B
5	VIN B	8	VOUT B
6	CTL B	7	SET B

ABSOLUTE MAXIMUM RATINGS ⑨

V_{IN}	Input Voltage ⑦	40V	T_{ST}	Storage Temperature Range	-65°C to +150°C
P_D	Power Dissipation	Internally Limited	T_{LD}	Lead Temperature Range (10 Seconds)	300°C
I_{OUT}	Output Current (Each Output)	1.0A	T_C	Case Operating Temperature	
T_J	Junction Temperature	+150°C		MSK 5953RH	-40°C to +85°C
				MSK 5953K/H/E	-55°C to +125°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ⑧ ⑩	Group A Subgroup	MSK 5953K/H/E Min.	MSK 5953K/H/E Typ.	MSK 5953K/H/E Max.	MSK 5953RH Min.	MSK 5953RH Typ.	MSK 5953RH Max.	Units
Set Pin Current (I_{SET})	$V_{CTL}=V_{IN}=3.0V$ $V_{OUT}=1.0V$ $1mA \leq I_{LOAD} \leq 1.0A$	1	9.80	10.0	10.20	9.80	10.0	10.20	uA
		2,3	9.80	-	10.20	-	-	-	uA
	Post Radiation	1	TBD	TBD	TBD	TBD	TBD	TBD	uA
Output Offset Voltage (V_{OS})	$V_{CTL}=V_{IN}=3.0V$ $V_{OUT}=1.0V$	1	-5	0	5	-5	0	5	mV
	$I_{LOAD}=1mA$	2,3	-6	-	6	-	-	-	mV
Load Regulation (ΔV_{OS})	$V_{CTL}=V_{IN}=3.0V$	1	-	-	1.3	-	-	1.3	mV
	$V_{OUT}=1.0V$	2,3	-	-	1.3	-	-	-	mV
	$1mA \leq I_{LOAD} \leq 1.0A$ (ΔI_{SET}) ②	1	-	-0.1	-	-	-0.1	-	nA
Line Regulation (ΔI_{SET})	$3V \leq V_{IN}=V_{CTL} \leq 25V$	1	-	-	0.5	-	-	0.5	nA/V
	$V_{OUT}=1.0V$	2,3	-	-	0.5	-	-	-	nA/V
	$I_{LOAD}=1mA$ (ΔV_{OS}) ②	1	-	0.003	-	-	0.003	-	mV/V
V_{IN} Dropout Voltage	$V_{OUT}=1.0V$ $I_{LOAD}=1.0A$	1	-	TBD	500	-	-	500	mV
	$V_{CTL}=3.0V$	2,3	-	-	500	-	-	-	mV
CTL Pin Dropout Voltage	$V_{OUT}=1.0V$ $I_{LOAD}=1.0A$	1	-	-	1.6	-	-	1.6	V
	$V_{IN}=3.0V$	2,3	-	-	1.6	-	-	-	V
CTL Pin Current	$V_{IN}=2.0V$ $V_{OUT}=1.0V$	1	-	-	6	-	-	6	mA
	$V_{CTL}=3.0V$ $I_{LOAD}=100mA$	2,3	-	-	6	-	-	-	mA
Current Limit	$V_{CTL}=V_{IN}=5.0V$ $V_{OUT}=1.0V$	1	0.9	TBD	-	0.9	-	-	A
		2,3	0.9	-	-	-	-	-	A
	Post Radiation	1	TBD	TBD	TBD	TBD	TBD	TBD	A
Minimum Load Current ⑥	$V_{CTL}=V_{IN}=25V$	-	-	-	1	-	-	1	mA
Ripple Rejection ②	$F=120Hz$ $\Delta V_{IN}=0.5Vpp$	-	-	75	-	-	75	-	dB
Thermal Resistance ②	Junction to Case @125°C	-	-	9.9	10.5	-	9.9	10.5	°C/W

NOTES:

① Output is decoupled to ground using a 3.3µF tantalum low ESR capacitor in parallel with a 0.1µF ceramic capacitor unless otherwise specified. (See Figure 1).
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade devices shall be tested to subgroup 1 unless otherwise specified.
④ Class V devices shall be 100% tested to subgroups 1,2 and 3.
⑤ Subgroup 1 $T_A=T_C=+25°C$
Subgroup 2 $T_A=T_C=+125°C$
Subgroup 3 $T_A=T_C=-55°C$
⑥ Minimum load current verified while testing line regulation.
⑦ The output current limit is dependant on the input to output voltage differential (VIN-VOUT). At VIN-VOUT > 26V the available output current may be reduced to zero amps. Refer to the current limit curve for typical current limit characteristics.
⑧ All limits and specifications apply to each individual regulator.
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 TBD TID, are identical unless otherwise specified.

OUTPUT VOLTAGE

A single resistor (RSET) from the SET pins to ground creates the reference voltage for the internal Error Amplifier. The MSK 5953RH SET pins each supply a constant current of 10uA that develops the reference voltage. The output voltage is simply Rset x 10uA. In the event that both outputs will be the same value, both SET pins may be tied together and a single resistor used for output voltage selection, according to the formula VOUT = RSET x 20µA. Since the output is internally driven by a unity-gain amplifier, an alternative to using Rset is to connect a high quality reference source to the SET pin. With a minimum load requirement of 1mA on the Output, the Output Voltage can be adjusted to near 0V. To bring the output voltage to 0V, the load must be connected to a slightly negative voltage supply to sink the 1mA minimum load current from a 0V output.

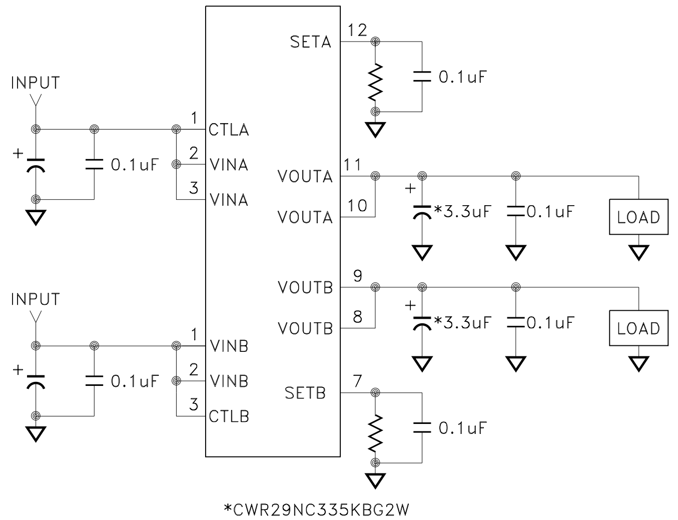


FIGURE 1

OUTPUT CAPACITANCE

For stability purposes, the MSK 5953RH requires a minimum output capacitor of 2.2µF with an ESR of 0.5Ω or less. Tantalum or ceramic capacitors are recommended. A larger capacitance value will improve transient response for increased load current changes. Consideration must also be given to temperature characteristics of the capacitors used.

ADDITIONAL STABILITY

Capacitors placed in parallel with the SET pin resistors to ground, will improve the output transient response and filter noise in the system. To reduce output noise, typically less than 100pF is all that will be required. Capacitors up to 1µF can be used, however consideration must be given to the effect the time constant created will have on the startup time.

LOAD REGULATION

The MSK 5953RH specified load regulation is Kelvin Sensed, therefore the parasitic resistance of the system must be considered to design an acceptable load regulation. The overall load regulation includes the specified MSK 5953RH load regulation plus the parasitic resistance multiplied by the load current as shown in Figure 2. RSO is the series resistance of all conductors between the MSK 5953RH output and the load. It will directly increase output load regulation error by a voltage drop of ΔIo x RSO. Rss is the series resistance between the set pin and the load. RSS will have little effect on load regulation if the set pin trace is connected as close to the load as possible keeping the load return current on a separate trace as shown. RSR is the series resistance of all of the conductors between the load and the input power source return. RSR will not effect load regulation if the set pin is connected with a Kelvin Sense type connection as shown in Figure 2, but it will increase the effective dropout voltage by a factor of IO x RSR. Keeping RSO and RSR as low as possible will ensure minimal voltage drops and wasted power.

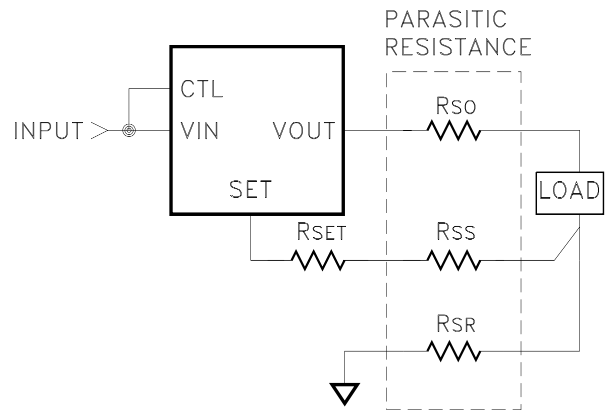


FIGURE 2 (Each Regulator)

INCREASED CURRENT CAPACITY

When currents greater than 1.0 A are needed, the MSK 5953 RH's outputs may be paralleled to double the current capacity. As shown in Figure 3, the VIN and SET pins must be tied together. The VOUT pins are connected to the load with consideration to the conductor resistance. The conductor resistance of each MSK 5953RH VOUT connection to the load, must be equal to create equal load sharing. As little as 10mΩ ballast resistance typically ensures better than 80% equal sharing of load current at full load. Additional consideration must be given to the effect the additional VOUT conductor resistance has on load regulation; see paragraph titled "Load Regulation".

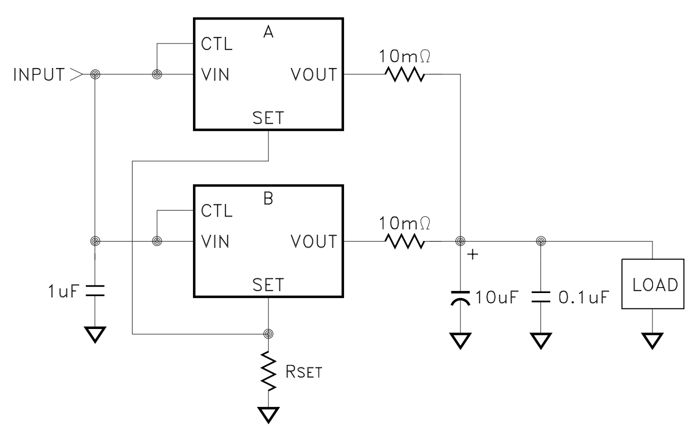


FIGURE 3

IMPROVING INITIAL ACCURACY AND REDUCING TEMPERATURE DRIFT

The initial output accuracy of the MSK 5953RH due to set pin current tolerance and set point resistor accuracy can be reduced to 0.2% using the MSK 109RH radiation hardened precision reference. Minimal drift of the MSK 109RH from temperature extremes and irradiation ensure very tight regulation. The circuit can be configured to use the 2.5V reference to directly set the output at 2.5V or with a slight variation it can provide any output within the operating range of the MSK 5953RH down to 0V output. Select Rs to maintain between 1mA and 10mA of current through the reference; see Figure 4 below. Rs may be tied to VIN or another power source. The optional trim resistor can be used to further trim out initial output and system error. Reference the MSK 109RH data sheet for application circuits that provide stable output voltages across the full operating range of the MSK 5953RH including down to 0V output and the operating characteristics of the MSK 109RH.

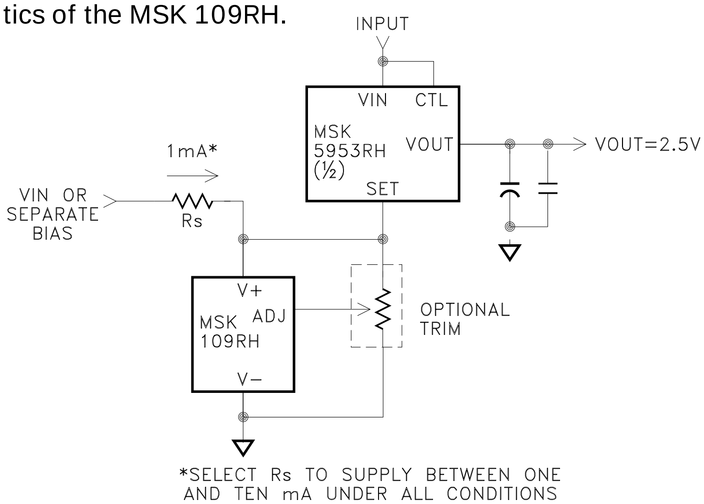


FIGURE 4

ADDING SHUTDOWN

The MSK 5953RH can be easily shutdown by either reducing R_{SET} to 0Ω or connecting a transistor from the set pin to ground. By connecting two transistors, as shown in Figure 5, a low current voltage source is all that is required to take the set pin to ground as well as pull the output voltage to ground. Q2 pulls the output voltage to ground when no load is present and only needs to sink 10mA. Use a low leakage switching diode between VOUT and SET to avoid overstress during shutdown transitions.

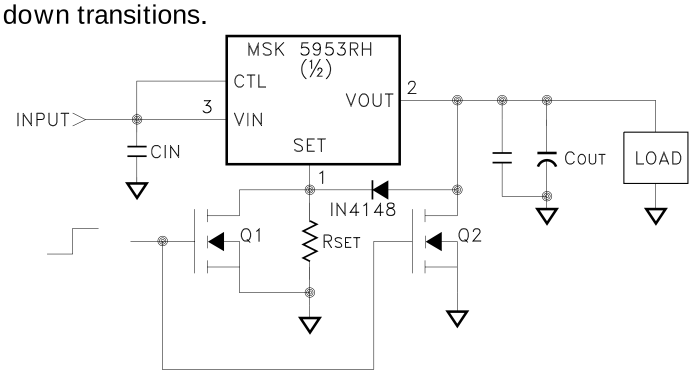


FIGURE 5

COINCIDENT TRACKING

For applications that require multiple output voltages and tight control over voltage differentials, the coincident tracking shown in Figure 6 may be used. In this configuration regulator B is configured for an output voltage of 0.8V with reference to output A. Output B will never exceed output A by more than 0.8V but will be 3.3V with respect to ground when output A is at the specified 2.5V. Although a very small portion of the overall current, it should be noted that load connected to regulator A must sink the 10µA set pin current of regulator B.

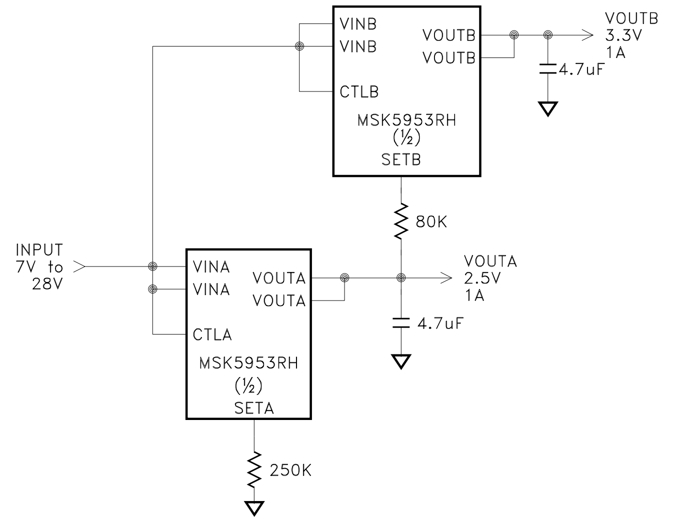


FIGURE 6

APPLICATION NOTES CONT'D

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.

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 the thermal calculations for the package with the regulator operating at one-half of its maximum rated output current.

Conditions for MSK 5953RH:

VIN = +3.0V; I_{OUT} = +0.50A VOUT = +1.0V

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

P_D = (VIN - VOUT)(I_{OUT})
P_D = (3-1)(0.50)
= 1.0W

3.) For conservative design, set T_J = +125°C Max.
4.) For this example, worst case T_A = +90°C.
5.) $R\theta_{JC}$ = 7.3°C/W from the Electrical Specification Table.
6.) $R\theta_{CS}$ = 0.15°C/W for most thermal greases.
7.) Rearrange governing equation to solve for $R\theta_{SA}$:

$R\theta_{SA} = ((T_J - T_A)/P_D) - (R\theta_{JC}) - (R\theta_{CS})$
= (125°C - 90°C)/1.0W - 10.5°C/W - 0.15°C/W
= 24.4°C/W

In this case the result is 24.4°C/W. Therefore, a heat sink with a thermal resistance of no more than 24.4°C/W must be used in this application to maintain regulator circuit junction temperature under 125°C.

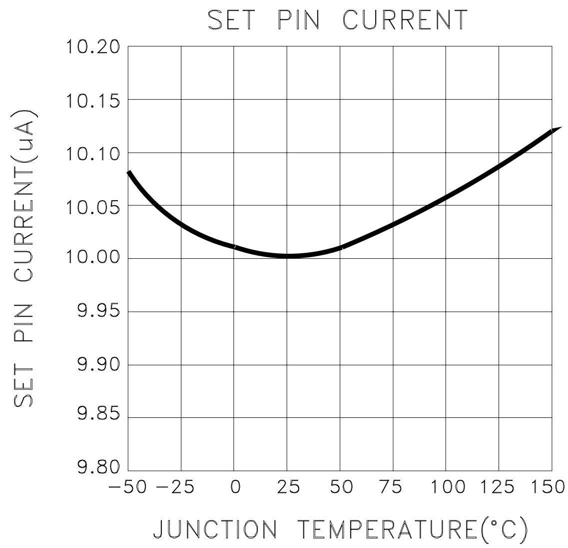
TOTAL DOSE RADIATION TEST PERFORMANCE

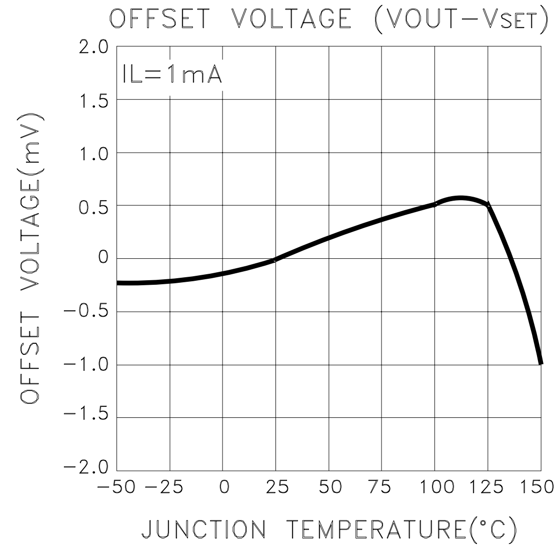
Radiation performance curves for TID testing will be generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout the TID test process and can be located in the MSK 5953RH radiation test report. The complete radiation test report will be available in the RAD HARD PRODUCTS section on the MSK website.

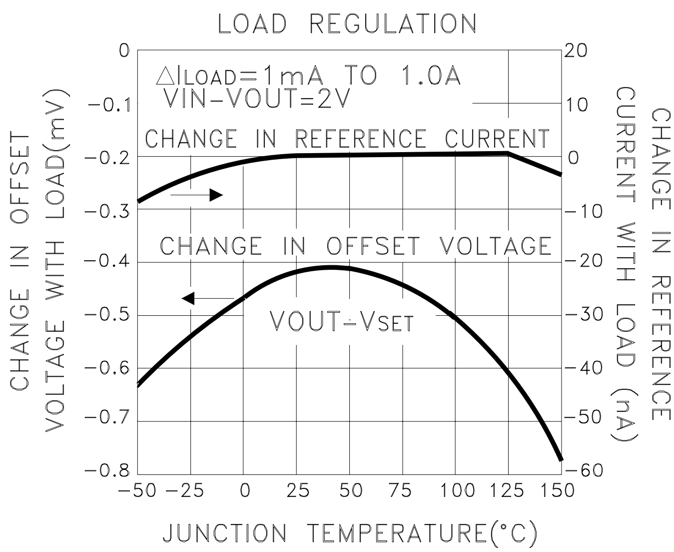
ADDITIONAL APPLICATION INFORMATION

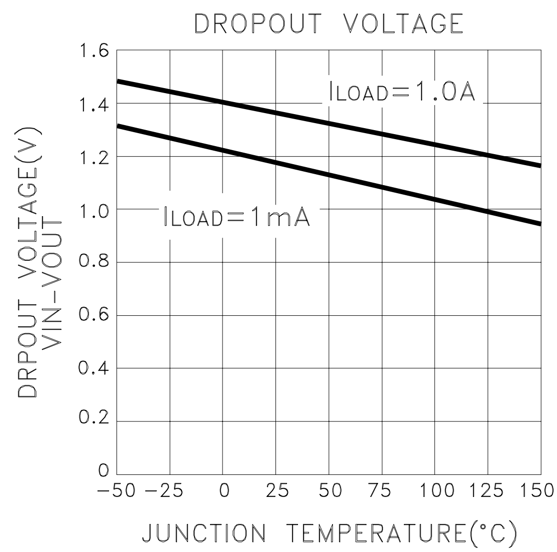
For additional applications information, please reference Linear Technology Corporation's® LT3080 and RH3080 data sheets.

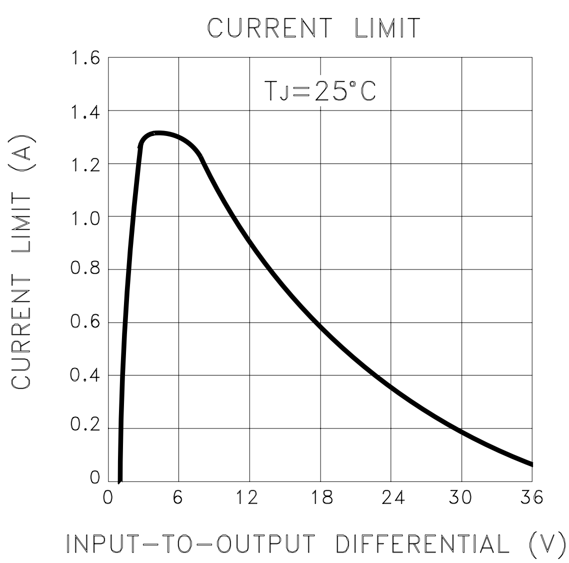
TYPICAL PERFORMANCE CURVES

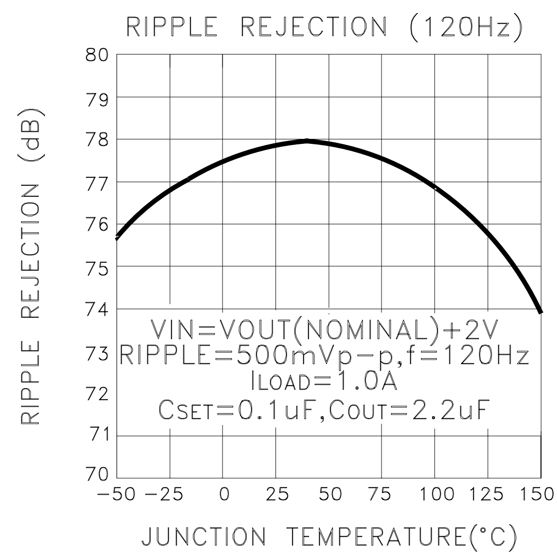




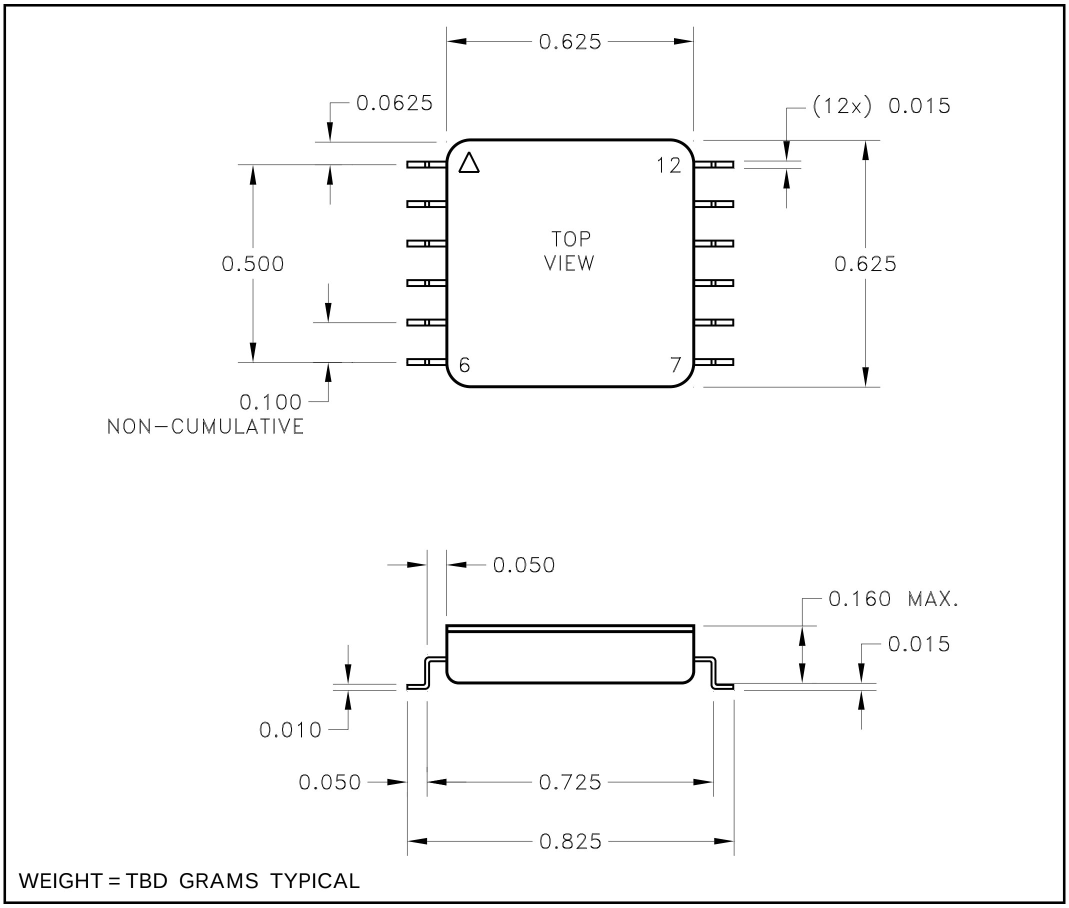








MECHANICAL SPECIFICATIONS



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

ORDERING INFORMATION

Part Number	Screening Level
MSK5953RH	INDUSTRIAL
MSK5953ERH	EXTENDED RELIABILITY
MSK5953HRH	MIL-PRF-38534 CLASS H
MSK5953KRH	MIL-PRF-38534 CLASS K

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