MBT-143-E eTC™ Rejustor™ Adjustable 1:9 Divider with Adjustable TCR

GENERAL DESCRIPTION

The MBT-143-E adjustable resistor divider consists of a pair of ***eTC Rejustors*** which allow independent, precision control of both the resistance and Temperature Coefficient of Resistance (TCR) for each resistor. Access is provided to both ends of the divider and to the center-tap. This allows control for the DC offset voltage with adjustable positive, negative or flat linear temperature response for the pair.

Independent adjustment of resistance and TCR for each resistor in the divider is accomplished by heating and cooling the resistive poly-silicon element in a closed-loop system under control of ***Rejustor*** Calibration tools and Rejust-it software.

The 1:9 divider can be configured in either orientation. With the smaller Rejustor connected between the supply and the output and the larger Rejustor connected between the output and ground, the 1:9 divider provides an output range from +25mV/V to -40mV/V, and a temperature coefficient of output from +60µV/V/K to -50µV/V/K (refer to Figure 4) around the nominal (900mV/V).

Adjustment is performed in-circuit to correct for offset errors and temperature induced drift on a unit-by-unit basis. Precision adjustment of the MBT-143-E is performed after temperature testing to calibrate and compensate precision analog systems.

Adjustment changes the physical properties of the resistors. No external memory or boot-up is required. The material is physically altered to have a new electrical response. After adjustment, ***eTC Rejustor*** dividers feature fast response to temperature and exhibit high stability.

Resistance and TCR can be matched to within 0.1%, or better, of the target value.

The divider operates from -55°C to +125°C[1]. The divider is ideal for precision gain setting and bridge balance circuits where set-on-test adjustment and high-precision are required.

eTC REJUSTOR APPLICATIONS

- Precision resistance and temperature compensation for:
  - Sensors
  - Precision voltage references
  - Optical Components
  - Gas detectors
  - Instrumentation amplifiers
  - LCD Displays
  - Passive filters
- Replaces manual trim pots, digital pots, precision resistors and laser trimming
- Replaces temperature sensors

FEATURES

- Each Resistor is independently electrically adjustable to any value from its as-manufactured value down 40% (e.g. 14Kohms down to 8.4Kohms), with accuracy 0.1% or better
- Each Resistor's Temperature Coefficient is independently adjustable such that the TC of the divider output is adjustable between +60µV/V/K and -50µV/V/K (refer to Figure 4 and 5)
- Max voltage drop across the divider: 16V
- Low noise: Typ. -15dB
- Passive device requires no power during operation
- Divider Power Rating up to 2.0mW at 70°C
- Operating Temperature Range -55°C to +125°C
- In-circuit adjustable at wafer, component, board or system level
- QFN 16-pin and SOIC 8-pin RoHS, Pb-free and Green package

eTC REJUSTOR BENEFITS

- Eliminates Quantization Errors and wiper resistance errors associated with digital potentiometers
- Eliminates laser trimming
- Non-Volatile "Set and Forget" adjustment. Requires no power during operation or storage
- Automated temperature compensation in the analog domain for circuits with temperature-induced error
- Null out the *cumulative temperature-sensitivities* of (all) other components in the system
- Adjustment system suitable for volume-production
- y=mx+b generator
  - Where m is TCR
  - x is temperature
  - b is offset

FUNCTIONAL BLOCK DIAGRAM

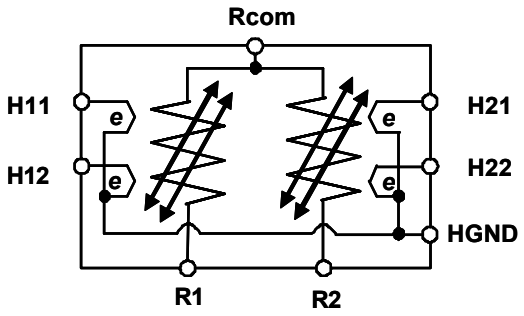


Figure 1: Functional Block Diagram. The Dual arrows represent the ability to independently adjust the resistor's ohmic value and TCR

[1] Limited by the reliability of plastic packaging at high temperature..

ELECTRICAL SPECIFICATIONS

Table 1: RATINGS – *Rejustors* 0°C < T_A < +70°C; unless otherwise noted

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Rated Power	Per Divider		2.0		mW
Operating Temperature (T_A)	As specified in this datasheet	0		+70	°C
	As specified in Application Note APP21 - *"**Rejustor** Operating Guidelines for -55 to +125°C Operation"*	-55		+125	°C
	Beyond -55 to +125°C	Contact Microbridge			
Isolation Voltage	Between any pins. Subject to power limits		80		V
Relative self-heating change in resistance	When both ***Rejustors*** carry the same current			0.4	%
Nominal Resistance	***Rejustor 1 (R1)***		14		KΩ
	Rejustor 2 (R2)		126		KΩ
Resistance Tolerance	T_A=+25°C, prior to any trimming	-10		+10	%
Resistance adjustment range	Each Rejustor value can be adjusted downward	40			%
Ratio Adjustment Range	Ratio = R2/R1 (see Figs 4,5 for details)	5.4		15	-
TC-Ratio Adjustment Range	Relative TC between two Rejustors (see Figs 4,5)	-500		+500	ppm/K
Resistance Ratio Tolerance	As-manufactured, unadjusted divider Ratio = R2/R1 (i.e. 1.03:1)	-3		+3	%
Divider TCR Match	As-manufactured, unadjusted divider	-40		+40	ppm/K
Offset Adjustment Range	Refer to Figure 4 and 5 for details	-40		+40	mV/V
TC-Offset Adjustment Range	Refer to Figure 4 and 5 for details	-60		+60	µV/VK
Offset adjustment precision	With adjustment feedback measurement directly related to divider output voltage.		±1		mV/V[2]
TC-Offset adjustment precision	Assuming two TC measurements and adjustment feedback measurement directly related to divider output voltage.		±5		µV/VK
Adjustment Time			1-5		sec[3]
Thermal Time Constant QFN SOIC	Package to die. Does not include board to package thermal delay. Refer to Figure 2 Refer to Figure 3	Time to achieve 62% of final value 1.7s for 100°C ?Temperature 3.2s for 100°C ?Temperature			

Table 2: RELIABILITY DATA

Characteristics	Limit	Test Method or Conditions
Thermal Shock/ Cycling	±1mV/V[4]	JESD22-A104, -65°C to 125°C, 1000 cycles at 2 cycles/hour
High Temperature Exposure (long-term stability)	±1mV/V	JESD22-A103 150°C, 1000hrs
Humidity and Moisture Resistance	±1mV/V	JESD22-A101, 85% RH, 85°C, 1000hrs
Operational Life Test	±1mV/V	JESD22-A108, 125°C, 1000 hrs., static operation at rated power, by analysis
Shock	± 0.3mV/V	500G, 1ms duration, X,Y,Z axes each 5 shocks
Vibration, High Frequency	± 0.3mV/V	Max acceleration 20G, 20~2000~20Hz, 8 min, X,Y,Z each 4 sweeps

[2] Adjustment precision is limited by temperature control, accuracy of measurement and adjustment equipment and may increase adjustment time.

[3] Using Microbridge's scalable production-calibration hardware (based on the NI-DAQ platform from National Instruments) and Rejust-it software, multiple units can be calibrated simultaneously during roughly the same amount of time.

[4] Resistance drifts in a positive direction. Best stability is achieved at adjustments at least 10% down from the as-manufactured resistance.

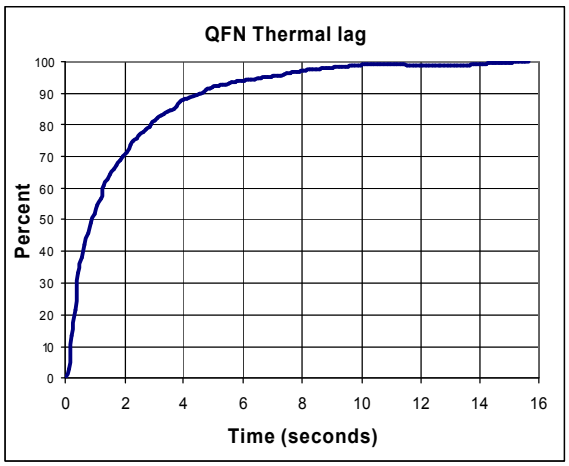


Figure 2: QFN Thermal Response Time 100°C Temperature Change

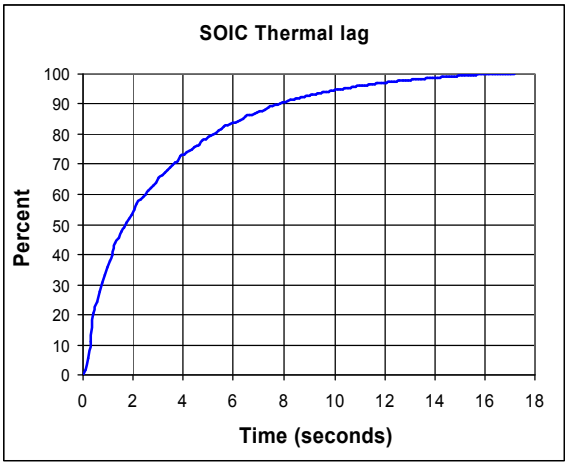


Figure 3: SOIC Thermal Response Time 100°C Temperature Change

Table 3: PACKAGE ELECTRICAL CHARACTERISTICS

Characteristics	Specification (Typical)	Test Method or Conditions
SOIC Capacitive Loading	1.0pF	Per package pin, by analysis at 100MHz
SOIC Mutual Capacitance	0.1pF	By analysis at 100MHz
QFN Capacitive Loading	0.7pF	Per package pin, by analysis at 100MHz
QFN Mutual Capacitance	0.1pF	By analysis at 100MHz

Table 4: MANUFACTURABILITY DATA

Characteristics	Test Method or Conditions
ESD Discharge	JESD22-A114, human body model weakest pin pair, all lead combinations. Class 1A
Solder ability	J-STD-020C, MSL1, 260°C convection reflow for SOIC-8 and QFN-16 packages

PACKAGING OPTIONS

Table 5: NOMINAL PACKAGE DIMENSIONS

Type	Lead Count	Body Width	Body Length	Lead Form	Tip to Tip	Body Thickness	Standoff	Overall Height	JEDEC/ EIAJ
SOIC	8	3.9mm	4.89mm	0.4mm	6.0mm	1.47mm	0.175mm	1.62mm	MS-012

Type	Lead Count	Body Width	Body Length	Lead Pitch	Lead Width	Lead Length	Body Thickness	JEDEC/ EIAJ
QFN	16	3.0mm	3.0mm	0.5mm	0.25mm	0.4mm	0.85mm	MO-220

ORDERING INFORMATION

Table 6: ORDERING INFORMATION

Part Number	Order Code	Package	Part Marking[5]	Delivery	Quantity
MBT-143-E	112T	SOIC-8	112T-ZZZZ	Tape and Reel	3000[6]
MBT-143-E	112P	QFN-16	112P-ZZZZ	Tape and Reel	3000[7]

[5] Where ZZZZ represents the 4-digit date code
[6] Sample quantities are available in tubes
[7] Smaller sample quantities available on tape

ACTIVE ADJUSTMENT RANGE

The active adjustment range is shown in the 2-dimensional plots below. Offset is defined as the deviation of the output voltage from the nominal output voltage for unadjusted ***Rejustors***.

For a 1:9 divider the nominal output voltage is 900mV/V.

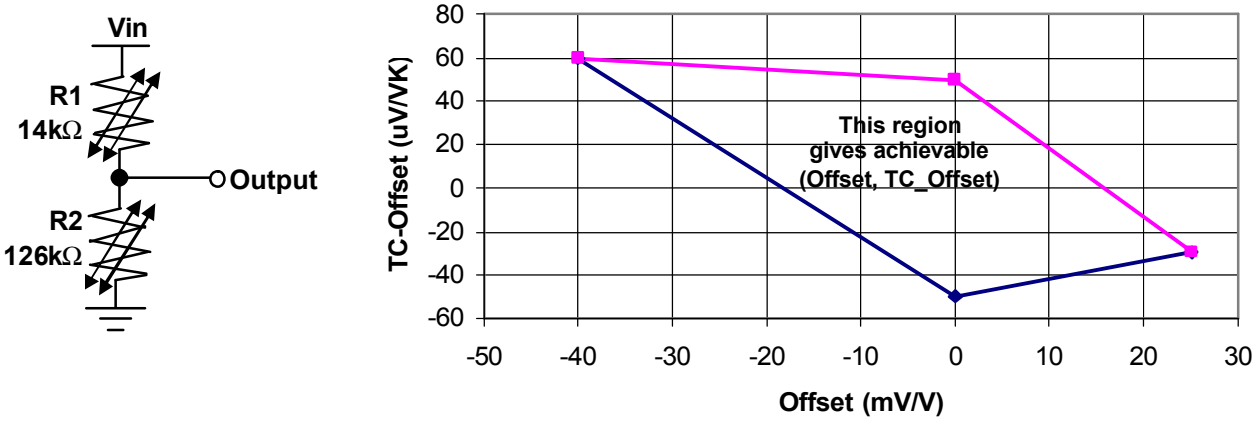


Figure 4: eTC Divider: 1:9 Region of achievable values (Offset and TC-Offset),

For a 9:1 divider the nominal output voltage is 100mV/V.

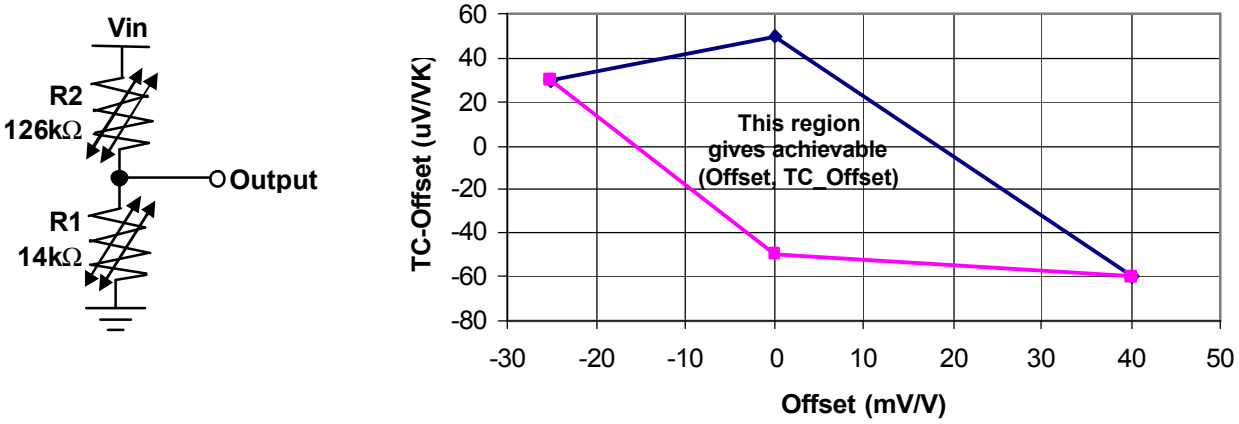


Figure 5: eTC Divider: 9:1 Region of achievable trim values (Offset and TC-Offset),

eTC *REJUSTOR* EXAMPLES

The chart in Figure 6 provides several examples of the output offset and temperature response that can be achieved with the ***eTC Rejustor*** divider. An infinite number of combinations are achievable with the same ***Rejustor*** divider adjusted to different output parameters including the five examples shown below. Output offset voltage is shown as a function of temperature where the initial offset is specified at 20°C.

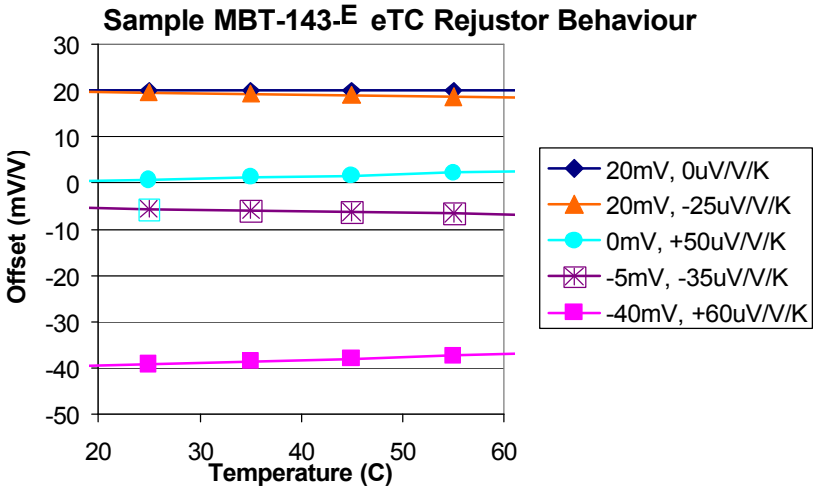


Figure 6: Example eTC *Rejustor* Response

APPLICATION EXAMPLES

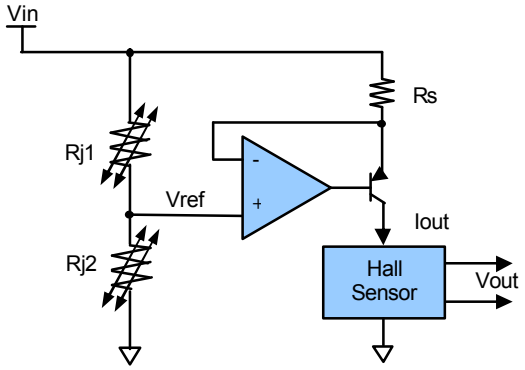


Figure 7: Hall-effect Sensor Application Circuit

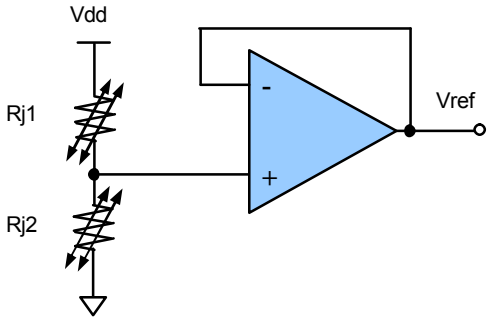


Figure 8: Buffered Divider

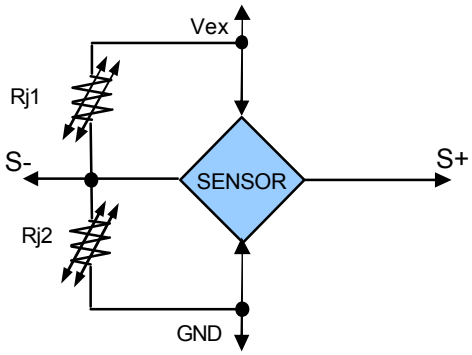


Figure 9: Simple *eTC Rejustor* Compensation for a Wheatstone Bridge Sensor

APPLICATION EXAMPLES (CONTINUE)

Rejustor Compensation of Analog Device ADR-425 Voltage Reference

Figure 10(a) shows the simplified block diagram of ADR-425 voltage reference with Microbridge eTC Rejustor divider MBT-143E. The measured results of the output reference voltage versus temperature are shown in Figure 10(b). As shown from the results, the TC performance of the output reference voltage can be significantly improved with the temperature compensation of eTC Rejustors. Please contact Microbridge for more details of this specific application.

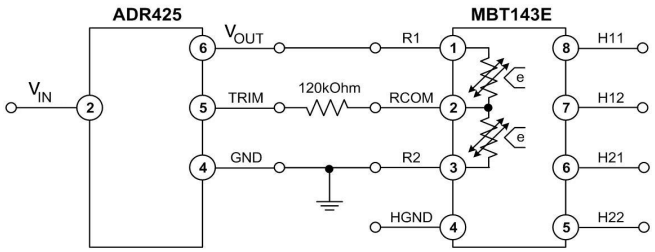


Fig. 10 (a) Simplified Block Diagram of ADR-425 Voltage Reference with MBT-143E eTC Rejustors

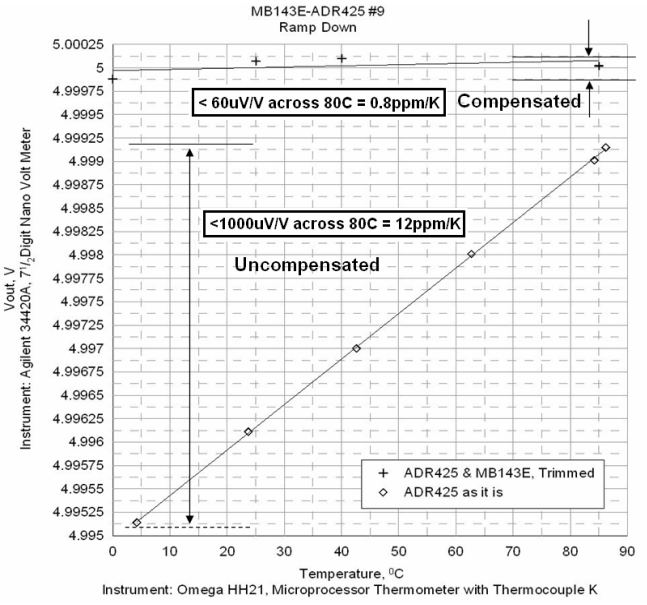


Fig. 10 (b) Measured Output Reference Voltage versus Temperature of ADR425 with and without Rejustor Compensation.

FUNCTIONAL DESCRIPTION

Microbridge ***Rejustors*** with ***eTC*** represent a technology revolution in adjustment and temperature compensation for precision electronic systems. Each ***Rejustor*** within the divider allows independent, precision adjustment of resistance and temperature response. The ***eTC Rejustor*** Divider responds as described in the 2-dimensional diagram in figure 4 and 5 when configured as a voltage divider.

An ***eTC Rejustor*** divider allows adjustment of the divider output voltage away from its initial output voltage ("Offset" in mV per Volt applied to the top of the divider), and at the same time allows independent adjustment of the temperature coefficient of the output voltage ("TC-Offset" in µV per degree Kelvin per volt applied to the divider). In this way, a temperature-conditioned voltage divider is obtained.

eTC Rejustor dividers can be adjusted in-circuit to generate a resistance ratio and temperature profile to compensate temperature and offset sensitive devices. The resistance of each ***eTC Rejustor*** is adjusted to correct for manufacturing variance in the uncompensated circuit. In addition, the ***Rejustor's*** temperature response is adjusted to counteract the temperature coefficients of the uncompensated circuit. In other words the ***Rejustor*** is adjusted in-circuit to compensate for offset and cumulative temperature drift of all the components within the circuit.

eTC Rejustor dividers are used in-circuit in places where offset and temperature drift correction are required. The application examples, above, demonstrate samples where the output from the divider controls the performance of the overall circuit. During the calibration process, the ***eTC Rejustor*** divider is connected to the low-cost MBK-408A ***Rejustor*** Calibration Tool, or equivalent hardware[8]. The Calibration tool provides the electrical connections to monitor the circuit output behavior and drive power into the auxiliary pins of the ***Rejustor***. Power applied to the auxiliary pins controls the heating and cooling process

[8] Using Microbridge's scalable production-calibration hardware (based on the NI-DAQ platform from National Instruments) and Rejust-it software, multiple units can be calibrated simultaneously during roughly the same amount of time for high-volume applications.

which in-turn changes the resistance and TCR of the divider. Refer to Figure 11 for a sample connection between the calibration tool and the MBT-143-E. Connection to the calibration tool is only required during adjustment.

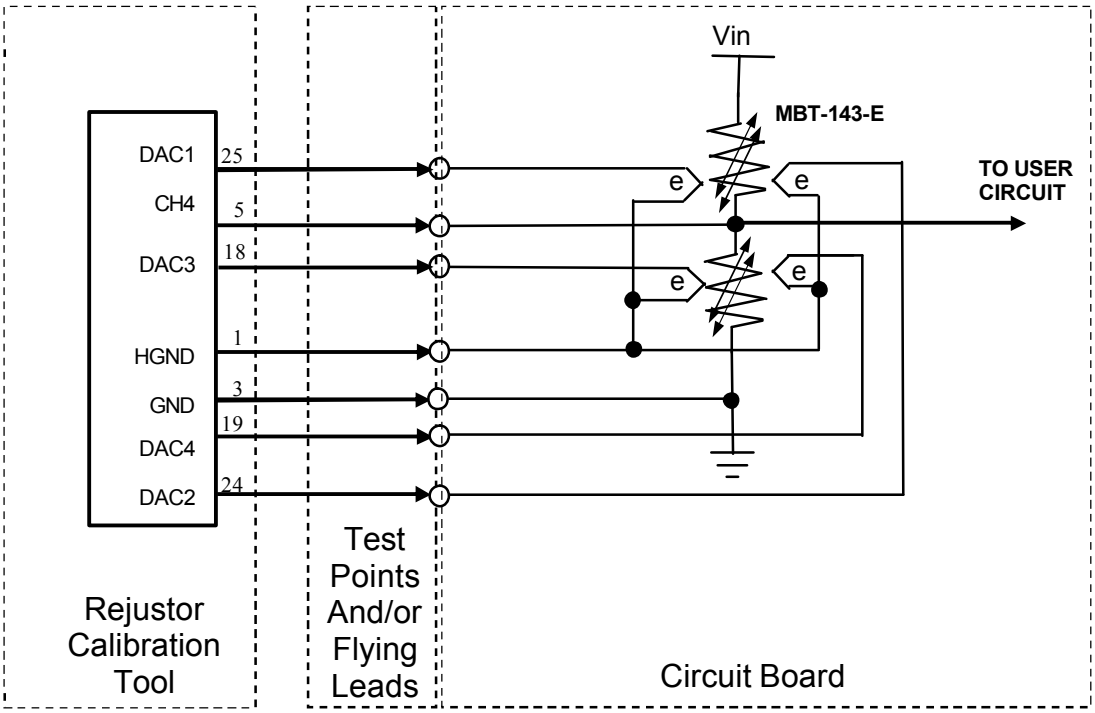


Figure 11: Rejustor Hardware Connection

Rejust-it software, provided with the ***Rejustor*** Calibration Tool as LabVIEW-based executable, controls the adjustment process using the ***Rejustor*** Calibration Tool in a closed-loop feedback system. ***Rejustors*** are automatically adjusted to the target offset and TCR values, as specified. Typically the overall drift of the circuit is measure (using two data points; cool and hot) and entered into Rejust-it. The ***Rejustor*** Calibration tool measures the offset prior to adjustment. Normally the targets are 0 offset and 0 TC-Offset (although different targets are also valid). A 1-5-second sequence of electrical heating pulses, governed by Microbridge's proprietary algorithms, is enough to fine-tune the material properties.

After adjustment, the circuit is disconnected from the ***Rejustor*** Calibration tool. The ***Rejustor*** does not require active power to maintain its adjusted resistance and TCR. The material properties of the ***Rejustor*** are altered to affect the current flow, which means the resistance is changed. ***eTC Rejustors*** are intended for set-and-forget applications that involve factory calibration. The devices can be adjusted dozens-of-times, as required for periodic maintenance.

The resistive element is electrically isolated from both substrate and auxiliary (heater) pins and can therefore float, electrically.

Compensated ***eTC Rejustors*** are highly stable and provide fast temperature response. Once adjusted, ***eTC Rejustors*** retain their electrical and temperature performance characteristics indefinitely. ***Rejustors*** can be adjusted many times, bi-directionally without compromising stability or performance.

Microbridge ***Rejustors*** are an electrical replacement for mechanical compensation techniques. They replace manual trim pots, digital pots and laser trimming. ***eTC Rejustors*** replace compensation techniques using metals, such as aluminum, to provide temperature compensation. The Microbridge Technologies ***eTC Rejustor*** family of electrically adjustable micro-resistors can be matched to values for precision control of sensors, voltage regulators, amplifiers and other applications.

eTC Rejustor Dividers are available in compact QFN 16-pin and SOIC 8-pin packages.

PIN CONFIGURATION

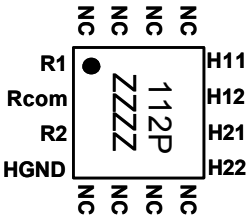


Figure 12: Pin-out
16-lead QFN package

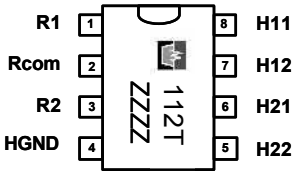


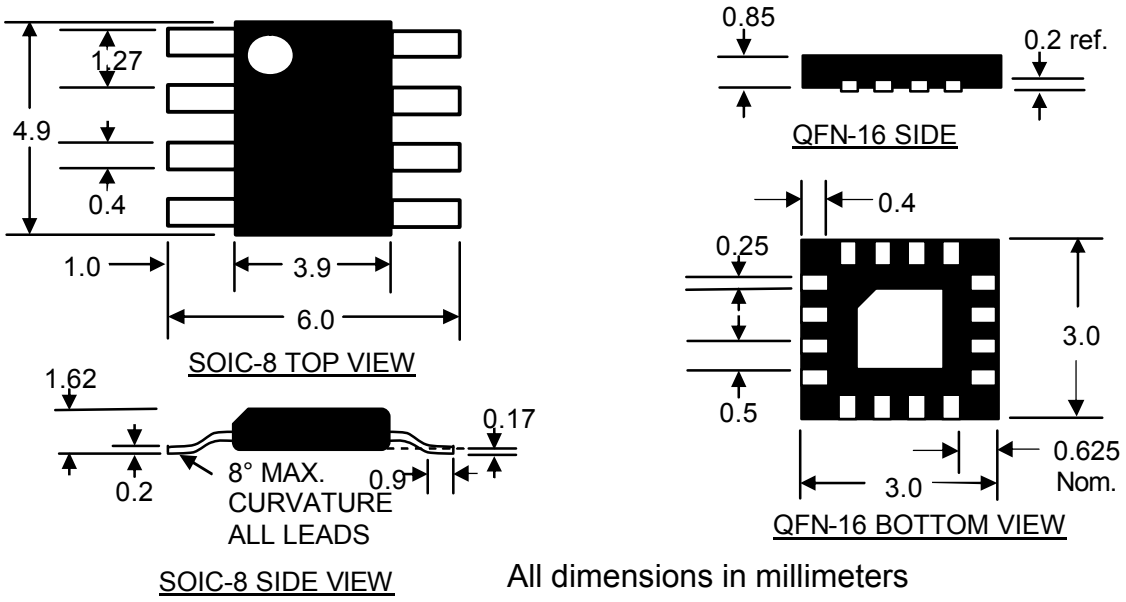
Figure13: Pin-out
8-pin SOIC package

PIN FUNCTIONAL DESCRIPTIONS

Table 7: MBT-143-E Pin Function Descriptions

Mnemonic	Description	*eTC Rejustor QFN Pin No.*	*eTC Rejustor SOIC Pin No.*
R1	*Rejustor* 1 Terminal	1	1
Rcom	*Rejustor* Divider Center	2	2
R2	*Rejustor* 2 Terminal	3	3
HGND	Adjustment Ground	4	4
H22	*Rejustor* 2 Adjustment Input 2	9	5
H21	*Rejustor* 2 Adjustment Input 1	10	6
H12	*Rejustor* 1 Adjustment Input 2	11	7
H11	*Rejustor* 1 Adjustment Input 1	12	8
NC	No connect	5, 6, 7, 8, 13, 14, 15, 16	

PACKAGING INFORMATION



All dimensions in millimeters

Figure 14: Package Dimensions

TAPE CARRIER PACKAGING

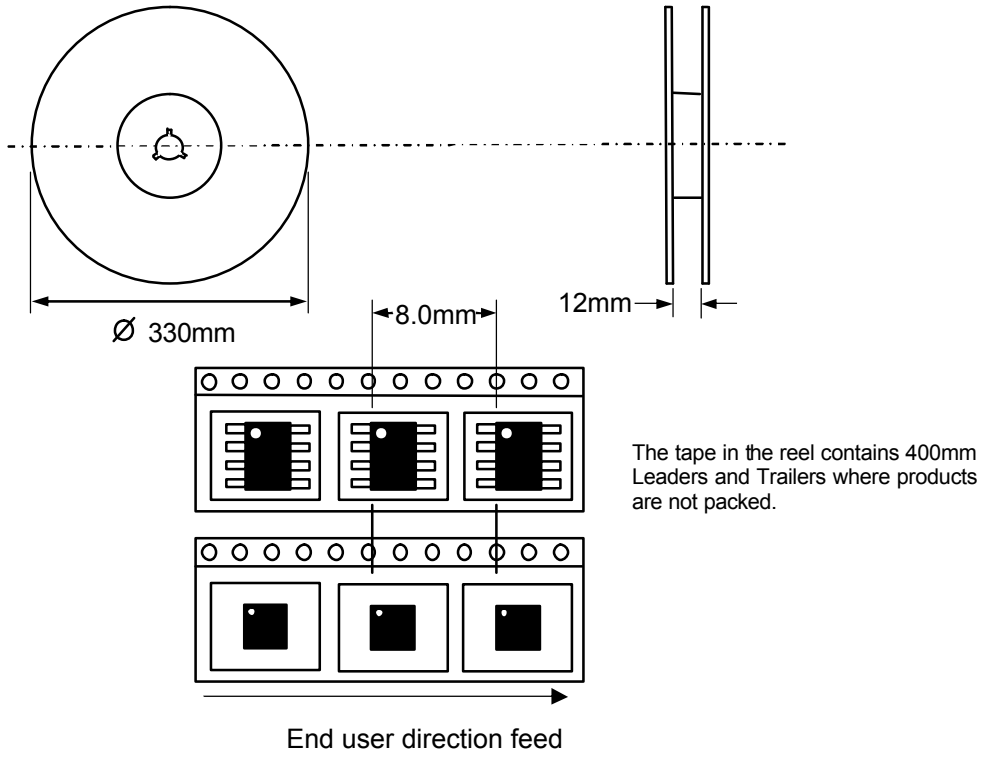


Figure 15: Tape Carrier Dimensions

Please check with Microbridge Technologies Inc prior to design to ensure you have the latest revision of the datasheet for this part.