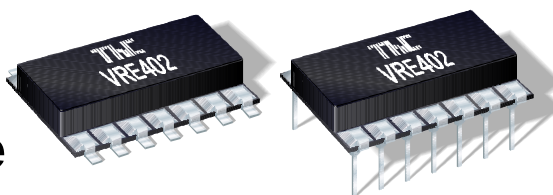




VRE402

Precision Dual Reference



THALER CORPORATION • 2015 N. FORBES BOULEVARD • TUCSON, AZ. 85745 • (520) 882-4000

FEATURES

- $\pm 2.500\text{ V OUTPUT} \pm 0.250\text{ mV} (.01\%)$
- **TEMPERATURE DRIFT: $0.6\text{ ppm}/^\circ\text{C}$**
- **LOW NOISE: $1.5\mu\text{V}_{\text{pp}}$ (0.1-10Hz)**
- **TRACKING ERROR: 0.2 mV max.**
- **EXCELLENT LINE REGULATION: 6 ppm/V Typ.**
- **SURFACE MOUNT AND DIP PACKAGES**

PIN CONFIGURATION

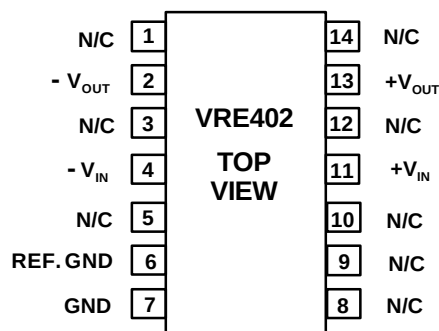


FIGURE 1

DESCRIPTION

The VRE402 is a low cost, high precision, $\pm 2.5\text{V}$ reference. Packaged in 14 pin DIP or SMT packages, the device is ideal for new designs that need a high performance reference.

The device provides ultrastable $\pm 2.500\text{V}$ output with $\pm 0.250\text{ mV} (.01\%)$ initial accuracy and a temperature coefficient of $0.6\text{ ppm}/^\circ\text{C}$. This improvement in accuracy is made possible by a unique, patented multipoint laser compensation technique developed by Thaler Corporation.

Another key feature of this reference is the 0.3 mV maximum tracking error between the positive and negative output voltages over the operating temperature range. This is extremely important in high performance systems for reducing overall system errors.

For designs which use the DIP package in a socket, there is a reference ground pin to eliminate reference ground errors.

The VRE402 is recommended for use as a reference for high precision A/D and D/A converters which require an external precision reference. The device is ideal for calibrating scale factor on high resolution A/D converters. The VRE402 offers superior performance over monolithic references.

SELECTION GUIDE

Model	Initial Error mV	Temp. Coeff. ppm/ $^\circ\text{C}$	Temp. Range $^\circ\text{C}$
VRE402A	0.25	0.6	0°C to $+70^\circ\text{C}$
VRE402B	0.40	1.0	0°C to $+70^\circ\text{C}$
VRE402C	0.50	2.0	0°C to $+70^\circ\text{C}$
VRE402J	0.25	0.6	-40°C to $+85^\circ\text{C}$
VRE402K	0.40	1.0	-40°C to $+85^\circ\text{C}$
VRE402L	0.50	2.0	-40°C to $+85^\circ\text{C}$

For package option add D for DIP or S for Surface Mount to end of model number.

ELECTRICAL SPECIFICATIONS

VRE402

Vps = ±15V, T = 25°C, RL = 10KΩ unless otherwise noted.

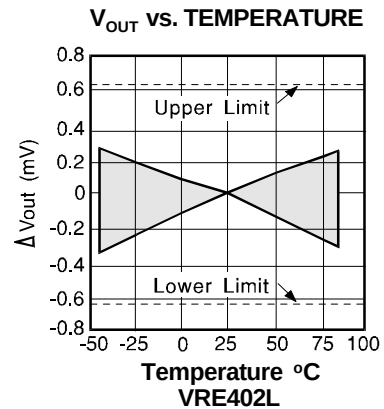
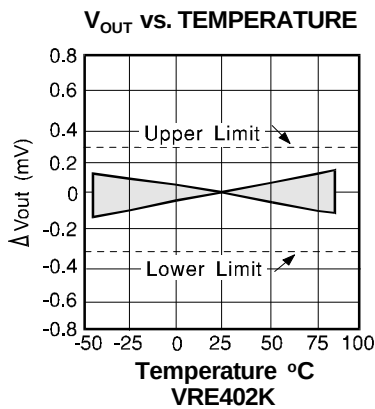
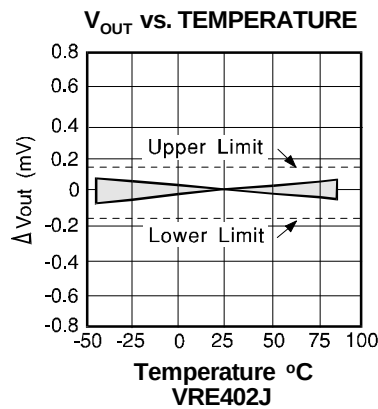
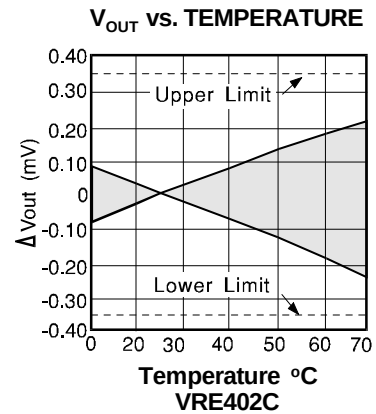
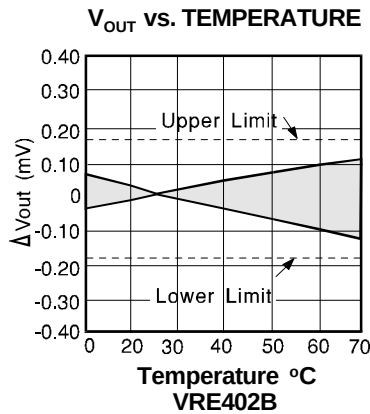
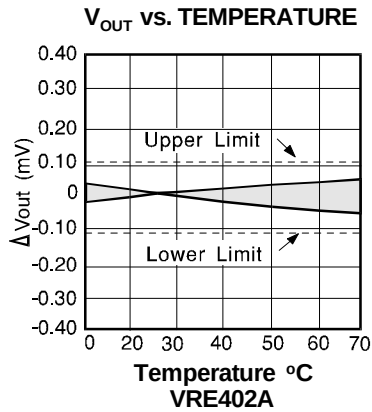
MODEL	A/J			B/K			C/L				
PARAMETER	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS	
ABSOLUTE RATINGS											
Power Supply	±13.5	±15	±22	*	*	*	*	*	*	V	
Operating Temp. (A,B,C)	0		+70	*	*	*	*	*	*	°C	
Operating Temp. (J,K,L)	-40		+85	*	*	*	*	*	*	°C	
Storage Temperature	-65		+150	*	*	*	*	*	*	°C	
Short Circuit Protection	Continuous				*			*			
OUTPUT VOLTAGE											
VRE402		±2.5			*			*		V	
OUTPUT VOLTAGE ERRORS											
Initial Error ⁽¹⁾		1	0.25		2	0.40		3	0.50	mV	
Warmup Drift											
T _{min} - T _{max} ⁽²⁾			0.6				1.0			2.0	ppm
Tracking Error ⁽³⁾			0.2			0.3			0.4	ppm/°C	
Long-Term Stability		6			*			*		mV	
Noise (.1-10Hz)		1.5			*			*		ppm/1000hrs	
OUTPUT CURRENT											
Range	±10			*			*			μVpp	
REGULATION											
Line		3	10		*	*		*	*	ppm/V	
Load		3			*			*		ppm/mA	
POWER SUPPLY CURRENTS ⁽⁴⁾											
+PS		7	9		*	*		*	*	mA	
-PS		4	6		*	*		*	*	mA	

NOTES: *Same as A/J Models.

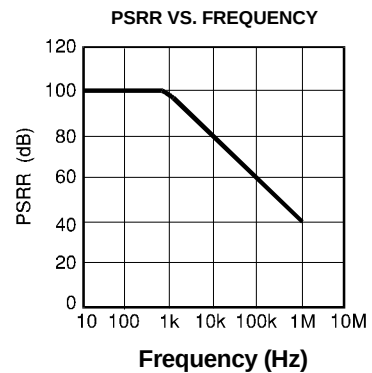
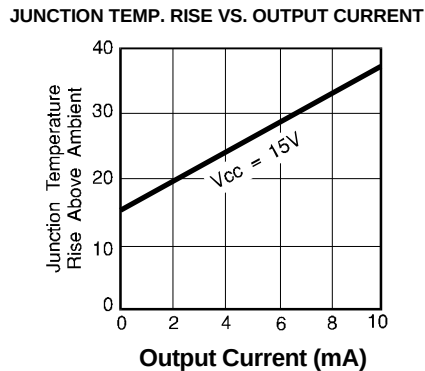
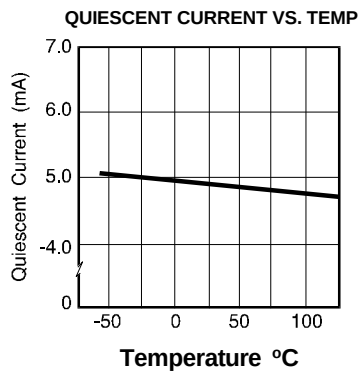
- The specified values are without external trim.
- The temperature coefficient (tc) is determined by the box method using the following formula:
- The tracking error is the deviation between the positive and negative output over the operating temp. range.
- The specified values are unloaded.

$$tc = \frac{V_{max} - V_{min}}{V_{nominal} \times (T_{max} - T_{min})} \times 10^6$$

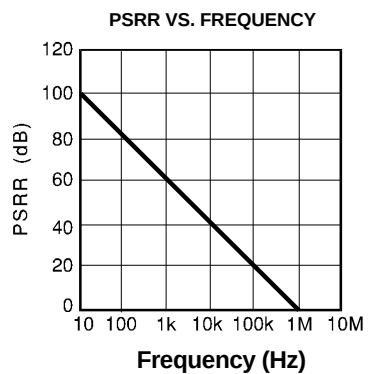
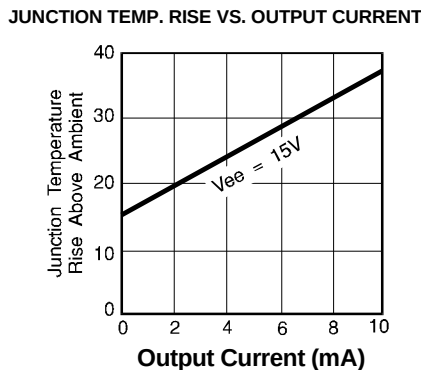
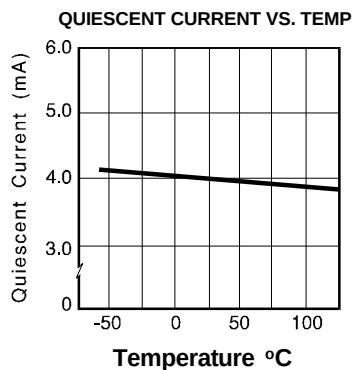
TYPICAL PERFORMANCE CURVES



----- POSITIVE OUTPUT (TYP) -----



----- NEGATIVE OUTPUT (TYP) -----



DISCUSSION OF PERFORMANCE

THEORY OF OPERATION

The following discussion refers to the schematic in figure 2 below. A FET current source is used to bias a 6.3V zener diode. The zener voltage is divided by the resistor network R1 and R2. This voltage is then applied to the noninverting input of the operational amplifier which amplifies the voltage to produce a 2.500V output. The gain is determined by the resistor networks R3 and R4: $G=1 + R4/R3$. The 6.3V zener diode is used because it is the most stable diode over time and temperature.

The current source provides a closely regulated zener current, which determines the slope of the references' voltage vs. temperature function. By trimming the zener current a lower drift over temperature can be achieved. But since the voltage vs. temperature function is nonlinear this compensation technique is not well suited for wide temperature ranges.

Thaler Corporation has developed a nonlinear compensation network of thermistors and resistors that is used in the VRE series voltage references. This proprietary network eliminates most of the nonlinearity in the voltage vs. temperature function. By adjusting the slope, Thaler Corporation produces a very stable voltage over wide temperature ranges.

This network is less than 2% of the overall network resistance so it has a negligible effect on long term stability.

The VRE402 reference has its ground brought out on two pins (pin 6 and 7) which are connected internally. This allows the user to achieve greater accuracy when using a socket. Voltage references have a voltage drop across their power supply ground pin due to quiescent current flowing through the contact resistance. If the contact resistance was constant with time and temperature, this voltage drop could be trimmed out. When the reference is plugged into a socket, this source of error can be as high as 20ppm. By connecting pin 7 to the power supply ground and pin 6 to a high impedance ground point in the measurement circuit, the error due to the contact resistance can be eliminated. If the unit is soldered into place, the contact resistance is sufficiently small that it does not effect performance.

VRE402

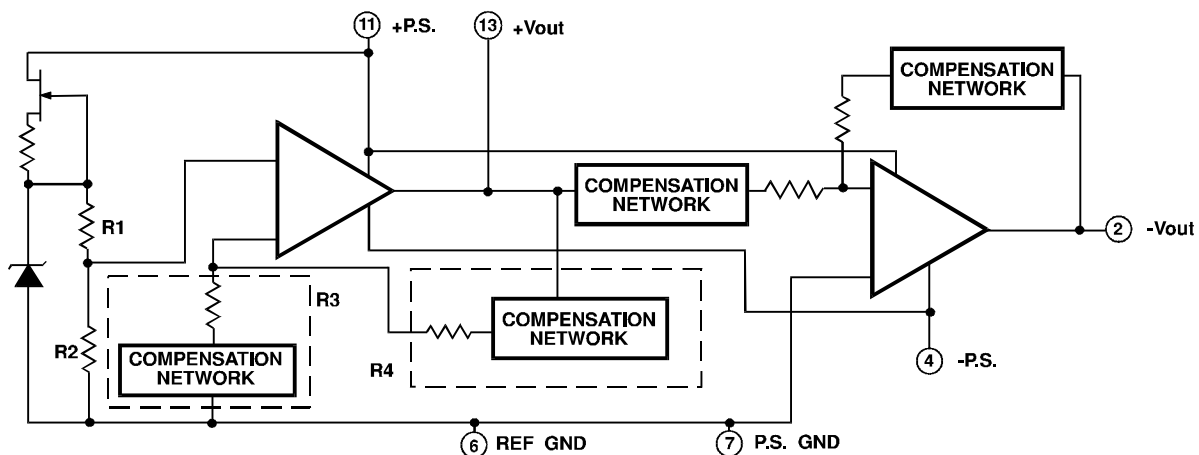
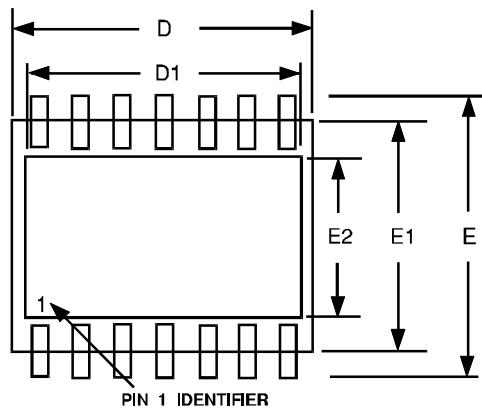


FIGURE 2

MECHANICAL

FIGURE 3



	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.495	.526	12.5	13.3
B	.098	.103	2.48	2.62	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
C	.103	.118	2.62	3.00	P	.090	.110	2.29	2.79
C1	.009	.020	0.22	0.51	Q	.024	.035	0.61	.890
C2	.054	.062	1.37	1.57	S	.040	.060	1.02	1.52
D	.690	.715	17.5	18.1					
D1	.666	.680	16.9	17.2					

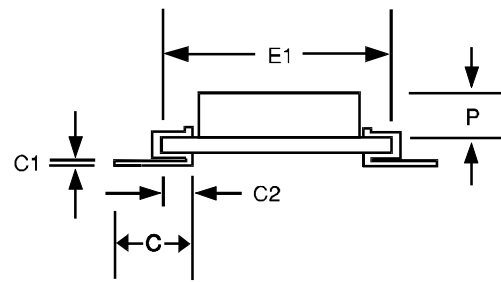
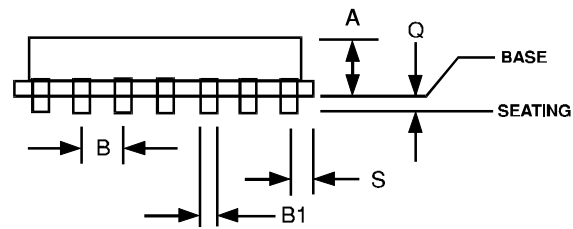
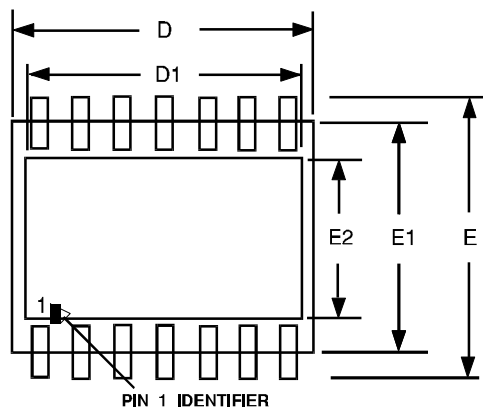
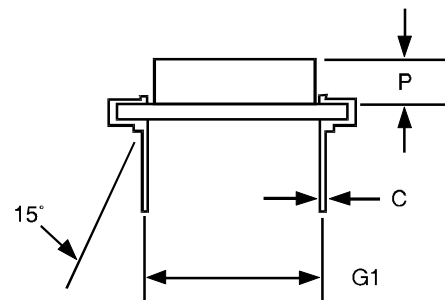
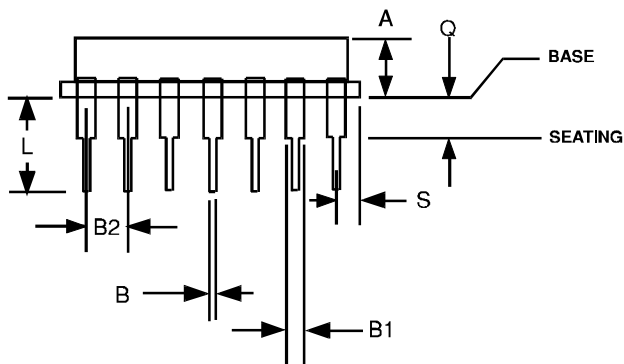


FIGURE 4



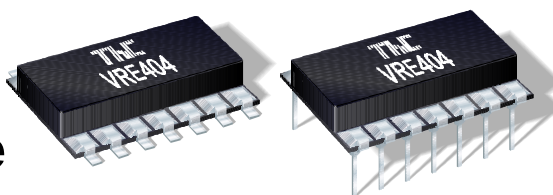
	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.410	.435	10.4	11.0
B	.018	.027	.460	.690	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
B2	.097	.103	2.46	2.62	G1	.285	.315	7.24	8.00
C	.009	.020	0.22	0.51	L	.195	.225	4.95	5.72
D	.690	.715	17.5	18.1	P	.090	.110	2.29	2.79
D1	.666	.680	16.9	17.2	Q	.050	.070	1.27	1.79
					S	.040	.060	1.02	1.52





VRE404

Precision Dual Reference



THALER CORPORATION • 2015 N. FORBES BOULEVARD • TUCSON, AZ. 85745 • (520) 882-4000

FEATURES

- ± 4.500 V OUTPUT ± 0.400 mV (.01%)
- TEMPERATURE DRIFT: 0.6 ppm/°C
- LOW NOISE: $3\mu\text{V}_{\text{pp}}$ (0.1-10Hz)
- TRACKING ERROR: 0.3 mV max.
- EXCELLENT LINE REGULATION: 6ppm/V Typ.
- SURFACE MOUNT AND DIP PACKAGES

PIN CONFIGURATION

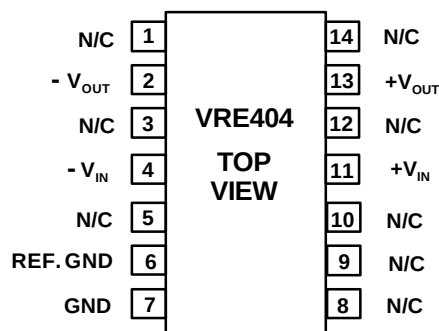


FIGURE 1

DESCRIPTION

The VRE404 is a low cost, high precision, ± 4.5 V reference. Packaged in 14 pin DIP or SMT packages, the device is ideal for new designs that need a high performance reference.

The device provides ultrastable ± 4.500 V output with ± 0.450 mV (.01%) initial accuracy and a temperature coefficient of 0.6 ppm/°C. This improvement in accuracy is made possible by a unique, patented multipoint laser compensation technique developed by Thaler Corporation.

Another key feature of this reference is the 0.3 mV maximum tracking error between the positive and negative output voltages over the operating temperature range. This is extremely important in high performance systems for reducing overall system errors.

For designs which use the DIP package in a socket, there is a reference ground pin to eliminate reference ground errors.

The VRE404 is recommended for use as a reference for high precision D/A and A/D converters which require an external precision reference. The device is ideal for calibrating scale factor on high resolution A/D converters. The VRE404 offers superior performance over monolithic references.

SELECTION GUIDE

Model	Initial Error mV	Temp. Coeff. ppm/°C	Temp. Range °C
VRE404A	0.45	0.6	0°C to +70°C
VRE404B	0.70	1.0	0°C to +70°C
VRE404C	0.90	2.0	0°C to +70°C
VRE404J	0.45	0.6	-40°C to +85°C
VRE404K	0.70	1.0	-40°C to +85°C
VRE404L	0.90	2.0	-40°C to +85°C

For package option add D for DIP or S for Surface Mount to end of model number.

ELECTRICAL SPECIFICATIONS

VRE404

Vps = ±15V, T = 25°C, RL = 10KΩ unless otherwise noted.

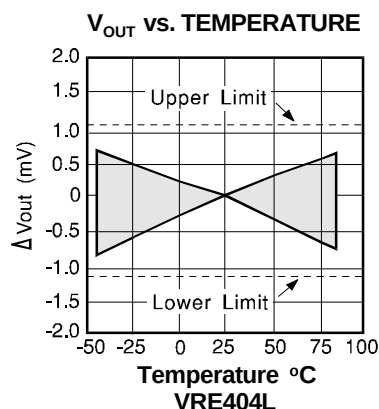
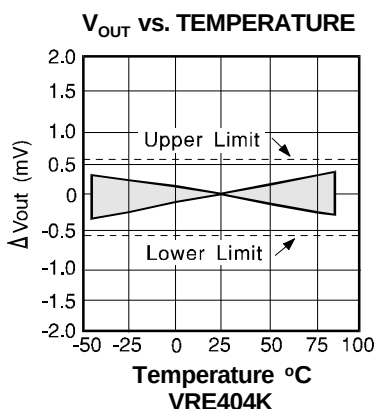
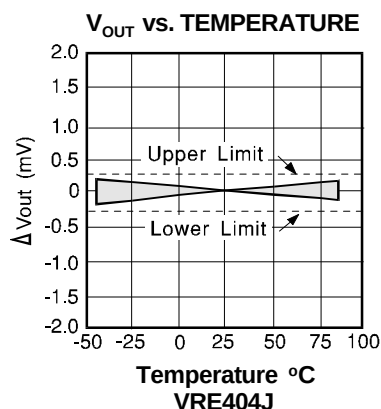
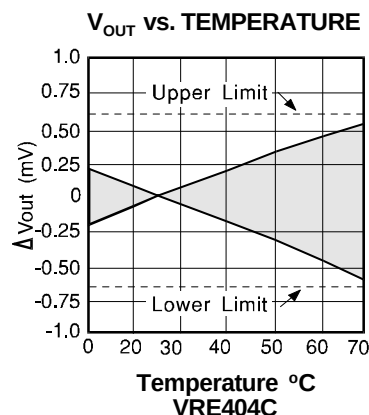
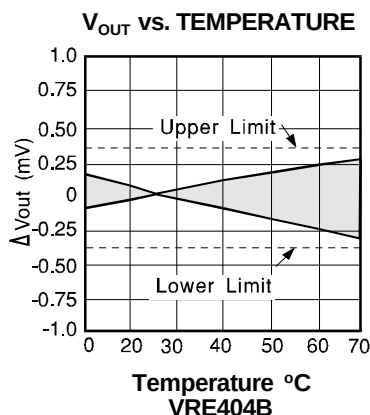
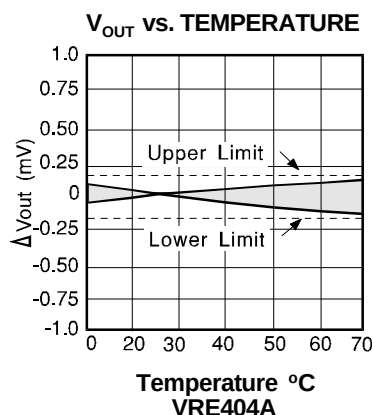
MODEL	A/J			B/K			C/L				
PARAMETER	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS	
ABSOLUTE RATINGS											
Power Supply	±13.5	±15	±22	*	*	*	*	*	*	V	
Operating Temp. (A,B,C)	0		+70	*	*	*	*	*	*	°C	
Operating Temp. (J,K,L)	-40		+85	*	*	*	*	*	*	°C	
Storage Temperature	-65		+150	*	*	*	*	*	*	°C	
Short Circuit Protection	Continuous				*			*			
OUTPUT VOLTAGE											
VRE404		±4.5			*			*		V	
OUTPUT VOLTAGE ERRORS											
Initial Error ⁽¹⁾		1	0.45		2	0.70		3	0.90	mV	
Warmup Drift											ppm
T _{min} - T _{max} ⁽²⁾			0.6			1.0			2.0	ppm/°C	
Tracking Error ⁽³⁾			0.3			0.4			0.5	mV	
Long-Term Stability		6			*			*		ppm/1000hrs	
Noise (.1-10Hz)		3			*			*		μVpp	
OUTPUT CURRENT											
Range	±10			*			*			mA	
REGULATION											
Line		3	10		*	*		*	*	ppm/V	
Load		3			*			*		ppm/mA	
POWER SUPPLY CURRENTS ⁽⁴⁾											
+PS		7	9		*	*		*	*	mA	
-PS		4	6		*	*		*	*	mA	

NOTES: *Same as A/J Models.

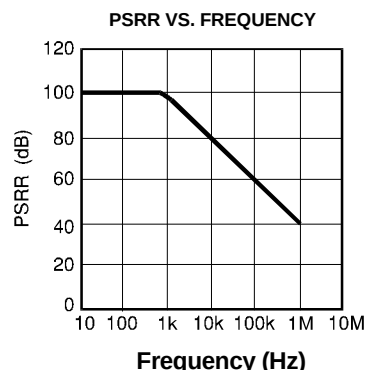
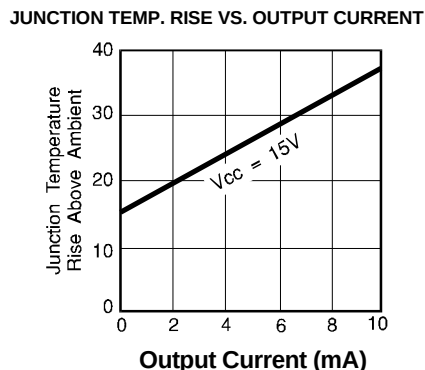
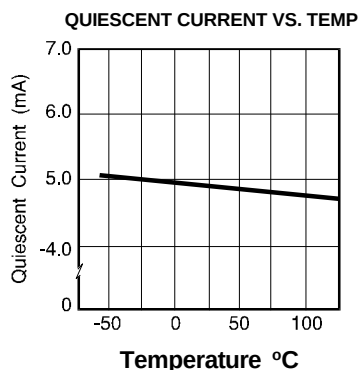
- The specified values are without external trim.
- The temperature coefficient (tc) is determined by the box method using the following formula:
- The tracking error is the deviation between the positive and negative output over the operating temp. range.
- The specified values are unloaded.

$$tc = \frac{V_{max} - V_{min}}{V_{nominal} \times (T_{max} - T_{min})} \times 10^6$$

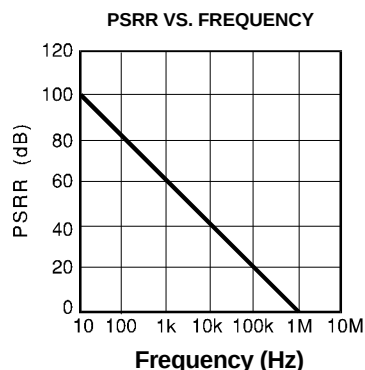
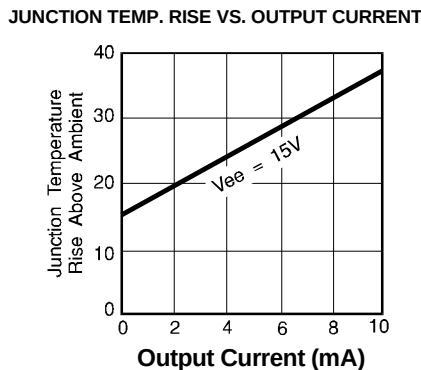
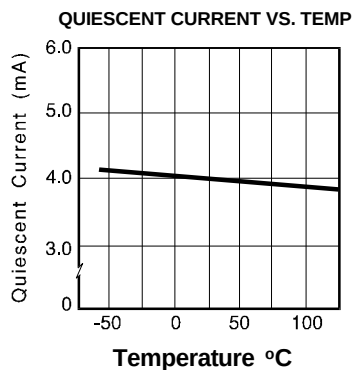
TYPICAL PERFORMANCE CURVES



----- POSITIVE OUTPUT (TYP) -----



----- NEGATIVE OUTPUT (TYP) -----



DISCUSSION OF PERFORMANCE

THEORY OF OPERATION

The following discussion refers to the schematic in figure 2 below. A FET current source is used to bias a 6.3V zener diode. The zener voltage is divided by the resistor network R1 and R2. This voltage is then applied to the noninverting input of the operational amplifier which amplifies the voltage to produce a 4.500V output. The gain is determined by the resistor networks R3 and R4: $G=1 + R4/R3$. The 6.3V zener diode is used because it is the most stable diode over time and temperature.

The current source provides a closely regulated zener current, which determines the slope of the references' voltage vs. temperature function. By trimming the zener current a lower drift over temperature can be achieved. But since the voltage vs. temperature function is nonlinear this compensation technique is not well suited for wide temperature ranges.

Thaler Corporation has developed a nonlinear compensation network of thermistors and resistors that is used in the VRE series voltage references. This proprietary network eliminates most of the nonlinearity in the voltage vs. temperature function. By adjusting the slope, Thaler Corporation produces a very stable voltage over wide temperature ranges.

This network is less than 2% of the overall network resistance so it has a negligible effect on long term stability.

The VRE404 reference has its ground brought out on two pins (pin 6 and 7) which are connected internally. This allows the user to achieve greater accuracy when using a socket. Voltage references have a voltage drop across their power supply ground pin due to quiescent current flowing through the contact resistance. If the contact resistance was constant with time and temperature, this voltage drop could be trimmed out. When the reference is plugged into a socket, this source of error can be as high as 20ppm. By connecting pin 7 to the power supply ground and pin 6 to a high impedance ground point in the measurement circuit, the error due to the contact resistance can be eliminated. If the unit is soldered into place, the contact resistance is sufficiently small that it does not effect performance.

VRE404

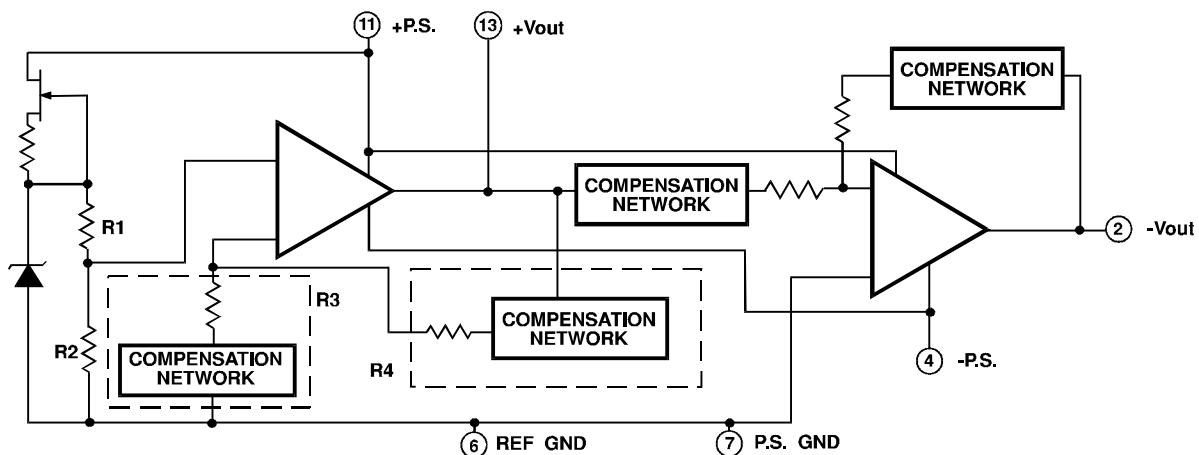
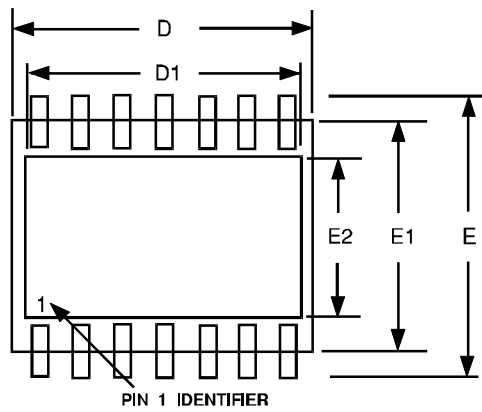


FIGURE 2

MECHANICAL

FIGURE 3



	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.495	.526	12.5	13.3
B	.098	.103	2.48	2.62	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
C	.103	.118	2.62	3.00	P	.090	.110	2.29	2.79
C1	.009	.020	0.22	0.51	Q	.024	.035	0.61	.890
C2	.054	.062	1.37	1.57	S	.040	.060	1.02	1.52
D	.690	.715	17.5	18.1					
D1	.666	.680	16.9	17.2					

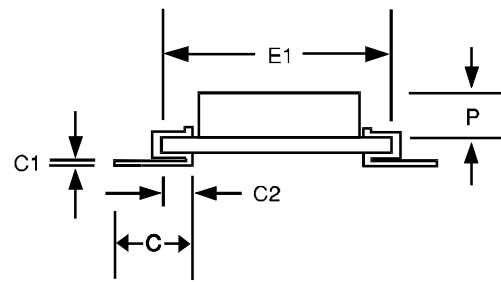
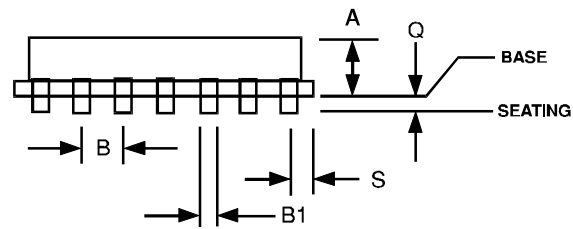
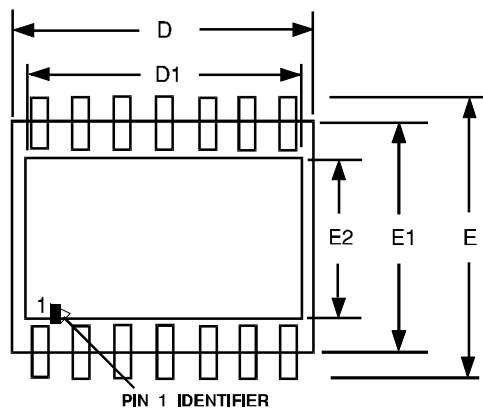
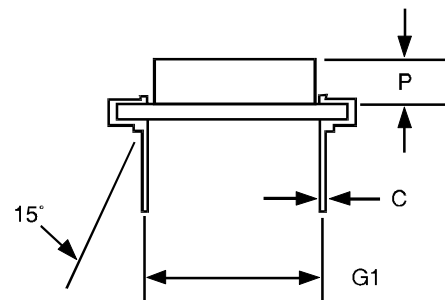
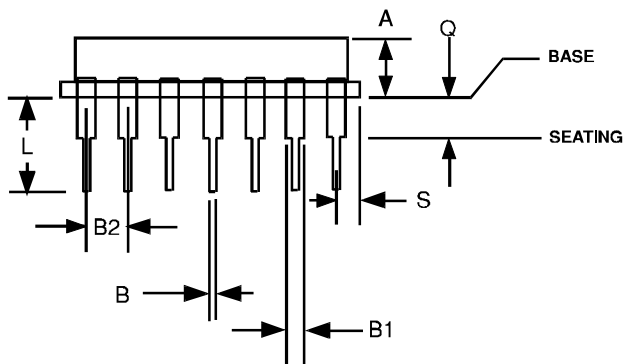


FIGURE 4

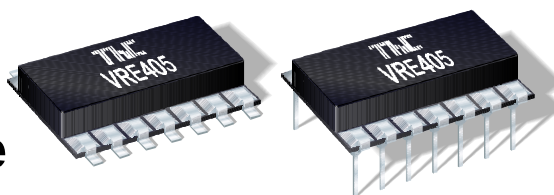


	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.410	.435	10.4	11.0
B	.018	.027	.460	.690	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
B2	.097	.103	2.46	2.62	G1	.285	.315	7.24	8.00
C	.009	.020	0.22	0.51	L	.195	.225	4.95	5.72
D	.690	.715	17.5	18.1	P	.090	.110	2.29	2.79
D1	.666	.680	16.9	17.2	Q	.050	.070	1.27	1.79
					S	.040	.060	1.02	1.52





VRE405 Precision Dual Reference



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FEATURES

- $\pm 5.000\text{ V}$ OUTPUT $\pm 0.500\text{ mV}$ (.01%)
- TEMPERATURE DRIFT: $0.6\text{ ppm}/^\circ\text{C}$
- LOW NOISE: $3\mu\text{V}_{\text{pp}}$ (0.1-10Hz)
- TRACKING ERROR: 0.3 mV max.
- EXCELLENT LINE REGULATION: 6 ppm/V Typ.
- SURFACE MOUNT AND DIP PACKAGES

PIN CONFIGURATION

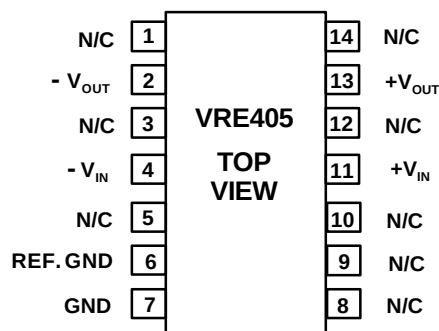


FIGURE 1

DESCRIPTION

The VRE405 is a low cost, high precision, $\pm 5.0\text{V}$ reference. Packaged in 14 pin DIP or SMT packages, the device is ideal for new designs that need a high performance reference.

The device provides ultrastable $\pm 5.000\text{V}$ output with $\pm 0.500\text{ mV}$ (.01%) initial accuracy and a temperature coefficient of $0.6\text{ ppm}/^\circ\text{C}$. This improvement in accuracy is made possible by a unique, patented multipoint laser compensation technique developed by Thaler Corporation.

Another key feature of this reference is the 0.3 mV maximum tracking error between the positive and negative output voltages over the operating temperature range. This is extremely important in high performance systems for reducing overall system errors.

For designs which use the DIP package in a socket, there is a reference ground pin to eliminate the reference ground errors.

The VRE405 is recommended for use as a reference for high precision D/A and A/D converters which require an external precision reference. The device is ideal for calibrating scale factor on high resolution A/D converters. The VRE405 offers superior performance over monolithic references.

SELECTION GUIDE

Model	Initial Error mV	Temp. Coeff. ppm/°C	Temp. Range °C
VRE405A	0.5	0.6	0°C to +70°C
VRE405B	0.8	1.0	0°C to +70°C
VRE405C	1.0	2.0	0°C to +70°C
VRE405J	0.5	0.6	-40°C to +85°C
VRE405K	0.8	1.0	-40°C to +85°C
VRE405L	1.0	2.0	-40°C to +85°C

For package option add D for DIP or S for Surface Mount to end of model number.

ELECTRICAL SPECIFICATIONS

VRE405

Vps = ±15V, T = 25°C, RL = 10KΩ unless otherwise noted.

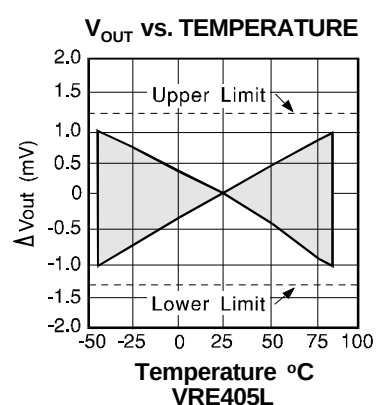
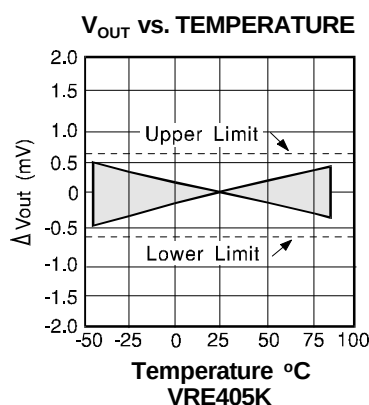
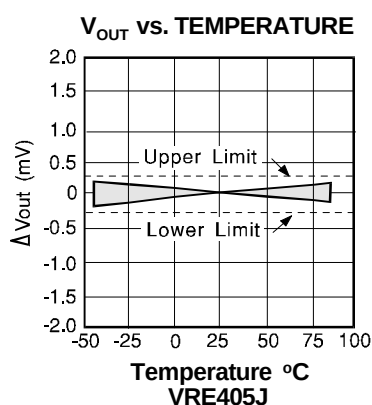
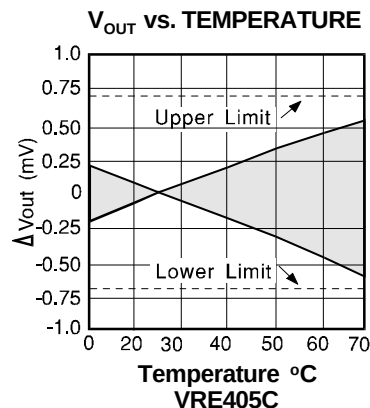
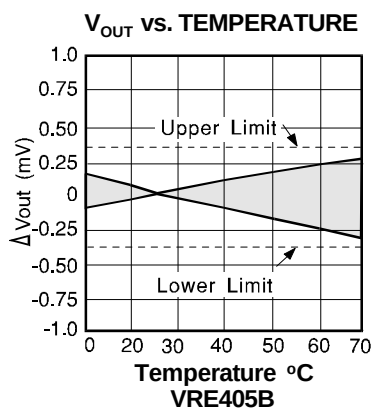
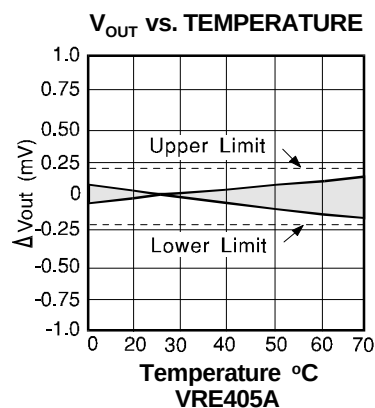
MODEL	A/J			B/K			C/L				
PARAMETER	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS	
ABSOLUTE RATINGS											
Power Supply	±13.5	±15	±22	*	*	*	*	*	*	V	
Operating Temp. (A,B,C)	0		+70	*	*	*	*	*	*	°C	
Operating Temp. (J,K,L)	-40		+85	*	*	*	*	*	*	°C	
Storage Temperature	-65		+150	*	*	*	*	*	*	°C	
Short Circuit Protection	Continuous				*			*			
OUTPUT VOLTAGE											
VRE405		±5.00			*			*		V	
OUTPUT VOLTAGE ERRORS											
Initial Error ⁽¹⁾		1	0.50		2	0.80		3	1.00	mV	
Warmup Drift											ppm
T _{min} - T _{max} ⁽²⁾			0.6			1.0			2.0	ppm/ °C	
Tracking Error ⁽³⁾			0.3			0.4			0.5	mV	
Long-Term Stability		6			*			*		ppm/1000hrs	
Noise (.1-10Hz)		3			*			*		μVpp	
OUTPUT CURRENT											
Range	±10			*			*			mA	
REGULATION											
Line		3	10		*	*		*	*	ppm/V	
Load		3			*			*		ppm/mA	
POWER SUPPLY CURRENTS ⁽⁴⁾											
+PS		7	9		*	*		*	*	mA	
-PS		4	6		*	*		*	*	mA	

NOTES: *Same as A/J Models.

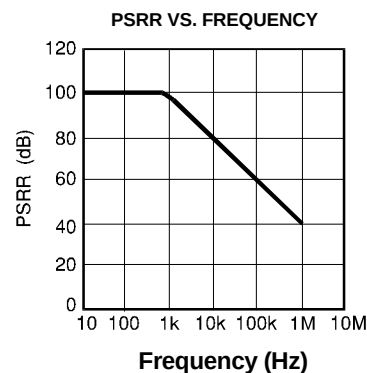
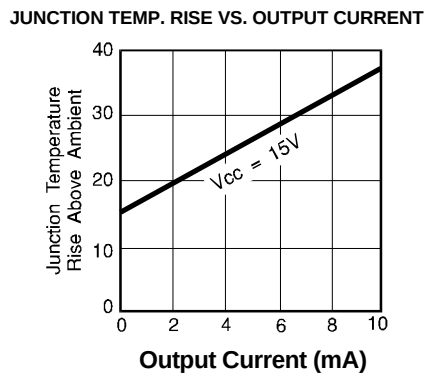
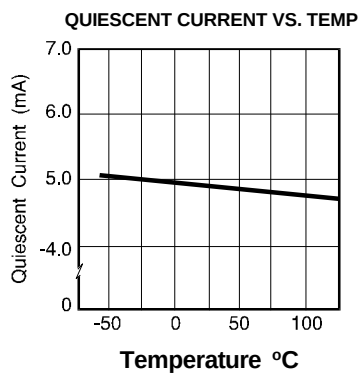
- The specified values are without external trim.
- The temperature coefficient (tc) is determined by the box method using the following formula:
- The tracking error is the deviation between the positive and negative output over the operating temp. range.
- The specified values are unloaded.

$$tc = \frac{V_{max} - V_{min}}{V_{nominal} \times (T_{max} - T_{min})} \times 10^6$$

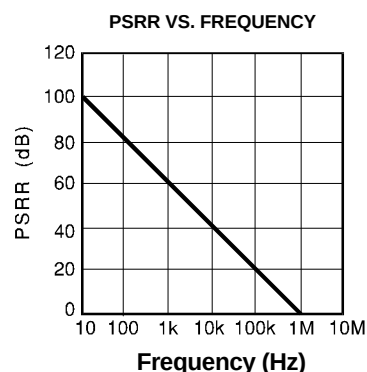
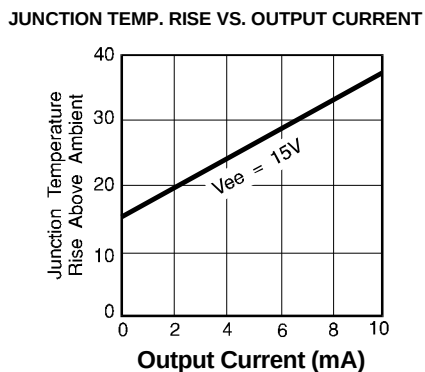
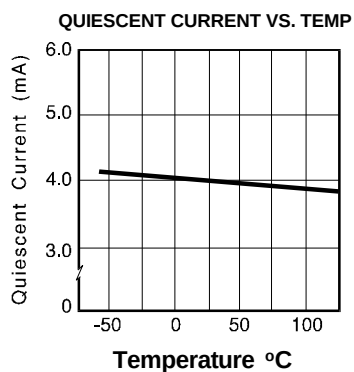
TYPICAL PERFORMANCE CURVES



----- POSITIVE OUTPUT (TYP) -----



----- NEGATIVE OUTPUT (TYP) -----



DISCUSSION OF PERFORMANCE

THEORY OF OPERATION

The following discussion refers to the schematic in figure 2 below. A FET current source is used to bias a 6.3V zener diode. The zener voltage is divided by the resistor network R1 and R2. This voltage is then applied to the noninverting input of the operational amplifier which amplifies the voltage to produce a 5.000V output. The gain is determined by the resistor networks R3 and R4: $G=1 + R4/R3$. The 6.3V zener diode is used because it is the most stable diode over time and temperature.

The current source provides a closely regulated zener current, which determines the slope of the references' voltage vs. temperature function. By trimming the zener current a lower drift over temperature can be achieved. But since the voltage vs. temperature function is nonlinear this compensation technique is not well suited for wide temperature ranges.

Thaler Corporation has developed a nonlinear compensation network of thermistors and resistors that is used in the VRE series voltage references. This proprietary network eliminates most of the nonlinearity in the voltage vs. temperature function. By adjusting the slope, Thaler Corporation produces a very stable voltage over wide temperature ranges.

This network is less than 2% of the overall network resistance so it has a negligible effect on long term stability.

The VRE405 reference has its ground terminal brought out on two pins (pin 6 and 7) which are connected internally. This allows the user to achieve greater accuracy when using a socket. Voltage references have a voltage drop across their power supply ground pin due to quiescent current flowing through the contact resistance. If the contact resistance was constant with time and temperature, this voltage drop could be trimmed out. When the reference is plugged into a socket, this source of error can be as high as 20ppm. By connecting pin 7 to the power supply ground and pin 6 to a high impedance ground point in the measurement circuit, the error due to the contact resistance can be eliminated. If the unit is soldered into place, the contact resistance is sufficiently small that it does not effect performance.

VRE405

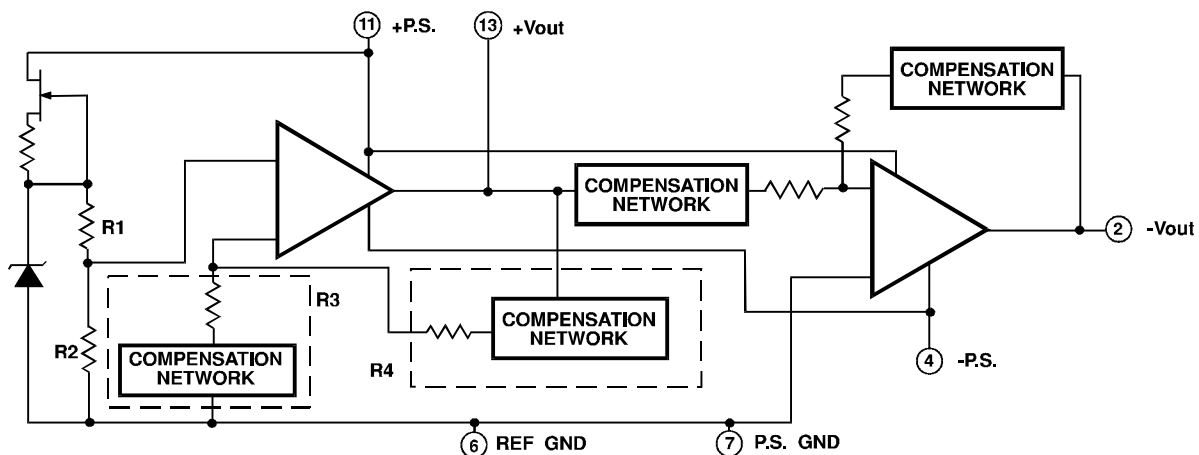
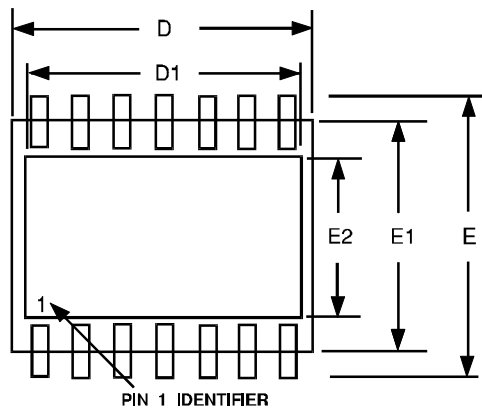


FIGURE 2

MECHANICAL

FIGURE 3



	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.495	.526	12.5	13.3
B	.098	.103	2.48	2.62	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
C	.103	.118	2.62	3.00	P	.090	.110	2.29	2.79
C1	.009	.020	0.22	0.51	Q	.024	.035	0.61	.890
C2	.054	.062	1.37	1.57	S	.040	.060	1.02	1.52
D	.690	.715	17.5	18.1					
D1	.666	.680	16.9	17.2					

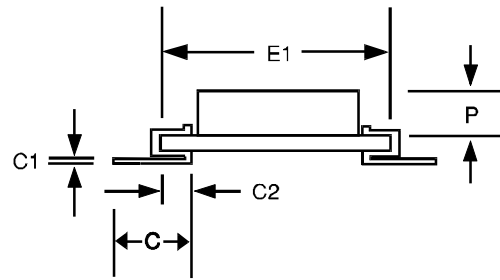
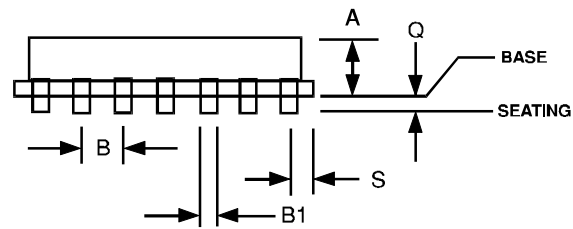
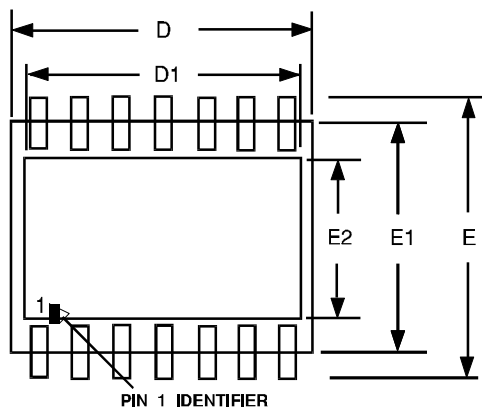
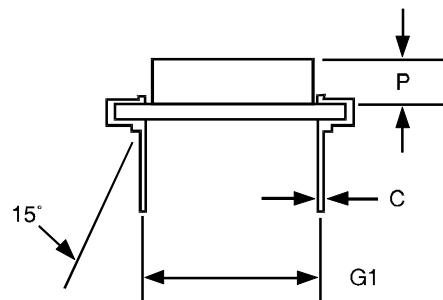
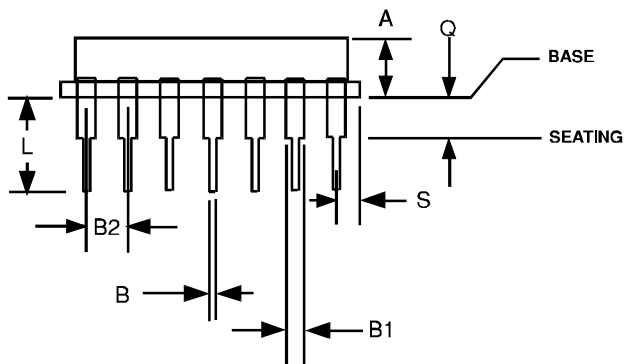


FIGURE 4



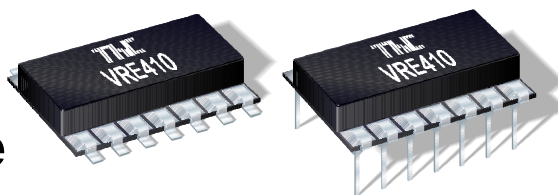
	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.410	.435	10.4	11.0
B	.018	.027	.460	.690	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
B2	.097	.103	2.46	2.62	G1	.285	.315	7.24	8.00
C	.009	.020	0.22	0.51	L	.195	.225	4.95	5.72
D	.690	.715	17.5	18.1	P	.090	.110	2.29	2.79
D1	.666	.680	16.9	17.2	Q	.050	.070	1.27	1.79
					S	.040	.060	1.02	1.52





VRE410

Precision Dual Reference



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FEATURES

- ± 10.000 V OUTPUT ± 1.000 mV (.01%)
- TEMPERATURE DRIFT: 0.6 ppm/°C
- LOW NOISE: $6\mu\text{V}_{\text{pp}}$ (0.1-10Hz)
- TRACKING ERROR: 0.5 mV max.
- EXCELLENT LINE REGULATION: 6ppm/V Typ.
- SURFACE MOUNT AND DIP PACKAGES

PIN CONFIGURATION

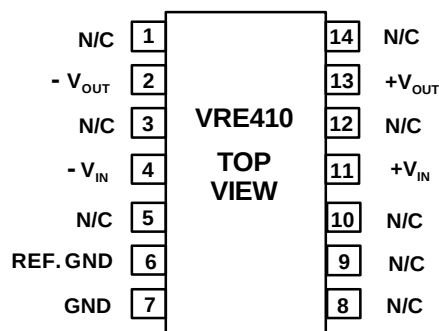


FIGURE 1

DESCRIPTION

The VRE410 is a low cost, high precision, ± 10.0 V reference. Packaged in 14 pin DIP or SMT packages, the device is ideal for new designs that need a high performance reference.

The device provides ultrastable ± 10.000 V output with ± 1.000 mV (.01%) initial accuracy and a temperature coefficient of 0.6 ppm/°C. This improvement in accuracy is made possible by a unique, patented multipoint laser compensation technique developed by Thaler Corporation.

Another key feature of this reference is the 0.5 mV maximum tracking error between the positive and negative output voltages over the full operating temperature range. This is extremely important in high performance systems for reducing overall system errors.

For designs which use the DIP package in a socket, there is a reference ground pin to eliminate reference ground errors.

The VRE410 is recommended for use as a reference for high precision D/A and A/D converters which require an external precision reference. The device is also ideal for calibrating scale factor on high resolution A/D converters. The VRE410 offers superior performance over monolithic references.

SELECTION GUIDE

Model	Initial Error mV	Temp. Coeff. ppm/°C	Temp. Range °C
VRE410A	1.0	0.6	0°C to +70°C
VRE410B	1.6	1.0	0°C to +70°C
VRE410C	2.0	2.0	0°C to +70°C
VRE410J	1.0	0.6	-40°C to +85°C
VRE410K	1.6	1.0	-40°C to +85°C
VRE410L	2.0	2.0	-40°C to +85°C

For package option add D for DIP or S for Surface Mount to end of model number.

ELECTRICAL SPECIFICATIONS

VRE410

Vps = ±15V, T = 25°C, RL = 10KΩ unless otherwise noted.

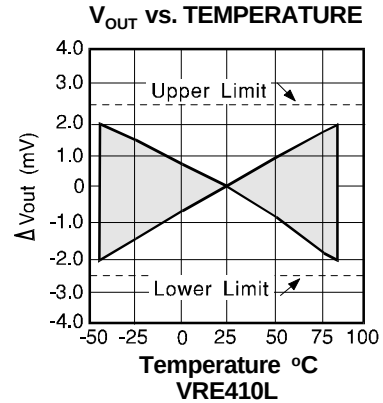
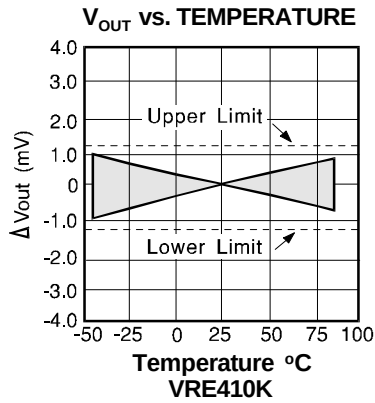
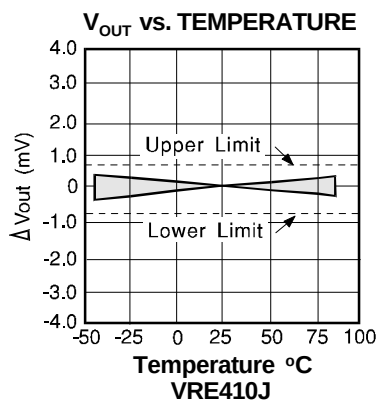
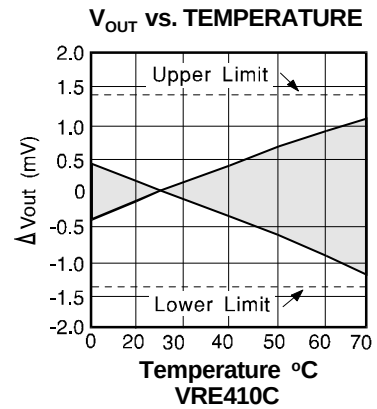
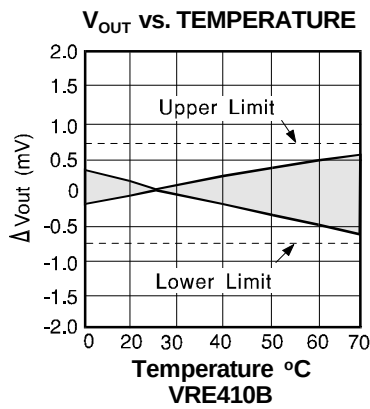
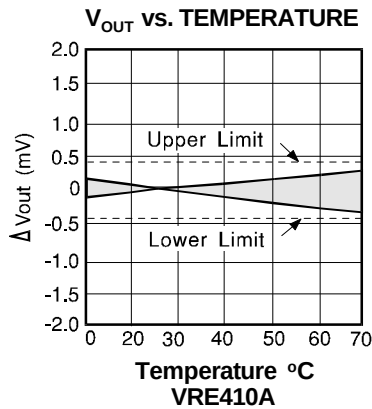
MODEL	A/J			B/K			C/L			
PARAMETER	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
ABSOLUTE RATINGS										
Power Supply	±13.5	±15	±22	*	*	*	*	*	*	V
Operating Temp. (A,B,C)	0		+70	*	*	*	*	*	*	°C
Operating Temp. (J,K,L)	-40		+85	*	*	*	*	*	*	°C
Storage Temperature	-65		+150	*	*	*	*	*	*	°C
Short Circuit Protection	Continuous				*			*		
OUTPUT VOLTAGE										
VRE410		±10.00			*			*		V
OUTPUT VOLTAGE ERRORS										
Initial Error ⁽¹⁾		1	1.00		2	1.60		3	2.00	mV
Warmup Drift										ppm
T _{min} - T _{max} ⁽²⁾			0.6				1.0			ppm/ °C
Tracking Error ⁽³⁾			0.5			0.7			1.0	mV
Long-Term Stability		6			*			*		ppm/1000hrs
Noise (.1-10Hz)		6			*			*		μVpp
OUTPUT CURRENT										
Range	±10			*			*			mA
REGULATION										
Line		3	10		*	*		*	*	ppm/V
Load		3			*			*		ppm/mA
POWER SUPPLY CURRENTS ⁽⁴⁾										
+PS		7	9		*	*		*	*	mA
-PS		4	6		*	*		*	*	mA

NOTES: *Same as A/J Models.

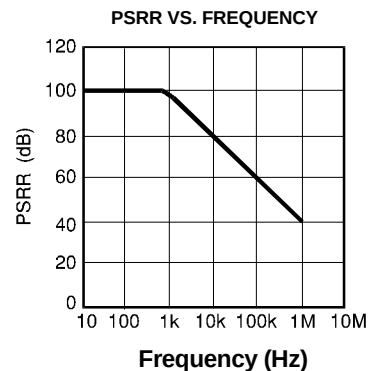
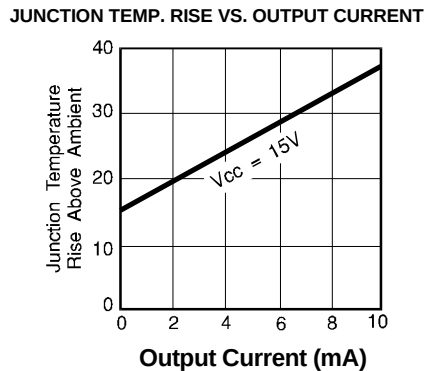
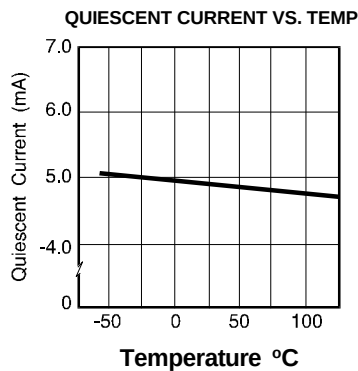
- The specified values are without external trim.
- The temperature coefficient (tc) is determined by the box method using the following formula:
- The tracking error is the deviation between the positive and negative output over the operating temp. range.
- The specified values are unloaded.

$$tc = \frac{V_{max} - V_{min}}{V_{nominal} \times (T_{max} - T_{min})} \times 10^6$$

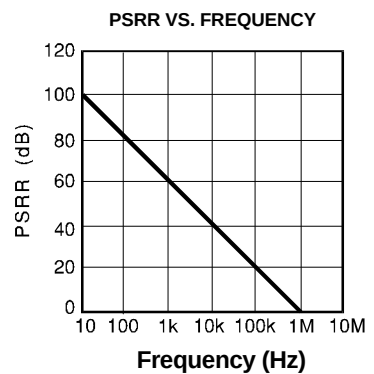
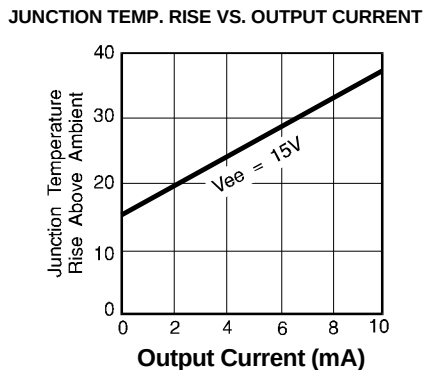
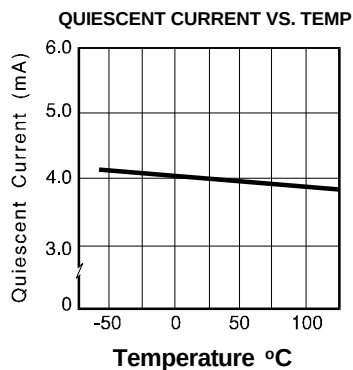
TYPICAL PERFORMANCE CURVES



----- POSITIVE OUTPUT (TYP) -----



----- NEGATIVE OUTPUT (TYP) -----



DISCUSSION OF PERFORMANCE

THEORY OF OPERATION

The following discussion refers to the schematic below. In operation, approximately 6.3 volts is applied to the noninverting input of the op amp. The voltage is amplified by the op amp to produce a 10.000V output. The gain is determined by the networks R1 and R2: $G=1 + R2/R1$. The 6.3V zener diode is used because it is the most stable diode over time and temperature.

The zener operating current is derived from the regulated output voltage through R3. This feedback arrangement provides a closely regulated zener current. This current determines the slope of the references' voltage vs. temperature function. By trimming the zener current a lower drift over temperature can be achieved. But since the voltage vs. temperature function is nonlinear this compensation technique is not well suited for wide temperature ranges.

Thaler Corporation has developed a nonlinear compensation network of thermistors and resistors that is used in the VRE series voltage references. This proprietary network eliminates most of the nonlinearity in the voltage vs. temperature function. By then adjusting the slope, Thaler Corporation produces a very stable voltage over wide temperature ranges.

The VRE400 series voltage references have the ground terminal brought out on two pins (pin 6 and 7) which are connected together internally. This allows the user to achieve greater accuracy when using a socket. Voltage references have a voltage drop across their power supply ground pin due to quiescent current flowing through the contact resistance. If the contact resistance was constant with time and temperature, this voltage drop could be trimmed out. When the reference is plugged into a socket, this source of error can be as high as 20ppm. By connecting pin 7 to the power supply ground and pin 6 to a high impedance ground point in the measurement circuit, the error due to the contact resistance can be eliminated. If the unit is soldered into place the contact resistance is sufficiently small that it doesn't effect performance.

VRE410

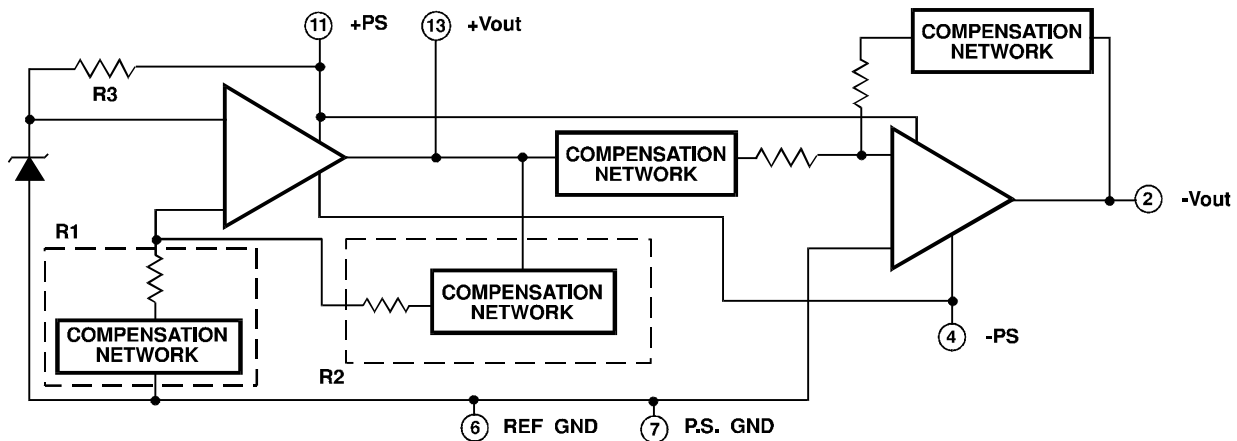
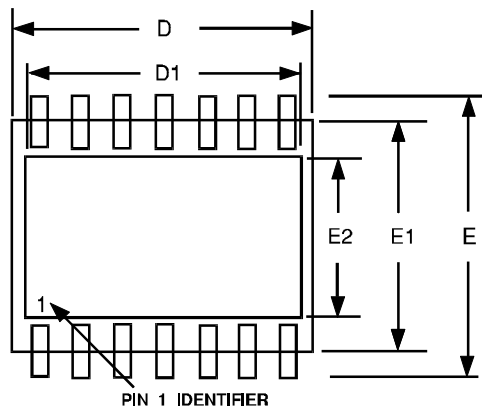


FIGURE 2

MECHANICAL

FIGURE 3



	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.495	.526	12.5	13.3
B	.098	.103	2.48	2.62	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
C	.103	.118	2.62	3.00	P	.090	.110	2.29	2.79
C1	.009	.020	0.22	0.51	Q	.024	.035	0.61	.890
C2	.054	.062	1.37	1.57	S	.040	.060	1.02	1.52
D	.690	.715	17.5	18.1					
D1	.666	.680	16.9	17.2					

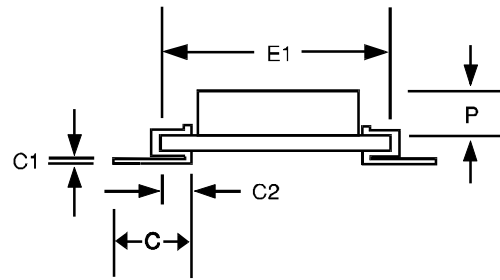
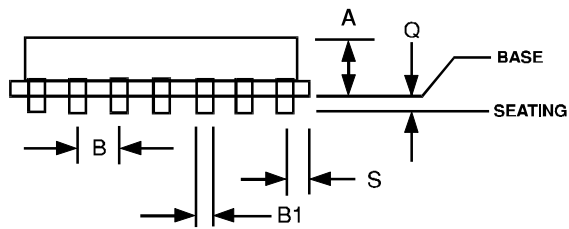
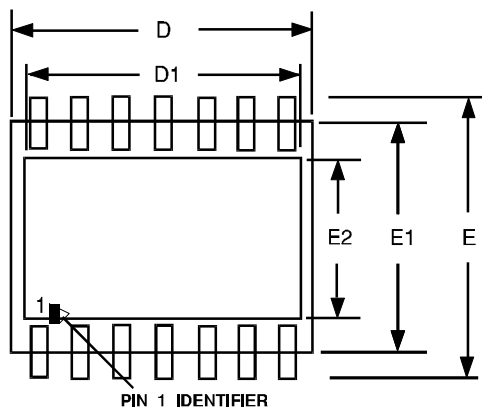


FIGURE 4



	INCHES		MILLIMETER			INCHES		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.114	.136	2.90	3.45	E	.410	.435	10.4	11.0
B	.018	.027	.460	.690	E1	.390	.415	9.91	10.5
B1	.047	.056	1.19	1.42	E2	.265	.270	6.73	6.86
B2	.097	.103	2.46	2.62	G1	.285	.315	7.24	8.00
C	.009	.020	0.22	0.51	L	.195	.225	4.95	5.72
D	.690	.715	17.5	18.1	P	.090	.110	2.29	2.79
D1	.666	.680	16.9	17.2	Q	.050	.070	1.27	1.79
					S	.040	.060	1.02	1.52

