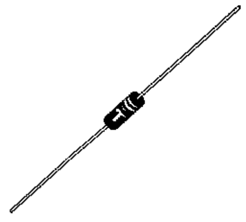
Transitron

SILICON REGULATORS

SUBMINIATURE TYPES



250 Milliwatts

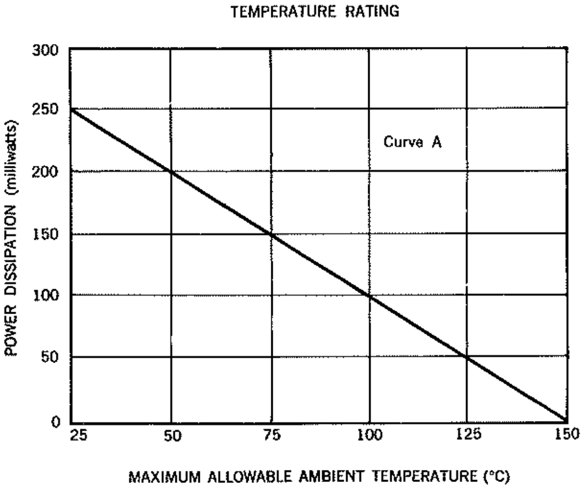
Transitron's subminiature glass silicon regulators (sometimes called Zener diodes) are constant voltage elements for control and similar circuitry. They provide excellent regulation and stability over a wide operating range, and are capable of carrying up to 50 milliamps of current. Their small size, axial lead design, and hermetically sealed glass encapsulation insure a rugged unit capable of providing long-term reliability under wide environmental extremes.

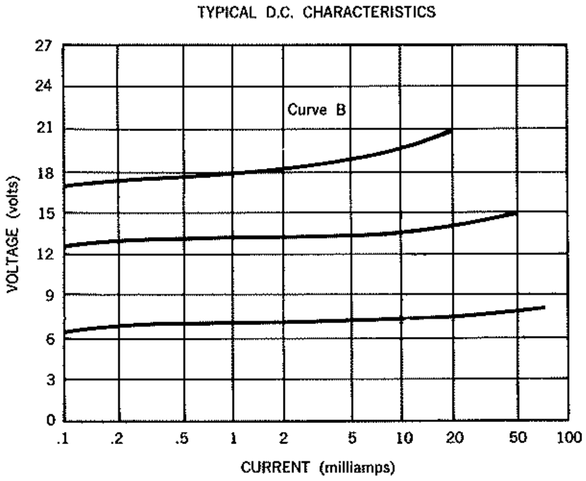
SPECIFICATIONS @ 25°C — RATINGS

TYPE	Voltage Range (volts)	Maximum Dynamic Resistance ① (ohms)	Test Current (ma)	Maximum Average Operating Current (ma) @ 25°C	Maximum Average Operating Current (ma) @ 125°C
1N761 (SV-5)	4.3 – 5.4	55	10	50	10
1N762 (SV-6)	5.2 – 6.4	20	10	40	8
1N763 (SV-7)	6.2 – 8.0	8	10	30	6
1N764 (SV-9)	7.5 – 10.0	15	10	25	5
1N765 (SV-11)	9.0 – 12.0	50	5	20	4
1N766 (SV-13)	11.0 – 14.5	70	5	17	3.5
1N767 (SV-15)	13.5 – 18.0	120	5	14	3
1N768 (SV-18)	17.0 – 21.0	200	5	12	2.5
1N769 (SV-24)	20.0 – 27.0	300	5	10	2

Maximum temperature range: −65°C to +150°C

① The dynamic resistance is measured by imposing a small AC current upon the test DC current.





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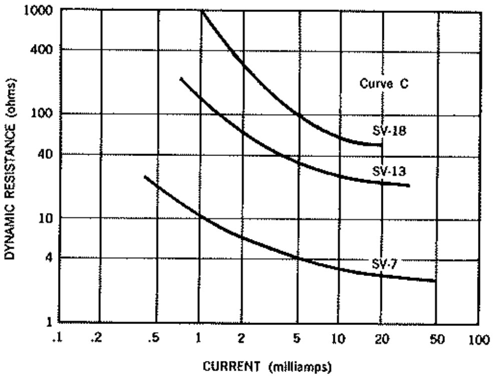
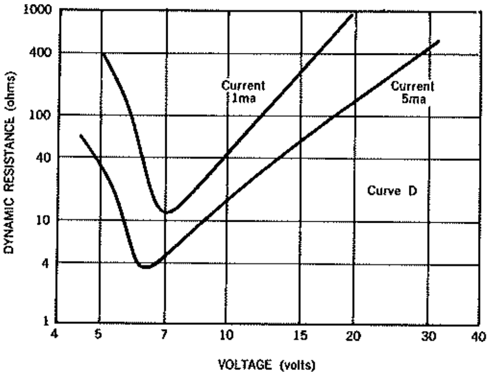


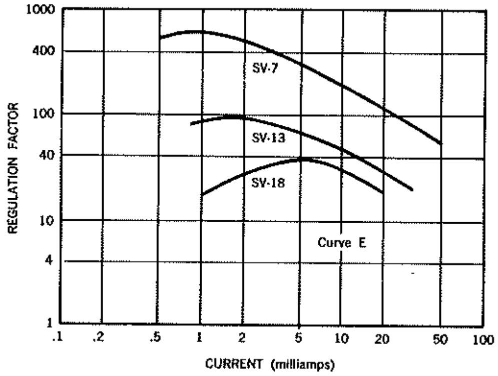


DYNAMIC RESISTANCE

The dynamic resistance of a silicon voltage regulator is a measure of the dependence of its voltage upon operating current. It is inversely proportional to the regulation at a specified current, and therefore provides a fundamental measure of the regulator's performance.

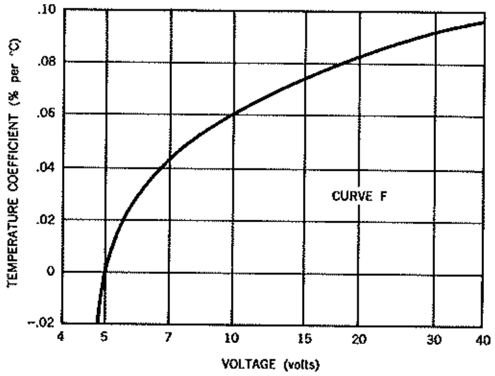
This resistance decreases with increasing current, and increases linearly with increasing ambient temperature, rising approximately 30% for 100°C. It is related to the voltage level of the regulator as shown in Curve D.

When selecting a regulator, careful consideration should be given to its operating conditions and their effect on dynamic resistance. Additional information on performance characteristics of regulators can be found in Applications Bulletin AN1352A.



REGULATION FACTOR

The regulation factor is a design parameter developed to give a simplified measure of a regulator's performance characteristics. This factor equals the regulator's DC resistance divided by its AC resistance. It may also be thought of as the percentage change in regulator current divided by the percentage change in output voltage. It is an expression of dynamic regulation only, however, and if the variations in input conditions are large or if they have a long-time duration, the change of dynamic resistance with current and the effect of change in junction temperature on voltage must be considered.

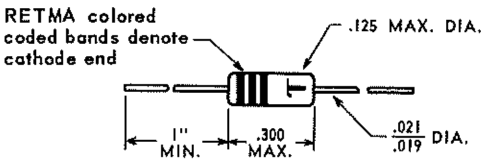


TEMPERATURE COEFFICIENT

The operating voltage of a silicon regulator varies with its ambient temperature conditions. This temperature dependence varies with the voltage level of the regulator as illustrated in Curve F. For a particular unit, this coefficient is constant for most operating conditions.

This change of voltage with temperature is an important characteristic of regulators that must be taken into consideration. If a lower coefficient for a particular application is desired than can be obtained from a single regulator, consideration should be given to using lower voltage or temperature compensated regulators.

MECHANICAL DATA



ENCAPSULATION: All glass hermetically sealed case insures complete environmental protection.

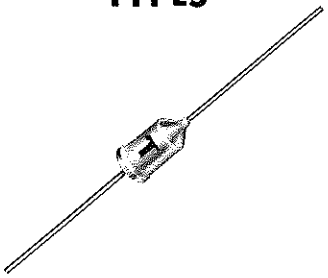
LEADS: Tinned dumet.

MAXIMUM ALTITUDE: Any.

It is recommended that a heat sink (long nose pliers) be used when soldering leads within 1/4" of glass base.

Transitron SILICON REGULATORS

MINIATURE TYPES



750 Milliwatts

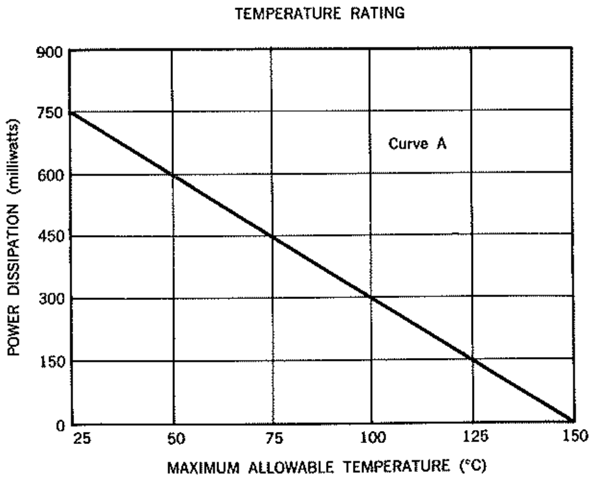
Transitron's miniature silicon regulators are constant voltage elements for control and similar circuitry. They provide excellent regulation and stability over a wide operating range, and are capable of carrying up to 150 milliamps of current. Their small size, axial lead design, and hermetically sealed encapsulation insure a rugged unit capable of providing long-term reliability under wide environmental extremes.

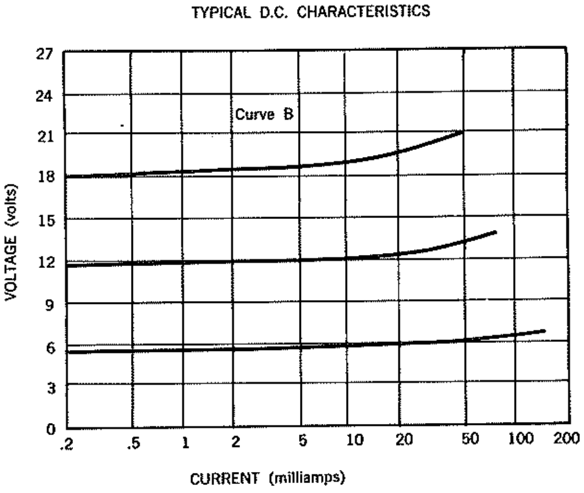
SPECIFICATIONS @ 25°C / RATINGS

TYPE	Voltage Range (volts)	Maximum Dynamic Resistance ① (Ohms)	Test Current (ma)	Maximum Average Operating Current (ma) @ 25°C	Maximum Average Operating Current (ma) @ 125°C
1N2032(SV-804)	4.3 – 5.4	55	10	150	30
1N2033(SV-805)	5.2 – 6.4	20	10	120	24
1N2034(SV-806)	6.2 – 8.0	8	10	90	18
1N2035(SV-808)	7.5 – 10.0	15	10	75	15
1N2036(SV-810)	9.0 – 12.0	50	5	60	12
1N2037(SV-812)	11.0 – 14.5	70	5	50	10
1N2038(SV-815)	13.5 – 18.0	120	5	40	8
1N2039(SV-818)	17.0 – 21.0	200	5	35	7
1N2040(SV-824)	20.0 – 27.0	300	5	27	5

Maximum temperature Range: −65°C to +150°C

① The dynamic resistance is measured by imposing a small AC current upon the test DC current.





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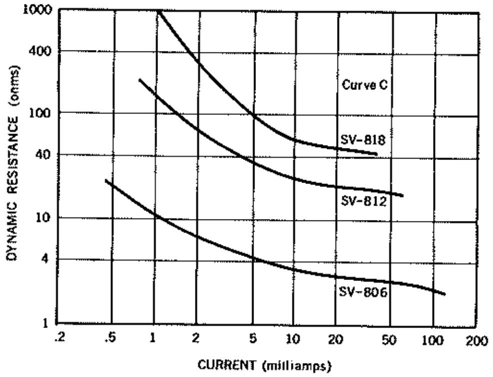
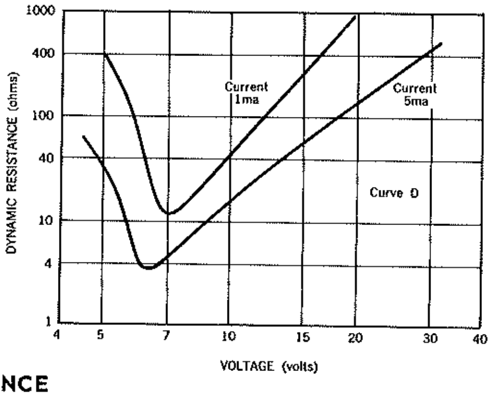


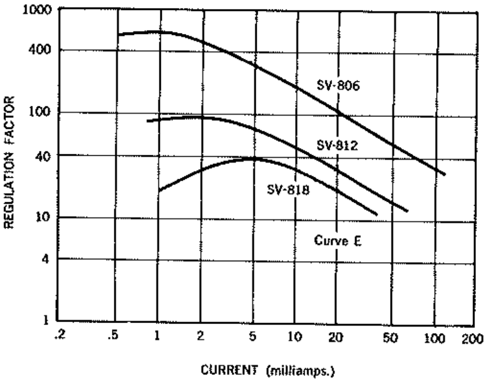


DYNAMIC RESISTANCE

The dynamic resistance of a silicon voltage regulator is a measure of the dependence of its voltage upon operating current. It is inversely proportional to the regulation at a specified current, and therefore provides a fundamental measure of the regulator's performance.

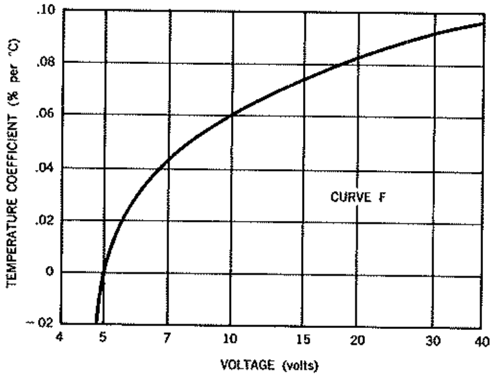
This resistance decreases with increasing current, and increases linearly with increasing ambient temperature, rising approximately 30% for 100°C. It is related to the voltage level of the regulator as shown in Curve D.

When selecting a regulator, careful consideration should be given to its operating conditions and their effect on dynamic resistance. Additional information on performance characteristics of regulators can be found in Applications Bulletin AN1352A.



REGULATION FACTOR

The regulation factor is a design parameter developed to give a simplified measure of a regulator's performance characteristics. This factor equals the regulator's DC resistance divided by its AC resistance. It may also be thought of as the percentage change in regulator current divided by the percentage change in output voltage. It is an expression of dynamic regulation only, however and if the variations in input conditions are large or they have a long-time duration, the change of dynamic resistance with current and the effect of change in junction temperature on voltage must be considered.

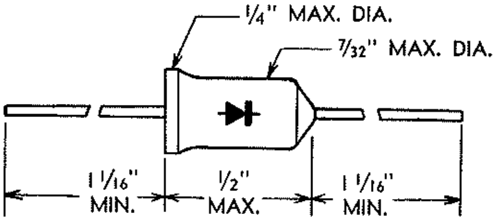


TEMPERATURE COEFFICIENT

The operating voltage of a silicon regulator varies with its ambient temperature conditions. This temperature dependence varies with the voltage level of the regulator as illustrated in Curve F. For a particular unit, this coefficient is constant for most operating conditions.

This change of voltage with temperature is an important characteristic of regulators that must be taken into consideration. If a lower coefficient for a particular application is desired than can be obtained from a single regulator, consideration should be given to using lower voltage or temperature compensated regulators.

MECHANICAL DATA



ENCAPSULATION:	Glass to Metal Hermetic Seal.
MOUNTING POSITION:	Any.
WEIGHT:	1.0 gram.
FINISH:	Gold plated case and leads.

It is recommended that a heat sink (long nose pliers) be used when soldering leads within 1/4" of glass base.

IMPORTANT: The case is electrically connected to the positive terminal of the regulator. Mounting should be arrange to minimize the possibility of electrical short circuits.

Transitron

SILICON REGULATORS

POWER TYPES

10 WATTS

Transitron's power regulators are constant voltage elements for control and similar circuitry. Their low thermal resistance and high current carrying capacity insure excellent regulation and stability up to two amperes of current. The glass-to-metal hermetic sealing and stud mounted construction insure a mechanically rugged unit capable of providing long-term reliability under wide environmental extremes.

SPECIFICATIONS @ 25°C

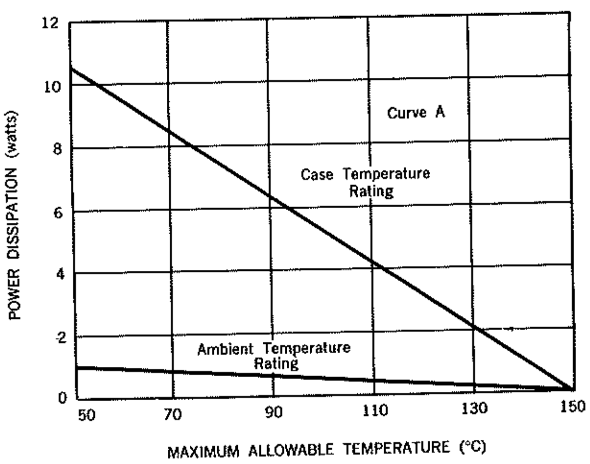
RATINGS

TYPE	Voltage Range (volts)	Maximum Dynamic Resistance ① (ohms)	Test Current (amps)	Maximum Average Operating Current	
				(amps) @ 55°C case	(ma) @ 125°C case
1N2041 (SV-904)	4.3 – 5.4	.5	1	2.0	500
1N2042 (SV-905)	5.2 – 6.4	.7	1	1.6	400
1N2043 (SV-906)	6.2 – 8.0	.8	1	1.2	300
1N2044 (SV-908)	7.5 – 10.0	.8	1	1.0	250
1N2045 (SV-910)	9.0 – 12.0	1.5	.5	.8	200
1N2046 (SV-912)	11.0 – 14.5	2	.5	.7	175
1N2047 (SV-915)	13.5 – 18.0	3	.5	.6	150
1N2048 (SV-918)	17.0 – 21.0	3	.5	.5	125
1N2049 (SV-924)	20.0 – 27.0	8	.15	.4	100

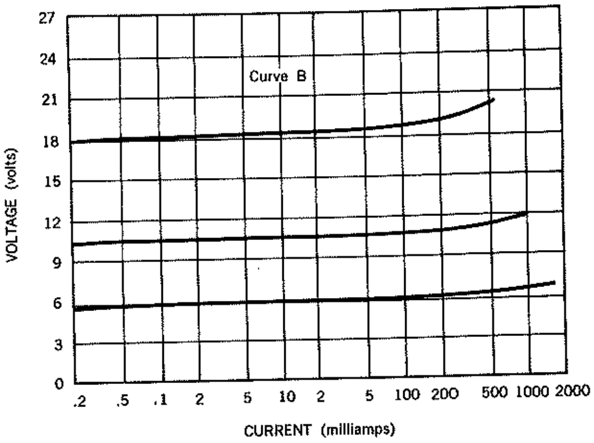
Maximum temperature range: –65°C to +150°C

① The dynamic resistance is measured by imposing a small AC current upon the test DC current.

TEMPERATURE RATING



TYPICAL DC CHARACTERISTICS



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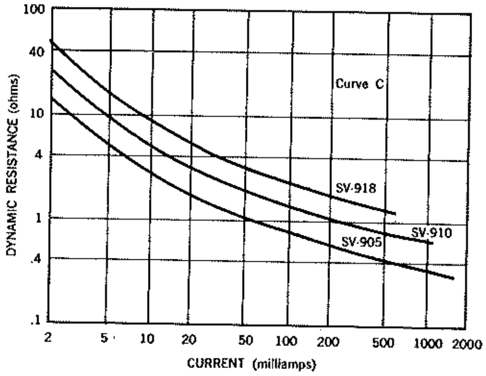

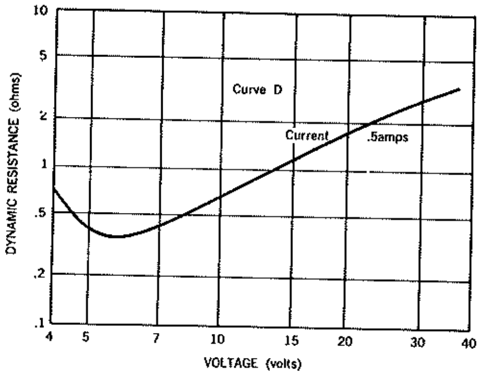

DYNAMIC RESISTANCE

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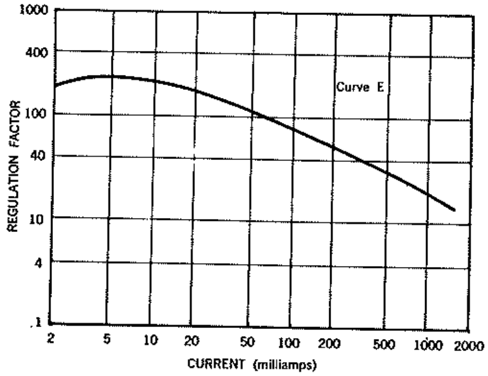
This resistance decreases with increasing current, and increases linearly with increasing ambient temperature, rising approximately 30% for 100°C. It is related to the voltage level of the regulator as shown in Curve D.

When selecting a regulator, careful consideration should be given to its operating conditions and their effect on dynamic impedance. Additional information on performance characteristics of regulators can be found in Applications Bulletin AN1352A.



REGULATION FACTOR

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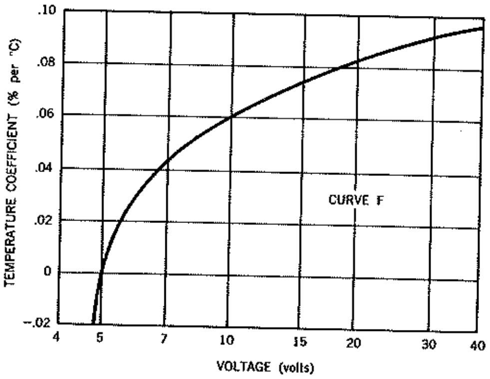
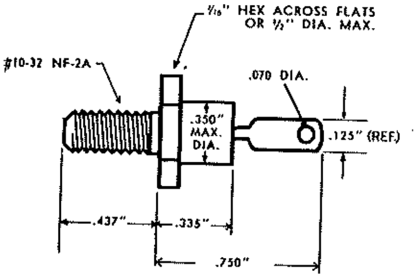


TEMPERATURE COEFFICIENT

The operating voltage of a silicon regulator varies with its ambient temperature conditions. This temperature dependence varies with the voltage level of the regulator as illustrated in Curve F. For a particular unit, this coefficient is constant for most operating conditions.

This change of voltage with temperature is an important characteristic of regulators that must be taken into consideration. If a lower coefficient for a particular application is desired than can be obtained from a single regulator, consideration should be given to using lower voltage or temperature compensated regulators.

MECHANICAL DATA



ENCAPSULATION: Glass to Metal Hermetic Seal.
MOUNTING POSITION: Any.
WEIGHT: 7 grams (.25 oz.) (with mounting hardware).

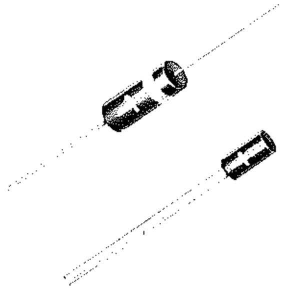
Insulating and mounting hardware is provided to electrically insulate the regulator from the heat sink mounting.

IMPORTANT: The outer case and mounting stud are electrically connected to the positive terminal of the regulator. Mounting should be arranged to minimize the possibility of electrical short circuits.

Transitron

SILICON REFERENCES

LOW TEMPERATURE COEFFICIENT TYPES



Transitron's low temperature coefficient references are designed to provide a stable reference voltage over an extreme range of operating conditions. The compact axial lead package can be installed as easily as a 2-watt resistor. Each reference is composed of hermetically sealed glass diodes selected for stable characteristics. Since these references contain no liquids, they may be operated in any position without voltage variation.

The SV3206 and SV3207 provide low temperature coefficients at high voltages economically by matching two of the 8.4 volt units.

SPECIFICATIONS

RATINGS

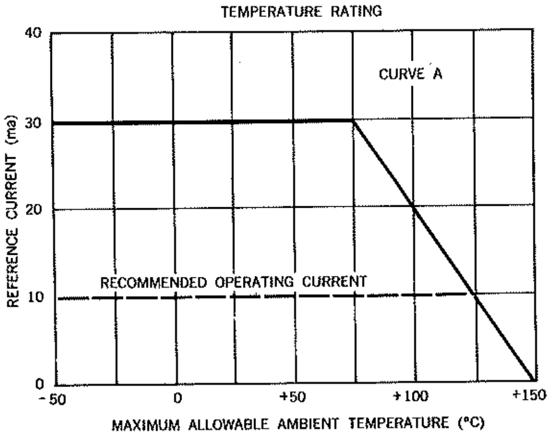
TYPE	Voltage Range at I_Z = 10ma at 25°C (Volts)		Temp. Coefficient [2] (-55°C to +100°C) at I_Z = 10 ma (%/°C)	Maximum Dynamic [3] Resistance at 25°C at I_Z = 10 ma (ohms)	T Storage Max. (°C)	Max. Operating Temp. at I_Z = 10 ma (°C)
	Min.	Max.				
1N429 [1]	5.9	6.5	±.01	20	–65 to +150	–65 to +125
SV-3170	6.7	7.4	±.02	10	–65 to +150	–65 to +125
SV-3171	6.7	7.4	±.01	10	–65 to +150	–65 to +125
SV-3173	8	8.8	±.005	15	–65 to +150	–65 to +125
SV-3174	8	8.8	±.003	15	–65 to +150	–65 to +125
SV-3175	8	8.8	±.002	15	–65 to +150	–65 to +125
SV-3176	8	8.8	±.001	15	–65 to +150	–65 to +125
SV-3206 [4]	16	17.6	±.002	30	–65 to +150	–65 to +125
SV-3207 [4]	16	17.6	±.001	30	–65 to +150	–65 to +125

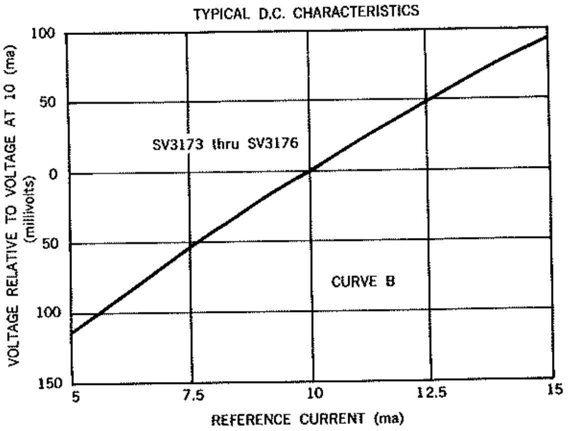
[1] Specified and rated @7.5 mA D.C.; single ended package.

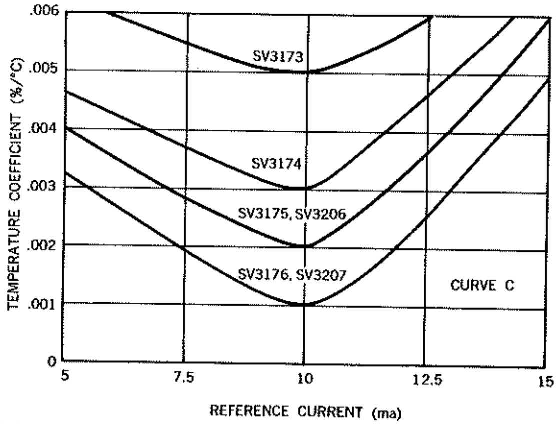
[2] Determined by measuring a change of voltage from –55°C to + 25°C and a change of voltage from +25°C to 100°C.

[3] The Dynamic Resistance is measured by superimposing a small A.C. Signal upon the test D.C. Current. $(I_{AC}\ \mathrm{RMS} \leqq \frac{1}{10} I_{DC}\ \mathrm{Test})$

[4] Matched set of two Low Voltage Assemblies.

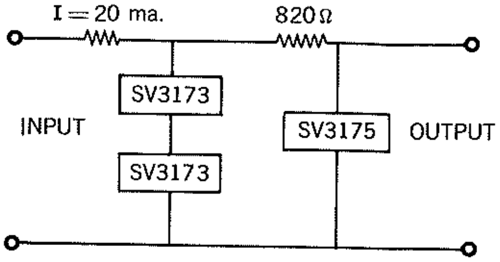






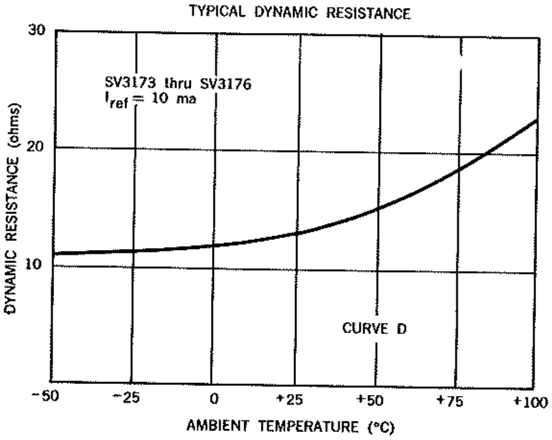
TEMPERATURE COEFFICIENT

The Transitron references are carefully matched at 10 milliamperes to insure a low temperature coefficient. The use of an operating current other then 10 milliamperes may result in a higher temperature coefficient, as shown on the graph. This factor is not critical for wide tolerance units such as the SV3173, but will be important for the SV3176.



STABILITY OF OPERATING CURRENT

Variations of the operating current cause changes in the reference voltage. In critical circuits best performance is obtained by providing a stable current source similar to that shown at left. As an example, the current must be held stable within 1% if a voltage stability of 0.1% with respect to current is desired.

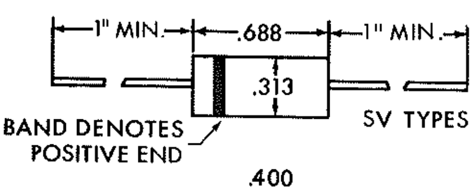


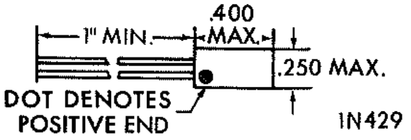
VOLTAGE STABILITY WITH LIFE

Tests run on samples of SV3175 references resulted in an average stability of 3 mv with less than 2% exceeding 8 mv following 500 hours of operation at 10 milliamperes and 75°C. This voltage stability is better than required when compared with a possible 25 mv change due to temperature coefficient alone across the −55°C to 100°C temperature range.

Many special reference assemblies have been designed for critical applications. For example, considerable savings are possible when a low temperature coefficient is needed for only a small temperature range. Our Applications Engineers will be glad to consider your requirements for special voltages, currents, temperature ranges, or special packaging.

MECHANICAL DATA





ENCAPSULATION: **Hermetically sealed glass diodes, assembled and potted in epoxy resin.**

MOUNTING POSITION: **Any.**

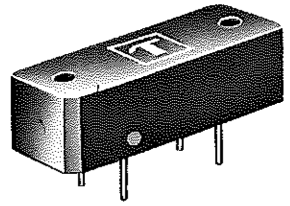
LEADS: **Tinned.**

"leadership in semiconductors"

Transitron

SILICON REFERENCES

REF-AMP



Transitron's Ref-Amp eliminates four components and reduces the temperature coefficient of practical regulator circuits. It consists of a voltage reference (temperature compensated zener diode) and a silicon amplifying transistor, packaged together for convenience in mounting. The Ref-Amp may be used to replace both the reference and the first stage transistor amplifier in regulated power supplies.

SPECIFICATIONS

MAXIMUM RATINGS

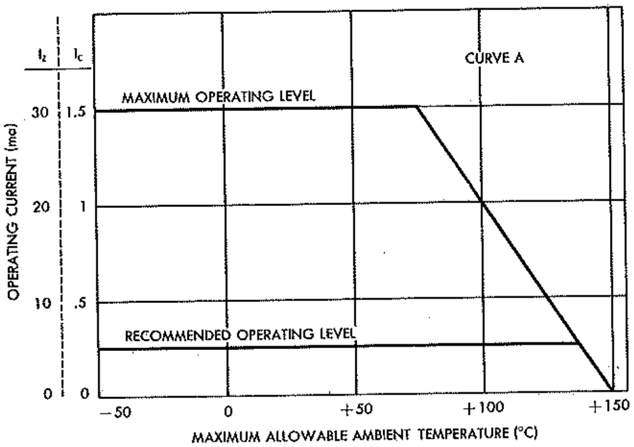
TYPE	Temperature Coefficient (%/°C) ①	Operating Temperature (Range (°C)	V_{BZ} @ 25°C (volts)		Measuring Conditions			Maximum Ratings		
			Min.	Max.	I_Z	I_C	V_{CE}	I_Z	V_{CE}	I_C
3N39	.005	– 20 to +71	8.3	9.8	5ma	250 μa	3V	30ma	30V	3ma
3N40	.003	– 20 to +71	8.3	9.8	5ma	250 μa	3V	30ma	30V	3ma
3N41	.002	– 20 to +71	8.3	9.8	5ma	250 μa	3V	30ma	30V	3ma
3N42	.005	– 55 to +100	8.3	9.8	5ma	250 μa	3V	20ma	30V	2ma
3N43	.003	– 55 to +100	8.3	9.8	5ma	250 μa	3V	20ma	30V	2ma
3N44	.002	– 55 to +100	8.3	9.8	5ma	250 μa	3V	20ma	30V	2ma

ADDITIONAL INFORMATION

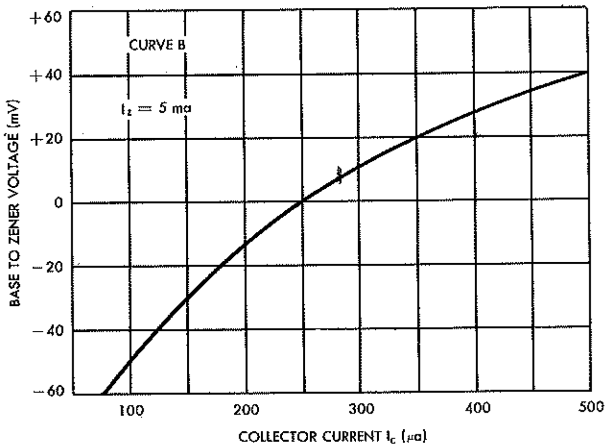
Maximum Storage Temperature	– 65°C to +150°C
Minimum D.C. Beta @.250 μa	20

① Temperature coefficient multiplied by rated temperature range determines maximum peak-to-peak % voltage variation allowed over the rated temperature range.

TEMPERATURE RATINGS



TYPICAL D.C. CHARACTERISTICS



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CATALOG NO. 29.29.10

100%/°C

100%

TYPICAL REF-AMP CIRCUIT

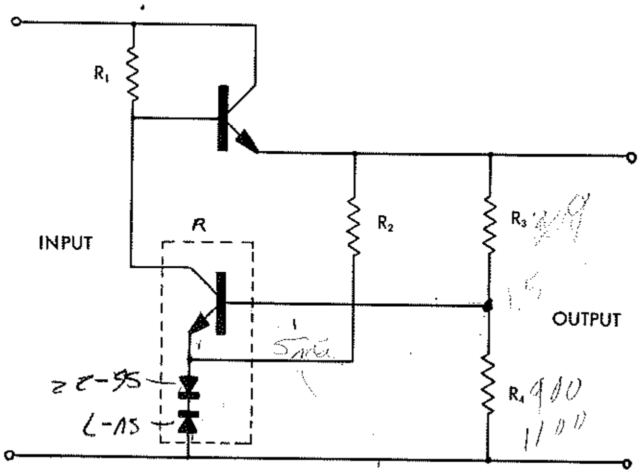


Fig. 1

Figure 1 shows a typical input stage in a power supply using the REF-AMP. As can be seen, only four resistors are required in addition to the REF-AMP and series transistor. R_2 provides bias current for the reference from the regulated output. R_1 supplies the REF-AMP collector and the series transistor base with operating current. The other two resistors form a voltage divider for sampling the output voltage. This is only one of many circuits possible using the REF-AMP. Higher currents can be regulated by placing emitter follower amplifiers between the REF-AMP collector and the series transistor base.

Reliability of voltage regulators is improved by the use of hermetically sealed, military quality silicon transistors and voltage regulators, and by the elimination of several components.

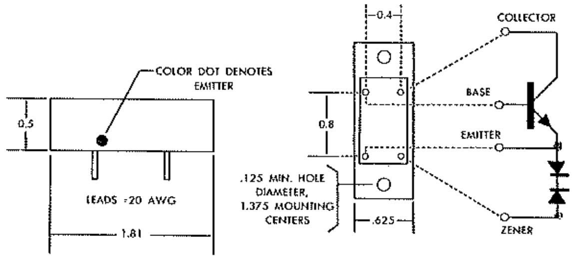
Thermal design insures that all junctions in the REF-AMP operate at essentially the same temperature, eliminating much of the voltage transient observed when some voltage references are subjected to rapid temperature changes.

Packaging of the REF-AMP has been engineered for easy mounting in printed circuit applications. It can, of course, be used in conventional chassis mounting also. The REF-AMP contains no liquids, and therefore is not sensitive to mounting position.

IMPORTANT FACTORS IN CIRCUIT DESIGN

1. CURRENT LEVELS: The low temperature coefficient characteristics of the REF-AMP are best realized when it is operated at a nominal collector current (I_C) of 250 microamps and a nominal regulator current (I_Z) of five milliamps. The temperature coefficient of V_{BZ} will become more positive at higher currents in either the collector or regulator. It will become more negative at lower collector or regulator currents.
2. CURRENT SWING: Curve B on the data sheet indicates the input voltage variation as a function of the REF-AMP collector current. The variation due to current is added to the variation due to temperature in determining the total REF-AMP voltage variation under actual operating conditions.
3. OPERATING TEMPERATURE RANGE: The two temperature ranges have been selected for the most common environmental conditions encountered in military and industrial applications. The maximum peak-to-peak voltage variation is determined by multiplying the rated temperature range by V_{BZ} and the temperature coefficient. Thus, a 3N41 with V_{BZ} = 8.8 volts will have a maximum voltage variation of 16 millivolts. Similarly, a 3N44 of the same voltage would have a maximum voltage variation of 27 millivolts over the wider temperature range.
4. SOURCE IMPEDANCE: In Figure 1, the source impedance is determined by resistors R_3 and R_4. The parallel equivalent resistance of these resistors should not exceed 1000 ohms. (Special REF-AMPS can be provided for source impedance up to 10,000 ohms).
5. COLLECTOR VOLTAGE: The 3N39 and 3N42 series REF-AMPS are designed for maximum collector voltages (V_{CE}) up to thirty volts, and will have long term reliability in twenty-eight volt applications. However, optimum results will be obtained by maintaining V_{CE} @ approximately three volts.

MECHANICAL DATA



ENCAPSULATION: Glass to metal hermetic seal encapsulated in epoxy package.

WEIGHT: 18 grams maximum.

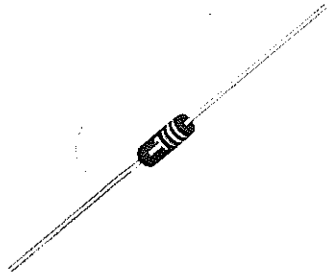
MOUNTING POSITION: Any.

MAXIMUM ALTITUDE: Any.

Transitron

SUBMINIATURE SILICON REFERENCES

LOW TEMPERATURE COEFFICIENT TYPES



Transitron's subminiature low temperature coefficient references are designed to provide a stable reference voltage over an extreme range of operating conditions. Their small size, axial lead design, and hermetically sealed glass encapsulation insure a rugged unit capable of providing long-term reliability under wide environmental extremes.

An ideal thermal connection between the "zener" diode and the compensating stabistor assure that the junctions operate at the same temperature, eliminating starting transients.

SPECIFICATIONS					RATINGS	
TYPE	Voltage Range at $I_Z = 7.5$ ma at 25°C (Volts)		Temp. Coefficient[2] (−55°C to +100°C) at $I_Z = 7.5$ ma (%/°C)	Maximum Dynamic Resistance at 25°C at $I_Z = 7.5$ ma (ohms)[3]	Operating and Storage Temperature Range (°C)	Max. Operating Temp. at $I_Z = 7.5$ ma (°C)
	Min.	Max.				
1N821	5.9	6.5	± .01	15	−65 to + 150	+ 125
1N822[1]	± 5.9	± 6.5	± .01	15	−65 to + 150	+ 125
1N823	5.9	6.5	± .005	15	−65 to + 150	+ 125
1N824[1]	± 5.9	± 6.5	± .005	15	−65 to + 150	+ 125
1N825	5.9	6.5	± .002	15	−65 to + 150	+ 125
1N827	5.9	6.5	± .001	15	−65 to + 150	+ 125

[1] Double anode types.

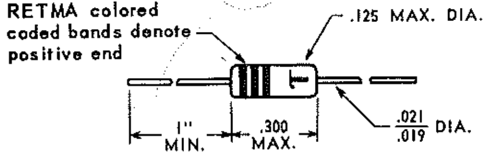
[2] Determined by measuring a change of voltage from −55°C to + 25°C and a change of voltage from + 25°C to 100°C.

[3] The Dynamic Resistance is measured by superimposing a small A.C. Signal upon the test D.C. Current. (I_{AC} RMS ≤ 1/10 I_{DC} Test)

1N822 and 1N824 types meet all specifications, including temperature coefficient, in both directions.

MECHANICAL DATA

.0005



ENCAPSULATION: All glass hermetically sealed case insures complete environmental protection.

LEADS: Tinned dumet.

MAXIMUM ALTITUDE: Any.

It is recommended that a heat sink (long nose pliers) be used when soldering leads within ¼" of glass base.

TE-1352F
3-59

Transitron

PB-2 (rev.)
February 5, 1950

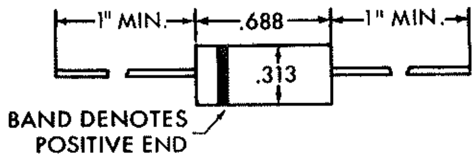
STANDARD PRECISION VOLTAGE REFERENCES

The Transitron standard precision voltage references provide reliable, uniform voltage references suitable for many critical applications. The compact axial lead construction (same size as a 2-watt resistor) is ideal for printed wiring board and terminal board mounting. Standard RETMA values of voltage are used to provide a number of convenient voltage levels between 10 and 100 volts. The 1% references are designed for all applications requiring critical uniformity. The rugged mechanical design of Transitron precision voltage references meet military environmental requirements.

±2% Tolerance	±1% Tolerance	Reference Voltage @ 25°C (Volts @ ma)		Maximum Dynamic Resistance* (Ohms @ ma)		Maximum Average Operating Current @ 25°C ma	Typical Temperature Coefficient (%/°C)
SV4010	SV4010A	10	1	90	10	50	± .02
SV4012	SV4012A	12	1	30	10	40	± .03
SV4015	SV4015A	15	1	20	10	30	± .05
SV4018	SV4018A	18	1	40	10	25	± .06
SV4022	SV4022A	22	1	120	5	20	± .07
SV4027	SV4027A	27	1	200	5	17	± .08
SV4033	SV4033A	33	1	240	5	14	± .08
SV4039	SV4039A	39	1	400	5	12	± .09
SV4047	SV4047A	47	.5	600	5	10	± .09
SV4056	SV4056A	56	.5	1000	5	9	± .09
SV4068	SV4068A	68	.5	1300	5	8	± .09
SV4075	SV4075A	75	.5	1600	5	7	± .09
SV4082	SV4082A	82	.5	2000	5	6	± .09
SV4091	SV4091A	91	.5	2500	5	5.5	± .09
SV4100	SV4100A	100	.5	3000	5	5	± .09

*The dynamic resistance is measured by imposing a small AC current upon the DC test current.

MECHANICAL DATA



ADDITIONAL CHARACTERISTICS AND RATINGS

Operating and Storage temperature range:
-55°C to +150°C

Max. Average Power Dissipation
500 mW

Peak Recurrent Power Dissipation
1500 mW

Transitron electronic corporation • wakefield, massachusetts

Catalog No. 29.27.9 (2-58)

Transitron Electronic Corp.

Supplement to
Preliminary Bulletin-2
Revision 2/5/58

STANDARD PRECISION VOLTAGE REFERENCES

The purpose of this supplement is to furnish standard specifications and ratings for 1% and 2% precision reference assemblies for types SV 4001 thru SV 4100A not listed on PB-2 dated 2-5-58.

Reference Voltage:

The final three digits of the numerical type designation specify the reference voltage of the unit.

e.g.: SV 4014 has a reference voltage of 14 volts.

Reference Voltage Tolerance:

1. Types in the SV 4000 series with no alphabetical suffix shall be selected to a voltage tolerance of ± 2%.

e.g.: SV 4014 is selected to 14 volts ± 2%.

2. Types in the SV 4000 series with the letter "A" as a suffix shall be selected a voltage tolerance of ±1%.

e.g. SV 4014A is selected to 14 volts ± 1%.

Reference Voltage test Current:

1. The reference voltage for types SV 4001 thru SV 4046A will be tested at a current of 1 ma.

2. The reference voltage for types SV 4047 thru SV 4100A will be tested at a current of .5 ma.

Maximum Dynamic Resistance:

1. For types not listed on PB-2 use the maximum dynamic resistance specification for the next higher or lower type which is listed, depending upon which listed type has the higher specification limit.

e.g.: for SV 4014 the spec. is 30 ohms at 10 ma
for SV 4016 the spec. is 40 ohms at 10 ma
for SV 4019 the spec. is 120 ohms at 5 ma

PB-1 (rev.)
June 5, 1957

Transitron

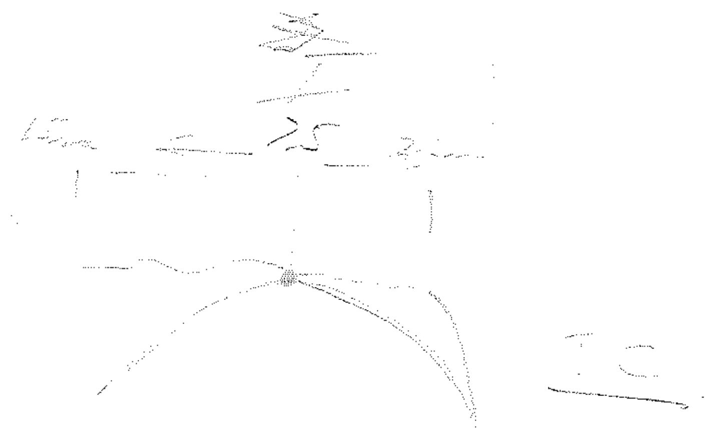
VOLTAGE REGULATORS WITH / 5% VOLTAGE TOLERANCE

Below are listed type numbers for regulators of all three classes with a 5% voltage tolerance at the test current used on the standard regulators from which they are selected. All other specifications are identical to the standard regulators.

Add 30% to the price of the standard regulators to obtain the price for the 5% voltage tolerance units.

5% Voltage Tolerance Selected Regulators

/ 5%	SV-5	SV-804	SV-904
4.5	SV-121	SV-1004	SV-2004
5	SV-122	SV-1005	SV-2005
	SV-6	SV-805	SV-905
5.5	SV-123	SV-1006	SV-2006
6	SV-124	SV-1007	SV-2007 6 v 5 2010W
	SV-7	SV-806	SV-906
6.5	SV-125	SV-1008	SV-2008
7	SV-126	SV-1009	SV-2009
7.5	SV-127	SV-1010	SV-2010
	SV-9	SV-808	SV-908
8	SV-128	SV-1011	SV-2011
8.5	SV-129	SV-1012	SV-2012
9	SV-131	SV-1013	SV-2013
9.5	SV-132	SV-1014	SV-2014
	SV-11	SV-810	SV-910
10	SV-133	SV-1015	SV-2015
11	SV-134	SV-1016	SV-2016
	SV-13	SV-812	SV-912
12	SV-135	SV-1017	SV-2017
13	SV-136	SV-1018	SV-2018
14	SV-137	SV-1019	SV-2019
	SV-15	SV-815	SV-915
15	SV-138	SV-1020	SV-2020
16	SV-139	SV-1021	SV-2021
17	SV-141	SV-1022	SV-2022
	SV-18	SV-818	SV-918
18	SV-142	SV-1023	SV-2023
19	SV-143	SV-1024	SV-2024
20	SV-144	SV-1025	SV-2025
	SV-24	SV-824	SV-924
22	SV-168	SV-1033	SV-2044
24	SV-169	SV-1034	SV-2045
26	SV-171	SV-1035	SV-2046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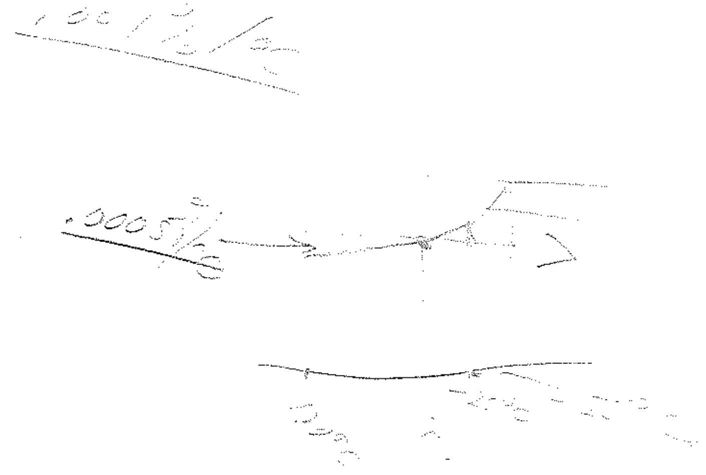
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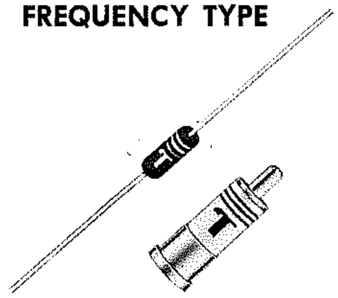
Transitron SILICON CAPACITORS

ULTRA HIGH FREQUENCY TYPE



Transitron's silicon capacitors (high frequency types) are micro-junction semiconductor capacitors designed to provide large voltage sensitivity with excellent UHF performance at temperatures up to 150°C. The special construction combines high Q and low series resistance with small junction capacitance, making these units especially attractive for parametric amplifier and voltage tuning applications in the 10 to 5000 megacycle range. The extremely low shunt leakage currents assure minimum circuit loading.

SPECIFICATIONS			CHARACTERISTICS AND RATINGS						
TYPE	Min. Q @ 100 Mc	Capacitance @ — 4V (pf) **	Max. Working Voltage	Typical Capacity @V max. (pf)	Typical Capacity @.1 V (pf)	Q Typical 50MC	Q Typical 100MC	F max *** (mc)	Series Resistance (ohms)
SCH-51 *SCH-51-A	40	0.5	10	.35	3	100	50	5000	85
SCH-52 *SCH-52-A	40	1.0	7	.8	5	100	50	5000	43
	** ±30%					*** F max = Qf			

*SCH 51-A and 52-A are encapsulated in the reversible microwave cartridge (ceramic).

The average cartridge capacitance adds 1.0 pf to the capacitance of the glass units. Exact values depend naturally upon the detailed construction of the crystal mount.

APPLICATION

Although frequently used at zero d.c. bias, best temperature correction (2 millivolts °C) of the bias point is achieved with stabistor compensation. Proper placement or shielding of the diode will often reduce the effective magnitude of the minimum capacitance. Padding or trimming with fixed capacitors may be utilized to raise the circuit Q and allow increased R.F. voltage amplitudes, although this decreases the voltage sensitivity of this combination proportionately.

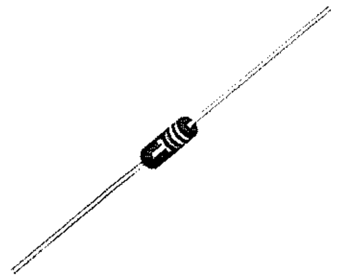
Operation at High RF Amplitudes

The silicon capacitor is a voltage controlled non-linear capacitor, and this characteristic is used here to obtain voltage tuning or frequency conversion. This must be kept in mind when operating at higher rf amplitudes where peak swings from the maximum inverse voltage to the forward conduction point (+ .4V) of the diode are encountered Series trimming with fixed capacitors is normally used to reduce the R.F. voltage amplitudes across the silicon capacitor diode.

TE-1312A
3-59

Transitron SILICON CAPACITORS

HIGH FREQUENCY TYPE



Transitron's silicon capacitors are small-area junction capacitors designed to provide excellent high frequency characteristics at temperatures up to 150°C. Their extremely low series resistance results in the highest possible "Q" at high frequencies, making them particularly useful in parametric amplifier, oscillator and pulse circuitry. Because capacitance varies with voltage, they will directly replace variable mica or air capacitors in almost any critical high frequency circuit.

SPECIFICATIONS

CHARACTERISTICS AND RATINGS

TYPE	Capacitance @ — 4V * (pf)	Saturation Voltage ** (volts) Min.	Typical Capacitance @ — .1 V (pf)	Capacitance @ Max. Operating Voltage (pf) Typical	Max. Operating Voltage (volts)	Typical Q @ 5 Mc @ — 4V	Typical Q @ 50 Mc @ — 4V	Typical Series Resistance (ohms)
SC-1	10	25	24	4.4	22	350	35	9.0
SC-2	20	25	48	8.0	22	350	35	4.5
SC-3	35	20	90	15	18	350	35	3.0
SC-5	50	12.5	120	25.	11	350	35	1.8
SC-7	70	10	165	55	9	350	35	0.9
SC-11	105	7	245	85	6	350	35	0.9
SC-15	150	7	360	120	6	350	35	0.6

* Range of capacitance at —4 volts is ± 20%

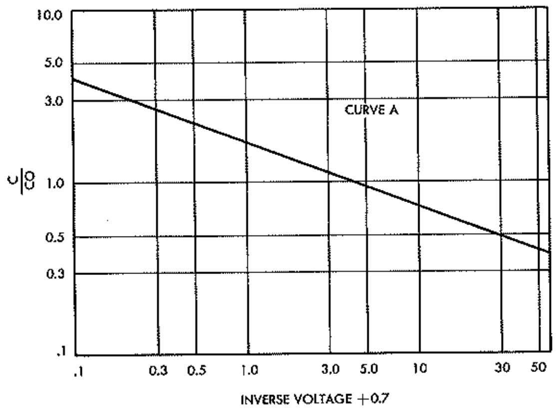
** Measured at 100 μa

ADDITIONAL INFORMATION

The temperature coefficient is defined by the following general formula:

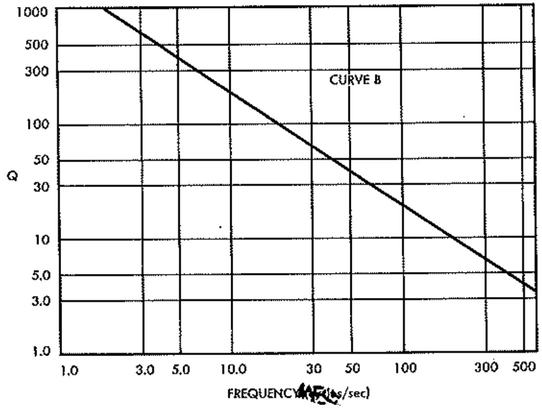
$$\frac{\Delta C}{\Delta T} = \sqrt[2.8]{\frac{V_B + .7}{V_B + .7 - .002\,(T-25)}} - 1$$

CAPACITANCE VS. VOLTAGE



Normalized graph shows the changes of capacity to be expected as a result of voltage changes. Voltage scale is plotted in "V_B + .7" volts to produce a linear relationship over a very wide range. Note that C = C_o when V_B = —4 volts.

"Q" VS. FREQUENCY



The Q factor of a silicon capacitor is measured at —4 volts and varies as a function of voltage in this manner:

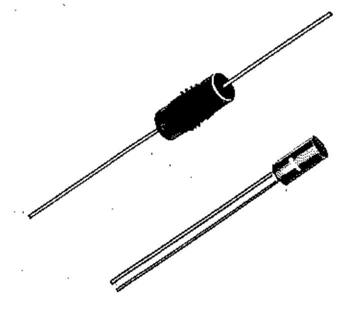
$$Q = \sqrt[2.8]{\frac{V_B + .7}{10.9\, f\, R_s\, C_o}}$$

Where C_o = C at —4 volts
f = operating frequency
R_s = series resistance
V_B = applied bias

Transitron

SILICON REFERENCES

LOW TEMPERATURE COEFFICIENT TYPES



Transitron's low temperature coefficient references are designed to provide a stable reference voltage over an extreme range of operating conditions. The compact axial lead package can be installed as easily as a 2-watt resistor. Each reference is composed of hermetically sealed glass diodes selected for stable characteristics. Since these references contain no liquids, they may be operated in any position without voltage variation.

The SV3206 and SV3207 provide low temperature coefficients at high voltages economically by matching two of the 8.4 volt units.

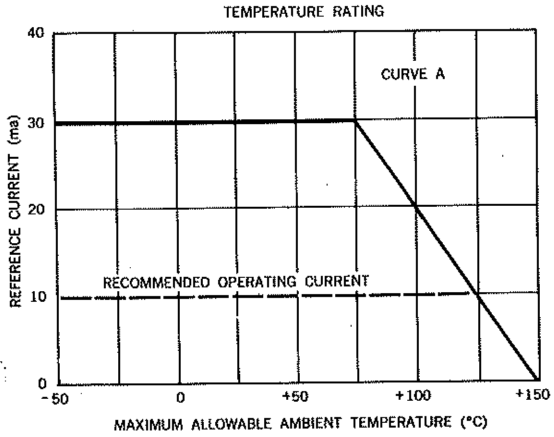
	SPECIFICATIONS				RATINGS	
TYPE	Voltage Range at I_Z = 10ma at 25°C (Volts)		Temp. Coefficient[2] (-55°C to +100°C) at I_Z = 10 ma (%/°C)	Maximum Dynamic[3] Resistance at 25°C at I_Z = 10 ma (ohms)	T Storage Max. (°C)	Max. Operating Temp. at I_Z = 10 ma (°C)
	Min.	Max.				
IN429[1]	5.9	6.5	±.01	20	–65 to +150	–65 to +125
SV-3170	6.7	7.4	±.02	10	–65 to +150	–65 to +125
SV-3171	6.7	7.4	±.01	10	–65 to +150	–65 to +125
SV-3173	8	8.8	±.005	15	–65 to +150	–65 to +125
SV-3174	8	8.8	±.003	15	–65 to +150	–65 to +125
SV-3175	8	8.8	±.002	15	–65 to +150	–65 to +125
SV-3176	8	8.8	±.001	15	–65 to +150	–65 to +125
SV-3206[4]	16	17.6	±.002	30	–65 to +150	–65 to +125
SV-3207[4]	16	17.6	±.001	30	–65 to +150	–65 to +125

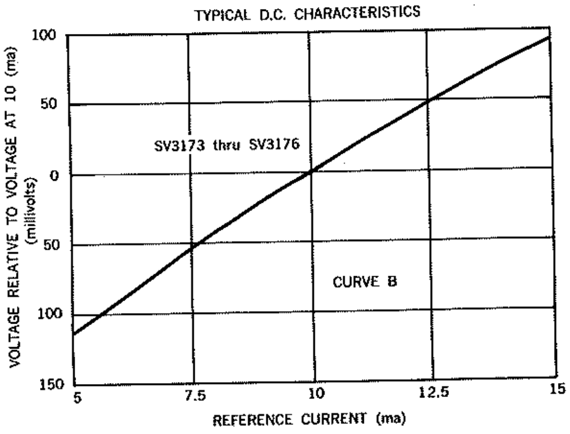
[1] Specified and rated @7.5 mA D.C.; single ended package.

[2] Determined by measuring a change of voltage from –55°C to + 25°C and a change of voltage from +25°C to 100°C.

[3] The Dynamic Resistance is measured by superimposing a small A.C. Signal upon the test D.C. Current. $(I_{AC}\ \text{RMS} \leqq \frac{1}{10} I_{DC}\ \text{Test})$

[4] Matched set of two Low Voltage Assemblies.


TEMPERATURE RATING


TYPICAL D.C. CHARACTERISTICS

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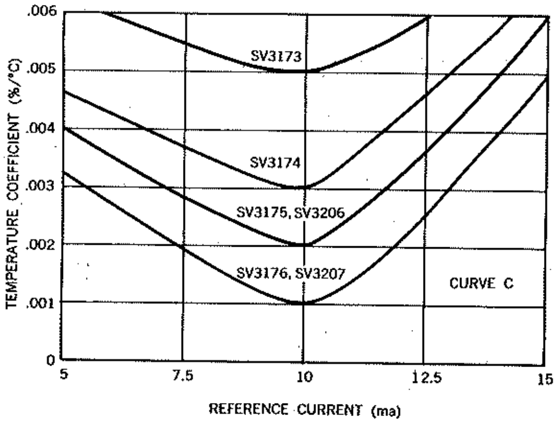
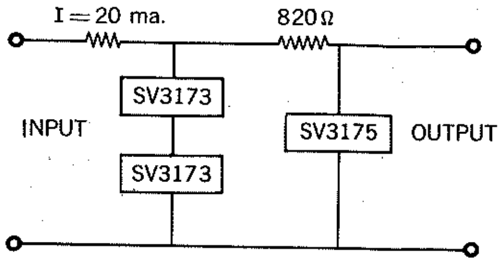


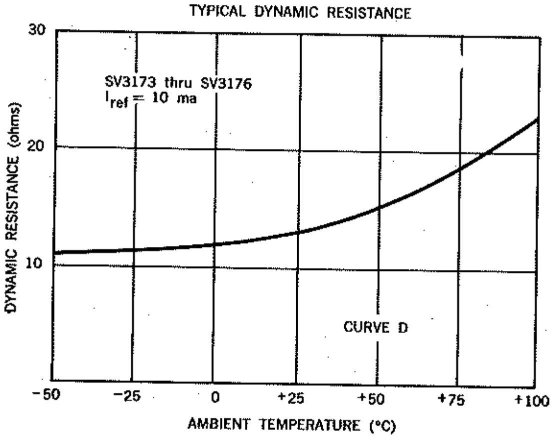
TEMPERATURE COEFFICIENT

The Transitron references are carefully matched at 10 milliamperes to insure a low temperature coefficient. The use of an operating current other then 10 milliamperes may result in a higher temperature coefficient, as shown on the graph. This factor is not critical for wide tolerance units such as the SV3173, but will be important for the SV3176.



STABILITY OF OPERATING CURRENT

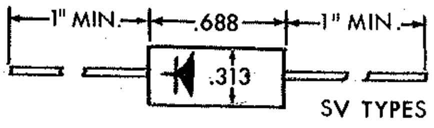
Variations of the operating current cause changes in the reference voltage. In critical circuits best performance is obtained by providing a stable current source similar to that shown at left. As an example, the current must be held stable within 1% if a voltage stability of 0.1% with respect to current is desired.



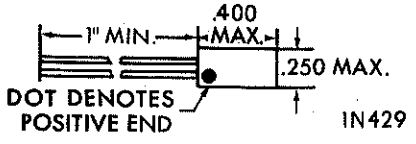
VOLTAGE STABILITY WITH LIFE

Tests run on samples of SV3175 references resulted in an average stability of 3 mv with less than 2% exceeding 8 mv following 500 hours of operation at 10 milliamperes and 75°C. This voltage stability is better than required when compared with a possible 25 mv change due to temperature coefficient alone across the –55°C to 100°C temperature range.

Many special reference assemblies have been designed for critical applications. For example, considerable savings are possible when a low temperature coefficient is needed for only a small temperature range. Our Applications Engineers will be glad to consider your requirements for special voltages, currents, temperature ranges, or special packaging.



MECHANICAL DATA



ENCAPSULATION: **Hermetically sealed glass diodes, assembled and potted in epoxy resin.**

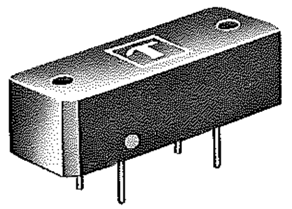
MOUNTING POSITION: **Any.**

LEADS: **Tinned.**

Transitron

SILICON REFERENCES

REF-AMP



Transitron's Ref-Amp eliminates four components and reduces the temperature coefficient of practical regulator circuits. It consists of a voltage reference (temperature compensated zener diode) and a silicon amplifying transistor, packaged together for convenience in mounting. The Ref-Amp may be used to replace both the reference and the first stage transistor amplifier in regulated power supplies.

SPECIFICATIONS

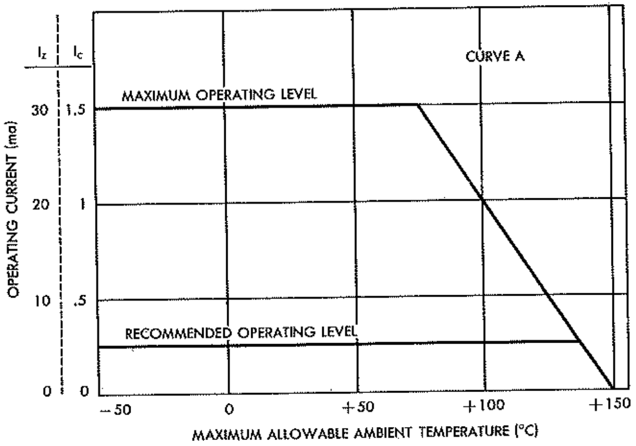
TYPE	Temperature Coefficient (%/°C) ①	Operating Temperature (Range (°C)	V_{BZ} @ 25°C (volts)		Measuring Conditions			MAXIMUM RATINGS		
			Min.	Max.	I_Z	I_C	V_{CE}	I_Z	V_{CE}	I_C
3N39	.005	– 20 to +71	8.3	9.8	5ma	250 μa	3V	30ma	30V	3ma
3N40	.003	– 20 to +71	8.3	9.8	5ma	250 μa	3V	30ma	30V	3ma
3N41	.002	– 20 to +71	8.3	9.8	5ma	250 μa	3V	30ma	30V	3ma
3N42	.005	– 55 to +100	8.3	9.8	5ma	250 μa	3V	20ma	30V	2ma
3N43	.003	– 55 to +100	8.3	9.8	5ma	250 μa	3V	20ma	30V	2ma
3N44	.002	– 55 to +100	8.3	9.8	5ma	250 μa	3V	20ma	30V	2ma

ADDITIONAL INFORMATION

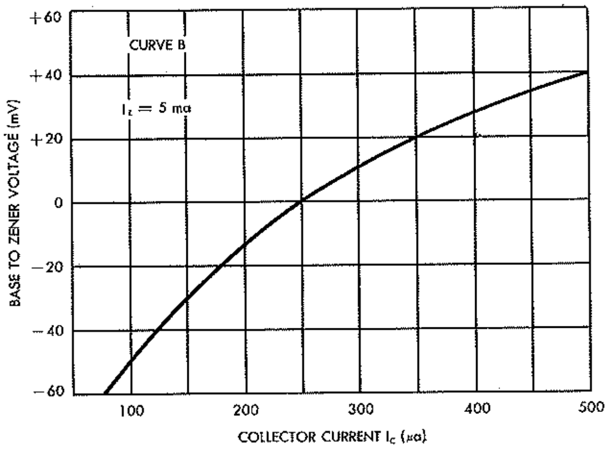
Maximum Storage Temperature	– 65°C to +150°C
Minimum D.C. Beta @ 250 μa	20

① Temperature coefficient multiplied by rated temperature range determines maximum peak-to-peak % voltage variation allowed over the rated temperature range.

TEMPERATURE RATINGS



TYPICAL D.C. CHARACTERISTICS



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TYPICAL REF-AMP CIRCUIT

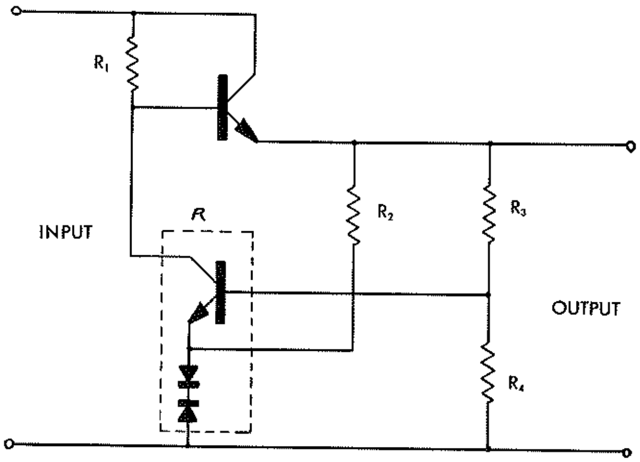


Fig. 1

Figure 1 shows a typical input stage in a power supply using the REF-AMP. As can be seen, only four resistors are required in addition to the REF-AMP and series transistor. R_2 provides bias current for the reference from the regulated output. R_1 supplies the REF-AMP collector and the series transistor base with operating current. The other two resistors form a voltage divider for sampling the output voltage. This is only one of many circuits possible using the REF-AMP. Higher currents can be regulated by placing emitter follower amplifiers between the REF-AMP collector and the series transistor base.

Reliability of voltage regulators is improved by the use of hermetically sealed, military quality silicon transistors and voltage regulators, and by the elimination of several components.

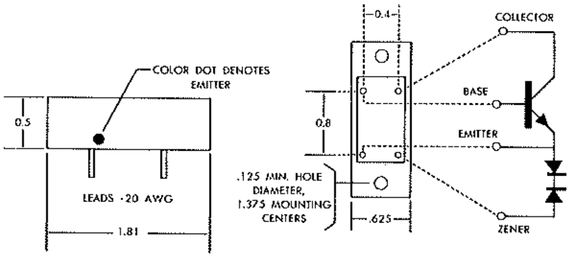
Thermal design insures that all junctions in the REF-AMP operate at essentially the same temperature, eliminating much of the voltage transient observed when some voltage references are subjected to rapid temperature changes.

Packaging of the REF-AMP has been engineered for easy mounting in printed circuit applications. It can, of course, be used in conventional chassis mounting also. The REF-AMP contains no liquids, and therefore is not sensitive to mounting position.

IMPORTANT FACTORS IN CIRCUIT DESIGN

1. CURRENT LEVELS: The low temperature coefficient characteristics of the REF-AMP are best realized when it is operated at a nominal collector current (I_C) of 250 microamps and a nominal regulator current (I_Z) of five milliamps. The temperature coefficient of V_{BZ} will become more positive at higher currents in either the collector or regulator. It will become more negative at lower collector or regulator currents.
2. CURRENT SWING: Curve B on the data sheet indicates the input voltage variation as a function of the REF-AMP collector current. The variation due to current is added to the variation due to temperature in determining the total REF-AMP voltage variation under actual operating conditions.
3. OPERATING TEMPERATURE RANGE: The two temperature ranges have been selected for the most common environmental conditions encountered in military and industrial applications. The maximum peak-to-peak voltage variation is determined by multiplying the rated temperature range by V_{BZ} and the temperature coefficient. Thus, a 3N41 with V_{BZ} = 8.8 volts will have a maximum voltage variation of 16 millivolts. Similarly, a 3N44 of the same voltage would have a maximum voltage variation of 27 millivolts over the wider temperature range.
4. SOURCE IMPEDANCE: In Figure 1, the source impedance is determined by resistors R_3 and R_4. The parallel equivalent resistance of these resistors should not exceed 1000 ohms. (Special REF-AMPS can be provided for source impedance up to 10,000 ohms).
5. COLLECTOR VOLTAGE: The 3N39 and 3N42 series REF-AMPS are designed for maximum collector voltages (V_{CE}) up to thirty volts, and will have long term reliability in twenty-eight volt applications. However, optimum results will be obtained by maintaining V_{CE} @ approximately three volts.

MECHANICAL DATA



ENCAPSULATION: Glass to metal hermetic seal encapsulated in epoxy package.

WEIGHT: 18 grams maximum.

MOUNTING POSITION: Any.

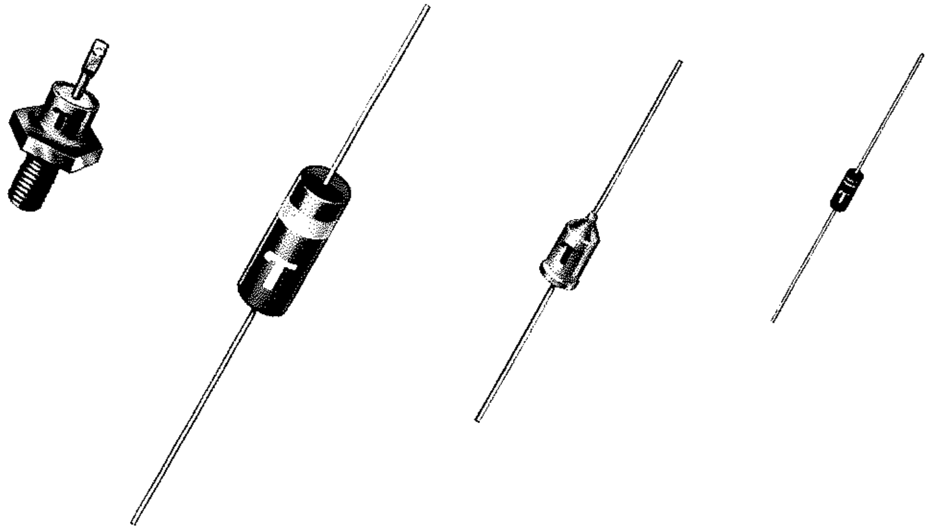
MAXIMUM ALTITUDE: Any.

SILICON VOLTAGE REGULATORS

APPLICATIONS NOTES

and

DESIGN INFORMATION



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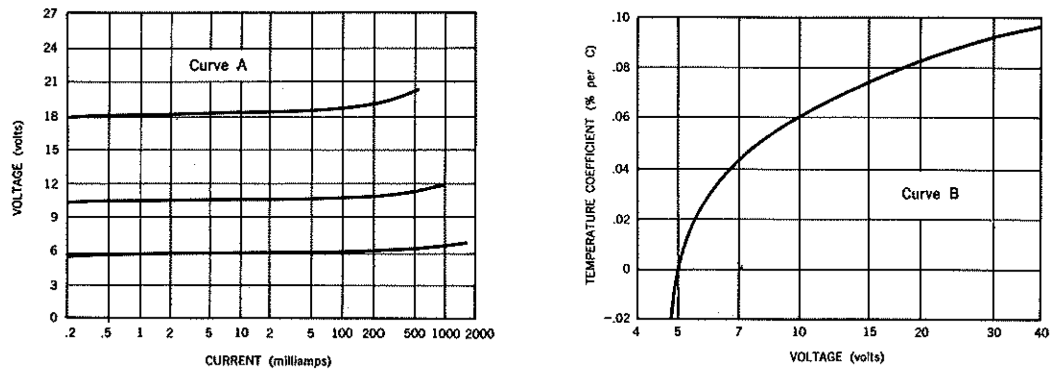
SILICON VOLTAGE REGULATORS

A silicon diode can be utilized as a voltage regulator if operated in the saturation region of its inverse characteristic. The E-I characteristics of some typical silicon regulators are shown below. As can be seen, the curve breaks sharply when the saturation voltage is reached and essentially a constant voltage is maintained over a wide current range.

The silicon diode, when used as a regulator or voltage reference, eliminates some of the problems inherent in other types of regulators. It is smaller, lighter in weight, and has a mechanical ruggedness unavailable in tubes or batteries. There is essentially no deterioration under storage and little or no aging over its operating life as compared with other regulating devices. Because aging and deterioration are reduced to unimportant factors, the silicon regulator has a long useful life expectancy.

Most other voltage regulators can provide regulation only at specific voltages and over limited current ranges. The silicon voltage regulator, however, can provide regulation at any desired voltage and over a very wide current range. Further, operating currents above an ampere are possible. The wide range of silicon regulator operation allows a new flexibility in circuit design.

TYPICAL DC CHARACTERISTICS



REGULATOR CHARACTERISTICS

The saturation voltage of a silicon regulator is determined by the type of silicon material used and is a controllable element in the manufacturing process. This voltage can be predetermined within certain limits for a particular regulator. The voltage is further dependent upon the operating ambient temperature. The coefficient that results is a constant for a given regulator and is related to its voltage, as illustrated in Curve B. This coefficient, as the graph indicates, approaches 0.1% per degree C at higher voltages, passes through zero in the region around 5.0 volts, and is negative at lower voltages.

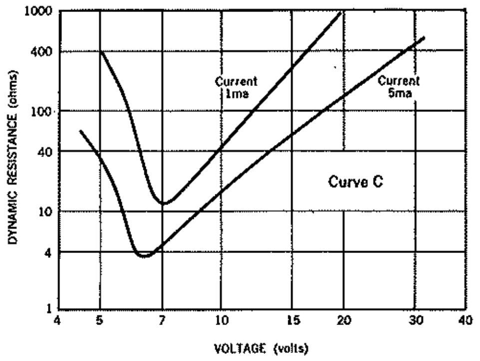
In any silicon regulator there is an inherent upper limit to the current range over which it can regulate. This limit is established by its heat dissipation capabilities. Because of this current limitation and because demands exist for regulators that will operate at currents in the vicinity of 1-2 amperes, various power classes of regulators have been developed.

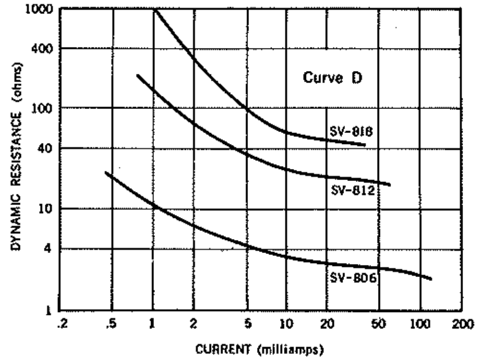
The basic parameter for measuring the regulating ability of a silicon voltage regulator is its dynamic resistance. The dynamic resistance is an expression of the change in voltage for a small change in current. It is measured by observing the AC voltage developed across the regulator when a small AC current is superimposed upon the operating DC current. Curve C shows the value of dynamic resistance as related to operating voltage. The lowest dynamic resistance is observed at about 6.5 volts, and from there it rises at a rate that is proportional to approximately the square of the voltage. In any particular regulator the dynamic resistance is further dependent upon the operating current. Curve D illustrates the magnitude of this change for a typical regulator. At any given current a variation in dynamic resistance is also observed with changes in ambient temperature. As temperature increases, the dynamic resistance increases linearly, rising approximately 30% for 100°C.

In order to express the regulating ability in a direct manner under various conditions, an element known as the regulation factor (F) has been developed. The derivation of this factor is as follows:

$$F = \frac{R_{dc}}{R_{ac}} = \frac{E_{dc}/I_{dc}}{R_{dynamic}} = \frac{E_{dc}/I_{dc}}{\Delta E/\Delta I} = \frac{\Delta I/I_{dc}}{\Delta E/E_{dc}} = \frac{\%_{change}\ I}{\%_{change}\ E}$$

This factor expresses the improvement in regulation that will be achieved and simplifies calculations for the designing of regulating circuitry.





THE PROPER SELECTION OF REGULATORS

To determine the degree of regulation that can be obtained from silicon regulators, several conditions must be known. These are: output voltage, operating current range, ambient temperature range, and the expected changes in input and output conditions. Once output voltage and the current range have been fixed, the two elements that affect overall regulation are the change in current through the regulator, and the change in ambient temperature conditions. If the temperature coefficient proves to be the limiting element in overall regulating ability, consideration should be given to utilizing a series string of lower voltage regulators which have smaller temperature coefficients. When extreme temperature stability is necessary, use selected and compensated voltage references. If the regulation factor in the operating current range is limiting, consideration should be given to operating at a current where this factor is higher, or utilizing lower voltage devices that will provide better overall regulation at a particular operating current.

The nature of the input variations over which the device is expected to regulate will determine the degree of regulation that can be expected. If the current changes in the regulator are less than 25% and of short duration, the regulation factor at the operating current expresses the operating characteristics of the device. If the current changes are larger, but still of short duration, the change in dynamic resistance, and therefore of the regulation factor with current, must be taken into consideration. If the current changes have a long-time duration, the operating junction temperature will change as a result of the changing power level. This causes a change in operating voltage as determined by the temperature coefficient. The general derivation of this thermally induced resistance is as follows:

$$\Delta T = E_{Reg} \cdot \Delta I \cdot {}^{\circ}C/W$$

$$\Delta E = \text{Temp. Coeff.} \cdot E_{Reg} \cdot \Delta T$$

$$\Delta E = \text{Temp. Coeff.} \cdot E_{Reg}{}^{2} \cdot \Delta I \cdot {}^{\circ}C/W$$

$$\therefore R_{induced} = \frac{\Delta E}{\Delta I} = \text{Temp. Coeff.} \cdot E_{Reg}{}^{2} \cdot {}^{\circ}C/W$$

After the thermally induced resistance of the device has been determined, it can be added to the dynamic resistance, and a new regulator factor, called the static regulation factor, can be determined:

Dynamic Resistance for Short duration surges = R_{dyn}

" " " Long " " = $R_{dyn} + R_{induced}$

$$F \text{ static} = \frac{E_{dc}/I_{dc}}{R_{dyn} + R_{induced}}.$$

If the current changes require that this static regulation be considered, a determination should be made as to whether the dynamic resistance or the thermally induced resistance is the dominating factor in limiting the regulation. Because dynamic resistance decreases with increasing current, while the thermally induced resistance is independent of operating current, the dynamic resistance will tend to dominate at lower currents, and the thermally induced resistance will limit regulation at higher currents.

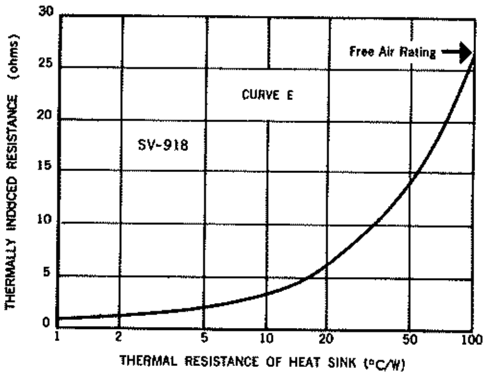
If thermally induced resistance is determined to be the limiting factor in a particular application, an improvement in regulation can be achieved by either utilizing lower voltage units in series, or by using units with higher power dissipation capabilities. With the lower voltage devices, regulation is improved because the temperature coefficient is smaller and the power dissipation per unit is reduced. A regulator with high heat dissipation capabilities will improve regulation, because the change in temperature at the junction per watt change in power dissipation is lower.

The magnitude of the thermally induced resistance for the various classes of regulators is illustrated below:

Subminiature Glass Regulator
SV-18 at 18 volts
Temp. Coef = .08% per °C
R induced = 130 ohms

Miniature Regulator
SV-818 at 18 volts
Temp. Coef = .08% per °C
R induced = 39 ohms

Power Regulator
SV-918 at 18 volts
Temp. Coef = .08% per °C
R induced (see curve)



CLOSE TOLERANCE SELECTION

In the large-scale manufacture of silicon voltage regulators, saturation voltages occur in a natural distribution about the desired value. This distribution has a span of approximately ±15%. The maximum and minimum voltage limits that have been established for our standard voltage regulator types are based upon this distribution. If a closer tolerance is desired, it becomes necessary to select special units from within this distribution. If the limit desired is less than ±5%, the selection yield becomes very low, resulting in limited availability and high cost for the selected unit.

However, very close tolerance silicon regulator assemblies can be obtained by connecting lower voltage units in series, which allows the use of the entire voltage distribution, and only requires that accurate measurements of voltage be made. This method of obtaining close tolerance devices is greatly preferred from the standpoint of lower cost and better availability, and offers the additional advantages of lower power dissipation, smaller temperature coefficient, and lower dynamic resistance than would be possible in a single higher voltage unit.

HIGHER VOLTAGE DEVICES

Silicon voltage regulators can provide good regulation at voltages above those specified for the standard types. There are two alternatives for obtaining regulation at higher voltages. A single unit rated for the desired voltage can be used, or lower voltage units can be used in series. The dynamic resistance and the thermal resistance will both be lower for the series combination. As a result, the regulation will be superior at all currents. In addition, the temperature coefficient will be lower, if low voltage units are used. Curve B shows this relation of voltage and temperature coefficient in detail. Much closer voltage tolerance is also possible when the desired voltage is obtained by a series combination. The series regulator assembly will also have higher current ratings as a result of its greater dissipation capability. This increased rating is directly proportional to the number of units used.

RELIABILITY

Whenever a series combination is considered for an application, the question of reliability can arise. It is normally assumed that reliability is inversely proportional to the number of elements involved. This assumption is correct, however, only if the load per element is independent of the number of elements used.

For given load conditions, the power dissipation per unit in a series combination will be inversely proportional to the number of units in series. For example, if two cells are used to obtain a given voltage, the dissipation in each of the series units will be one-half that of the single unit case. This means that the operating junction temperature will be significantly lower for the series regulators. Experience has indicated that life expectancy doubles with every 10°C drop in junction temperature. This means that if in a particular application the rise of the junction temperature is 40° above ambient when a single unit is used, the rise would be 20°C with the series combination. The life expectancy, therefore, would be approximately quadrupled and the reliability doubled in the series combination.