No. 31,158A
Supersedes No. 31,158

SPRAGUE® THE MARK OF RELIABILITY

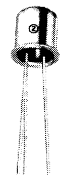
Engineering Bulletin

TYPE
2N2274
2N2275

TYPE 2N2274 AND 2N2275 SILICON PRECISION-ALLOY TRANSISTORS

DESIGNED FOR low-level chopper applications, Type 2N2274 Silicon Precision-Alloy Transistors feature extremely low leakage current, low offset voltage, and uniquely low inverted dynamic saturation resistance.

Type 2N2275 SPAT® identifies matched pairs of Type 2N2274 transistors with an offset voltage match guaranteed over the temperature range of +25 C to +65 C.



ACTUAL SIZE

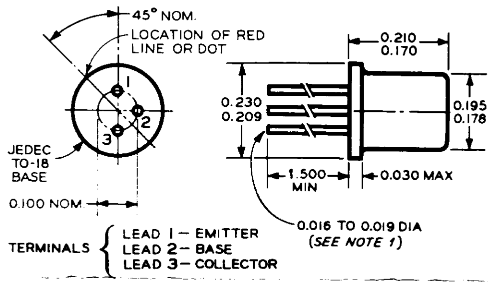
ABSOLUTE MAXIMUM RATINGS[1]

Storage Temperature	−65 C to + 140 C
Collector Voltage, V_{CBO}	−25 volts
Collector Voltage, V_{CEO}	−25 volts
Emitter Voltage, V_{EBO}	−25 volts
Emitter Voltage, V_{ECO}	−25 volts
Collector Current, I_C	−50 ma
Total Device Dissipation[2] at 25 C	150 mw
Lead Temperature at 1/16″ ± 1/32″ from case	230 C for 10 sec

[1] The maximum ratings are limiting absolute values above which the serviceability may be impaired from the viewpoint of life or satisfactory performance. The breakdown voltages may be far above the maximum voltage ratings. To avoid permanent damage to the transistors, do not attempt to measure these characteristics above the maximum ratings.

[2] Due to the nature of these transistors, the dissipation in the base emitter circuit may be appreciable under high base drive conditions and must be included in the total device dissipation. For temperatures above 25 C, derate by 1.3 mw/°C.

MECHANICAL SPECIFICATIONS



NOTE 1: THIS LEAD DIA APPLIES TO ZONE BETWEEN 0.050 AND 0.250 FROM BASE SEAT. IN ZONE BETWEEN 0.250 AND 0.050, A MAX OF 0.021 DIA IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIA IS NOT CONTROLLED.

DWG NO A-3806

ELECTRICAL CHARACTERISTICS[3] at T = 25 C

	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
	D-C CHARACTERISTICS					
I_{CBO}	Collector Cutoff Current	V_{CB} = −10V	—	—	3	nA
I_{CBO}	Collector Cutoff Current	V_{CB} = −10V, T = +65 C	—	—	45	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V	—	—	3	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V, T = +65 C	—	—	45	nA
I_{ECO}	Emitter Current	V_{EC} = −10V	—	—	3	nA
BV_{CBO}	Collector Breakdown Voltage	I_C = −1µA	25	—	—	volts
BV_{CEO}	Collector Breakdown Voltage	I_C = −10µA	25	—	—	volts
BV_{EBO}	Emitter Breakdown Voltage	I_E = −1µA	25	—	—	volts
BV_{ECO}	Emitter Breakdown Voltage	I_E = −1µA	25	—	—	volts
V_{RT}	Reach Through Voltage	V_{EB} = −1V	25	—	—	volts
h_{FE}	D-C Amplification Factor	V_{CE} = −0.5V, I_C = −5mA	10	15	—	—
V_{OFF}	Offset Voltage	I_B = −500µA	—	1.8	3.0	mV
V_{OFF}	Offset Voltage	I_B = −1mA	—	2.1	3.25	mV
V_{OFF}	Offset Voltage	I_B = −1.5 mA	—	2.4	3.5	mV
	HIGH FREQUENCY CHARACTERISTICS					
r_s	Inverted Dynamic Saturation Resistance[4]	I_B = −1.5mA, I_E = 100µA	4	11	17	ohms
C_{ib}	Input Capacitance	V_{EB} = −6V, I_C = 0, f = 4mc	—	4	6	pF
C_{ob}	Output Capacitance	V_{CB} = −6V, I_E = 0, f = 4mc	—	6	9	pF
C_{eb}	Emitter Diode Capacitance[5]	I_E = 0.25 µA, f = 10mc	—	12	16	pF
——	Emitter Diode Recovery Time[6]	I_B = −1.5mA nom.	—	6	15	µsec
f_T	Gain Bandwidth Product	V_{CE} = −6V, I_E = 1mA, f = 4mc	6	9	—	mc
	TYPE 2N2275 MATCHED PAIR DATA					
ΔV_{OFF}	Differential Offset Voltage[7]	I_B = −1.5mA, T_A = +25C to +65C	—	—	100	µV

[3] Typical values are for engineering guidance only.
[4] To be measured in circuit of Figure 1.
[5] To be measured in circuit of Figure 2.
[6] To be measured in circuit of Figure 3.
[7] To be measured in circuit of Figure 4.

"SPAT" is a registered trademark of the Philco Corp.

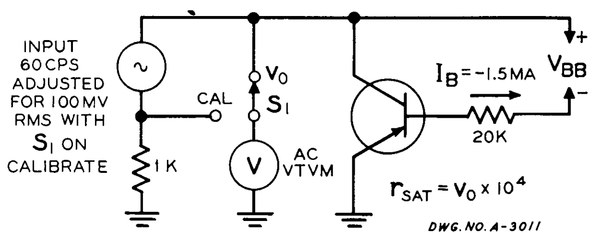


FIGURE 1
INVERTED DYNAMIC r_s TEST CIRCUIT

The inverted dynamic saturation resistance, which is the slope of the V_{OFF}, I_E characteristic at a specified base current, is measured in the circuit shown in Figure 1. The circuit reads r_s directly as the ratio of the a-c collector voltage, V_o to a calibrated a-c collector current.

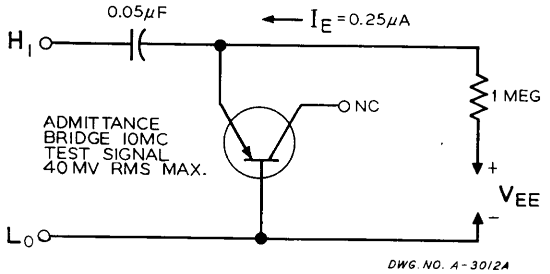


FIGURE 2
EMITTER DIODE CAPACITANCE TEST CIRCUIT

Figure 2 shows the test circuit for the measurement of the emitter diode capacitance, C_{eb}. The measurement is made with the emitter diode slightly forward biased (I_E = 0.25μA). The 10 MC test signal from the admittance bridge should be less than 40 MV RMS.

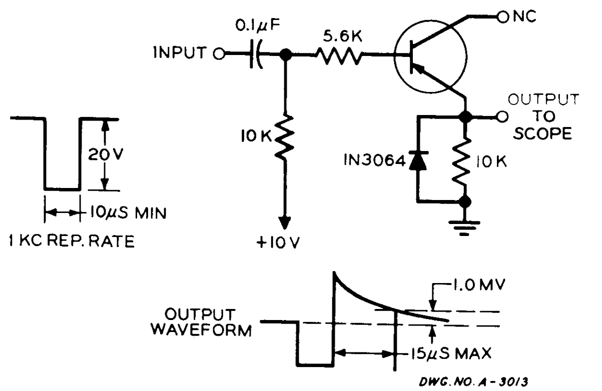


FIGURE 3
EMITTER DIODE RECOVERY TIME TEST CIRCUIT

The emitter diode reverse recovery time, a measure of the transient response of the chopper, is measured in the circuit of Figure 3. The measurement is made as the time for the emitter current to recover from a specified forward value to a specified reverse value. The IN3064 diode across the 10K emitter resistance serves to clamp the emitter potential to reduce the output voltage change to a convenient level.

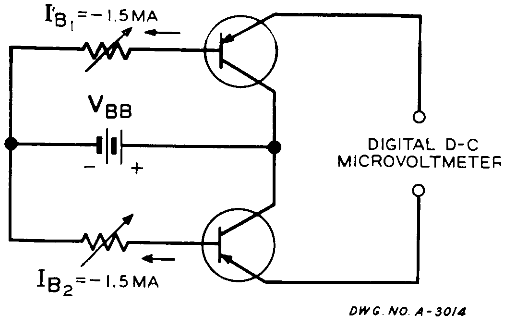


FIGURE 4
DIFFERENTIAL OFFSET VOLTAGE MATCH TEST CIRCUIT

The offset voltage match, ΔV_{OFF}, is measured in the circuit of Figure 4. The difference in the offset voltage at the specified base current is measured with a digital voltmeter.

In the construction of the components described, the full intent of the specification will be met. The Sprague Electric Company, however, reserves the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the design of its products. Components made under military approvals will be in accordance with the approval requirements.

ISSUE OF JUNE, 1964

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SPRAGUE Engineering Bulletin

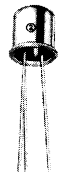
SPRAGUE THE MARK OF RELIABILITY

TYPE 2N2276 2N2277

TYPE 2N2276 AND 2N2277 SILICON PRECISION-ALLOY TRANSISTORS

EXTREMELY LOW leakage current, low offset voltage, and uniquely low inverted dynamic saturation resistance are the prime characteristics of Type 2N2276 Silicon Precision-Alloy Transistors, designed for use in low-level chopper applications.

Type 2N2277 SPAT® identifies matched pairs of Type 2N2276 Transistors with an offset voltage guaranteed over the temperature range of +25 C to +65 C.



ACTUAL SIZE

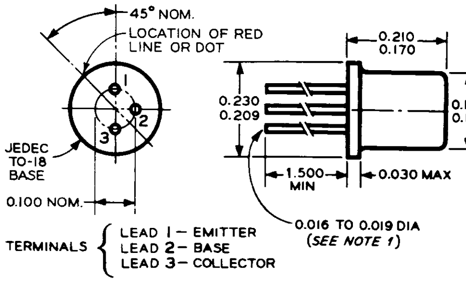
ABSOLUTE MAXIMUM RATINGS[1]

Storage Temperature .... −65 C to + 140 C
Collector Voltage, V_{CBO} .... −15 volts
Collector Voltage, V_{CEO} .... −10 volts
Emitter Voltage, V_{EBO} .... −15 volts
Emitter Voltage, V_{ECO} .... −10 volts
Collector Current, I_C .... −50 ma
Total Device Dissipation[2] at 25 C .... 150 mw
Lead Temperature at 1/16" ± 1/32" from case .... 230 C for 10 sec

[1] The maximum ratings are limiting absolute values above which the serviceability may be impaired from the viewpoint of life or satisfactory performance. The breakdown voltages may be far above the maximum voltage ratings. To avoid permanent damage to the transistors, do not attempt to measure these characteristics above the maximum ratings.

[2] Due to the nature of these transistors, the dissipation in the base emitter circuit may be appreciable under high base drive conditions and must be included in the total device dissipation. For temperatures above 25 C, derate by 0.8 mw/°C.

MECHANICAL SPECIFICATIONS



NOTE 1: THIS LEAD DIA APPLIES TO ZONE BETWEEN 0.050 AND 0.250 FROM BASE SEAT. IN ZONE BETWEEN 0.250 AND 0.050, A MAX OF 0.021 DIA IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIA IS NOT CONTROLLED.

DWG NO A-3806

ELECTRICAL CHARACTERISTICS[3] at T = 25 C

	CHARACTERISTICS	TEST CONDITIONS		MIN.	TYP.	MAX.	UNITS
	D-C CHARACTERISTICS						
I_{CBO}	Collector Cutoff Current	V_{CB} = −10V		—	—	3	nA
I_{CBO}	Collector Cutoff Current	V_{CB} = −10V	T = +65 C	—	—	45	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V		—	—	3	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V	T = +65 C	—	—	45	nA
I_{ECO}	Emitter Current	V_{EC} = −6V		—	—	3	nA
BV_{CBO}	Collector Breakdown Voltage	I_C = −1μA		15	—	—	volts
BV_{CEO}	Collector Breakdown Voltage	I_C = −10μA		10	—	—	volts
BV_{EBO}	Emitter Breakdown Voltage	I_E = −1μA		15	—	—	volts
BV_{ECO}	Emitter Breakdown Voltage	I_E = −1μA		10	—	—	volts
V_{RT}	Reach Through Voltage	V_{EB} = −1V		10	—	—	volts
h_{FE}	D-C Amplification Factor	V_{CE} = −0.5V	I_C = −5mA	10	15	—	—
V_{OFF}	Offset Voltage	I_B = −500μA		—	0.8	2.0	mV
V_{OFF}	Offset Voltage	I_B = −1mA		—	1.1	2.25	mV
V_{OFF}	Offset Voltage	I_B = 1.5 mA		—	1.4	2.5	mV
	HIGH FREQUENCY CHARACTERISTICS						
r_s	Inverted Dynamic Saturation Resistance[4]	I_B = −1.5mA	I_E = 100μA	4	10	17	ohms
C_{ib}	Input Capacitance	V_{EB} = −6V	I_C = 0 f = 4mc	—	4	6	pF
C_{ob}	Output Capacitance	V_{CB} = −6V	I_E = 0 f = 4mc	—	6	9	pF
C_{eb}	Emitter Diode Capacitance[5]	I_E = 0.25 μA	f = 10mc	—	12	16	pF
—	Emitter Diode Recovery Time[6]	I_B = −1.5mA nom.		—	6	15	μsec
f_T	Gain Bandwidth Product	V_{CE} = −6V	I_E = 1mA f = 4mc	6	9	—	mc
	TYPE 2N2277 MATCHED PAIR DATA						
ΔV_{OFF}	Differential Offset Voltage[7]	I_B = −1.5mA; T_A = +25C to +65C		—	—	—	100μV

[3] Typical values are for engineering guidance only.
[4] To be measured in circuit of Figure 1.
[5] To be measured in circuit of Figure 2.
[6] To be measured in circuit of Figure 3.
[7] To be measured in circuit of Figure 4.

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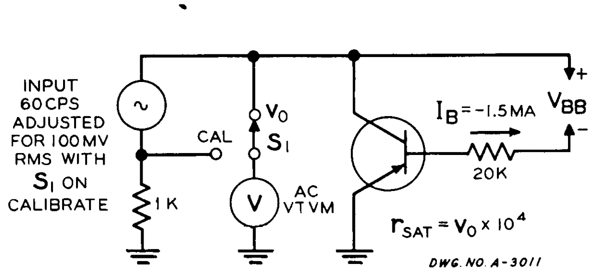

FIGURE 1
INVERTED DYNAMIC r_s TEST CIRCUIT

The inverted dynamic saturation resistance, which is the slope of the V_{OFF}, I_E characteristic at a specified base current, is measured in the circuit shown in Figure 1. The circuit reads r_s directly as the ratio of the a-c collector voltage, V_o to a calibrated a-c collector current.

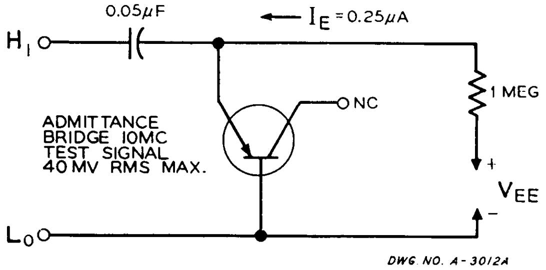

FIGURE 2
EMITTER DIODE CAPACITANCE TEST CIRCUIT

Figure 2 shows the test circuit for the measurement of the emitter diode capacitance, C_{eb}. The measurement is made with the emitter diode slightly forward biased ($I_E = 0.25\mu A$). The 10 MC test signal from the admittance bridge should be less than 40 MV RMS.

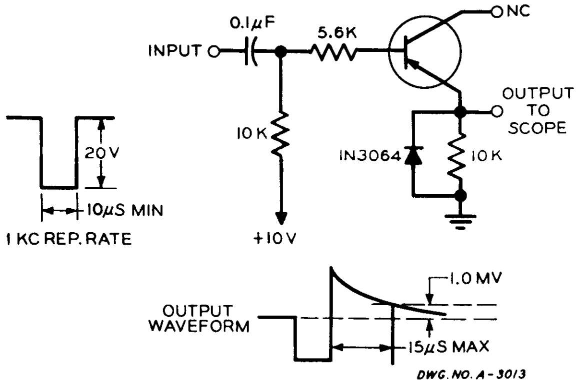

FIGURE 3
EMITTER DIODE RECOVERY TIME TEST CIRCUIT

The emitter diode reverse recovery time, a measure of the transient response of the chopper, is measured in the circuit of Figure 3. The measurement is made as the time for the emitter current to recover from a specified forward value to a specified reverse value. The IN3064 diode across the 10K emitter resistance serves to clamp the emitter potential to reduce the output voltage change to a convenient level.

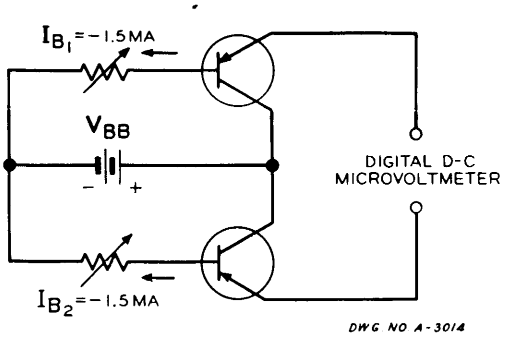

FIGURE 4
DIFFERENTIAL OFFSET VOLTAGE MATCH TEST CIRCUIT

The offset voltage match, ΔV_{OFF}, is measured in the circuit of Figure 4. The difference in the offset voltage at the specified base current is measured with a digital voltmeter.

ISSUE OF JUNE, 1964

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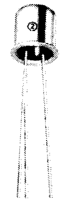
Engineering Bulletin

TYPE
2N2278
2N2279

TYPE 2N2278 AND 2N2279 SILICON PRECISION-ALLOY TRANSISTORS

DESIGNED FOR low-level chopper applications, Type 2N2278 Silicon Precision-Alloy Transistors feature extremely low leakage current, low offset voltage, and uniquely low inverted dynamic saturation resistance.

Type 2N2279 SPAT® identifies matched pairs of Type 2N2278 Transistors with an offset voltage match guaranteed over the temperature range of +25 C to +85 C.



ACTUAL SIZE

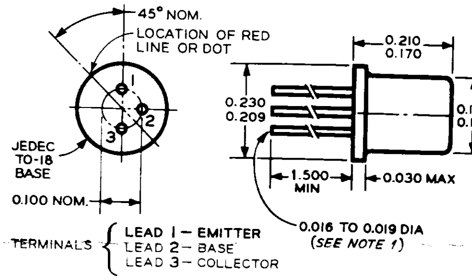
ABSOLUTE MAXIMUM RATINGS[1]

Storage Temperature	−65 C to + 140 C
Collector Voltage, V_{CBO}	−15 volts
Collector Voltage, V_{CEO}	−15 volts
Emitter Voltage, V_{EBO}	−15 volts
Emitter Voltage, V_{ECO}	−15 volts
Collector Current, I_C	−50 ma
Total Device Dissipation[2] at 25 C	150 mw
Lead Temperature at 1/16″ ± 1/32″ from case	230 C for 10 sec

[1] The maximum ratings are limiting absolute values above which the serviceability may be impaired from the viewpoint of life or satisfactory performance. The breakdown voltages may be far above the maximum voltage ratings. To avoid permanent damage to the transistors, do not attempt to measure these characteristics above the maximum ratings.

[2] Due to the nature of these transistors, the dissipation in the base emitter circuit may be appreciable under high base drive conditions and must be included in the total device dissipation. For temperatures above 25 C, derate by 1.3 mw/°C.

MECHANICAL SPECIFICATIONS



NOTE 1: THIS LEAD DIA APPLIES TO ZONE BETWEEN 0.050 AND 0.250 FROM BASE SEAT. IN ZONE BETWEEN 0.250 AND 0.050, A MAX OF 0.021 DIA IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIA IS NOT CONTROLLED.

DWG NO. A-3806

ELECTRICAL CHARACTERISTICS[3] at T = 25 C

	CHARACTERISTICS	TEST CONDITIONS		MIN.	TYP.	MAX.	UNITS
	D-C CHARACTERISTICS						
I_{CBO}	Collector Cutoff Current	V_{CB} = −10V		—	—	1	nA
I_{CBO}	Collector Cutoff Current	V_{CB} = −10V	T = +65C	—	—	15	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V		—	—	1	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V	T = +65C	—	—	15	nA
I_{ECO}	Emitter Current	V_{EC} = −10V		—	—	1	nA
BV_{CBO}	Collector Breakdown Voltage	I_C = −10nA		15	—	—	volts
BV_{CEO}	Collector Breakdown Voltage	I_C = −1μA		15	—	—	volts
BV_{EBO}	Emitter Breakdown Voltage	I_E = −10nA		15	—	—	volts
BV_{ECO}	Emitter Breakdown Voltage	I_E = −10nA		15	—	—	volts
V_{OFF}	Offset Voltage	I_B = −500μA		—	0.9	1.3	mV
V_{OFF}	Offset Voltage	I_B = −1mA		—	1.0	1.75	mV
V_{OFF}	Offset Voltage	I_B = −1.5mA		—	1.2	2.25	mV
	HIGH FREQUENCY CHARACTERISTICS						
r_s	Inverted Dynamic Saturation Resistance[4]	I_B = −1mA	I_E = 100μA	7	13	18	ohms
C_{ib}	Input Capacitance	V_{EB} = −6V	I_C = 0 f = 4mc	—	4	7	pF
C_{ob}	Output Capacitance	V_{CB} = −6V	I_E = 0 f = 4mc	—	6	9	pF
C_{eb}	Emitter Diode Capacitance[5]	I_E = 0.25μA	f = 10mc	—	12	16	pF
	Emitter Diode Recovery Time[6]	I_B = −1mA nom.		—	6	15	μsec
f_T	Gain Bandwidth Product	V_{CE} = −6V	I_E = 1mA f = 4mc	7.6	12	—	mc
	MATCHED PAIR DATA						
ΔV_{OFF}	Differential Offset Voltage[7]	I_B = −1mA T_A = +25C to +85C		—	—	50	μV

[3] Typical values are for engineering guidance only.
[4] To be measured in circuit of Figure 1.
[5] To be measured in circuit of Figure 2.
[6] To be measured in circuit of Figure 3
[7] To be measured in circuit of Figure 4

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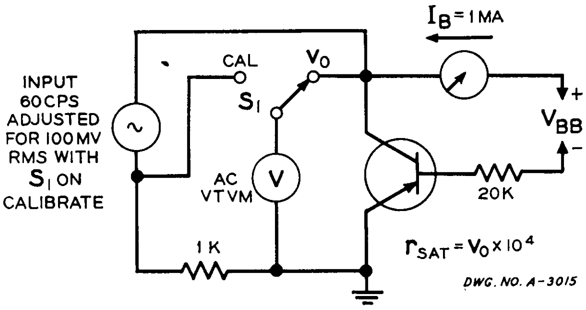


FIGURE 1
INVERTED DYNAMIC r_S TEST CIRCUIT

The inverted dynamic saturation resistance, which is the slope of the V_{OFF}, I_E characteristic at a specified base current, is measured in the circuit shown in Figure 1. The circuit reads r_S directly as the ratio of the a-c collector voltage, V_o to a calibrated a-c collector current.

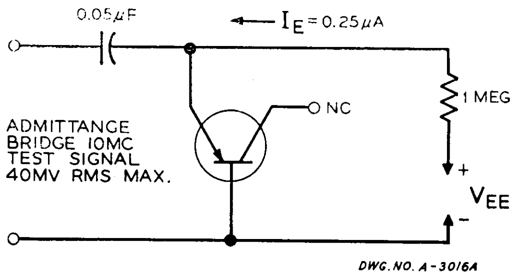


FIGURE 2
EMITTER DIODE CAPACITANCE TEST CIRCUIT

Figure 2 shows the test circuit for the measurement of the emitter diode capacitance, C_{eb}. The measurement is made with the emitter diode slightly forward biased (I_E = 0.25μA). The 10 MC test signal from the admittance bridge should be less than 40 MV RMS.

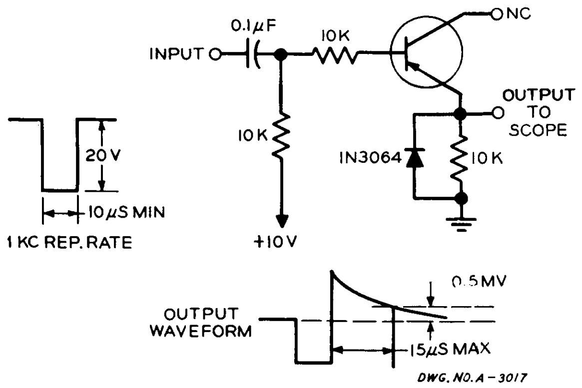


FIGURE 3
RECOVERY TIME TEST CIRCUIT

The emitter diode reverse recovery time, a measure of the transient response of the chopper, is measured in the circuit of Figure 3. The measurement is made as the time for the emitter current to recover from a specified forward value to a specified reverse value. The IN3064 diode across the 10K emitter resistance serves to clamp the emitter potential to reduce the output voltage change to a convenient level.

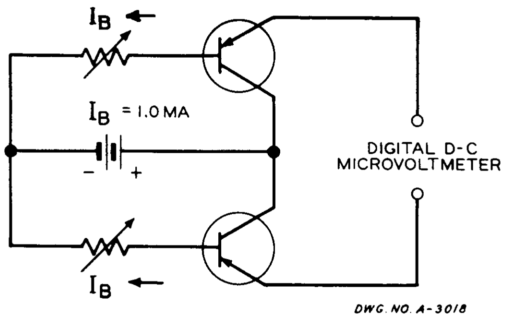


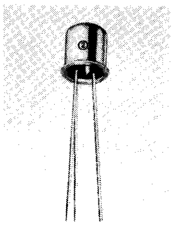
FIGURE 4
MATCHED OFFSET VOLTAGE TEST CIRCUIT

The offset vcltage match, ΔV_{OFF}, is measured in the circuit of Figure 4. The difference in the offset voltage at the specified base current is measured with a digital voltmeter.

SPRAGUE THE MARK OF RELIABILITY Engineering Bulletin

TYPE
2N2280
2N2281

TYPE 2N2280 AND 2N2281 SILICON PRECISION-ALLOY TRANSISTORS



ACTUAL SIZE

DESIGNED FOR low-level chopper applications, Type 2N2280 Silicon Precision-Alloy Transistors feature extremely low leakage current, low offset voltage, and a very low inverted dynamic saturation resistance.

Type 2N2280 transistor in matched pairs with an offset voltage match guaranteed over the temperature range of +25 C to +65 C are identified as Type 2N2281 SPAT® Transistors.

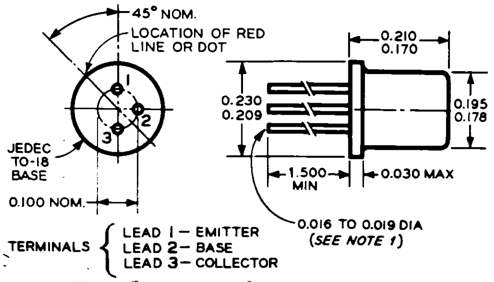
ABSOLUTE MAXIMUM RATINGS[1]

Storage Temperature .... −65 C to + 140 C
Collector Voltage, V_{CBO} .... −10 volts
Collector Voltage, V_{CEO} .... −6 volts
Emitter Voltage, V_{EBO} .... −10 volts
Emitter Voltage, V_{ECO} .... −6 volts
Collector Current, I_C .... −50 ma
Total Device Dissipation[2] at 25 C .... 150 mw
Lead Temperature at 1/16″ ± 1/32″ from case .... 230 C for 10 sec

[1] The maximum ratings are limiting absolute values above which the serviceability may be impaired from the viewpoint of life or satisfactory performance. The breakdown voltages may be far above the maximum voltage ratings. To avoid permanent damage to the transistors, do not attempt to measure these characteristics above the maximum ratings.

[2] Due to the nature of these transistors, the dissipation in the base emitter circuit may be appreciable under high base drive conditions and must be included in the total device dissipation. For temperatures above 25 C, derate by 1.3 mw/°C.

MECHANICAL SPECIFICATIONS



NOTE 1: THIS LEAD DIA APPLIES TO ZONE BETWEEN 0.050 AND 0.250 FROM BASE SEAT. IN ZONE BETWEEN 0.250 AND 0.050, A MAX OF 0.021 DIA IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIA IS NOT CONTROLLED.

DWG. NO. A-3806

ELECTRICAL CHARACTERISTICS[3] at T = 25 C

	CHARACTERISTICS	TEST CONDITIONS		MIN.	TYP.	MAX.	UNITS
	D-C CHARACTERISTICS						
I_{CBO}	Collector Cutoff Current	V_{CB} = − 6V		—	—	3	nA
I_{CBO}	Collector Cutoff Current	V_{CB} = − 6V	T = +65C	—	—	50	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = − 6V		—	—	3	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = − 6V	T = +65C	—	—	50	nA
BV_{CBO}	Collector Breakdown Voltage	I_C = −10μA		10	—	—	volts
BV_{CEO}	Collector Breakdown Voltage	I_C = −25μA		6	—	—	volts
BV_{EBO}	Emitter Breakdown Voltage	I_E = −10μA		10	—	—	volts
BV_{ECO}	Emitter Breakdown Voltage	I_E = −10μA		6	—	—	volts
$V_{CE(SAT)}$	Collector Saturation Voltage	I_C = −5mA	I_B = −0.8mA	—	0.05	0.1	volt
V_{BE}	Base Voltage	I_C = −5mA	I_B = −0.8 mA	—	0.9	1.35	volt
V_{OFF}	Offset Voltage	I_B = −250μA		—	0.6	1.0	mV
V_{OFF}	Offset Voltage	I_B = −1mA		—	0.7	1.5	mV
V_{OFF}	Offset Voltage	I_B = −1.5mA		—	1.0	2.0	mV
	HIGH FREQUENCY CHARACTERISTICS						
r_S	Inverted Dynamic Saturation Resistance[4]	I_B = −1 mA	I_E = 100μA	5	10	18	ohms
C_{ib}	Input Capacitance	V_{EB} = −3V	I_C = 0 f = 4mc	—	5	8	pF
C_{ob}	Output Capacitance	V_{CB} = −3V	I_E = 1mA f = 4mc	—	7	10	pF
	Emitter Diode Recovery Time[5]	I_B = −1mA nom.		—	6	15	μsec
f_T	Gain Bandwidth Product	V_{CE} = −3V	I_E = 1mA f = 4mc	16	24	—	mc
	MATCHED PAIR DATA						
ΔV_{OFF}	Differential Offset Voltage[6]	I_B = −1mA; T_A = +25C to +65C		—	—	100	μV

[3] Typical values are for engineering guidance only.
[4] To be measured in circuit of Figure 1.
[5] To be measured in circuit of Figure 2.
[6] To be measured in circuit of Figure 3.

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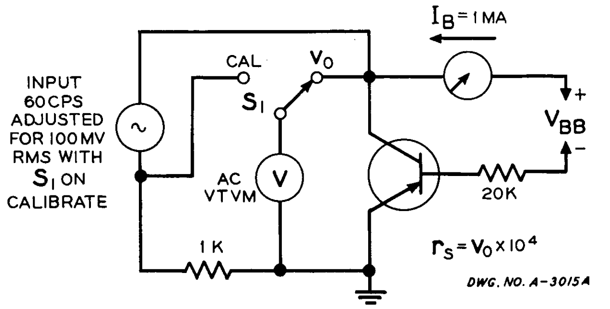

FIGURE 1

INVERTED DYNAMIC r_S TEST CIRCUIT

The inverted dynamic saturation resistance, which is the slope of the V_{EC}, I_E characteristic at a specified base current, is measured in the circuit shown in Figure 1. The circuit reads r_S directly as the ratio of the a-c collector voltage, V_o to a calibrated a-c collector current.

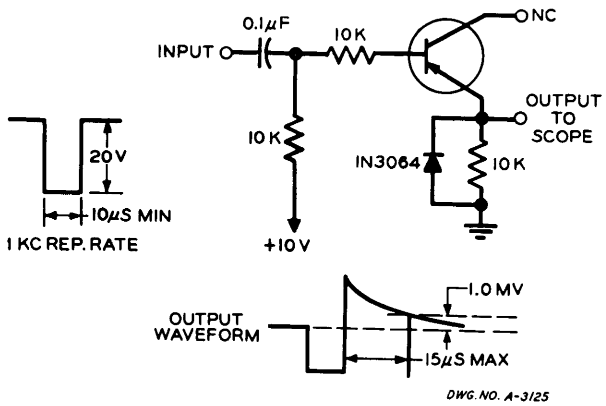

FIGURE 2

EMITTER DIODE RECOVERY TIME TEST CIRCUIT

The emitter diode reverse recovery time, a measure of the transient response of the chopper, is measured in the circuit of Figure 2. The measurement is made as the time for the emitter current to recover from a specified forward value to a specified reverse value. The IN3064 diode across the 10K emitter resistance serves to clamp the emitter potential to reduce the output voltage change to a convenient level.

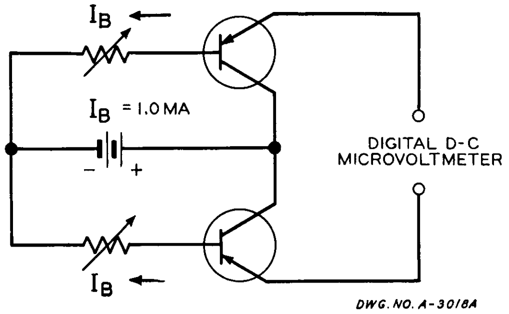

FIGURE 3

MATCHED OFFSET VOLTAGE TEST CIRCUIT

The offset voltage match, ΔV_{OFF}, is measured in the circuit of Figure 3. The difference in the offset voltage at the specified base current is measured with a digital voltmeter.

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SPRAGUE® THE MARK OF RELIABILITY — Engineering Bulletin

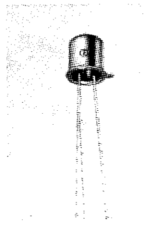
TYPE 2N2377

TYPE 2N2377 P-N-P SILICON PRECISION-ALLOY TRANSISTORS

DESIGNED for amplifier and oscillator applications at frequencies through 15 megacycles, Type 2N2377 Silicon Precision-Alloy Transistors may be operated at junction temperatures up to 140 C with excellent performance. The Type 2N2377 is electrically identical to Types 2N495 and 2N1118 but is housed in the JEDEC TO-18 case.

Rated at 150 mw total dissipation with a collector voltage rating of 25 volts, Type 2N2377 SPAT® transistors feature low leakage currents and low saturation voltage. The amplifier stage gain at 140 C is within a few db of the gain at room temperature.

Particularly well-suited for high-temperature applications, such as in airborne equipment, Type 2N2377 transistors are designed to meet the environmental requirements of Military Specification MIL-S-19500.



ACTUAL SIZE

ABSOLUTE MAXIMUM RATINGS[1]

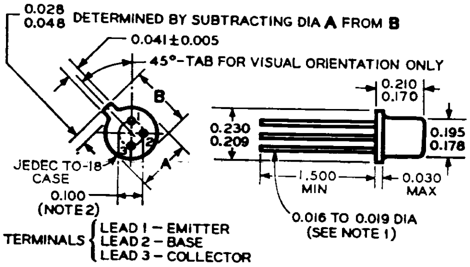
Storage Temperature .... −65 C to +140 C
Collector Voltage[2], V_{CE} or V_{CB} .... −25 volts
Collector Current, I_C .... −50 mA
Total Device Dissipation[3] at 25 C .... 150 mW
Derating Factor above 25 C .... 1.3 mW °C
Lead Temperature at 1/16″ ± 1/32″ from case .... 230 C for 10 sec

[1]The maximum ratings are limiting absolute values above which the serviceability may be impaired from the viewpoint of life or satisfactory performance.

[2]In this class of transistors, the maximum collector voltage is limited by the punchthrough phenomenon.

[3]Due to the nature of this transistor, the dissipation in the base emitter circuit may be appreciable under high base drive conditions and must be included in the total device dissipation. (See Input Characteristic Curves.)

MECHANICAL SPECIFICATIONS



NOTE 1: THIS LEAD DIA APPLIES TO ZONE BETWEEN 0.050 AND 0.250 FROM BASE SEAT. IN ZONE BETWEEN 0.250 AND 0.500, A MAX OF 0.021 DIA IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIA IS NOT CONTROLLED.

NOTE 2: MAX DIA LEADS AT GAGING PLANE $0.054^{+0.001}_{-0.000}$ BELOW BASE SEAT TO BE WITHIN 0.007 OF TRUE LOCATION RELATIVE TO MAX WIDTH TAB AND TO 0.230 MAX DIA MEASURED WITH SUITABLE GAGE. WHEN GAGE IS NOT USED, MEASUREMENT MADE AT BASE SEAT.

DWG. NO. A-3450A

ELECTRICAL CHARACTERISTICS[4] at T = 25 C

	CHARACTERISTICS	TEST CONDITIONS		MIN.	TYPICAL	MAX.	UNITS
D-C CHARACTERISTICS							
I_{CBO}	Collector Cutoff Current[5]	V_{CB} = −25 V		—	.002	1.0	µA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10 V		—	.001	0.1	µA
BV_{CEO}	Collector Voltage	I_{CEO} = −25 µA		25	—	—	volts
h_{FE}	Collector Voltage	V_{CE} = 0.5 V	I_C = −5 mA	10	25	100	—
SMALL SIGNAL PARAMETERS							
h_{fe}	Current Amplification Factor	V_{CE} = −6 V	I_E = 1 mA	15	30	120	—
f_T	Gain Bandwidth Product	V_{CE} = −6 V	I_E = 1 mA	8	20	—	mc
$r_b'C_c$	Extrinsic Base Resistance Collector Capacitance Product	f = 4 mc V_{CE} = −6 V	I_E = 1 mA	—	1450	5000	psec
C_{ob}	Output Capacitance	V_{CE} = − 6 V f = 4 mC	I_E = 1 mA	—	6	12	pF
h_{ib}	Input Resistance	V_{CE} = −6 V	I_E = 1 mA	—	40	90	ohms
h_{ob}	Output Admittance	V_{CE} = −6 V	I_E = 1 mA	—	1.5	2.5	µmhos

[4]Typical values are for engineering guidance only.

[5]The saturation current will approximately double with every 10 C of temperature. With ratings at any collector voltage then, the I_{CBO} may be calculated for any temperature by doubling the low voltage I_{CBO} for every 10 C and adding the difference between the room temperature I_{CBO} at the desired voltage and the room temperature I_{CBO} at low voltage.

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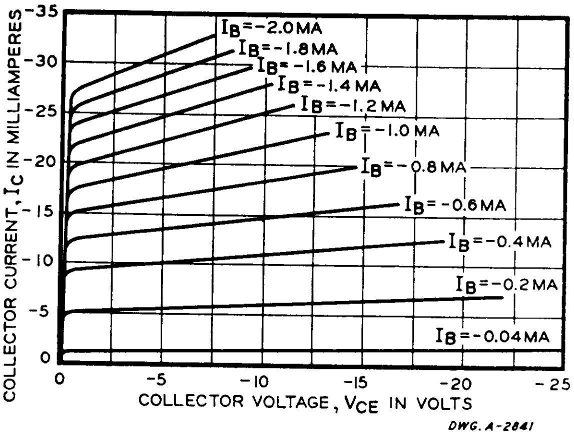
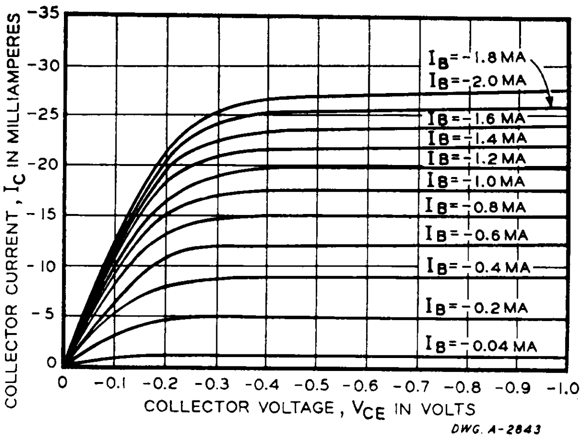
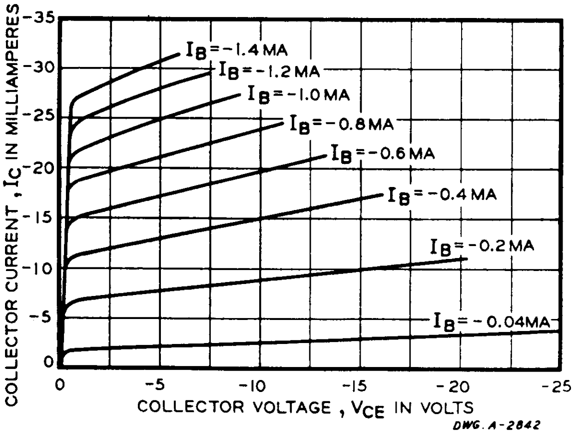
CHARACTERISTIC CURVES OF TYPE 2N2377 TRANSISTORS



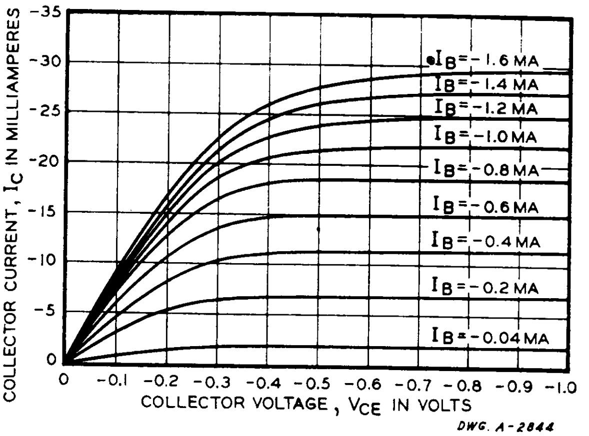
TYPICAL COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 25 C



TYPICAL SATURATED REGION COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 25 C

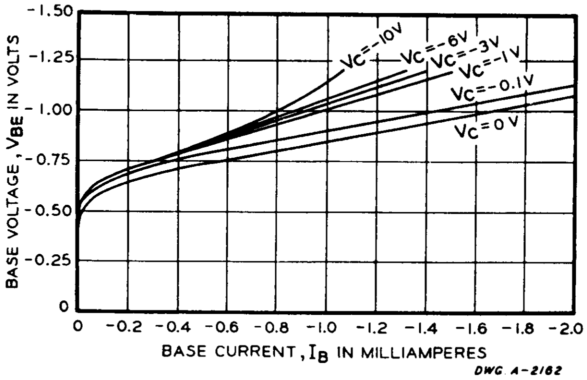


TYPICAL COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 125 C

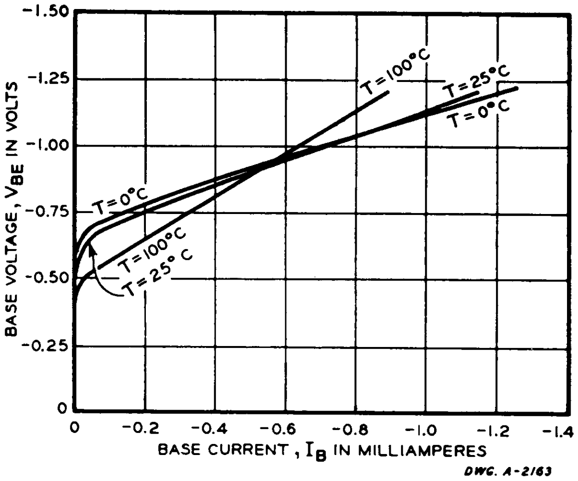


TYPICAL SATURATED REGION COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 125 C

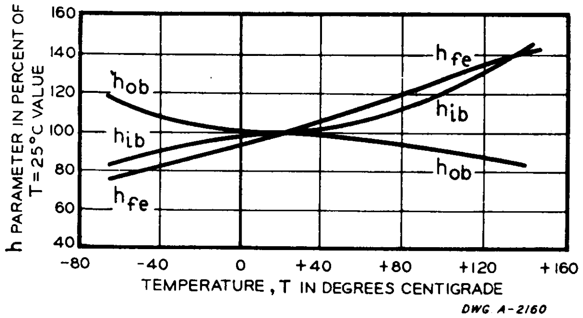
CHARACTERISTIC CURVES OF TYPE 2N2377 TRANSISTORS - - cont.



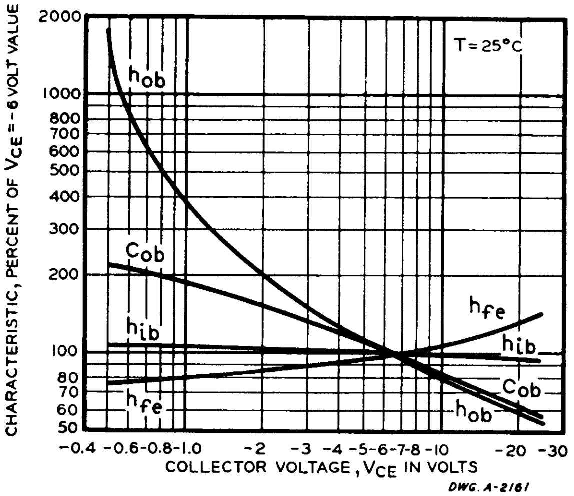
TYPICAL INPUT CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 25 C



TYPICAL INPUT CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 125 C

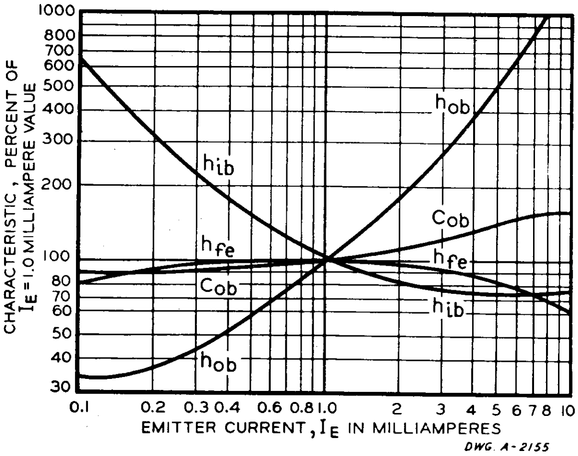


TYPICAL h PARAMETERS
AS A FUNCTION OF TEMPERATURE
NORMALIZED FOR 25 C
WITH V_{CE} = −6 VOLTS, I_E = 1.0 MA



TYPICAL CHARACTERISTICS
AS A FUNCTION OF COLLECTOR VOLTAGE
NORMALIZED FOR V_{CE} = −6 VOLTS
WITH I_E = 1.0 MA

CHARACTERISTIC CURVES OF TYPE 2N2377 TRANSISTORS - - cont.



TYPICAL CHARACTERISTICS AS A FUNCTION OF EMITTER CURRENT NORMALIZED FOR $I_E = 1.0$ MA WITH V_{CE} = −6 VOLTS

• • •

In the construction of the components described, the full intent of the specification will be met. The Sprague Electric Company, however, reserves the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the design of its products. Components made under military approvals will be in accordance with the approval requirements.

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Engineering Bulletin

TYPE **2N2378**

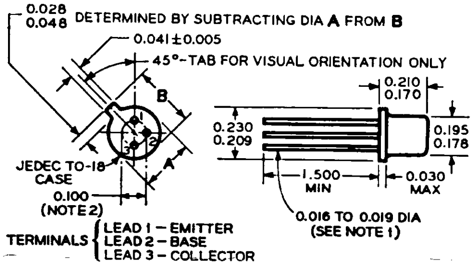
TYPE 2N2378 P-N-P SILICON PRECISION-ALLOY TRANSISTORS

HIGH-SPEED switching at high temperatures is the major application for the Type 2N2378 Silicon Precision-Alloy Transistors. The frequency at which β equals unity (f_T) is typically about 20 megacycles. The Type 2N2378 is electrically identical with Types 2N496 and 2N1119 but is housed in the JEDEC TO-18 case.

Since the saturation resistance is typically less than 10 ohms, the voltage drop at saturation is in the order of a tenth of a volt. Consequently, there is very low power dissipation in the "on" condition. This permits the designer to gain the advantages of low voltage operation and minimum load impedance.

Because the input voltage is usually four or five times the saturation voltage even at elevated temperatures, Type 2N2378 SPAT® transistors are particularly suited for direct coupled switching circuits. They feature very low leakage currents and a 150 mw rated dissipation at 25 C ambient temperature.

ACTUAL SIZE



NOTE 1: THIS LEAD DIA APPLIES TO ZONE BETWEEN 0.050 AND 0.250 FROM BASE SEAT. IN ZONE BETWEEN 0.250 AND 0.500, A MAX OF 0.021 DIA IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIA IS NOT CONTROLLED.

NOTE 2: MAX DIA LEADS AT GAGING PLANE 0.054 $^{+0.001}_{-0.000}$ BELOW BASE SEAT TO BE WITHIN 0.007 OF TRUE LOCATION RELATIVE TO MAX WIDTH TAB AND TO 0.230 MAX DIA MEASURED WITH SUITABLE GAGE. WHEN GAGE IS NOT USED, MEASUREMENT MADE AT BASE SEAT.

DWG. NO. A-34504

ABSOLUTE MAXIMUM RATINGS[1]

Storage Temperature .... −65 C to +140 C
Collector Voltage[2], V_{CB} or V_{CE} .... 10 volts
Collector Current, I_C .... −50 mA
Derating Factor above 25 C .... 1.3 mW/°C
Total Device Dissipation[3] at 25 C .... 150 mW
Lead Temperature at 1/16" ± 1/32" from case ....230 C for 10 sec

[1]The maximum ratings are limiting absolute values above which the serviceability may be impaired from the viewpoint of life or satisfactory performance. The diode breakdown and punchthrough voltages may be far above the maximum collector voltage rating. For this reason it is important that the 2N2378 not be tested above the maximum voltage rating to avoid permanent damage to the transistor.

[2]In this class of transistor, the maximum collector voltage is limited by the punchthrough phenomenon.

[3]Due to the nature of this transistor, the dissipation in the base emitter circuit may be appreciable under high base drive conditions and must be included in the total device dissipation. (See Input Characteristic Curves.)

ELECTRICAL CHARACTERISTIC[4] at T = 25 C

	CHARACTERISTICS	TEST CONDITIONS		MIN.	TYPICAL	MAX.	UNITS
		D-C CHARACTERISTICS					
I_{CBO}	Collector Cutoff Current[5]	V_{CB} = −10V		—	.001	0.1	μA
I_{EBO}	Emitter Cutoff Current	V_{EB} = −10V		—	.001	0.1	μA
I_{CEX}	Collector Cutoff Current	V_{CE} = −4.5V	V_{BE} = −0.45V	—	5	25	μA
BV_{CEO}	Collector Breakdown Voltage	I_C = −25 uA		—	—	10	volts
h_{FE}	Current Amplification Factor	V_{CE} = −0.5V	I_C = −15 mA	15	25	—	—
$V_{CE\,(SAT)}$	Collector Voltage	I_C = −5 mA	I_B = −0.8 mA	—	0.08	0.15	volts
V_{BE}	Input Voltage	I_C = −5 mA	I_B = −0.8 mA	0.75	0.9	1.0	volts
		SMALL SIGNAL PARAMETERS					
f_T	Gain Bandwidth Product	V_{CE} = −6 V, f = 4 mc	I_E = 1 mA	7.2	20	—	mc
$r_b'C_c$	Extrinsic Base Resistance Collector Capacitance Product	V_{CE} = −6 V	I_E = 1 mA	—	1500	5000	psec
C_{ob}	Output Capacitance	V_{CE} = −6 V	I_E = 1 mA	—	6	12	pF
K'_s	Hole Storage[6]	I_B = −1 mA		—	90	175	nsec

[4]Typical values are for engineering guidance only.

[5]The saturation current will approximately double with every 10 C of temperature. At any collector voltage, then, the I_{CBO} may be calculated for any temperature by doubling the low voltage I_{CBO} for every 10 C and adding the difference between the room temperature I_{CBO} at the desired voltage and the room temperature I_{CBO} at low voltage.

[6]To be tested in hole storage circuit. See page 4.

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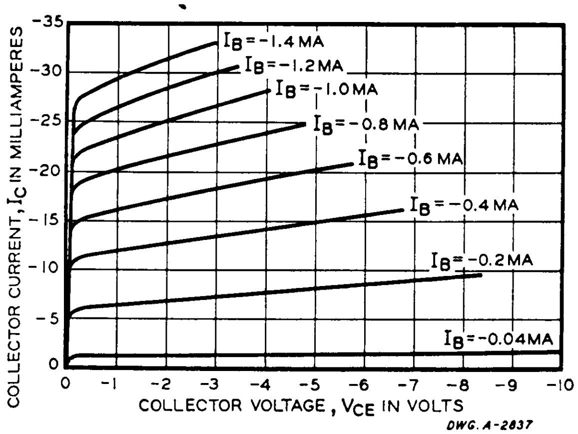
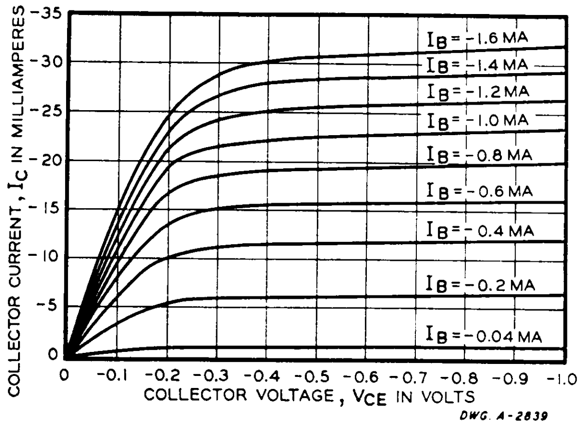
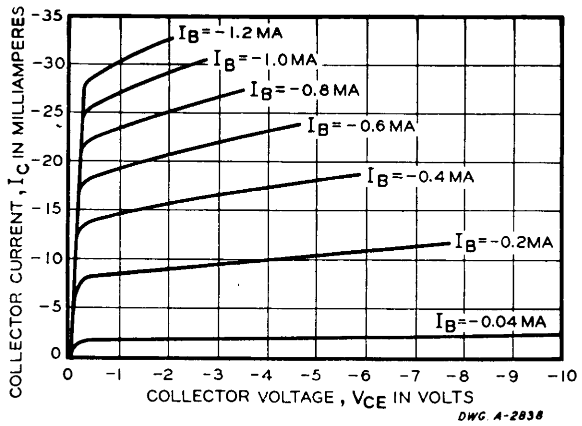
CHARACTERISTIC CURVES OF TYPE 2N2378 TRANSISTORS



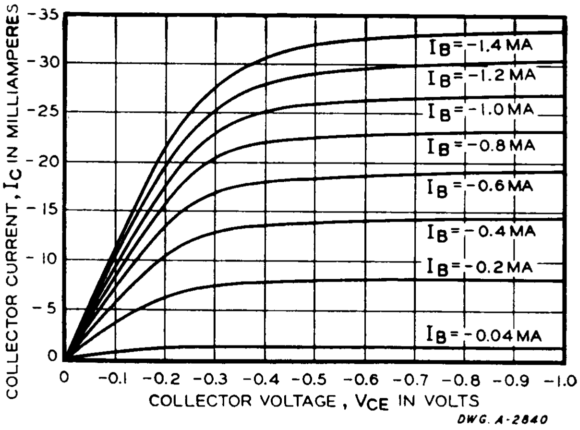
TYPICAL COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 25 C



TYPICAL SATURATED REGION COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 25 C

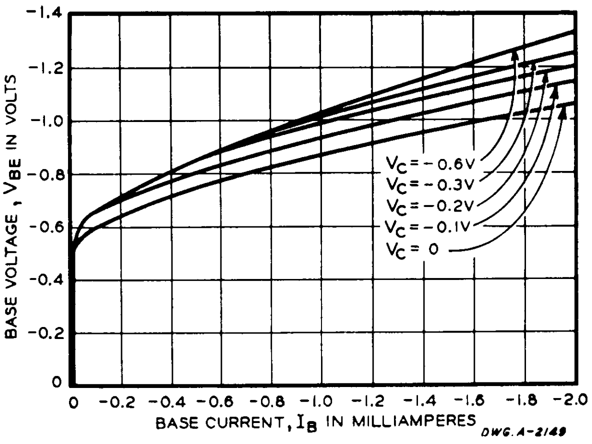


TYPICAL COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 125 C

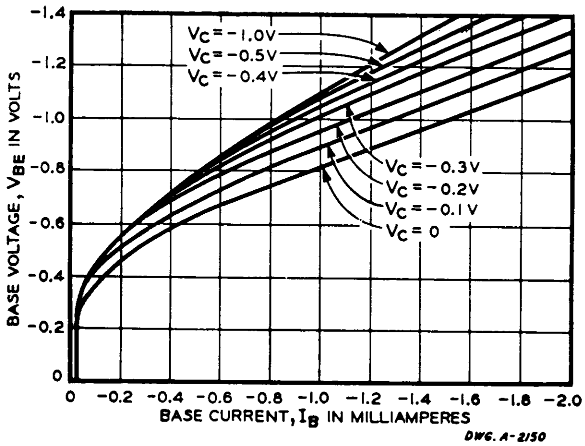


TYPICAL SATURATED REGION COLLECTOR CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 125 C

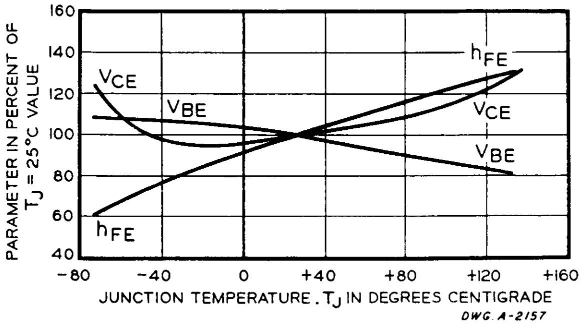
CHARACTERISTIC CURVES OF TYPE 2N2378 TRANSISTORS - - cont.



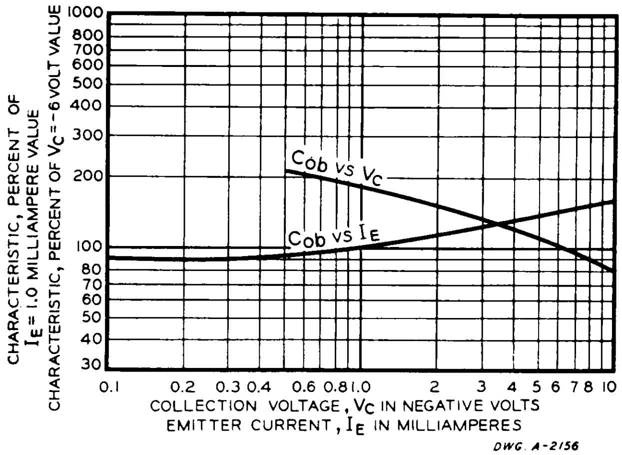
TYPICAL INPUT CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 25 C



TYPICAL INPUT CHARACTERISTICS
IN GROUNDED EMITTER CONFIGURATION
AT 125 C

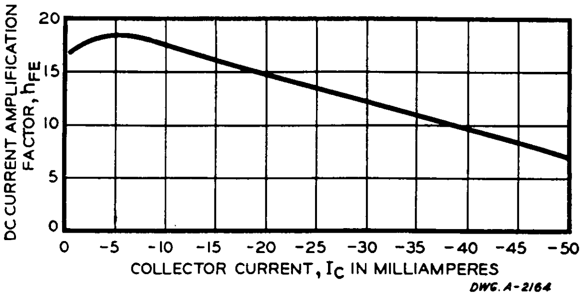


TYPICAL PARAMETERS
AS A FUNCTION OF JUNCTION TEMPERATURE
NORMALIZED FOR 25 C



TYPICAL CHARACTERISTICS AS A FUNCTION OF
COLLECTOR VOLTAGE AND EMITTER CURRENT
AT 25 C

CHARACTERISTIC CURVES OF TYPE 2N2378 TRANSISTORS - - cont.



TYPICAL D-C β
AS A FUNCTION OF COLLECTOR CURRENT
IN GROUNDED EMITTER CONFIGURATION
AT 25 C

● ● ●

HOLE STORAGE MEASUREMENT OF TYPE 2N2378 TRANSISTORS

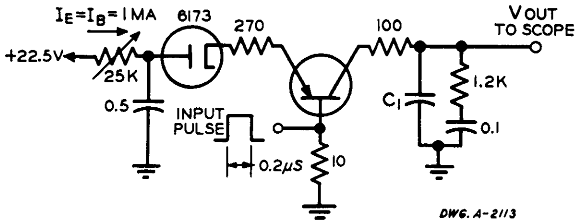
The hole storage factor K_s' is a device constant defined as the excess stored charge (in saturation) per unit excess base current, where excess base current is the amount of current supplied to the base in excess of that required to just keep the transistor in saturation. While the hole storage factor may be expressed in units of time, this is not a time measurement and does not imply that the storage time in any particular circuit is that specified.

The storage time in an actual circuit is a function of the ratio of both the "turn-on" base current and the "turn-off" base current to the "on" collector current. The storage time will be approximately

$$t_S \simeq K_S' \ln \frac{I_{B1} + I_{B2}}{\frac{I_{CS}}{h_{FE}} + I_{B2}},$$

where I_{B1} is the "turn-on" base current, I_{B2} is the "turn-off" base current (assumed to be reverse current) and I_{CS} is the "on" collector current.

HOLE STORAGE TEST CIRCUIT



C_1, rated at 500 pF, includes probe or scope capacitance. This value should be measured with the differentiating network disconnected.

$$K'_s = \frac{C_1 V_{OUT}}{I_E} = \frac{500}{1} V_{OUT} \frac{\mu\mu\text{coulombs}}{\text{mA}}$$ (These units are the equivalent of nsec.)