AB67
Colpitt's Oscillator

Operating Manual

Ver.1.1

An ISO 9001 : 2000 company

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TÜV

TÜV Rheinland Group

CERTIFICATE

The Certification Body for
Quality Management Systems
of TÜV Rheinland India Pvt. Ltd.

certifies in accordance with
TÜV Rheinland Group procedures that

Scientech Technologies Pvt. Ltd.

Unit-1: 94-101, Electronics Complex, Pardeshi Pura,
Indore – 452 010, Madhya Pradesh, India
Unit-2: 90-91, Electronics Complex, Pardeshi Pura,
Indore – 452 010, Madhya Pradesh, India

has established and applies a quality management system for

Design, Manufacture of Electronic Test & Measuring Instruments, Training Products for Electrical & Electronics Education and Providing Technology Training

An audit was performed, Report No. 07930

Proof has been furnished that the requirements according to

DIN EN ISO 9001: 2000

are fulfilled.

The certificate is valid until 2010-11-20

Certificate Registration No. **85 100 001 07930**

TÜV | NABCB QMS 010

Bangalore, 2007-11-21

The validity of this certificate is subject to timely completion of Surveillance audits as agreed in the Contract. The Validity of the Certificate can be verified under WWW.tuv.com with the Identification No. 9105027653

The certification Body of
TÜV Rheinland India Pvt. Ltd.

04/11/NABCB/00

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AB67
Colpitt's Oscillator

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RoHS Compliance

Scientech Products are RoHS Complied.

RoHS Directive concerns with the restrictive use of Hazardous substances (Pb, Cd, Cr, Hg, Br compounds) in electric and electronic equipments.

Scientech products are "Lead Free" and "Environment Friendly".

It is mandatory that service engineers use lead free solder wire and use the soldering irons upto (25 W) that reach a temperature of 450°C at the tip as the melting temperature of the unleaded solder is higher than the leaded solder.

Introduction

AB67 is a compact, ready to use **Colpitt's Oscillator** experiment board. This is useful for students to understand functionality of **Colpitt's Oscillator**. It can be used as stand alone unit with external DC Power Supply or can be used with **Scientech Analog Lab ST2612** which has built in DC Power Supply, AC Power Supply, function generator, modulation generator, continuity tester, toggle switches, and potentiometers.

List of Boards :

Model	Name
AB01	Diode characteristics (Si, Zener, LED)
AB02	Transistor characteristics (CB NPN)
AB03	Transistor characteristics (CB PNP)
AB04	Transistor characteristics (CE NPN)
AB05	Transistor characteristics (CE PNP)
AB06	Transistor characteristics (CC NPN)
AB07	Transistor characteristics (CC PNP)
AB08	FET characteristics
AB09	Rectifier Circuits
AB10	Wheatstone bridge
AB11	Maxwell's Bridge
AB12	De Sauty's Bridge
AB13	Schering Bridge
AB14	Darlington Pair
AB15	Common Emitter Amplifier
AB16	Common Collector Amplifier
AB17	Common Base Amplifier
AB18	RC-Coupled Amplifier
AB19	Cascode Amplifier
AB20	Direct Coupled Amplifier
AB21	Class A Amplifier
AB22	Class B Amplifier (push pull emitter follower)
AB23	Class C Tuned Amplifier
AB24	Transformer Coupled Amplifier
AB25	Phase Locked Loop (FM Demodulator & Frequency Divider / Multiplier)
AB26	FET Amplifier
AB27	Voltage Controlled Oscillator
AB28	Multivibrator (Mono stable/Astable)
AB29	F-V and V-F Converter
AB30	V-I and I-V Converter
AB31	Zener Voltage Regulator
AB32	Transistor Series Voltage Regulator
AB33	Transistor Shunt Voltage Regulator

AB35	DC Ammeter
AB37	DC Ammeter (0-2mA)
AB39	Instrumentation Amplifier
AB41	Differential Amplifier (Transistorized)
AB42	Operational Amplifier (Inverting / Non-inverting / Differentiator)
AB43	Operational Amplifier (Adder/Scalar)
AB44	Operational Amplifier (Integrator/ Differentiator)
AB45	Schmitt Trigger and Comparator
AB49	K Derived Filter
AB51	Active filters (Low Pass and High Pass)
AB52	Active Band Pass Filter
AB54	Tschebyscheff Filter
AB56	Fiber Optic Analog Link
AB57	Owen’s Bridge
AB58	Anderson’s Bridge
AB59	Maxwell’s Inductance Bridge
AB64	RC – Coupled Amplifier with Feedback
AB66	Wien Bridge Oscillators
AB68	Hartley Oscillator
AB80	RLC Series and RLC Parallel Resonance
AB82	Thevenin’s and Maximum Power Transfer Theorem
AB83	Reciprocity and Superposition Theorem
AB84	Tellegen’s Theorem
AB85	Norton’s theorem
AB88	Diode Clipper
AB89	Diode Clampers
AB90	Two port network parameter
AB91	Optical Transducer (Photovoltaic cell)
AB92	Optical Transducer (Photoconductive cell/LDR)
AB93	Optical Transducer (Phototransistor)
AB96	Temperature Transducer (RTD & IC335)
AB97	Temperature Transducer (Thermocouple)
AB101	DSB Modulator and Demodulator
AB102	SSB Modulator and Demodulator
AB106	FM Modulator and Demodulator

and many more…………

Theory

Oscillators are circuits that produce specific, periodic waveforms such as square, triangular, sawtooth, and sinusoidal. They can be made from some of the active or passive devices like transistors, FETs and Op-Amps in combination with devices such as resistors, capacitors, and inductors, to generate the output.

There are two main classes of oscillator; relaxation and sinusoidal. Relaxation oscillators generate the triangular, sawtooth and other nonsinuoidal waveforms. Sinusoidal oscillators consist of amplifiers with external components used to generate oscillation, or crystals that internally generate the oscillation. The focus here is on sine wave oscillators. Sine wave oscillators are used as references or test waveforms by many circuits.

An oscillator is a type of feedback amplifier in which part of the output is fed back to the input via a feedback circuit. If the signal fed back is of proper magnitude and phase, the circuit produces alternating currents or voltages. Two requirements for oscillation are

1. The magnitude of the loop gain A_vB must be at least 1, and

2. The total phase shift of the loop gain A_vB must be equal to 0^o or 360^o. If the amplifier causes a phase shift of 180^o, the feedback circuit must provide an additional phase shift of 180^o so that the total phase shift around the loop is 360^o.

Colpitt's Oscillator :

The **Colpitt's Oscillator** is one of the simplest and best known oscillators and is used extensively in circuits, which work at radio frequencies. Figure1 shows the basic **Colpitt's Oscillator** circuit configuration. The transistor is in voltage divider bias which sets up Q-point of the circuit. In the circuit note that V_{out} is actually the AC voltage across C2. This voltage is fed back to the base and sustains oscillations developed across the tank circuit, provided there is enough voltage gain at the oscillation frequency.

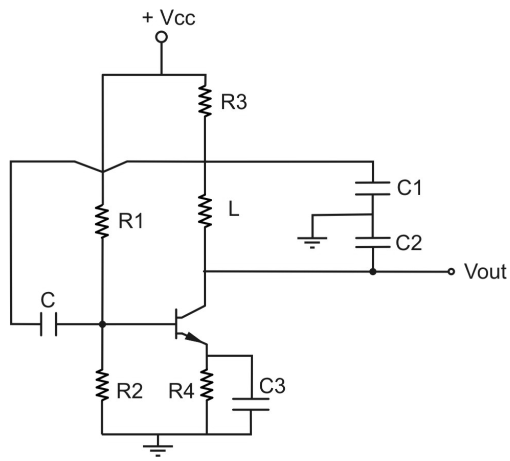

Figure 1

The resonant frequency of the **Colpitt's Oscillator** can be calculated from the tank circuit used. We can calculate the approximately resonant frequency as

$$\text{Resonant Frequency (fr)} = \frac{1}{2p\sqrt{LC}} \quad \ldots\ldots\ldots\ldots\ldots \ (1)$$

Here, the capacitance used is the equivalent capacitance the circulating current passes through. In **Colpitt's Oscillator** the circulating current passes through the series combination of C_1 and C_2. Therefore equivalent capacitance is,

$$\text{Cequ} = \frac{C_1C_2}{C_1 + C_2}$$

Starting condition for oscillations is

$$AB>1$$

Where,

B is approximately equal to C_1/C_2.

The feedback should be enough to start oscillations under all conditions as different transistors, are used at varying, temperatures, voltages, etc. But the feedback should not be so large that you lose the required output. The resonant frequency can be changed by either changing the value of inductor or changing the value of capacitor but the combination of the three components should satisfy the above given two conditions for oscillation.

Experiment

Objective :
Study of operation of Colpitt's Oscillator

Equipments Needed :

1. Analog board **AB67**

2. DC Power Supplies +12V from external source or **ST2612** Analog Lab

3. Oscilloscope 20 MHz, Caddo 802 or equivalent

4. 2mm Patch Cords

Circuit diagram : Circuit used to study the operation of **Colpitt's Oscillator** is as shown in figure 2.

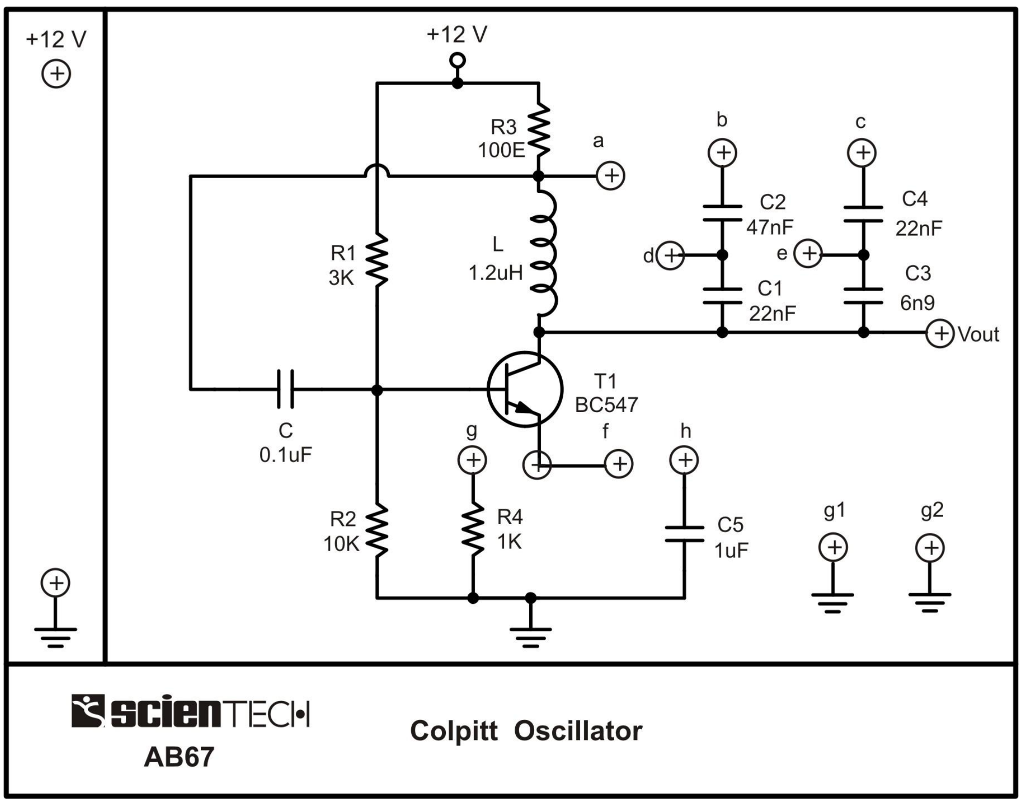

Figure 2

Procedure:

- Study of **Colpitt's Oscillator** proceed as follows :

1. Connect +12V DC Power Supply at their indicated position from external source or ST2612 Analog Lab.

2. Connect a patch cord between points a and b and another patch chord between points d and g1.

3. Connect patch chord between points f and h and another patch chord between points g and emitter of transistor T1.

4. Switch 'On' the Power Supply.

5. Connect oscilloscope between points V_{out} and g2 on AB67 board.

6. Record the value of output frequency on oscilloscope.

7. Calculate the resonant frequency using equation 1.

8. Compare measured frequency with the theoretically calculated value.

9. Switch 'Off' the supply.

10. Remove the patch chord connected between points a and b and connect it between points a and c.

11. Remove the patch chord connected between points d and g1 and connect it between points e and g2.

12. Follow the procedure from point 4 to 8.

13. Connect +5V Supply instead of +12V Supply and follow the procedure from point 2 to point 11.

Result :

When patch chord connected across C1 and C2

Practically calculated Output frequency (on CRO): …………………….

Theoretically calculated values

Cequ : ……………………………………... (use equation 2)

Resonant frequency : ………………….. (use equation 1)

Output voltage amplitude : …………………… Vp-p

When patch chord connected across C3 and C4

Practically calculated Output frequency (on CRO): …………………….

Theoretically calculated values

Cequ : ……………………………………... (use equation 2)

Resonant frequency : ………………….. (use equation 1)

Output voltage amplitude : …………………… Vp-p

Record above results separately for +12V input voltage and +5V input voltage.

Data Sheet

FAIRCHILD SEMICONDUCTOR®

BC546/547/548/549/550

Switching and Applications

- High Voltage: BC546, V_{CEO}=65V
- Low Noise: BC549, BC550
- Complement to BC556 ... BC560

1 TO-92

1. Collector 2. Base 3. Emitter

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage : BC546 : BC547/550 : BC548/549	80 50 30	V V V
V_{CEO}	Collector-Emitter Voltage : BC546 : BC547/550 : BC548/549	65 45 30	V V V
V_{EBO}	Emitter-Base Voltage : BC546/547 : BC548/549/550	6 5	V V
I_C	Collector Current (DC)	100	mA
P_C	Collector Power Dissipation	500	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_{CBO}	Collector Cut-off Current	V_{CB}=30V, I_E=0			15	nA
h_{FE}	DC Current Gain	V_{CE}=5V, I_C=2mA	110		800	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA I_C=100mA, I_B=5mA		90 200	250 600	mV mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA I_C=100mA, I_B=5mA		700 900		mV mV
V_{BE} (on)	Base-Emitter On Voltage	V_{CE}=5V, I_C=2mA V_{CE}=5V, I_C=10mA	580	660	700 720	mV mV
f_T	Current Gain Bandwidth Product	V_{CE}=5V, I_C=10mA, f=100MHz		300		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		3.5	6	pF
C_{ib}	Input Capacitance	V_{EB}=0.5V, I_C=0, f=1MHz		9		pF
NF	Noise Figure : BC546/547/548 : BC549/550 : BC549 : BC550	V_{CE}=5V, I_C=200μA f=1KHz, R_G=2KΩ V_{CE}=5V, I_C=200μA R_G=2KΩ, f=30~15000MHz		2 1.2 1.4 1.4	10 4 4 3	dB dB dB dB

h_{FE} Classification

Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800

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Typical Characteristics

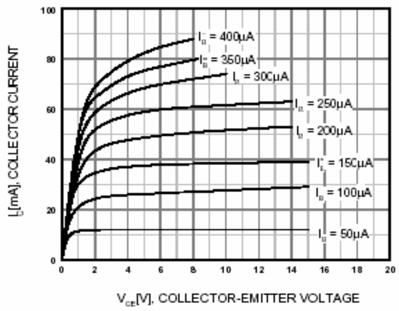

Figure 1. Static Characteristic

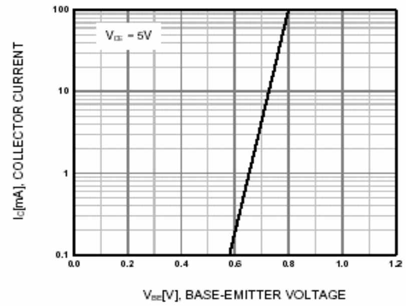

Figure 2. Transfer Characteristic

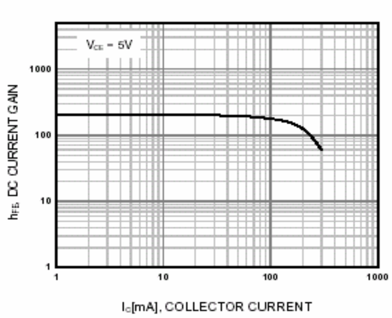

Figure 3. DC current Gain

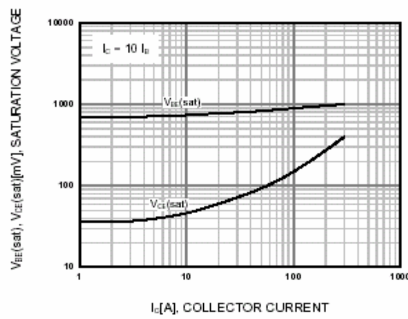

Figure 4. Base-Emitter Saturation Voltage Collector-Emitter Saturation Voltage

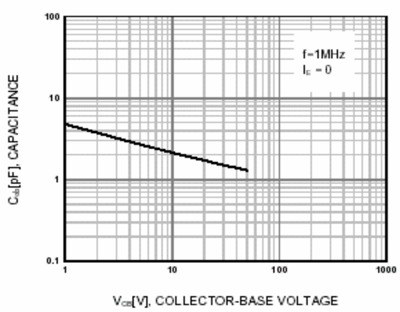

Figure 5. Output Capacitance

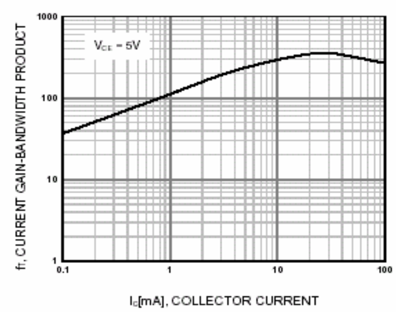

Figure 6. Current Gain Bandwidth Product

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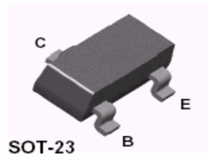
FAIRCHILD
SEMICONDUCTOR™

2N3906 MMBT3906 PZT3906



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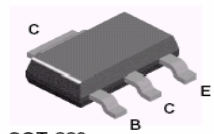

SOT-223

PNP General Purpose Amplifier

This device is designed for general purpose amplifier and switching applications at collector currents of 10 µA to 100 mA.

Absolute Maximum Ratings* T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CEO}	Collector-Emitter Voltage	40	V
V_{CBO}	Collector-Base Voltage	40	V
V_{EBO}	Emitter-Base Voltage	5.0	V
I_C	Collector Current - Continuous	200	mA
T_J, T_{stg}	Operating and Storage Junction Temperature Range	-55 to +150	°C

*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES:
1) These ratings are based on a maximum junction temperature of 150 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.
3) All voltages (V) and currents (A) are negative polarity for PNP transistors.

Thermal Characteristics T_A = 25°C unless otherwise noted

Symbol	Characteristic	Max			Units
		2N3906	*MMBT3906	**PZT3906	
P_D	Total Device Dissipation Derate above 25°C	625 5.0	350 2.8	1,000 8.0	mW mW/°C
$R_{\theta JC}$	Thermal Resistance, Junction to Case	83.3			°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	200	357	125	°C/W

*Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06."
**Device mounted on FR-4 PCB 36 mm X 18 mm X 1.5 mm; mounting pad for the collector lead min. 6 cm^2.

2N3906 / MMBT3906 / PZT3906

PNP General Purpose Amplifier

(continued)

Electrical Characteristics

T_A = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage*	I_C = 1.0 mA, I_B = 0	40		V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 µA, I_E = 0	40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 µA, I_C = 0	5.0		V
I_{BL}	Base Cutoff Current	V_{CE} = 30 V, V_{BE} = 3.0 V		50	nA
I_{CEX}	Collector Cutoff Current	V_{CE} = 30 V, V_{BE} = 3.0 V		50	nA
ON CHARACTERISTICS					
h_{FE}	DC Current Gain *	I_C = 0.1 mA, V_{CE} = 1.0 V I_C = 1.0 mA, V_{CE} = 1.0 V I_C = 10 mA, V_{CE} = 1.0 V I_C = 50 mA, V_{CE} = 1.0 V I_C = 100 mA, V_{CE} = 1.0 V	60 80 100 60 30	300	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 10 mA, I_B = 1.0 mA I_C = 50 mA, I_B = 5.0 mA		0.25 0.4	V V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 10 mA, I_B = 1.0 mA I_C = 50 mA, I_B = 5.0 mA	0.65	0.85 0.95	V V
SMALL SIGNAL CHARACTERISTICS					
f_T	Current Gain - Bandwidth Product	I_C = 10 mA, V_{CE} = 20 V, f = 100 MHz	250		MHz
C_{obo}	Output Capacitance	V_{CB} = 5.0 V, I_E = 0, f = 100 kHz		4.5	pF
C_{ibo}	Input Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 100 kHz		10.0	pF
NF	Noise Figure	I_C = 100 µA, V_{CE} = 5.0 V, R_S =1.0kΩ,f=10 Hz to 15.7 kHz		4.0	dB
SWITCHING CHARACTERISTICS					
t_d	Delay Time	V_{CC} = 3.0 V, V_{BE} = 0.5 V,		35	ns
t_r	Rise Time	I_C = 10 mA, I_{B1} = 1.0 mA		35	ns
t_s	Storage Time	V_{CC} = 3.0 V, I_C = 10mA		225	ns
t_f	Fall Time	I_{B1} = I_{B2} = 1.0 mA		75	ns

*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

NOTE: All voltages (V) and currents (A) are negative polarity for PNP transistors.

Spice Model

PNP (Is=1.41f Xti=3 Eg=1.11 Vaf=18.7 Bf=180.7 Ne=1.5 Ise=0 Ikf=80m Xtb=1.5 Br=4.977 Nc=2 Isc=0 Ikr=0 Rc=2.5 Cjc=9.728p Mjc=.5776 Vjc=.75 Fc=.5 Cje=8.063p Mje=.3677 Vje=.75 Tr=33.42n Tf=179.3p Itf=.4 Vtf=4 Xtf=6 Rb=10)

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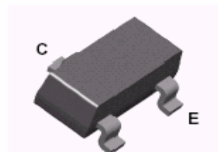
2N3906 MMBT3906 PZT3906



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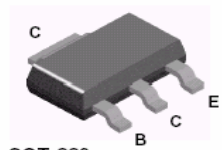

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BC546/547/548/549/550

Typical Characteristics

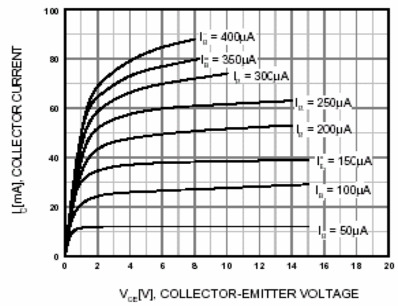

Figure 1. Static Characteristic

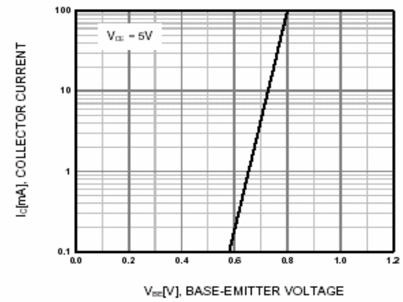

Figure 2. Transfer Characteristic

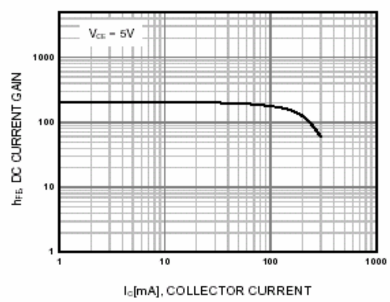

Figure 3. DC current Gain

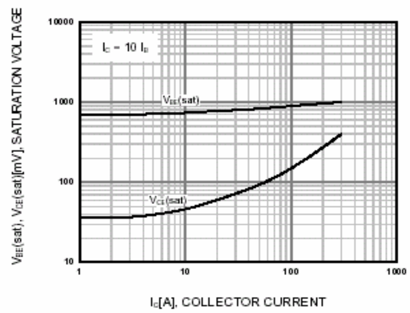

Figure 4. Base-Emitter Saturation Voltage
Collector-Emitter Saturation Voltage

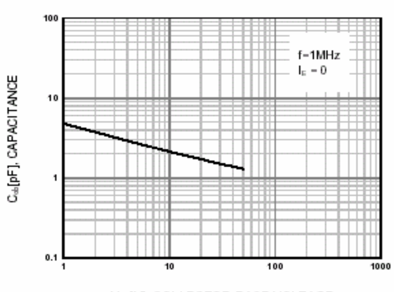

Figure 5. Output Capacitance

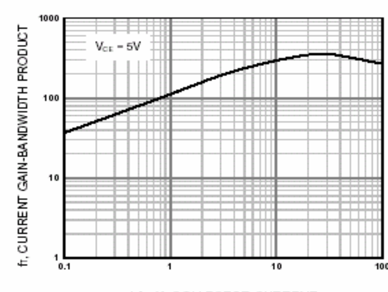

Figure 6. Current Gain Bandwidth Product

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Warranty

1. We guarantee the product against all manufacturing defects for 24 months from the date of sale by us or through our dealers. Consumables like dry cell etc. are not covered under warranty.
2. The guarantee will become void, if
   - **a)** The product is not operated as per the instruction given in the operating manual.
   - **b)** The agreed payment terms and other conditions of sale are not followed.
   - **c)** The customer resells the instrument to another party.
   - **d)** Any attempt is made to service and modify the instrument.
3. The non-working of the product is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type, serial number of the product and date of purchase etc.
4. The repair work will be carried out, provided the product is dispatched securely packed and insured. The transportation charges shall be borne by the customer.

For any Technical Problem Please Contact us at **service@scientech.bz**

List of Accessories

1. 2 mm Patch Cords (Red) ....1 No.
2. 2 mm Patch Cord (Blue) .... 2 Nos.
3. 2 mm Patch Cord (Black) .... 3 Nos.
4. e-Manual...1 No.

Updated 30-03-2009