AB04
Common Emitter NPN
Transistor Characteristics

Operating Manual

Ver.1.1

An ISO 9001 : 2000 company

Scientech Technologies Pvt. Ltd.

94-101, Electronic Complex Pardesipura,
Indore- 452010, India
Tel : 91-731- 2570301/02, 4211100
Fax: 91- 731- 2555643
e mail : info@scientech.bz
Website : www.scientech.bz
Toll free : 1800-103-5050

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

www.tuv.com

AB04
Common Emitter NPN
Transistor Characteristics

Table of Contents

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

AB04 is a compact, ready to use **Transistor Characteristics** experiment board. This is useful for students to plot different characteristics of NPN transistor in common base configuration and to understand various region of operation of PNP transistor. 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 potentiometer.

List of Boards :

Model	Name
AB01	Diode characteristics (Si, Zener, LED)
AB02	Transistor characteristics (CB NPN)
AB03	Transistor characteristics (CB PNP)
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 (Monostable / 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
AB67	Colpitt Oscillator
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

Transistor characteristics are the curves, which represent relationship between different DC currents and voltages of a transistor. These are helpful in studying the operation of a transistor when connected in a circuit. The three important characteristics of a transistor are:

1. Input characteristic.

2. Output characteristic.

3. Constant current transfer characteristic.

Input Characteristic :

In common emitter configuration, it is the curve plotted between the input current (I_B) verses input voltage (V_{BE}) for various constant values of output voltage (V_{CE}).

The approximated plot for input characteristic is shown in figure 1. This characteristic reveal that for fixed value of output voltage V_{CE}, as the base to emitter voltage increases, the emitter current increases in a manner that closely resembles the diode characteristics.

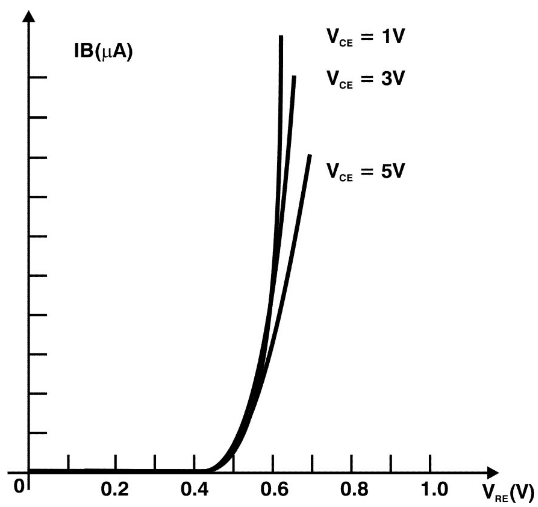


Figure 1

Output Characteristic :

This is the curve plotted between the output current I_C verses output voltage V_{CE} for various constant values of input current I_B.

The output characteristic has three basic region of interest as indicated in figure 2 the active region, cutoff region and saturation region.

In active region the collector base junction is reverse biased while the base emitter junction if forward biased. This region is normally employed for linear (undistorted) amplifier.

In cutoff region the collector base junction and base emitter junction of the transistor both are reverse biased. In this region transistor acts as an 'Off' switch.

In saturation region the collector base junction and base emitter junction of the transistor both are forward biased. In this region transistor acts as an on switch.

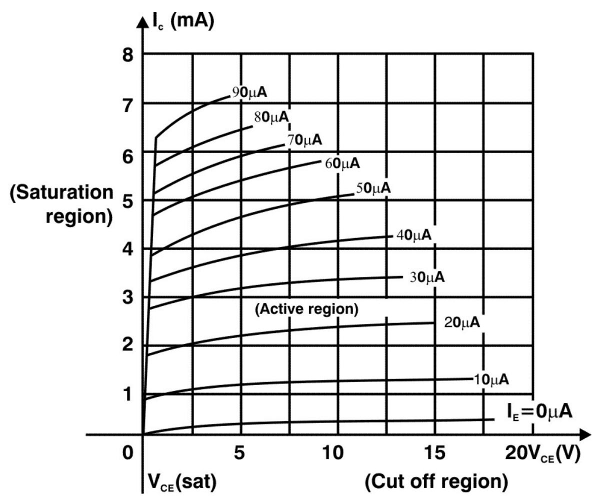


Figure 2

Constant current transfer Characteristics :

This is the curve plotted between output collector current I_C versus input base current I_B for constant value of output voltage V_{CE}.

The approximated plot for this characteristic is shown in figure 3.

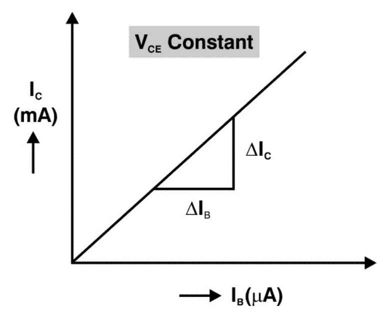


Figure 3

Experiment

Objective :

Study of the characteristics of NPN transistor in common emitter configuration and to evaluate :

1. **Input resistance**
2. **Output resistance**
3. **Current gain**

Equipments Needed :

1. Analog board of **AB04.**
2. DC power supplies +12V, +5V from external source or **ST2612 Analog Lab**.
3. Digital Multimeter (3 numbers).
4. 2 mm patch cords.

Circuit diagram :

Circuit used to plot different characteristics of transistor is shown in figure 4.

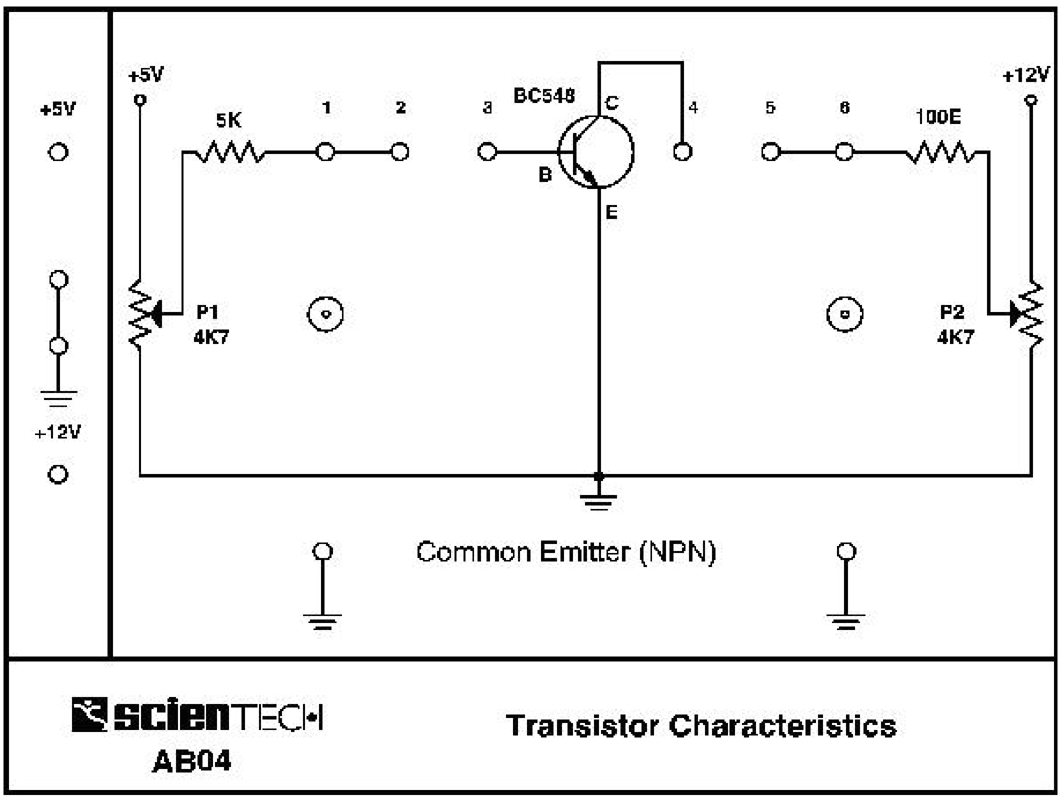


Figure 4

Procedure :

- Connect +5V and +12V DC power supplies at their indicated position from external source or **ST2612 Analog Lab**.
- To plot input characteristics proceed as follows :

1. Rotate both the potentiometer P_1 and P_2 fully in CCW (counter clockwise direction).

2. Connect Ammeter between test point 2 and 3 to measure input base current $I_B(\mu A)$.

3. Short or connect a 2mm patch cord between test point 4 and 5.

4. Connect one voltmeter between test point 1 and ground to measure input voltage V_{BE} other voltmeter between test point 6 and ground to measure output voltage V_{CE}.

5. Switch 'On' the power supply.

6. Vary potentiometer P_2 and set a value of output voltage V_{CE} at some constant value (1V, 3V...)

7. Vary the potentiometer P_1 so as to increase the value of input voltage V_{BE} from zero to 0.8V in step and measure the corresponding values of input current I_B for different constant value of output voltage V_{CE} in an observation Table 1.

8. Rotate potentiometer P_1 fully in CCW direction.

9. Repeat the procedure from step 6 for different sets of output voltage V_{CE}.

10. Plot a curve between input voltage V_{BE} and input current I_B as shown in figure 1 using suitable scale with the help of Observation Table l. This curve is the required input characteristic.

Observation Table 1 :

S. no.	Input voltage V_{BE}	Input current I_B(mA) at constant value of output voltage		
		V_{CE} = 1V	V_{CE} = 3V	V_{CE} =5V
1.	0.0V			
2.	0.1V			
3.	0.2V			
4.	0.3V			
5.	0.4V			
6.	0.5V			
7.	0.6V			
8.	0.7V			
9.	0.8V			

- To plot output characteristics proceed as follows:

1. Switch ‘Off’ the power supply.

2. Rotate both the potentiometer P_1 and P_2 fully in CCW (counter clockwise direction).

3. Connect voltmeter between test point 6 and ground to measure output voltage V_{CE}.

4. Connect one Ammeter between test point 2 and 3 to measure input current I_B(µA) and other Ammeter between test point 4 and 5 to measure output current I_C(mA).

5. Switch ‘On’ the power supply.

6. Vary potentiometer P_1 and set a value of input current I_B at some constant value (0µA, 10µA......100µA)

7. Vary the potentiometer P_2 so as to increase the value of output voltage V_{CE} from zero to maximum value in step and measure the corresponding values of output current I_C for different constant value of input current I_B in an observation table2.

8. Rotate potentiometer P_2 fully in CCW direction.

9. Repeat the procedure from step 6 for different sets of input current I_B.

10. Plot a curve between output voltage V_{CE} and output current I_C as shown in figure 2 using suitable scale with the help of Observation Table 2. This curve is the required output characteristic.

Observation Table 2 :

S. No.	Output voltage V_{CE}	Output current I_C (mA) at constant value of input current				
		I_B = 0mA	I_B =10mA	I_B =20mA	I_B =30mA	I_B =40mA
1.	0.0V					
2.	0.5V					
3.	1.0V					
4.	2.0V					
5.	3.0V					
6.	4.0V					
7.	5.0V					
8.	6.0V					
9.	7.0V					
10.	8.0V					

- To plot constant current transfer characteristics proceed as follows:

1. Switch ‘Off’ the power supply.

2. Rotate both the potentiometer P_1 and P_2 fully in CCW (counter clockwise direction).

3. Connect voltmeter between test point 6 and ground to measure output voltage V_{CE}.

4. Connect one Ammeter between test point 2 and 3 to measure input current I_B (mA) and other Ammeter between test point 4 and 5 to measure output current I_C (mA).

5. Switch ‘On’ the power supply.

6. Vary potentiometer P_2 and set a value of output voltage V_{CE} at maximum value.

7. Vary the potentiometer P_1 so as to increase the value of input current I_B from zero to 10mA in step and measure the corresponding values of output current I_C in an Observation Table 3.

8. Plot a curve between output current I_C and input current I_B as shown in figure 3 using suitable scale with the help of observation Table 3. This curve is the required Transfer characteristic.

Observation Table 3 :

S. No.	Input current I_B (mA)	Output Current I_c (Ma) At Constant Output Voltage V_{ce} = Maximum
1.	00.0µA	
2.	10.0µA	
3.	20.0µA	
4.	30.0µA	
5.	40.0µA	
6.	50.0µA	
7.	60.0µA	
8.	70.0µA	
9.	80.0µA	
10.	90.0µA	
11.	100.0µA	

Calculations :

1. **Input resistance :** It is the ratio of change in the input voltage V_{BE} to change in the input current I_B at constant value of output voltage V_{CE} or it is the reciprocal of the slope obtained from the input characteristic.

   Mathematically :

$$R_{In} \frac{1}{\text{Slope from Input charecteristics}} = \frac{1}{\Delta I_B/\Delta V_{BE}} = \frac{\Delta V_{BE}}{\Delta I_{B \text{ at constant VCB}}}$$

   To calculate input resistance determine the slope from the input characteristic curve obtained from observation Table 1. Reciprocal of this slope will give the required input resistance.

2. **Output resistance :** It is the ratio of change in the output voltage V_{CE} to change in the output current I_C at constant value of input current I_B or it is the reciprocal of the slope obtained from the output characteristic.

   Mathematically :

$$R_{In} \frac{1}{\text{Slope from Input charecteristics}} = \frac{1}{\Delta I_C/\Delta V_{CE}} = \frac{\Delta V_{CE}}{\Delta I_{C \text{ at constant IB}}}$$

   To calculate output resistance determine the slope from the output characteristic curve obtained from observation Table 2. Reciprocal of this slope will give the required output resistance.

3. **Current gain :** It is the ratio of change in the output current I_C to change in the input current I_B at constant value of output voltage V_{CE} or it is the slope obtained from the constant current transfer characteristic. It is denoted by β_{ac}

Mathematically :

b_{ac} = **Slope of constant current transfer characteristic** = $\frac{D\mathbf{I_C}}{D\mathbf{I_B}}$

To calculate current gain, determine the slope from the constant current transfer characteristic curve obtained from observation Table 3. This slope is the required current gain.

Results :

Input resistance R_{in} = ____________

Output resistance R_{out} _________ =

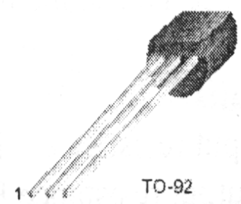
Current Gain β_{ac} = ____________

Data Sheet

BC546/547/548/549/550

Switching and Applications

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



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

Typical Characteristics

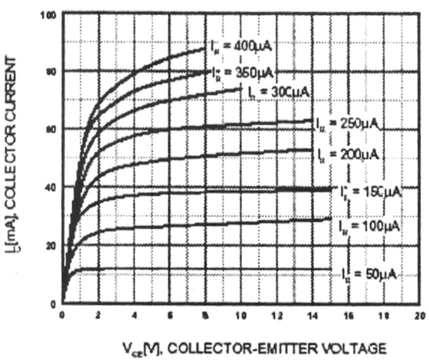


Figure 1. Static Characteristic

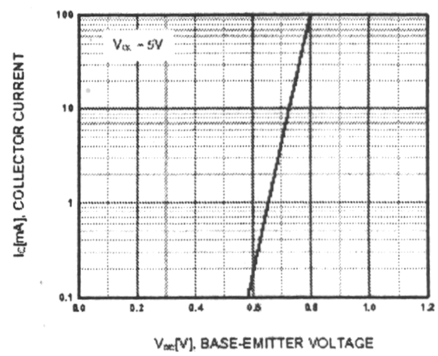


Figure 2. Transfer Characteristic

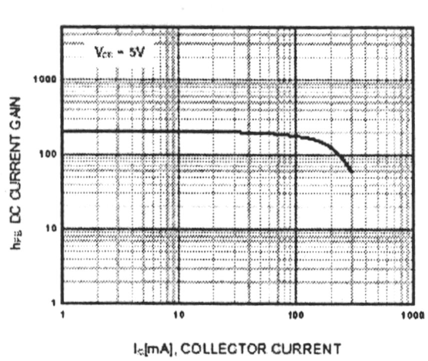


Figure 3. DC current Gain

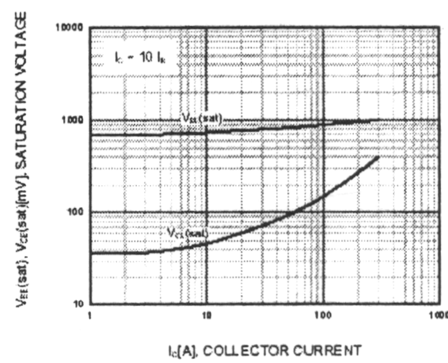


Figure 4. Base-Emitter Saturation Voltage
Collector-Emitter Saturation Voltage

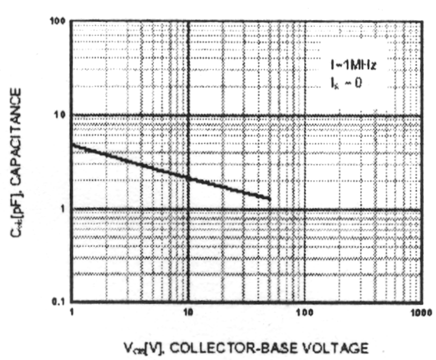


Figure 5. Output Capacitance

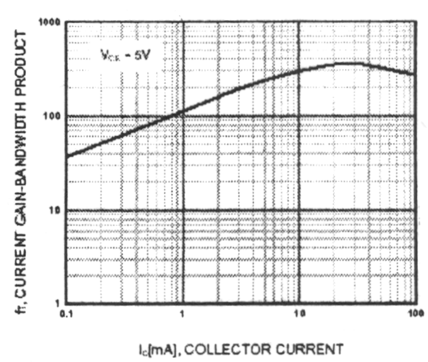


Figure 6. Current Gain Bandwidth Product

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

Updated 08-01-2009