



**DECEMBER 2004**

**APPLICATION AND COMMISSIONING  
MANUAL FOR NUMERICAL  
VOLTS / HERTZ PROTECTION RELAY  
TYPE - MBT191**

**EASUN REYROLLE LIMITED**

ISSUE NO : 2<sup>nd</sup> Issue

DATE OF ISSUE : 28 - 12 - 2004

DEPARTMENT : AS

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# **CHAPTER 1 - APPLICATION**

## **1.1. INTRODUCTION**

The type MBT191 numeric Volts / Hertz relay combines the power and flexibility of microprocessor technology. Two-stage protection, multiple inverse & definite time characteristics and wide range of settings are available. Moreover, supervisory components and self – monitoring features give high confidence of serviceability.

## **1.2. APPLICATION**

MBT191 is a numerical Volts / Hertz protection relay, which can be used to protect the generator and power transformer from excessive magnetic flux density levels. When these V/HZ ratios are exceeded, saturation of the magnetic core of the generator or connected transformers can occur and stray flux will be induced in to non-laminated components which are not designed to carry flux, So damage can occur within seconds. It is general practice to provided V/F relaying to protect generators and transformers from these excessive magnetic flux density levels. This protection is typically independent of V/HZ control in the excitation system. Hence high flux density levels will result from over voltage, under frequency or a combination of both. MBT 191 has the ability to detect and to provide protection for the above said over fluxing condition. Over excitation will heat up equipment, So sufficient time should be elapsed before the equipment again put in to service. MBT 191 has inbuilt cooling time feature for this application.

### **1.2.1. Two Elements**

MBT191 relay has two stages of Volts / Hertz protection, each stage can be set for DTL or Inverse characteristics. Two stages of DTL can be used to realize traditional two step over excitation protection. The inverse time element with four types of inverse characteristics provides superior protection by closely approximating the equipment's over excitation curve.

### **1.2.2. Multiple Characteristics**

Volts / Hertz protection function is provided with four inverse characteristics and DTL characteristics in each element. There are 160 inverse characteristics in each element out of which, the one that provides closure co-ordination with the protected equipment can be selected by selecting a type, out of four types of inverse characteristics and appropriate time multiplier setting.

## Extremely Inverse 1(EI 1) Characteristics

$$t = \frac{9.5}{(M^2 - 1)^2} * Tm \text{ Secs}$$

The following three inverse characteristics follows ANSI standard.

$$t = e^{\frac{-(M*100 - K)}{C}} \text{ Minutes}$$

Characteristics	K value	C value
EI 2	$115 + ((T_m * 10) - 1) * 2.5$	4.8858
EI 3	$113.5 + ((T_m * 10) - 1) * 2.5$	3.04
EI 4	$108.75 + ((T_m * 10) - 1) * 2.5$	2.449

And

$$M = \frac{(V / F)}{(V_n / F_n) * B}$$

Where,

- $t$  - Operating Time
- $Tm$  - Time Multiplier Setting
- $V_n$  - Nominal voltage setting in volts.
- $f_n$  - Nominal frequency setting in Hertz.
- $V / F$  - Volt/Hertz measured
- $V_n / F_n$  - Nominal Volt/Hertz setting
- $e$  - Exponential function
- $B$  - Multiplier setting for volts per hertz  
 $V_n / F_n$  ratio.

## Timer Settings:

Time Multiplier Setting

0.025 to 1.0 in steps of 0.025(For all inverse characteristics)

Definite time lag (DTL) characteristics

0.1 to 999.9 Secs in steps of 0.1 Sec (For element 1 & 2)

Reset Timer

1 to 1200 Secs in steps of 1 Sec

### **1.2.3. Cooling Time Delay (Reset Timer)**

Due to over excitation, the protected equipment will be heated up. So sufficient time should be elapsed before the equipment again put in to service. The MBT 191 relay has resetting time (Settable) feature for providing the enough cooling to the protected equipment. After trip occurs due to over fluxing, till the resetting time delay (which is settable in the relay) the starter indication will be on and the relay cannot be reset. By connecting starter C/O contact in the breaker closing circuit, closing interlock can be provided. With this closing interlock, only after resetting the relay the breaker can be closed again. This gives enough cooling time, which is necessary to cool the equipment when any over-excitation occurs and before it is put again into the operation.

### **1.2.4 Nominal Voltage And Frequency**

MBT 191 accepts the PT voltage input either from line-line voltage or line-neutral voltage. The range of voltage setting is from 50V to 150 V. The same relay can be used for 50 Hz or 60 Hz protection application. The nominal frequency setting is either 50Hz or 60Hz.

### **1.2.5 Blocking input**

The relay is also provided with an external digital input, which can be used to block the operation of the relay whenever it is desired.

### **1.2.6 Generator Over-Excitation Protection**

MBT 191 can be used to give protection against over excitation condition for the generator by measuring the line voltage through PT. The voltage input from line - line voltage or line - neutral voltage.

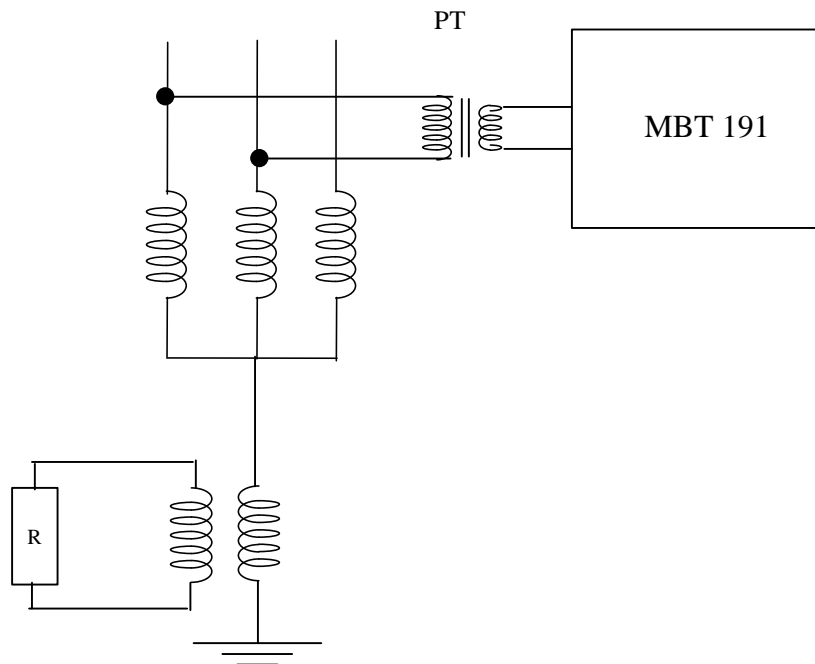


Fig.1 Typical Connections For MBT 191 Relay To Generator Over Excitation Protection.

### 1.2.7 Transformer Over-Fluxing Protection

In transformers over fluxing is often caused by poor regulation of voltage and frequency on the power system. Over fluxing condition can occur if the ratio of voltage to frequency exceeds a predetermined value. Transformers can withstand and are rated for a certain level of over fluxing but it can't withstand continuous over fluxing. MBT 191 can be applied for the protection of transformers from over fluxing condition.

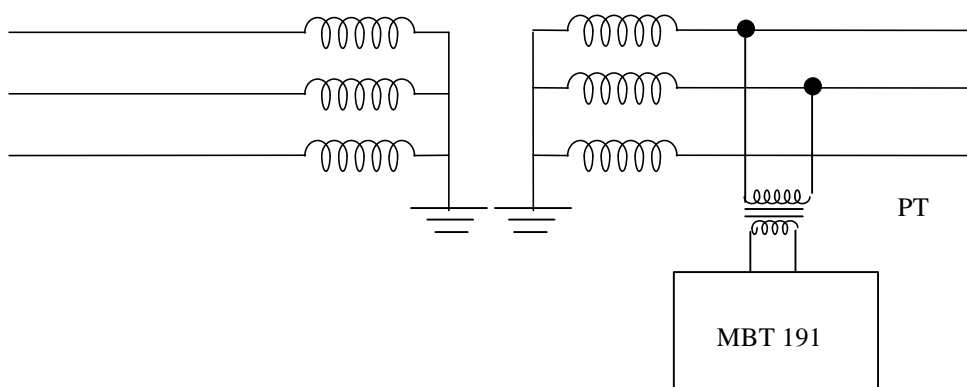


Fig.2 Typical Connection For MBT 191 Relay To Transformer Over-Fluxing Protection.

# CHAPTER 2 - INSTALLATION

## 2.1. UNPACKING

On receipt, remove the relay from the carton box in which it was received and inspect it for obvious damage. It is recommended that the relay is not removed from the relay case. To prevent the possible ingress of dirt, the sealed polythene bag should not be opened until the relay is to be used. If damage has been sustained, please inform **Easun Reyrolle Ltd.**, for necessary action.

## 2.2. STORAGE

When the relay is not required for immediate use, it should be returned to its original carton and stored in a clean dry place.

## 2.3. HANDLING

The relay's electronic circuits are protected from damage by static discharge when the relay is housed in its case. When relay is withdrawn from the case, static handling procedures should be observed:

- Before removing the relay from its case the operator must first ensure that he is at the same potential as the relay, by touching the case.
- The relay must not be handled by any of the relay terminals at the rear of the chassis.
- Ensure that anyone else handling the relay is at the same potential.

As there are no user serviceable parts and adjustable user settings inside the relay, there should be no requirement to remove any modules from the chassis. If any modules are removed or tampered with, then the guarantee will be invalidated.

## 2.4. MOUNTING

Mount the relay using 2 nos mounting straps and 1no earth strap. Ensure that an earth wire is connected to the earth strap from the earth terminal 23. Terminal 23 should be directly connected to the system ground.

Only settings or trip details can be accessed via the pushbuttons when the cover is fitted. To change the settings the front cover has to be removed. Sealing arrangement is provided in one of the four knurling screws fitted on the cover. Sealing can be done using a sealing wire. Thus mechanical interlock is provided to avoid unauthorised setting change.



## 2.5. EQUIPMENT

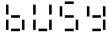
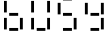
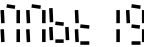


### 2.5.1. HMI (Human Machine Interface)

The user friendly HMI provided on the front panel has following hardware. Six digits, 7 segment LED display (First two digits are Red color and other four digits are Green color). First two digits (Red) displays Main menu or Type of fault when selected for Setting mode or Trip indication respectively. Remaining four digits (Green) displays Sub menu or "trip" indication respectively.

- 1) Green LED - Protection healthy indication.
- 2) Yellow LED - Starter indication.
- 3) Red LED - Trip indication.
- 4) - Key - Up scrolling
- 5) - Key - Down scrolling
- 6) ® Key - Sub menu
- 7) ' Key - Enter/Reset/Cancel/To check Version.

## 2.6. SETTING INSTRUCTIONS:

### 2.6.1. How To Operate HMI


- Remove the front cover by unscrewing the four knurling screws.
- Apply DC supply. Terminals 22, 24 and 23 are for +Ve, -Ve and Ground respectively as per relay rating. When the relay powers up it takes few seconds to complete the self-test routine.
- Ensure Protection Healthy LED (Green) is ON and  indication appears on the LED display unit. Wait till the  indication goes off.
- Press - or - key,  is displayed.
- Press - key, it displays  on first two digits and  on second four digits.

 - Represents Main menu

 - Represents Sub menu

- Pressing - key repeatedly scrolls down the Main menu in the following order on the display.

  - Nominal voltage setting

  - Nominal frequency setting

$b1 \ 100$  - Element 1 Voltage/frequency setting  
 $b2 \ 100$  -Element 2 Voltage/frequency setting  
 $c1 \ 811$  -Element 1 characteristics setting  
 $c2 \ 814$  -Element 2 characteristics setting  
 $t1 \ 0.100$  -Element 1 Time multiplier setting  
 $t2 \ 0.300$  -Element 2 Time multiplier setting  
 $rt \ 1$  -Reset time Delay

### 2.6.2. Voltage Setting

$Un \ 110$  Setting range: 50 V to 150 V in steps of 1V

From  $Un \ 110$  Main menu, press Submenu  $\textcircled{R}$  Key, 3mm LED in the  $\textcircled{R}$  Key lit. It indicates that the Sub menu is activated.

$Un \ 110$  - Element 1 & 2 voltage setting

By pressing - or + key choose the desired voltage value and press  $\textcircled{R}$  key. Now Submenu LED goes OFF and the Main menu appears on the LED display.

### 2.6.3. Frequency setting

$Fn \ 50$  Setting range: 50 Hz or 60 Hz

From  $Fn \ 50$  Main menu, press Submenu  $\textcircled{R}$  Key, 3mm LED in the  $\textcircled{R}$  Key lit. It indicates that the Sub menu is activated.

$Fn \ 50$  - Element 1 & 2 frequency setting

By pressing - or + key choose the desired frequency value and press  $\textcircled{R}$  key. Now Submenu LED goes OFF and the Main menu appears on the LED display.

### 2.6.4. Volts/Hertz setting

$b1$  &  $b2$  Setting range: OFF or 1.00 to 1.50 in steps of 0.01

From  $b1 \ 1.00$  or  $b2 \ 1.00$  Main menu, press Submenu  $\textcircled{R}$  Key, 3mm LED in the  $\textcircled{R}$  Key lit. It indicates that the Sub menu is activated.

$b1 \ 1.00$  or  $b2 \ 1.00$  - Element 1 or 2 Volts/Hertz setting

By pressing - or + key choose the desired Volts\Hertz value and press  $\text{\textcircled{R}}$  key. Now Submenu LED goes OFF and the Main menu appears on the LED display.

### 2.6.5. Characteristics Setting

$\text{\textcircled{1}}$  or  $\text{\textcircled{2}}$  Setting range:  $\text{\textcircled{1}}$  or  $\text{\textcircled{2}}$  or  $\text{\textcircled{3}}$  or  $\text{\textcircled{4}}$  or  $\text{\textcircled{5}}$

From  $\text{\textcircled{1}}$   $\text{\textcircled{1}}$  or  $\text{\textcircled{2}}$   $\text{\textcircled{1}}$  Main menu, press Submenu  $\text{\textcircled{R}}$  Key, 3mm LED in the  $\text{\textcircled{R}}$  Key lit. It indicates that the Sub menu is activated.

$\text{\textcircled{1}}$   $\text{\textcircled{1}}$  or  $\text{\textcircled{2}}$   $\text{\textcircled{1}}$  - Element 1 or Element 2 Inverse characteristics setting

By pressing + key repeatedly the Sub menu will scroll down in the following order on the display unit.

$\text{\textcircled{1}}$  - Inverse characteristics 1

$\text{\textcircled{2}}$  - Inverse characteristics 2

$\text{\textcircled{3}}$  - Inverse characteristics 3

$\text{\textcircled{4}}$  - Inverse characteristics 4

$\text{\textcircled{5}}$  - Definite Time Lag

By pressing - or + key choose the desired characteristic and press  $\text{\textcircled{R}}$  key. Now Submenu LED goes OFF and the Main menu appears on the LED display.

### 2.6.6. Time Multiplier Setting And Definite Time Lag

$\text{\textcircled{1}}$  or  $\text{\textcircled{2}}$  Setting range: 0.025 to 1.0 in steps of 0.025 (time multiplier for all inverse characteristics) or 0.1 to 999.9 Secs in steps of 0.1 Sec (Time delay for definite time lag)

From  $\text{\textcircled{1}}$   $\text{\textcircled{1}}$  Main menu, press  $\text{\textcircled{R}}$  key to get Sub menu and select or  $\text{\textcircled{5}}$   $\text{\textcircled{1}}$  Once again press the  $\text{\textcircled{R}}$  key (Sub menu LED goes OFF) to get back the main menu.

Press + key repeatedly to get  $\text{\textcircled{1}}$   $\text{\textcircled{0.1}}$   $\text{\textcircled{00}}$  main menu

Press  $\text{\textcircled{R}}$  key (Submenu LED On) to get Submenu.

Pressing - or + key, changes TIME MULTIPLIER or TIME DELAY setting.

After selecting the desired setting, once again press the  $\text{\textcircled{R}}$  key (Sub menu LED goes OFF) to get back the main menu.

### 2.6.7. RESET TIME

Setting range: 1 to 1200 Secs in steps of 1 Sec (Reset time is common for both elements)

From Main menu, press  $\leftarrow$  key repeatedly to get Main menu. Press  $\text{\textcircled{R}}$  key (Submenu LED On) to get Submenu. Pressing the  $\rightarrow$  or  $\leftarrow$  key, changes the current setting in 1sec increments. Upon selecting the desired setting, once again press the  $\text{\textcircled{R}}$  key (Sub menu LED goes OFF) to return to the main menu.

### 2.6.8. Acceptance Of Settings

For the relay to accept the above setting changes press  $\rightarrow$  push switch once, now the display goes off and the settings are updated. By pressing any switch again

indication will appear.

Ensure all the chosen settings are as per requirements.

To change existing settings, choose corresponding Main menu and select the Sub menu (ensure LED ON), using  $\rightarrow$  or  $\leftarrow$  key change the previous setting and once again press the Sub menu switch  $\rightarrow$  (LED OFF). Finally press Enter  $\rightarrow$  switch once.

### **ENSURE 'X' KEY IS PRESSED TO ACCEPT THE SETTING CHANGES**

### 2.6.9. TO CHECK THE RELAY VERSION

Press X push switch four times quickly. Example of relay Version display is as follows:

19 1001 - Represents M B T 191 relay, version 1.

To get back the main menu presses  $\rightarrow$  or  $\leftarrow$  key.

### 2.6.10. Trip Indication And Resetting Of Trip Indication

When the relay operates, RED LED indicates tripping. To find the 'Type of fault', press any arrow key.

b1t r1P Indicates Element 1 operated

b2t r1P Indicates Element 2 operated

**Once the fault is cleared, press ' X ' key twice to reset the trip indication.**

Ensure to reset the relay before the breaker is closed.

# CHAPTER 3 - COMMISSIONING

## 3.1. REQUIRED TEST EQUIPMENT'S

- 500V insulation test sets.
- Secondary injection voltage source with variable voltage and variable frequency.
- Time interval meter.
- Primary injection equipment.
- A DC supply with a nominal voltage within the working range of the relays DC auxiliary supply and status input ratings.

## 3.2. INSPECTION

Ensure that all connections are tight and in accordance with the relay wiring diagram and the scheme diagram. Check if the relay is correctly programmed and the relay is fully inserted into the case.

## 3.3. APPLYING SETTINGS

The relay settings for the particular application should be applied before any secondary testing is started.

## 3.4. PRECAUTIONS

Before testing commences, the equipment should be isolated from the potential transformers and the PTs to be open-circuited, in line with the local site procedures. The tripping and alarm circuits should also be isolated, where practical. Also, ensure that trip links are removed. Ensure that correct DC auxiliary voltage and polarity is applied. See the relevant scheme diagrams for the relay connections.

## 3.5. TESTS

### 3.5.1. Insulation Test

Connect together the terminals of the AC voltage inputs, status input, DC auxiliary power supply and output terminals together. Measure the insulation resistance between these terminals and earth.

Connect together the terminals of the DC auxiliary power supply (only +ve and -ve) and measure the insulation resistance between these terminals and all other terminals connected together to earth.

Connect together status input terminals and measure the insulation resistance between these terminals and output terminals, AC voltage input terminals connected together as a group to earth.

Connect together the AC voltage input terminals and measure the insulation resistance between these terminals and all other output terminals connected together to earth.

A minimum value of 2.5 to 3 Mega ohms can be considered as satisfactory value.

### 3.5.2. Secondary Injection Test

Select the relay configuration and settings for the application. Note that the MBT 191 relay can be connected either as 63.5V or 110V rated device. The user should check this before commencing secondary test.

#### A. Pick up and Reset Test

This test checks accuracy of the Voltage/Frequency settings for the relay's over fluxing characteristics. Adopt a typical setting for testing purpose. This test is done in two steps

- i) Pickup and reset test with variable voltage & constant frequency,
- ii) Pickup and reset test with variable frequency & constant voltage.

i) Apply single-phase or phase-phase voltage into the voltage-input terminal with constant frequency. Slowly increase the voltage until the starter LED (yellow) operates by keeping frequency at constant value and record the V/F pick up value in Table 1. Reduce the voltage until the LED goes off and record this as the reset level. In this test frequency is fixed and voltage is varied to get varies V / F values. Refer Fig.3.

Connection	Adopted Pick-Up Setting (V/F)	Measured Pick-Up (V/F)	Theoretical V/F Reset % V/F	Measured V/F Reset % V/F
Phase-Phase				
Phase-Neutral				

**TABLE 1**

ii) Apply single-phase or phase-phase voltage into the voltage-input terminal with constant voltage. Slowly decrease the frequency until the starter LED (yellow) operates by keeping voltage at constant value and record the V/F pick up value in Table 2. Increase the frequency the LED goes off and record this as the reset level. In this test voltage is fixed and frequency is varied to get varies V / F values.

Connection	Adopted Pick-Up Setting (V/F)	Measured Pick-Up (V/F)	Theoretical V/F Reset % V/F	Measured V/F Reset % V/F
Phase-Phase				
Phase-Neutral				

**TABLE 2**

## **B. Inverse / DTL Characteristics Timing Test**

This test checks the accuracy of the main time delay characteristics (EI 1-4/DTL). Select the relay voltage/frequency setting characteristics and time multiplier settings as required and then inject a voltage with constant frequency or constant voltage with variable frequency, which is a multiple of the relay setting.

A time interval meter should be connected to the correct output contact terminals. The timer should be started by the source and stopped by the relay trip contacts. A secondary injection timing test circuit is illustrated in Fig. 4. The secondary injection test equipment should be made 'OFF', once the relay contact is closed

In table 3 & 4 record the theoretical value & actual value of each characteristic with time multiplier set to 1.000.

- i) Inverse/DTL timing test with variable voltage & constant frequency,
  - ii) Inverse/DTL timing test with variable frequency & constant voltage.
- i) Adopt Volts/Hertz setting as 1X Volts/Hertz. Apply a variable voltage with constant frequency, resulting Volts/Hertz as 1.1 X Volts/Hertz and 1.5 X Volts/Hertz. Note down the reading in the table 3.



Characteristic	1.1 x Volts/Hertz		1.5x Volts/Hertz	
	Theoretical operating time (Secs.)	Measured operating time (Secs.)	Theoretical operating time (Secs.)	Measured operating time (Secs.)
EI 1				
EI 2				
EI 3				
EI 4				
DTL				

**TABLE 3**

ii) Adopt Volts/Hertz setting as 1X Volts/Hertz. Apply a variable frequency voltage with constant voltage, resulting Volts/Hertz as 1.1 X Volts/Hertz and 1.5 X Volts/Hertz. Note down the reading in the table 4.

Characteristic	1.1 x Volts/Hertz		1.5x Volts/Hertz	
	Theoretical operating time (Secs.)	Measured operating time (Secs.)	Theoretical operating time (Secs.)	Measured operating time (Secs.)
EI 1				
EI 2				
EI 3				
EI 4				
DTL				

**TABLE 4**

### C. Blocking Test

Apply rated DC input voltage to the blocking input terminals. Then the relay will be blocked from its operation. In this condition, application any voltage will not cause any operation.

**Note: Blocking input is rated for 24/30 V DC nominal voltage input (18 to 36 V operating range) without any external resistors. For higher DC nominal voltage input use external dropper resistors (R1 & R2) as given in the fig. 6 chapter 4 - drawings.**

### D. Output Relays

The MBT 191 relay has following O/P relays.

Element 1 Operated	- 2 NO, (1,2 & 3,4)
Element 2 Operated	- 2 NO, (13,14 & 15,16)
Protection Unhealthy	- 1 NC, (17,18)
Starter (With common end)	- 1 NO (19,20) & 1 NC (19,21)

### **1.Element 1 Operated - 2 NO**

These 2 NO contacts are energized from element 1 and can be used while testing the inverse or DTL characteristics of element 1.

### **2.Element 2 Operated - 2 NO**

These 2 NO contacts are energized from element 2 and can be used while testing the inverse or DTL characteristics of element 2.

### **3. Protection unhealthy - 1 NC**

This contact shall be used for alarm / annunciation purposes.

### **4. Starter (With common end) - 1 NO & 1 NC**

These contacts can be used while testing the pick up and reset value of the relay.

## **3.5.3. Primary Injection**

Primary injection tests are essential to check the ratio and polarity of the transformers as well as the primary & secondary wiring.

Using the circuit shown in Fig. 5, check the potential transformer ratio and PT phase to earth connection. Inject a voltage of sufficient magnitude. The secondary Voltage is

$$V_s = \text{Primary Voltage} / \text{PT ratio}$$

## **3.5.4. Putting In To Service**

After completing all tests satisfactorily, the relay should be put into service as follows:

1. Make a final check of the secondary wiring and tightness of all terminal connections.
2. Insert the DC supply fuse.
3. Check the relay healthy indication/display.
4. Replace the relay cover.
5. Insert the trip links.
6. Perform trip test by secondary injection.
7. Remove all test connections

## CHAPTER 4 - DRAWINGS

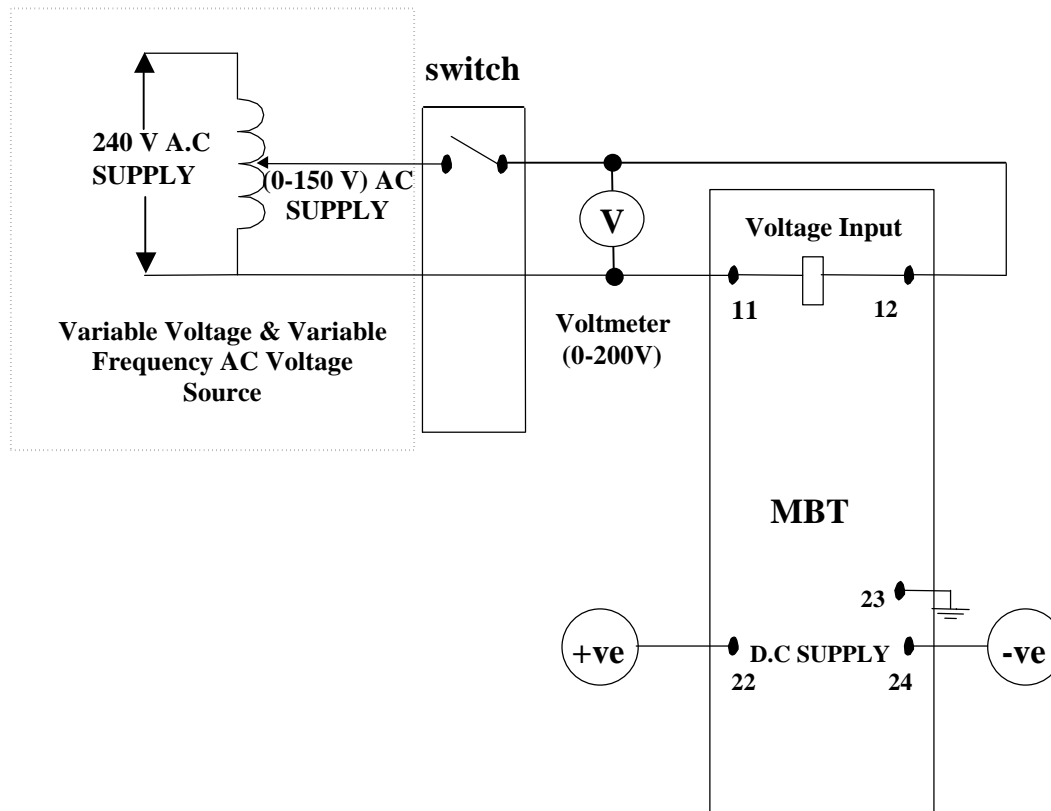


Fig 3 - Pickup & Reset Test Circuit

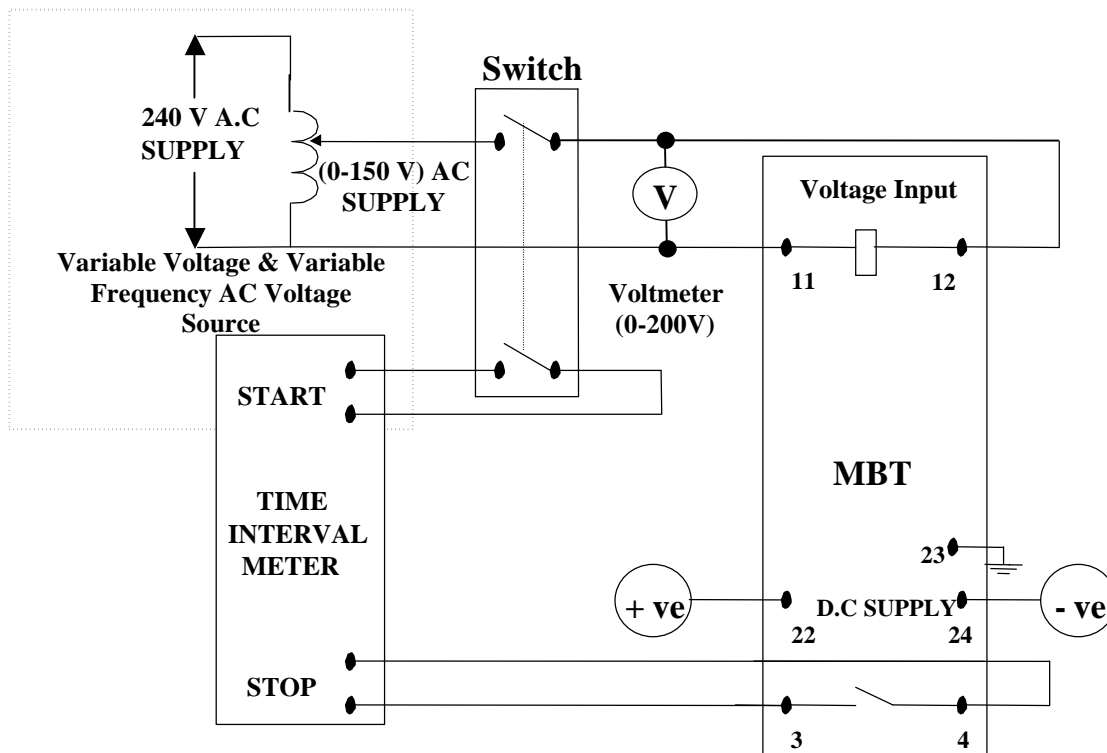


Fig 4 – Inverse/DTL Characteristics Test Circuit

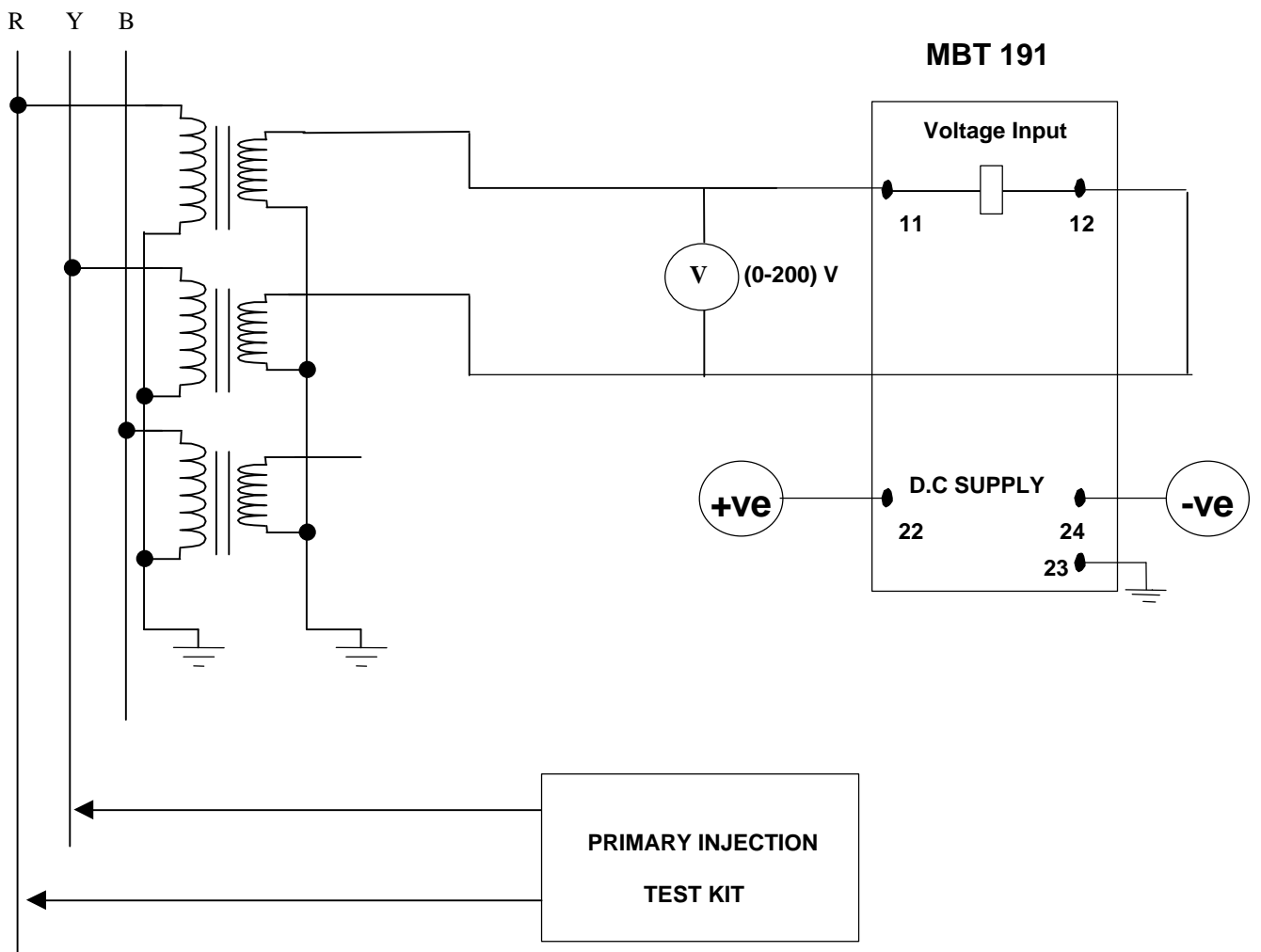
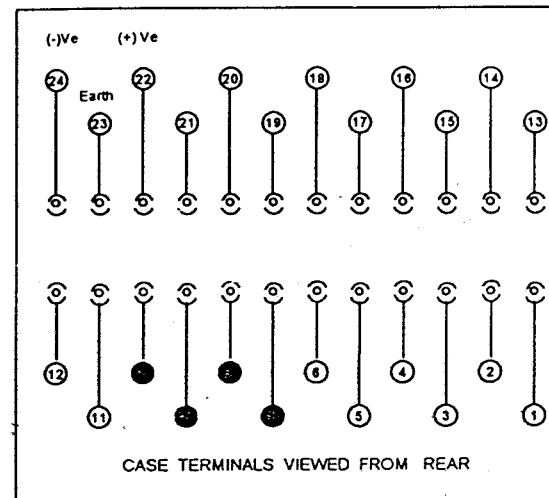
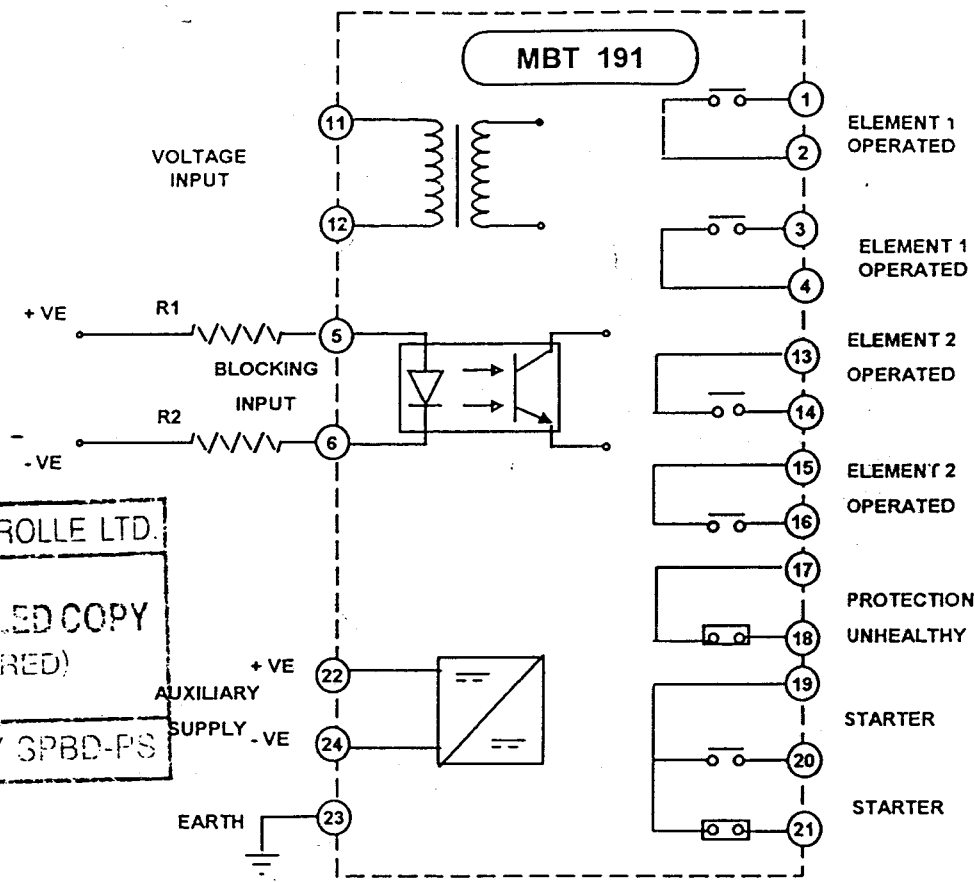


Fig 5 - Primary Injection Test Circuit

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Note :

1. Blocking input is rated for 24 / 30 V DC nominal voltage input (18 to 36V operating range) without any external resistors. For higher DC nominal voltage input, use external dropper resistors (R1 & R2) as follows.

Blocking Input External Resistances		
Nominal Voltage	Operating range	R1 & R2
48V DC	36 to 60V	1.0 k $\Omega$ $\pm$ 5% ; 9 W
110V DC	88 to 135 V	3.9 k $\Omega$ $\pm$ 5% ; 9 W
220V DC	176 to 280 V	8.2 k $\Omega$ $\pm$ 5% ; 9 W

2. Terminal No.23 (Earth) is to be connected directly to Earth bar.



### WIRING DIAGRAM FOR MBT 191 RELAY

Drawing No. :- 8431W20192

EASUN REYROLLE LIMITED,  
 HOSUR, INDIA.

REV

No.	Sig.	DATE	No.	Sig.	DATE	No.	Sig.	DATE

DATE	27.07.2004	CHECKED	G.Marutharaj
DRAWN	S.Ayyanar	APPROVED	

SUPERSEDES SHEET  
 8431W20191 1 OF 1