Calibration of DC Ammeter Using Feedback Control

PROJECT REPORT

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Sponsored by

PRICOL, Coimbatore

IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
BACHELOR OF ENGINEERING IN
ELECTRICAL & ELECTRONICS ENGINEERING
OF THE BHARATHIAR UNIVERSITY

1997 - 98

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Kumaraguru College of Technology

COIMBATORE - 641 006.

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Kumaraguru College of Technology

COIMBATORE – 641 006.

CERTIFICATE

This is to certify that the Project entitled

CALIBRATION OF DC AMMETER USING FEEDBACK CONTROL

has been submitted by

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Certified that the candidate with University Register No. . . . .
was examined in project work Viva-Voce Examination held on . . . .

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HRD/PROJECT/98

31st March 1998

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the following Final BE (EEE) students of Kumaraguru College of Technology, Coimbatore have carried out a project work in our organisation in Plant Maintenance Department from 1st January 1998 to 31st March 1998.

1. Mr T Binu
2. Mr B Bharath
3. Mr SM Rajaram
4. Mr S Srithar

The title of the project was "CALIBRATION OF DC AMMETER USING FEEDBACK CONTROL".

During this period, their attendance and conduct were found to be good.

We wish them the very best for a bright future.

LT COL S PURUSHOTHAMAN
DEPUTY GENERAL MANAGER - HUMAN RESOURCES

ACKNOWLEDGEMENT

It is with deep sense of gratitude that we thank our project Guide **Mrs.RANI THOTTUNGAL, M.A., M.E., M.I.S.T.E.,** Lecturer, Department of Electrical and Electronics Engineering, for her guidance and invaluable suggestions, the keen and constant interest evinced by her through out the course of this project.

We are highly grateful to **Dr. K.A.PALANISWAMY, B.E., M.Sc. (Engg.), Ph.D., M.I.S.T.E., C.Eng (I), F.I.E.,** Professor and Head of the Electrical and Electronics Engineering Department, for his enthusiasm and encouragement which has been instrumental in the success of this 'project.

We thank our Principal, **Dr. S.SUBRAMANIAN,B.E., M.Sc.(Engg), Ph.D., S.M.IEEE,** for his kind patronage.

We are thankful to **Lt.Col.S.PURUSHOTHAMAN,** Deputy General Manager, HRD, **M/s.PREMIER INSTRUMENTS AND CONTROLS LTD, COIMBATORE – 641 020** for granting permission to do this project in the Industry.

We thank **Mr.K.RAJAN,** Manager, **Mr.G.SIVASALAPATHY,** Assistant Manager and **Mr.ALEXANDAR,** Chief Engineer, PMD of PRICOL who rendered it possible to complete this project. We also thank workers of PRICOL who helped us a lot to complete this project. They provided us the necessary data and relevant materials for this project.

Last but not the least, we also thank the Teaching and Non-Teaching staff members of Electrical & Electronics Engineering department and student friends for their kind co-operation during the course of this project.

SYNOPSIS

The feedback controlled D.C. ammeter calibrator is designed specifically for calibrating dashboard indicator, indicating the charging and discharging of D.C. batteries which is widely used in two wheelers as well as four wheelers.

As the industry have frequent fluctuations at the input supply, it is very necessary to suppress the fluctuations while calibrating. The newly designed calibrator is standardised by including a feedback circuit which compensates any fluctuation in the input supply such that no disturbance is felt when the meter under test is calibrated with the standard meter.

The calibrator provides a variable range of testing current (0A to 50A), in both positive and negative directions.

CONTENTS

CHAPTER – 1

INTRODUCTION

Calibration of a meter is a process by which the standard meter is compared with manufactured meter for detecting the accuracy of the newly manufactured meter. While calibrating, if any deviation is found in the newly manufactured meter with that of standard meter, the new meter is adjusted to match the standard one.

The Battery charge indicator meter, which shows both the charging and discharging of the current, has to be tested for both positive and negative directions of current. This project provides relay circuits to change the direction of current so that both the positive as well as negative current in the newly manufactured meter is calibrated with $\pm 1\%$ accuracy.

This project takes care about the ISO standard requirements of the calibrating equipment with regulation of 1% variation when the input variation is about $\pm 10\%$.

The principle used to regulate current is the standard feedback control. The error developed due to the change in the input signal is compared with the reference and the error is amplified through a differential amplifier which is fed back to the oscillatory circuit which varies its pulse width to maintain a regulated output.

The various circuits which forms the calibrator are as follows:

A relay circuit to get deflection in both the directions.

A control circuit to stabilise the input given to the triac.

A synchronising circuit to synchronise the a.c. supply and control circuit output.

A separate power supply for relay and power devices.

1.1. BLOCK DIAGRAM

The major circuits involved in the D.C. ammeter calibrator are

1.1.1. Voltage control by triac:

The circuit consists of bi-directional device triac which is connected with triggering circuit for gate pulses. Any variation in the input supply is sensed by control circuit and given to triac gate input, hence better regulation is obtained.

1.1.2. Rectifier circuit:

The stepped down input supply is rectified into a smooth dc. by the rectifier circuit. The standard D.C. being given to the test meter panel.

1.1.3. Control Circuit:

The control circuit involves pre-amplifier, buffer amplifies and differential amplifies which senses any change in the input supply. This circuit is used to fix the range of current in the calibrator.

1.1.4. Triggering circuit:

The triggering circuit used here is UJT relaxation oscillator circuit, which supplies the gate pulses to the triac.

1.1.5. Meter Panel:

The meter panel consists of standard meter and the meter to be tested.

1.1.6. Relay circuit:

Relay circuit is used to change the direction of current in both negative and positive.

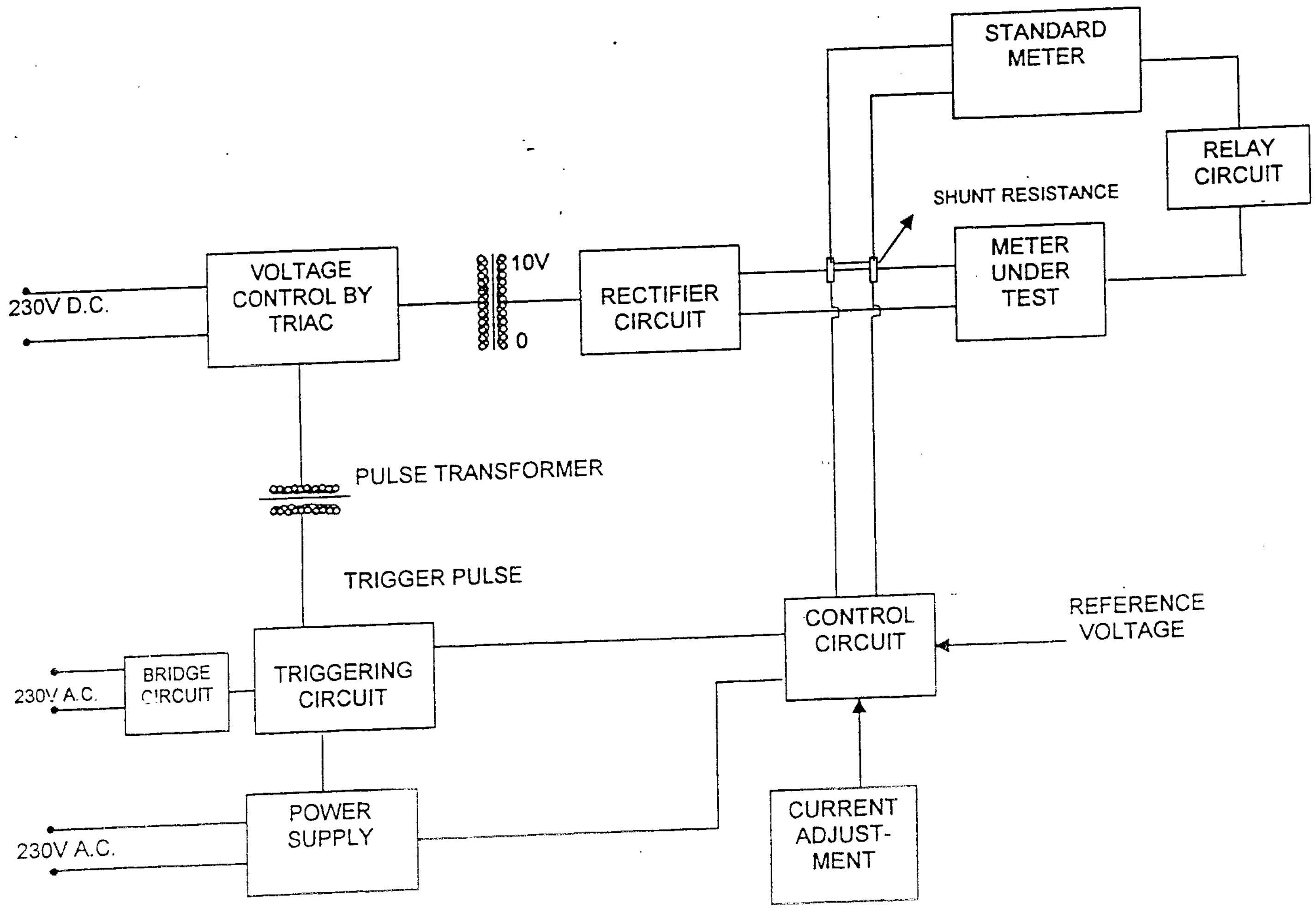

Fig. 1.1 BLOCK DIAGRAM OF FEEDBACK CONTROLLED CIRCUIT

CHAPTER – 2

CIRCUIT DESIGN

2.1. POWER CIRCUIT

2.1.1. INTRODUCTION

The power circuit consists of the input power supply 230 V, 50 Hz with triac which regulates the input given to the meter panel. The change in the triggering pulse angle, provides the regulation of the circuit.

The triac is used for the stabilization of the input. The triac controlled circuit consists of

(i) Power circuit for Triac

(ii) Driver or trigger circuit

(iii) Controller.

2.1.2. Power Circuit for Triac:

The power circuit consists of thyristors and diodes. The diode is rated at 60A and 5V, the 230V being stepped down to 5V by a centre tap transformer. The triac is connected in series, the gate pulse being provided through a pulse transformer. The thyristors and the triac are being mounted on a heat sink to dissipate the heat being generated.

2.1.3. Driver or Trigger Circuit:

The trigger circuit consists of the UJT relaxation oscillator which produces train of pulses and this being given to the gate of the triac through a pulse transformer. The pulse transformer acts as a isolation between the power circuit and control circuit. The trigger circuit is in between the controller and the power device, triac.

2.1.4. Controller:

The controller circuit consists of the operational amplifiers which acts as a feedback to the UJT input such that the input to the meter panel is regulated.

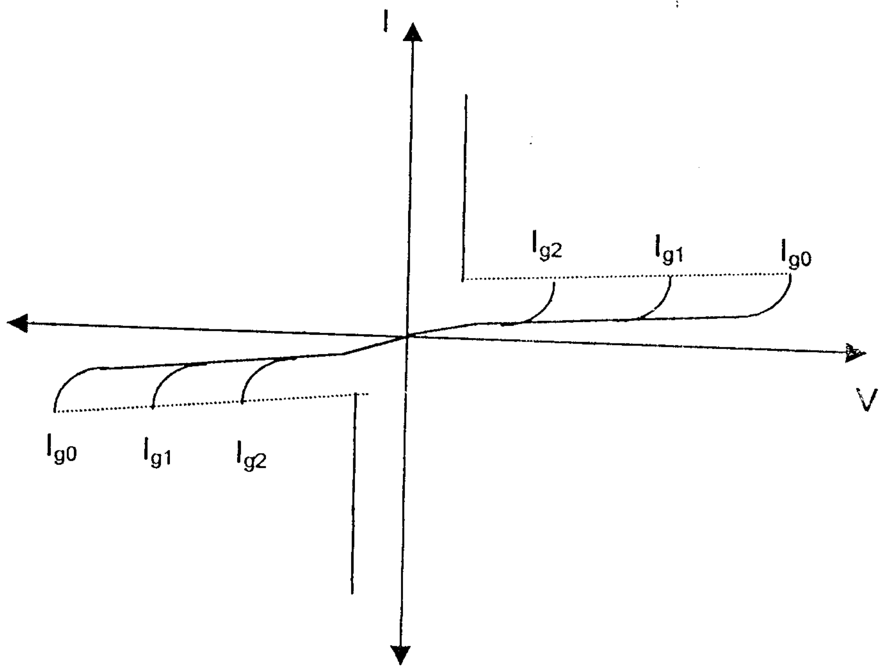

Fig. 2.1. V – I CHARACTERISTICS OF TRIAC

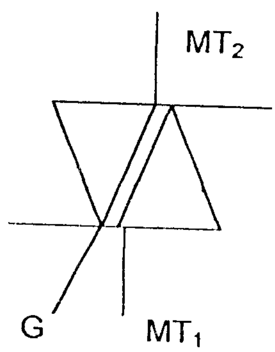

Fig. 2.2. CIRCUIT SYMBOL OF TRIAC

2.1.5. Triggering:

The triggering of triac can be done in three ways.

(i) Pulse triggering

(ii) Single pulse triggering

(iii) D.C. triggering

The method being employed here is the pulse triggering. The UJT oscillator produces a train of pulses to trigger the triac at various instances which inturn is governed by control circuit.

2.1.6. Relays:

Relay 1 in the circuit diagram is used to switch ON or OFF the calibrator, the relay1 is also connected to the range setting circuit such that it cuts off the supply whenever the current exceeds the setting current.

Relay 2 and Relay 3 are connected so that the current direction can be changed from positive to negative range or vise versa. These relays are connected to the standard meter as well as meter under test.

Push buttons are provided to energise these relays such that the direction of current can be changed whenever needed while calibrating.

2.1.7. Filter:

Inductive filter is used to smoothen the pulsating D.C. produced at the output of the step down transformer, the choke being connected to the centre tap. Separate connection to a step down transformer is made to connect the regulator circuits, which needs 16V as input.

The standard meter of the panel has been designed to have 1 Amp of current for 1mV. A shunt resistance is provided such that same current is allowed to follow both in standard meter as well as meter to be tested.

2.2. CONTROL CIRCUIT

2.2.1. INTRODUCTION

The control circuit uses operational amplifier IC741 to detect any change in the input supply and magnify the error such that it can feed it to UJT oscillatory circuit which inturn regulates the output at the meter panel. The control circuit is also used to set the range of current, both positive and in negative directions of current.

The various operational amplifiers used are as follows.

2.2.2. Buffer Amplifier:

Buffer amplifier or voltage follower has unity gain and hence the input voltage is equal to the output voltage. The buffer amplifier has high input impedance and zero output impedance. The output voltage has same magnitude and phase as that of input voltage. Here maximum of 12V can be set. The buffer amplifier acts as a reference voltage to the error or differential amplifier.

2.2.3. Pre Amplifier:

The input of the preamplifier is taken from the transformer output of the power circuit. The input to preamplifier may be in few milli-volts, hence it should be amplified using this preamplifiers. As the power circuit is in high current area, there is chance of getting sparks in the meters and hence there will be current drop accordingly. In order to avoid these drawbacks the preamplifier is used.

2.2.4. Error Amplifier:

The error amplifier is the differential amplifier. This amplifier amplifies the difference between two signals. The two inputs given to the error amplifier are

i) The reference voltage taken from the output of the buffer amplifier.

ii) The output taken from the preamplifier

The difference between these two signals taken from the buffer amplifies and pre amplifier is amplified by the difference or error amplifier. This signal is given to the oscillatory circuit.

2.2.5. UJT Relaxation Oscillator.

UJT exhibits negative resistance characteristics and hence it can be used as a relaxation oscillator. Also the external resistance connected to the UJT are small in comparison with the internal resistance of the UJT base, hence the circuit using uni-junction transistor is fairly simple and less expensive.

The output of the differential amplifier is amplified through a transistor and given to base 1 of the uni-junction transistor. Another input for the base 2 of the UJT is from the synchronization circuit.

The diodes are connected to UJT such that it is reverse biased, hence it allows only the negative voltage from the error amplifier into the UJT oscillatory circuit.

The oscillatory circuit thus created causes pulses at the base. This output is given to a darlington circuit. The darlington circuit gives high impedance and high gain. It matches the impedance of the AC input given to base 1 and the signal given to the gate of the triac. It also acts as an amplification of the oscillatory output.

2.2.6. Isolator:

An isolator is used to isolate the power circuit of high current and control circuit of low current. The pulse transformer is used as an isolator here. The turn ratio being 1:1, the pulse from the darlington pair is given to the pulse transformer.

In this circuit, the capacitor is charged through the resistance until the capacitor voltage reaches the peak-point emitter voltage of the UJT. At this time, the UJT turns on. The capacitor is discharged through the primary of the pulse transformer. A pulse is produced at the primary, as well as at the secondary of the pulse transformer. This is the gate triggering pulse. When the voltage across the capacitor sinks, the UJT turns off and the capacitor charges again and the whole process repeats itself.

The period of oscillation T is fairly independent of temperature. The time period is given as

$$T = \frac{1}{f} = RC \ln \frac{1}{1-\eta} \qquad (2.1)$$

Where η is the intrinsic stand off ratio of UJT

The value of the capacitor should be such as to store sufficient charge to trigger the SCR. The charging resistance must be sufficiently small to admit the required peak point current of the UJT from the supply voltage.

If the emitter diode drop is neglected

$$R < \frac{V_1 - V_P}{I_P} \qquad (2.2.)$$

Where V_1 is the UJT supply voltage

V_p is the peak point emitter voltage of the UJT

I_P is the peak point emitter current of the UJT

Again, resistance must be sufficiently large for the voltage at the intersection point of the load line and UJT characteristic curve to be greater than the valley voltage of the UJT

$$R > \frac{V_1 - Vv}{Iv} \qquad (2.3)$$

V_v is the valley voltage for a particular inter-base voltage V_{BB} of the UJT.

I_V is the valley current corresponding to V_V.

The above two equations specify the maximum and minimum limit of the value of resistance R for the condition of relaxation oscillator.

2.3. SYNCHRONISING CIRCUIT

The synchronising circuit synchronises the triggering pulses with the A.C. input to the UJT relaxation oscillator. A bridge circuit from the main supply with zener diode connected across it forms the synchronising circuit, the zener diode provides stabilisation of the supply voltage and helps in the production of pulses of equal magnitude.

The UJT triggers when its emitter voltage exceeds the peak- point voltage of the emitter which is a function of the supply voltage. In the relaxation oscillator circuit, the emitter voltage is the voltage across the capacitor, C and is saw-toothed.

The UJT will trigger when

Where

$$V_e > V_P \approx \eta V_1 \qquad (2.4.)$$

V_c is the voltage across the capacitor

V_p is the peak point voltage of UJT

η is the intrinsic stand off ratio of UJT

V_1 is the supply voltage.

The mode of UJT control makes the supply line synchronisation a simple matter in a.c. circuits. The voltage V_1 is derived from the unfiltered output of a zener–diode-clipped full wave rectified a.c supply line voltage.

The voltage V_1 will clip when

$$e < V_z \qquad (2.5)$$

Where,

e is the instantaneous supply voltage

V_z is the voltage across the zener diode,

2.4. RELAY DRIVING CIRCUIT

The relays are used to change the direction of current in both positive and negative direction. Push buttons PB1 and PB2 (refer fig.) are used to drive the relays.

The push buttons PB1 is used to get the deflection of current in negative direction and PB2 for positive direction of current.

The relays are energised by switching on the transistor by biasing it. When PB2 is pressed, the 12V supply is given to the base of the transistor CL100, now the transistor is biased. Now the relays 2 and 3 is energised as 30V is applied across it or the relay is said to be switched on.

The 30V supply is used to bias the other two transistors in the circuit. As the transistor gets biased it inturn energies the relay 1. Hence the deflection will be in positive direction.

When PB1 is pressed, the transistor is not biased and remains off since no supply is given to the base of the transistor the relays 2 and 3 remain non-energised. But it energies the relay 1, hence the direction of current is in the negative direction.

The relay energising coil is provided with a diode which protects the transistor when the supply is switched off suddenly.

2.5. POWER SUPPLY

Step-down transformers are used to get low voltages. A 16V supply is tapped from the secondary of the step down transformers and given to the regulators 7812 and 7912 which is used to produce a constant voltage of +12V and –12V. The constant +12V is used in the control circuit for reference voltage.

The regulatory circuit for 12V regulatory circuit is connected with capacitors to improve the performance and to eliminate transient spikes which may cause damage to the regulator circuit.

Again for energising the relay circuit, 30V supply is required, for this a 22V secondary output transformer is connected to the supply and is given to the bridge rectifier circuit which rectifies the input.

$$V_{dc} = 1.414 \times V_{AC} \qquad (2.7)$$

Which is approximately equal to 30V.

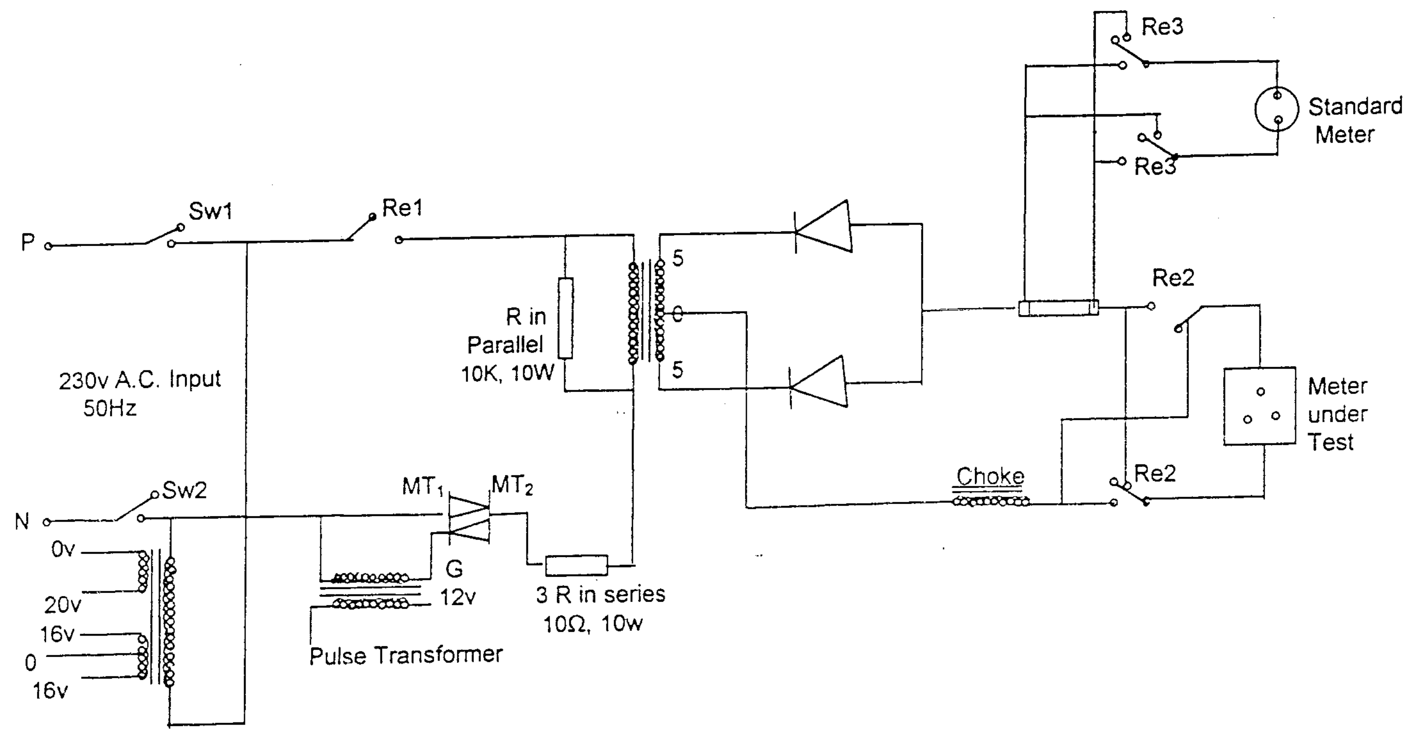

Fig.2.1 POWER CIRCUIT

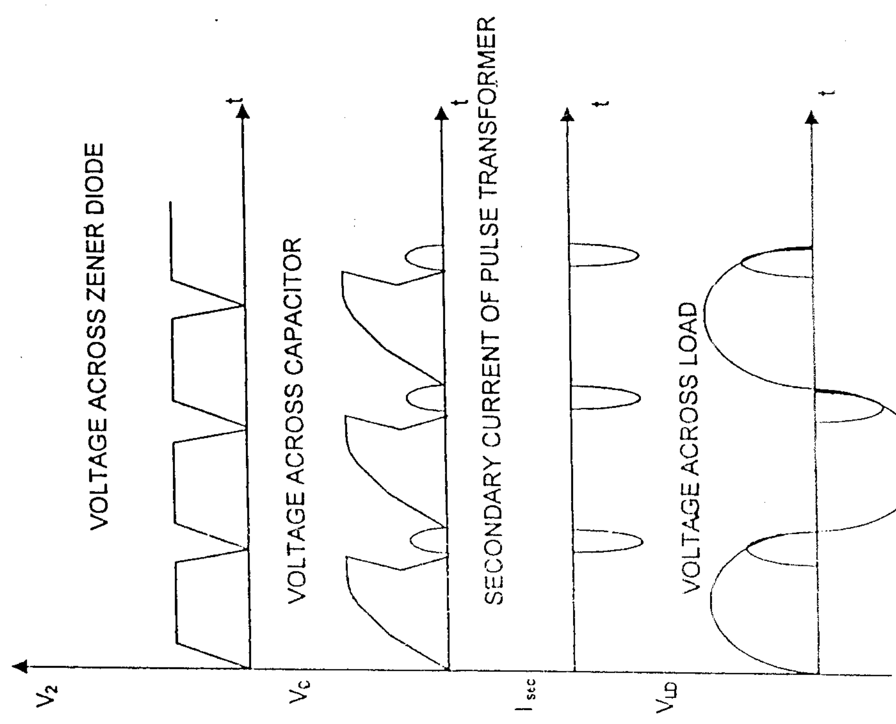

Fig.2.2 WAVEFORM AT VARIOUS POINTS

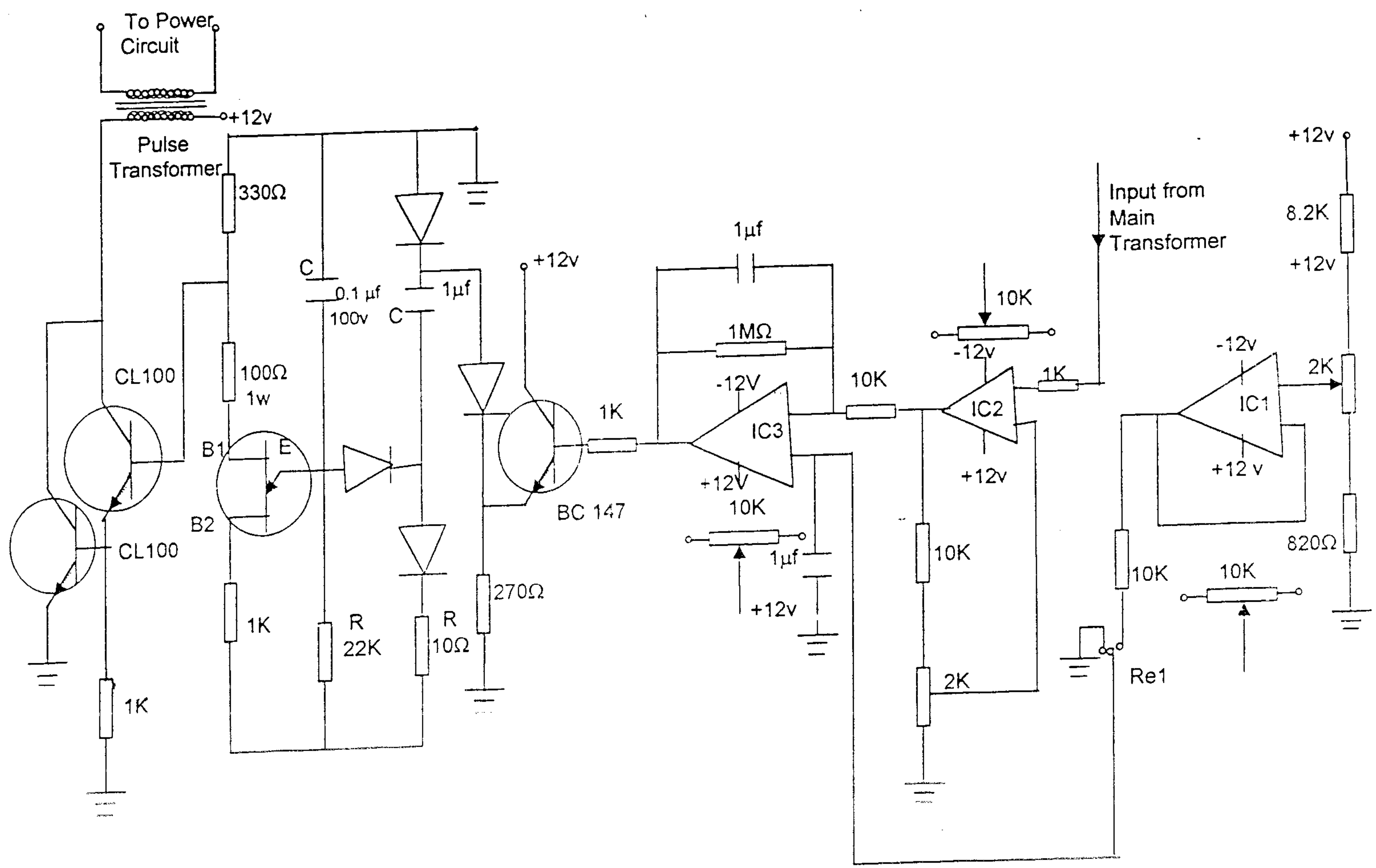

Fig.2.3 CONTROL CIRCUIT

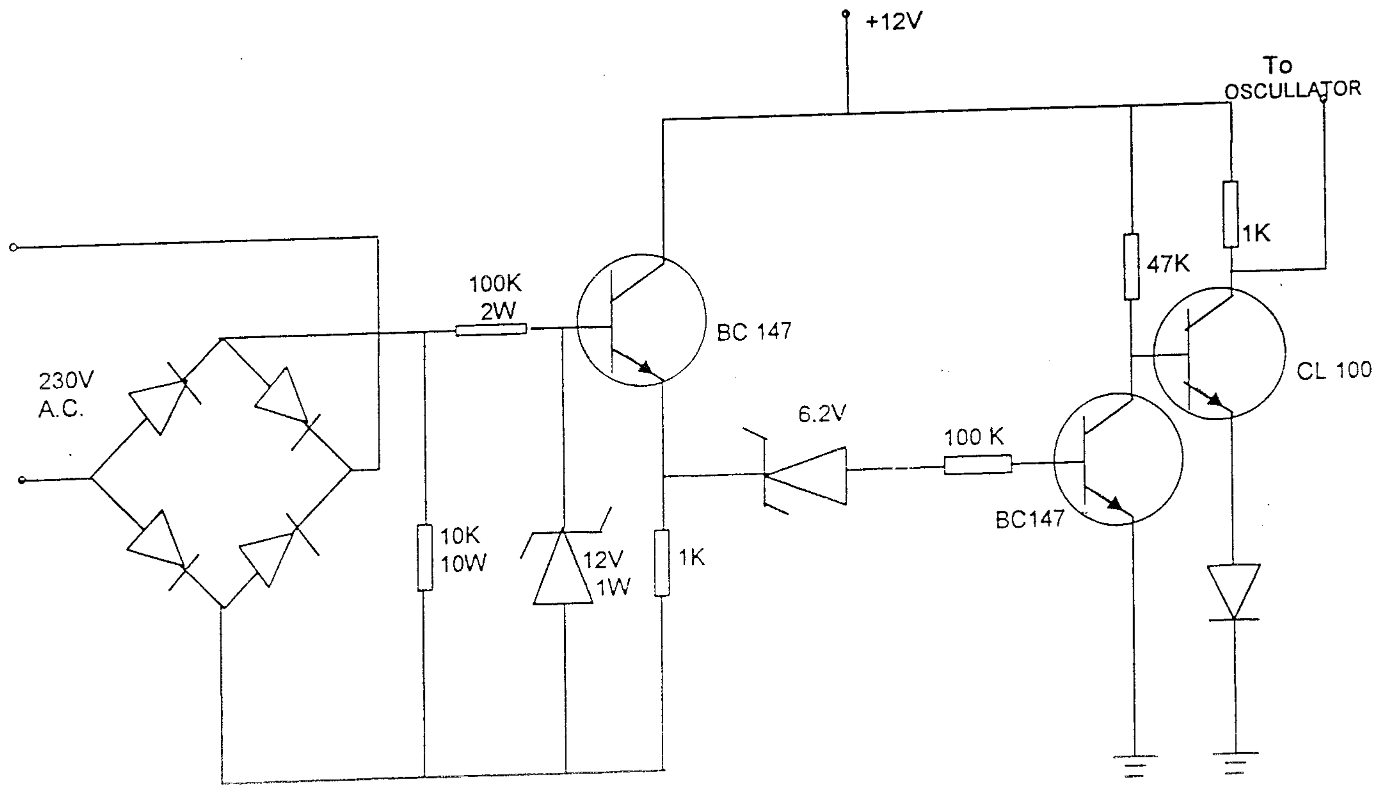

Fig 2.4 SYNCHRONISING CIRCUIT

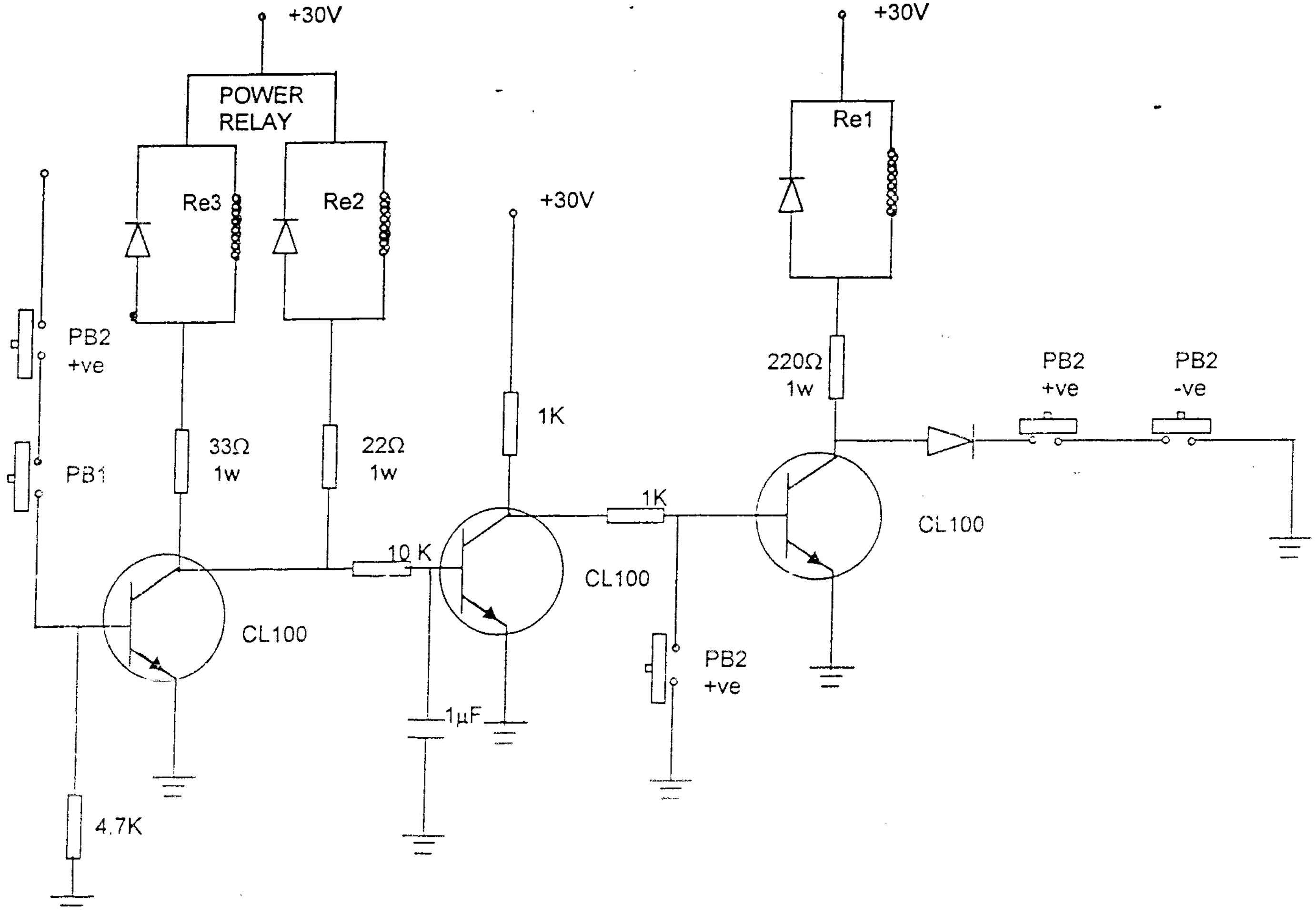

Fig. 2.5 RELAY DRIVING CIRCUIT

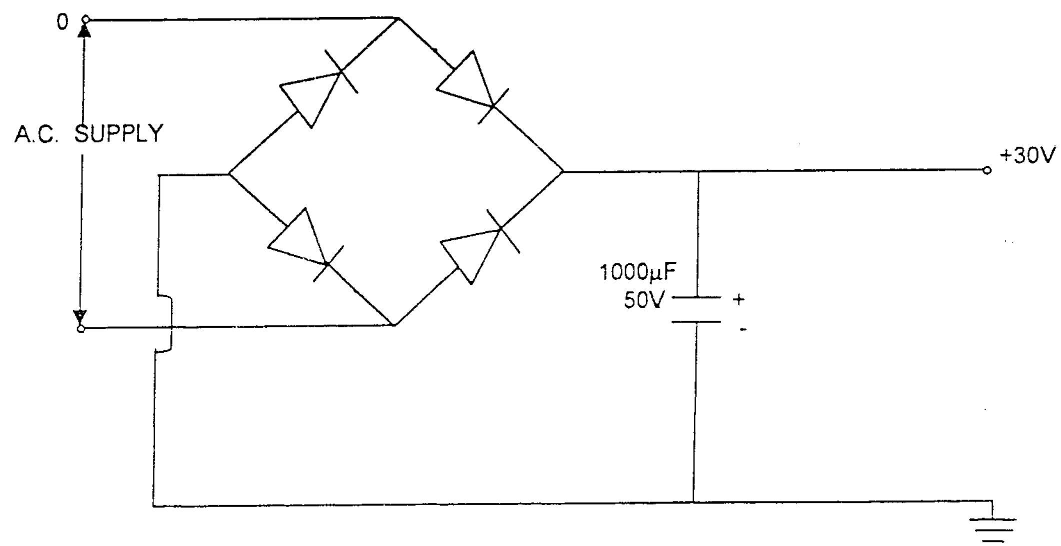

Fig 2.6 30V POWER SUPPLY

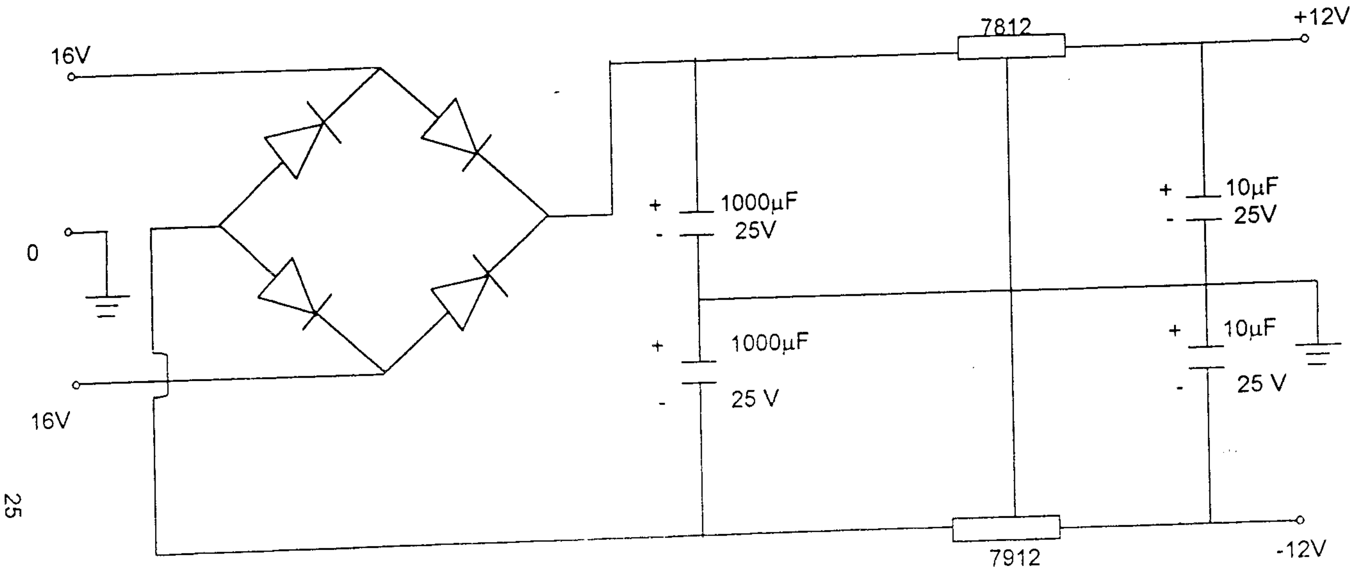

Fig 2.7 ± 12V POWER SUPPLY

CHAPTER – 3

FABRICATION AND TESTING

3.1. FRONT PANEL

The circuit shown in fig. 2.1.0 is fabricated. The power circuit, synchronising circuit and the control circuit are fabricated on a PCB. The transformer for various lower voltage requirements amounted on the calibrator box base. A fan is mounted at the side of the box to remove the heat from the arrangement. The box is about 24 inches in length, 20 inches in breadth and 20 inches in height. The front panel shown in the fig. 2.1.1.

The front panel of the D.C. ammeter calibrator consists of the following

3.1.1. ON – OFF Switch:

The supply is given to the calibrator through this switch, which switches on or off the calibrator.

3.1.2. Indication Lamp:

To indicate the availability of power in the calibrator circuit.

3.1.3. Digital panel meter:

The digital panel meter is the standard D.C. ammeter used to calibrate the meter under test. This is used as the reference meter.

3.1.4. Variable range switch:

This switch is provided to vary the current range from 0 to 50 Amps.

3.1.5. Push buttons:

Push buttons are provided to get the deflection of current in both the directions, the push buttons being connected to the relay circuit.

3.1.6. Three hold pin:

Three pin setup for inserting the meter to be tested.

3.1.7. Potentiometers:

Potentiometers are provided to set the range of current as well as to change the value of current.

3. Insert the meter to be calibrated to the terminals provided on the front panel.

4. Operate the push button "+". The current in both the standard and the meter to be tested flows in positive direction. Now any error in the newly manufactured meter can be tested, using the calibrator and required adjustment can be made in the meter such that it reads same as the standard meter.

5. The meter is now tested for negative direction. The "-" push button is operated, the current will flow in negative direction. The meter to be tested can be compared with newly manufactured meter for negative deflection of current. The necessary adjustments is made on the meter with deflection error.

6. The variable range switch allows the operator to set a particular range within which the meter can be tested.

3.2. SPECIFICATIONS AND OPERATING INSTRUCTIONS

3.2.1. SPECIFICATION:

Accuracy	:	1% of set value
Current range	:	Variable from 0 to 50Amps
Line regulation	:	1% for mains voltage variation of ± 1%
Read out	:	moving coil D.C. Ammeter ± 1%
Power supply	:	230V ± 10% 50Hz A.C. single phase
		350 Watts

3.2.2. OPERATING INSTRUCTIONS

The operating instructions to be following while calibrating the meter to be tested are

1. The instrument is provided with three pin mains cord. Make sure that the line, neutral and ground are connected properly.

2. Connect the instrument to the suitable three pin mains outlet switch the instrument "ON" by the "POWER ON" switch. If the line, neutral and ground are not connected properly the indication lamp will not glow.

3.3. TESTING AND RESULT

This model has been tested at Premier Instruments and Controls limited and worked upto the expectation.

Line Regulation	: 1% for Mains voltage of ± 10%
Accuracy	: 1% of set value.

The following results were obtained at the meter testing and calibrating department, when few newly manufactured meter were tested with this newly designed calibrator. The results are as follows

Meter under Test	POSITIVE				NEGATIVE			
	Set value			Error rectification	Set value			Error rectification
	0	25	50		0	25	50	
Meter 1	0.1	25.1	50.1	-0.1	0.1	24.9	49.9	+0.1
Meter 2	0.16	25.16	50.16	-0.16	0.16	24.84	49.84	+0.16
Meter 3	-0.12	24.88	49.88	+0.12	-0.12	25.12	50.12	-0.12

When the same meters were tested in the old rheostatic methods, following results were obtained.

Meter under Test	POSITIVE				NEGATIVE			
	Set value			Error rectification	Set value			Error rectification
	0	25	50		0	25	50	
Meter1	0.21	25.21	50.21	-0.21	0.21	24.79	49.79	+0.21
Meter 2	0.23	25.23	50.23	-0.23	0.23	24.77	49.77	+0.23
Meter 3	-0.22	24.78	49.78	+0.22	-0.22	25.22	50.22	-0.22

When same meters were tested with another accurate method with ISI standard meter, the following results were obtained.

Meter under Test	POSITIVE				NEGATIVE			
	Set value			Error rectification	Set value			Error rectification
	0	25	50		0	25	50	
Meter 1	0.1	25.1	50.1	-0.1	0.1	24.9	49.9	+0.1
Meter 2	0.15	25.15	50.15	-0.15	0.15	24.85	49.85	+0.15
Meter 3	-0.12	24.88	49.88	+0.12	-0.12	25.12	50.12	-0.12

Comparison of Rheostatic method and newly designed calibrator is as follows.

Meter under Test	Set value	Positive		Negative	
		Rheostatic Method	Newly designed calibrator	Rheostatic Method	Newly designed calibrator
1	0	-0.21	-0.1	0.21	0.1
	25	-0.21	-0.1	0.21	0.1
	50	-0.21	-0.1	0.21	0.1
2	0	-0.23	-0.16	0.23	0.16
	25	-0.23	-0.16	0.23	0.16
	50	-0.23	-0.16	0.23	0.16
3	0	-0.22	-0.12	0.22	0.12
	25	-0.22	-0.12	0.22	0.12
	50	-0.22	-0.12	0.22	0.12

3.4. COST ESTIMATION

S.No.	Components	Cost Rs. P.
1.	Main Transformer	2,000.00
2.	230 V / 230 V Isolation	1,400.00
3.	Choke	2,000.00
4.	230 V/24 V, 1 A Transformer	70.00
5.	230 V / 12V-0-12V Transformer	45.00
6.	50A, 15 mV indicating ammeter with shunt	1,100.00
7.	PCB (3 Numbers)	300.00
8.	100 A power diode (2 Numbers)	1,200.00
9.	24V 2 c/o. DEN relay (2 Numbers)	925.00
10.	24 V 3 C/O MCC relay (2 Numbers)	400.00
11.	Heat sink	900.00
12.	Electronic Components	860.00
	Total	11,200.00

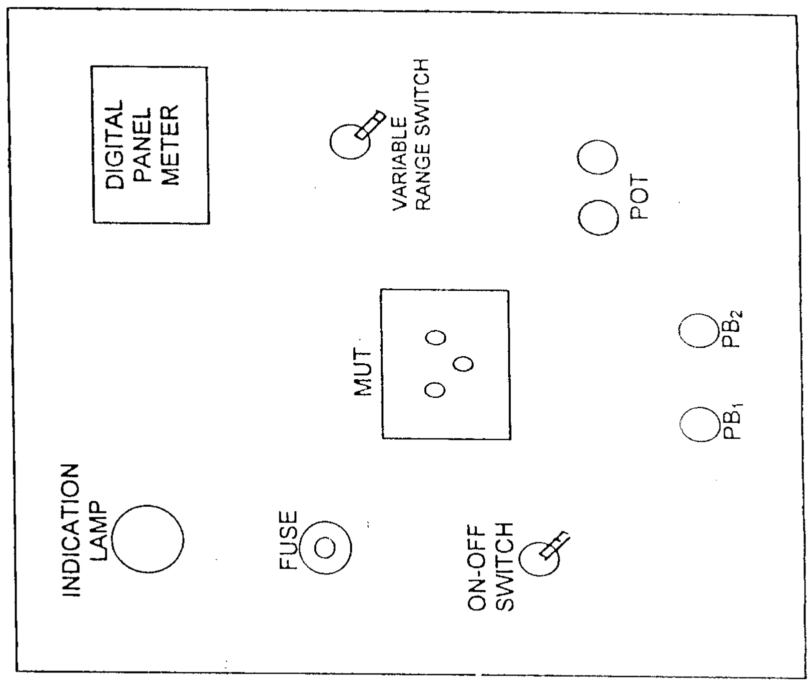

Fig.3.1 FRONT PANEL

- Initial spike of current on both standard and meter to be tested

REFERENCES

1. M.S.BERDE, "Thyristor Engineering", Mcgraw Hill Publication, New Delhi, 1989.

2. K.R.BOTKHAR, "Integrated Circuits", Mcgraw Hill Publication, New Delhi, 1987.

3. M.RAMAMOORTHY, "Thyristors and Their Applications", East West Press, New Delhi, 1977.

4. P.C. SEN, "Power Electronics", Tata McGraw Hill, New Delhi, 1988.

5. W. SHEPHERD and G.N. HULLEY, "Power Electronics and Motor Control", Cambridge University, Cambridge, 1987.

6. D.A. BRADELY, "Power Electronics", Van Nostrand, Reinhold, 1987.

7. JACOB MILLMAN and CHRISTOS C. HALKIAS, "Integrated Electronics", Tata McGraw Hill Edition, New Delhi, 1991.

8. D. ROY CHOUDHURY and SHAIL JAIN, "Linear Integrated Circuits", New Age International (P) Ltd., New Delhi, 1996.

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Low Peak Point Current — 2 μA (Max)
Low Emitter Reverse Current — 200 nA (Max)
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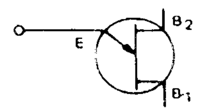
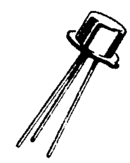
2N2647

PN UJTs





CASE 22A-01
STYLE 1

3

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Dissipation, Note 1	P_D	300	mW
RMS Emitter Current	$I_{E(RMS)}$	50	mA
Peak Pulse Emitter Current, Note 2	i_E	2	Amps
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Operating Junction Temperature Range	T_J	−65 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

'Indicates JEDEC Registered Data.

Notes: 1. Derate 3 mW/°C increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.

2. Capacitor discharge — 10 μF or less, 30 volts or less.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V), Note 1	2N2646	η	0.56	—	0.75	—
	2N2647		0.68	—	0.82	
Interbase Resistance (V_{B2B1} = 3 V, I_E = 0)		r_{BB}	4.7	7	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3 V, I_E = 0, T_A = −55°C to +125°C)		αr_{BB}	0.1	—	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA), Note 2		$V_{EB1(sat)}$	—	3.5	—	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	—	15	—	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	2N2646	I_{EB2O}	—	0.005	12	µA
	2N2647		—	0.005	0.2	
Peak Point Emitter Current (V_{B2B1} = 25 V)	2N2646	I_P	—	1	5	µA
	2N2647		—	1	2	
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms), Note 2	2N2646	I_V	4	6	—	mA
	2N2647		8	10	18	
Base-One Peak Pulse Voltage (Note 3, Figure 3)	2N2646	V_{OB1}	3	5	—	Volts
	2N2647		6	7	—	

*Indicates JEDEC Registered Data.

Notes:

1. Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_F}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
V_F = Emitter to Base-One Junction Diode Drop (≈ 0.45 V @ 10 µA)

2. Use pulse techniques: PW ≈ 300 µs, duty cycle ≤ 2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1
UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

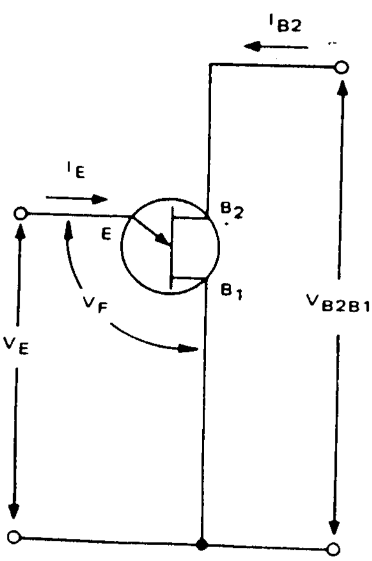


FIGURE 2
STATIC EMITTER CHARACTERISTIC CURVES
(Exaggerated to Show Details)

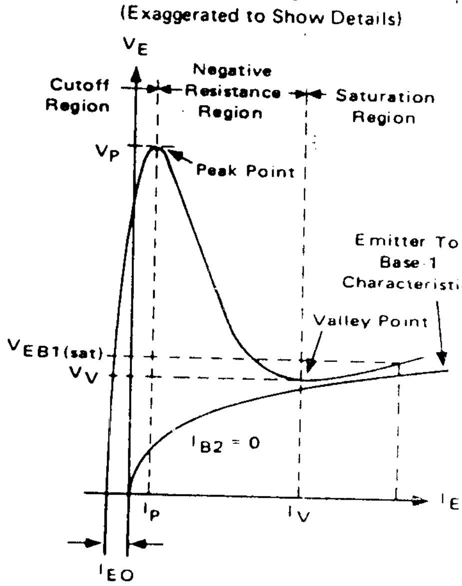
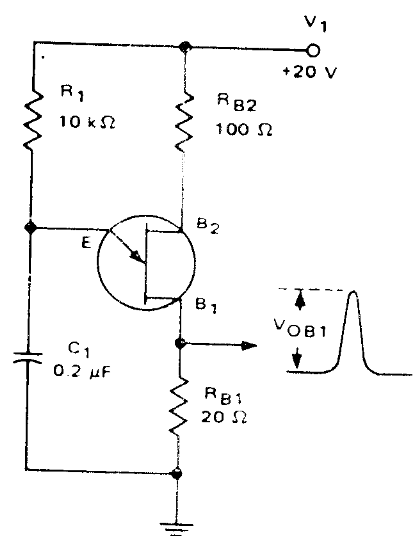


FIGURE 3 – V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)



RECTIFIER NUMBERING SYSTEM

PART NUMBER KEY XXX X XX XX XX X

- PREFIX (TYPE DESIGNATOR) — XXX
- X:
  - F = FULLY ISOLATED
  - S = SURFACE MT (SMB/SMC)
  - D = DPAK
  - B = D^2PAK
  - H = MEGAHERTZ
- XX: I_O
- XX: V_R (X10 EXCEPT SCHOTTKY)
- XX: SUFFIX (DUAL DESIGNATOR)
- X:
  - R = REVERSE
  - L = LOW V_F
  - E = ENERGY

PREFIX KEY

MUR = MOTOROLA ULTRA FAST RECTIFIER
MBR = MOTOROLA (SCHOTTKY) BARRIER RECTIFIER
MR = MOTOROLA STANDARD & FAST RECOVERY

SUFFIX KEY

CT = CENTER TAP (DUAL) TO–220, TO–3, POWERTAP
PT = CENTER TAP (DUAL) TO–218 PACKAGE
WT = CENTER TAP (DUAL) TO–247 / TO–3P

EXAMPLE:	MUR	30	20	WT
	MOTOROLA ULTRAFAST	30 AMP	200 V	CENTER TAP (DUAL) TO–247
EXAMPLE:	MBR	30	45	WT
	MOTOROLA SCHOTTKY	30 AMP	45 V	CENTER TAP (DUAL) TO–247

5

Application Specific Rectifiers

The focus for Rectifier Products continues to be on Schottky and Ultrafast technologies, with process and packaging improvements to achieve greater efficiency in high frequency switching power supplies, and high current mainframe supplies. Our new product thrust is intended to be more "application specific" than in the past, while continuing to strive for broad market acceptance.

Table 1. Low V_F Schottky Rectifiers

State of the art geometry is used in low V_F Schottky devices for improved efficiency in low voltage, high frequency switching power supplies, free–wheeling diodes, polarity protection diodes and "OR"ing diodes.

Device	I_O Amps	V_{RRM} (Volts)	V_F @ Rated I_O and Temperature Volts (Max)	I_R @ Rated V_{RRM} mAmps (Max)	Package
MBR0520L	0.5	20	0.33	0.25	SOD–123
MBRS130LT3	1	30	0.395	1	SMB
MBRB3030CTL	30	30	0.58	5	D^2PAK
MBRB2535CTL	25	35	0.41	10	D^2PAK
MBR2535CTL	25	35	0.41	5	TO–220
MBR/MBRB2515L	25	15	0.42	15	TO–220/D^2PAK
MBR6030L	60	30	0.38	50	DO–203AB
MBRP20030CTL	200	30	0.39	5	POWERTAP
MBRP60035CTL	600	35	0.50	10	POWERTAP

Table 2. MEGAHERTZ Rectifiers

MEGAHERTZ Series — This group of ultrafast rectifiers is designed to provide improved efficiency in very high frequency switching power supplies and for use in power factor correction circuits.

Device	I_O Amps	V_{RRM} (Volts)	Maximum V_F @ Rated I_O and Temp. (Volts)	Maximum I_R @ Rated V_{RRM} (mAmps)	t_{rr} (Nanosecond)
MURH840CT	8	400	1.7	0.01	28
MURH860CT	8	600	2.0	0.01	28

5

Table 3. SCANSWITCH Rectifiers

These ultrafast rectifiers are designed for improved performance in very high resolution monitors and work stations where forward recovery time (t_{fr}) and high voltage (1200–1500 volts) are primary considerations.

Device	I_O Amps	V_{RRM} (Volts)	Maximum t_{fr} (Nanoseconds)	Maximum t_{rr} (Nanoseconds)	V_{RFM} (6) (Volts)
MUR5150E	5	1500	225	175	20
MUR880E	8	800	—	75	—
MUR10120E	10	1200	175	175	14
MUR10150E	10	1500	175	175	16
MR10120E	10	1200	175	1000	14
MR10150E	10	1500	175	1000	16

Table 4. Automotive Transient Suppressors

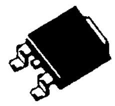
Automotive transient suppressors are designed for protection against over–voltage conditions in the auto electrical system including the "LOAD DUMP" phenomenon that occurs when the battery open circuits while the car is running.

Device	I_O Amps	V_{RRM} (Volts)	$V_{(BR)}$ (Volts)	I_{RSM}(7) (Amps)	T (°C)
MR2535L	35	20	24–32	110	175

(5)Schottky barrier device.
(6)V_{RFM} = Maximum Transient Overshoot Voltage.
(7)Time constant = 10 ms, Duty Cycle ≤ 1%, T_C = 25°C.

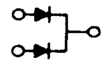
Devices listed in bold, italic are Motorola preferred devices.

Case 369A
DPAK
Style 3



Case 418B
D^2PAK
Style 3

"CT" Suffix:



Non–"CT" Suffix:

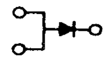


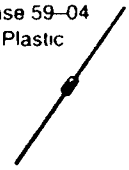
Table 5. Surface Mount Schottky Rectifiers (continued)

V_{RRM} (Volts)	I_O(1) (Amperes)	I_O Rating Condition	Device	Max V_F @ i_F T_C = 25°C (Volts)	I_{FSM} (Amperes)	T_J Max (°C)	Package
40	3	T_C = 125°C	***MBRD340***	0.60 @ 3.0 A	75	150	DPAK
60	3	T_C = 125°C	***MBRD360***	0.60 @ 3.0 A	75	150	DPAK
40	6	T_C = 130°C	***MBRD640CT***	0.70 @ 3.0 A	75	150	DPAK
60	6	T_C = 130°C	***MBRD660CT***	0.70 @ 3.0 A	75	150	DPAK
35	8	T_C = 100°C	***MBRD835L*** ★	0.40 @ 3.0 A 0.51 @ 8.0 A	100	125	DPAK
35	10	T_C = 90°C	***MBRD1035CTL*** ★	0.49 @ 10 A	100	125	DPAK
45	15	T_C = 105°C	***MBRB1545CT***	0.84 @ 15 A	150	150	D^2PAK
60	20	T_C = 110°C	***MBRB2060CT***	0.95 @ 20 A	150	150	D^2PAK
100	20	T_C = 110°C	***MBRB20100CT***	0.85 @ 10 A 0.95 @ 20 A	150	150	D^2PAK
200	20	T_C = 125°C	***MBRB20200CT*** ★	1.0 @ 20 A	150	150	D^2PAK
15	25	T_C = 90°C	***MBRB2515L*** ★	0.45 @ 25 A	150	100	D^2PAK
35	25	T_C = 110°C	***MBRB2535CTL***	0.47 @ 12.5 A 0.55 @ 25 A	150	125	D^2PAK
45	25	T_C = 130°C	***MBRB2545CT***	0.82 @ 30 A	150	150	D^2PAK
30	30	T_C = 115°C	***MBRB3030CT*** ★	0.51 @ 15 A 0.62 @ 30 A	300	150	D^2PAK
30	30	T_C = 95°C	***MBRB3030CTL*** ★	0.58 @ 30 A	150	125	D^2PAK
30	40	T_C = 110°C	***MBRB4030*** ★	0.53 @ 40 A	300	150	D^2PAK

(1) I_O is total device current capability.
★ New Product

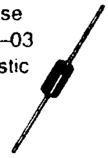
Devices listed in bold, italic are Motorola preferred devices.

Case 59–04
Plastic



Cathode = Polarity Band

Case
267–03
Plastic



Cathode = Polarity Band

Case
60–01
Metal
Style 1

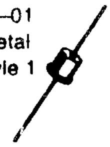


Table 6. Axial Lead Schottky Rectifiers

V_{RRM} (Volts)	I_O (Amperes)	I_O Rating Condition	Device	Max V_F @ I_F T_C = 25°C (Volts)	I_{FSM} (Amperes)	T_J Max (°C)	Case
20	1	T_A = 55°C $R_{\theta JA}$ = 80°C/W	***1N5817***	0.45 @ 1.0 A	25	125	59–04
30	1	T_A = 55°C $R_{\theta JA}$ = 80°C/W	***1N5818***	0.55 @ 1.0 A	25	125	59–04
40	1	T_A = 55°C $R_{\theta JA}$ = 80°C/W	***1N5819***	0.60 @ 1.0 A	25	125	59–04
60	1	T_A = 55°C $R_{\theta JA}$ = 80°C/W	***MBR160***	0.75 @ 1.0 A	25	150	59–04
100	1	T_A = 120°C $R_{\theta JA}$ = 50°C/W	***MBR1100***	0.79 @ 1.0 A	50	150	59–04
20	3	T_A = 76°C $R_{\theta JA}$ = 28°C/W	***1N5820***	0.457 @ 3.0 A	80	125	267–03
30	3	T_A = 71°C $R_{\theta JA}$ = 28°C/W	***1N5821***	0.500 @ 3.0 A	80	125	267–03
40	3	T_A = 61°C $R_{\theta JA}$ = 28°C/W	***1N5822***	0.525 @ 3.0 A	80	125	267–03
40	3	T_A = 65°C $R_{\theta JA}$ = 28°C/W	***MBR340***	0.600 @ 3.0 A	80	150	267–03
60	3	T_A = 65°C $R_{\theta JA}$ = 28°C/W	***MBR360***	0.740 @ 3.0 A	80	150	267–03
100	3	T_A = 100°C $R_{\theta JA}$ = 28°C/W	***MBR3100***	0.79 @ 3.0 A	150	150	267–03
20	5	T_A = 30°C $R_{\theta JA}$ = 25°C/W	***1N5823***	0.360 @ 5.0 A	500	125	60–01
30	5	T_A = 40°C $R_{\theta JA}$ = 25°C/W	***1N5824***	0.370 @ 5.0 A	500	125	60–01
40	5	T_A = 45°C $R_{\theta JA}$ = 25°C/W	***1N5825***	0.380 @ 5.0 A	500	125	60–01

Devices listed in bold, italic are Motorola preferred devices.

absolute maximum ratings over operating temperature ranges (unless otherwise noted)†

Input voltage, V_I: µA7824C	40 V
All others	35 V
Continuous total power dissipation at (or below) 25°C free-air temperature (see Note 1)	2 W
Continuous total power dissipation at (or below) 90°C case temperature (see Note 1)	15 W
Operating free-air, T_A, case, T_C, or virtual junction, T_J, temperature range	−40 to 150°C
Storage temperature range, T_{stg}	−65 to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: For operation above 25°C free-air or 90°C case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

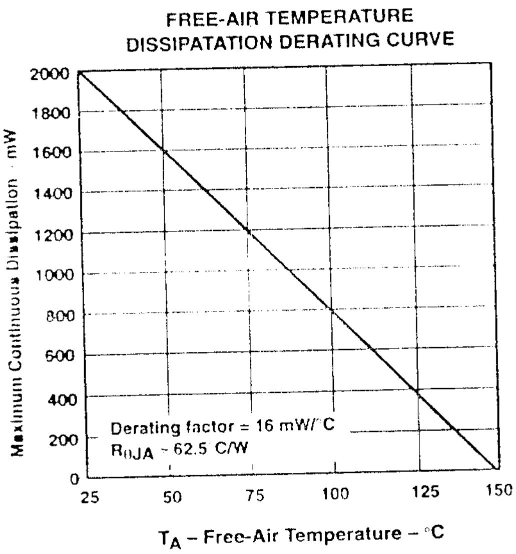


Figure 1

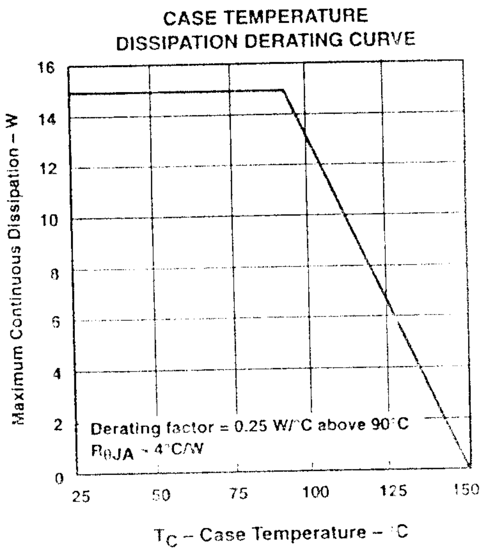
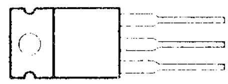


Figure 2

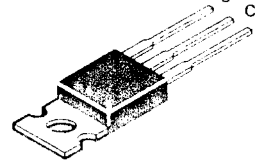
- 3-Terminal Regulators
- Output Current Up to 1.5 A
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct Replacements for Fairchild μA7800 Series

KC PACKAGE
(TOP VIEW)



The common terminal is in electrical contact with the mounting base.

TO-220AB



description

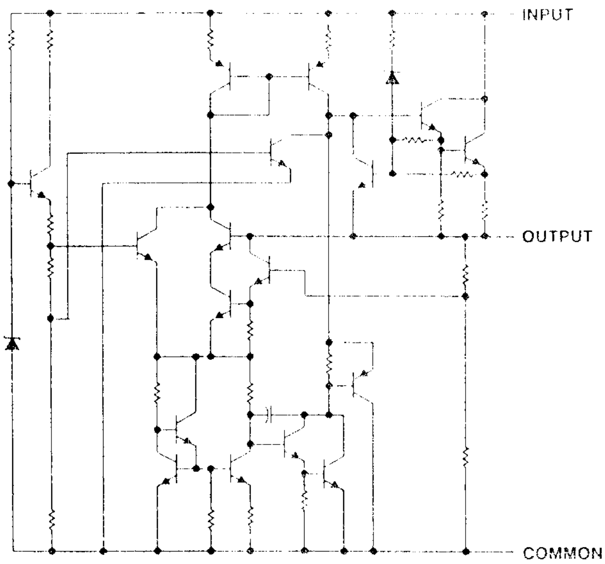
This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also used as the power-pass element in precision regulators.

The μA7800C series is characterized for operation over the virtual junction temperature range of 0°C to 125°C. The μA7805Q and μA7812Q are characterized for operation over the virtual junction temperature range of −40°C to 125°C.

AVAILABLE OPTIONS

T_J	$V_{O(nom)}$ (V)	PACKAGED DEVICES PLASTIC FLANGE-MOUNT (KC)	CHIP FORM (Y)
0°C to 125°C	5	μA7805CKC	μA7805Y
	6	μA7806CKC	μA7806Y
	8	μA7808CKC	μA7808Y
	8.5	μA7885CKC	μA7885Y
	10	μA7810CKC	μA7810Y
	12	μA7812CKC	μA7812Y
	15	μA7815CKC	μA7815Y
	18	μA7818CKC	μA7818Y
	24	μA7824CKC	μA7824Y
−40°C to 125°C	5	μA7805QKC	—
	12	μA7812QKC	—

schematic



recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	µA7805C	7	25	V
	µA7806C	8	25	
	µA7808C	10.5	25	
	µA7885C	10.5	25	
	µA7810C	12.5	28	
	µA7812C	14.5	30	
	µA7815C	17.5	30	
	µA7818C	21	33	
	µA7824C	27	38	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J	µA7800C Series	0	125	°C
	µA7805Q, µA7812Q	–40	125	

electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA7805C, µA7805Q MIN	TYP	MAX	UNIT
Output voltage‡	I_O = 5 mA to 1 A, V_I = 7 V to 20 V, P ≤ 15 W	25°C	4.8	5	5.2	V
		Full range§	4.75		5.25	
Input voltage regulation	V_I = 7 V to 25 V	25°C		3	100	mV
	V_I = 8 V to 12 V			1	50	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	Full range§	62	78		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Output resistance	f = 1 kHz	Full range§		0.017		Ω
Temperature coefficient of output voltage	I_O = 5 mA	Full range§		–1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		40		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.2	8	mA
Bias current change	V_I = 7 V to 25 V	Full range§			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.
§ Full range virtual junction temperature is 0°C to 125°C for the µA7805C and –40°C to 125°C for the µA7805Q.

electrical characteristics at specified virtual junction temperature, V_I = 11 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	μA7806C MIN	μA7806C TYP	μA7806C MAX	UNIT
Output voltage‡		25°C	5.75	6	6.25	V
	I_O = 5 mA to 1 A, V_I = 8 V to 21 V, P ≤ 15 W	0°C to 125°C	5.7		6.3	
Input voltage regulation	V_I = 8 V to 25 V	25°C		5	120	mV
	V_I = 9 V to 13 V			1.5	60	
Ripple rejection	V_I = 9 V to 19 V, f = 120 Hz	0°C to 125°C	59	75		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		14	120	mV
	I_O = 250 mA to 750 mA			4	60	
Output resistance	f = 1 kHz	0°C to 125°C		0.019		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		45		μV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 8 V to 25 V	0°C to 125°C			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		550		mA
Peak output current		25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 14 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	μA7808C MIN	μA7808C TYP	μA7808C MAX	UNIT
Output voltage‡		25°C	7.7	8	8.3	V
	I_O = 5 mA to 1 A, V_I = 10.5 V to 23 V, P ≤ 15 W	0°C to 125°C	7.6		8.4	
Input voltage regulation	V_I = 10.5 V to 25 V	25°C		6	160	mV
	V_I = 11 V to 17 V			2	80	
Ripple rejection	V_I = 11.5 V to 21.5 V, f = 120 Hz	0°C to 125°C	55	72		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		12	160	mV
	I_O = 250 mA to 750 A			4	80	
Output resistance	f = 1 kHz	0°C to 125°C		0.016		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		52		μV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 10.5 V to 25 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		450		mA
Peak output current		25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 15 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS		T_J†	μA7885C MIN	μA7885C TYP	μA7885C MAX	UNIT
Output voltage‡			25°C	8.15	8.5	8.85	V
	I_O = 5 mA to 1 A, P ≤ 15 W	V_I = 11 V to 23.5 V,	0°C to 125°C	8.1		8.9	
Input voltage regulation	V_I = 10.5 V to 25 V		25°C		6	170	mV
	V_I = 11 V to 17 V				2	85	
Ripple rejection	V_I = 11.5 V to 21.5 V,	f = 120 Hz	0°C to 125°C	54	70		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		25°C		12	170	mV
	I_O = 250 mA to 750 mA				4	85	
Output resistance	f = 1 kHz		0°C to 125°C		0.016		Ω
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		55		μV
Dropout voltage	I_O = 1 A		25°C		2		V
Bias current			25°C		4.3	8	mA
Bias current change	V_I = 10.5 V to 25 V		0°C to 125°C			1	mA
	I_O = 5 mA to 1 A					0.5	
Short-circuit output current			25°C		450		mA
Peak output current			25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 17 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS		T_J†	μA7810C MIN	μA7810C TYP	μA7810C MAX	UNIT
Output voltage‡			25°C	9.6	10	10.4	V
	I_O = 5 mA to 1 A, P ≤ 15 W	V_I = 12.5 V to 25 V,	0°C to 125°C	9.5	10	10.5	
Input voltage regulation	V_I = 12.5 V to 28 V		25°C		7	200	mV
	V_I = 14 V to 20 V				2	100	
Ripple rejection	V_I = 13 V to 23 V,	f = 120 Hz	0°C to 125°C	55	71		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		25°C		12	200	mV
	I_O = 250 mA to 750 mA				4	100	
Output resistance	f = 1 kHz		0°C to 125°C		0.018		Ω
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		70		μV
Dropout voltage	I_O = 1 A		25°C		2		V
Bias current			25°C		4.3	8	mA
Bias current change	V_I = 12.5 V to 28 V		0°C to 125°C			1	mA
	I_O = 5 mA to 1 A					0.5	
Short-circuit output current			25°C		400		mA
Peak output current			25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA7812C MIN	µA7812C TYP	µA7812C MAX	UNIT
Output voltage‡	I_O = 5 mA to 1 A, V_I = 14.5 V to 27 V, P ≤ 15 W	25°C	11.5	12	12.5	V
		Full range§	11.4		12.6	
Input voltage regulation	V_I = 14.5 V to 30 V	25°C		10	240	mV
	V_I = 16 V to 22 V			3	120	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	Full range§	55	71		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		12	240	mV
	I_O = 250 mA to 750 mA			4	120	
Output resistance	f = 1 kHz	Full range§		0.018		Ω
Temperature coefficient of output voltage	I_O = 5 mA	Full range§		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		75		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 14.5 V to 30 V	Full range§			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		350		mA
Peak output current		25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.
§ Full range virtual junction temperature is 0°C to 125°C for the µA7812C and −40°C to 125°C for the µA7812Q.

electrical characteristics at specified virtual junction temperature, V_I = 23 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA7815C MIN	µA7815C TYP	µA7815C MAX	UNIT
Output voltage‡	I_O = 5 mA to 1 A, V_I = 17.5 V to 30 V, P ≤ 15 W	25°C	14.4	15	15.6	V
		0°C to 125°C	14.25		15.75	
Input voltage regulation	V_I = 17.5 V to 30 V	25°C		11	300	mV
	V_I = 20 V to 26 V			3	150	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	0°C to 125°C	54	70		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		12	300	mV
	I_O = 250 mA to 750 mA			4	150	
Output resistance	f = 1 kHz	0°C to 125°C		0.019		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		90		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.4	8	mA
Bias current change	V_I = 17.5 V to 30 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		230		mA
Peak output current		25°C		2.1		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 27 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA7818C MIN	µA7818C TYP	µA7818C MAX	UNIT
Output voltage‡		25°C	17.3	18	18.7	V
	I_O = 5 mA to 1 A, V_I = 21 V to 33 V, P ≤ 15 W	0°C to 125°C	17.1		18.9	
Input voltage regulation	V_I = 21 V to 33 V	25°C		15	360	mV
	V_I = 24 V to 30 V			5	180	
Ripple rejection	V_I = 22 V to 32 V, f = 120 Hz	0°C to 125°C	53	69		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		12	360	mV
	I_O = 250 mA to 750 mA			4	180	
Output resistance	f = 1 kHz	0°C to 125°C		0.022		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		110		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.5	8	mA
Bias current change	V_I = 21 V to 33 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		200		mA
Peak output current		25°C		2.1		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 33 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA7824C MIN	µA7824C TYP	µA7824C MAX	UNIT
Output voltage‡		25°C	23	24	25	V
	I_O = 5 mA to 1 A, V_I = 27 V to 38 V, P ≤ 15 W	0°C to 125°C	22.8		25.2	
Input voltage regulation	V_I = 27 V to 38 V	25°C		18	480	mV
	V_I = 30 V to 36 V			6	240	
Ripple rejection	V_I = 28 V to 38 V, f = 120 Hz	0°C to 125°C	50	66		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		12	480	mV
	I_O = 250 mA to 750 mA			4	240	
Output resistance	f = 1 kHz	0°C to 125°C		0.028		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.5		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		170		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.6	8	mA
Bias current change	V_I = 27 V to 38 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		150		mA
Peak output current		25°C		2.1		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, $V_I = 10$ V, $I_O = 500$ mA, $T_J = 25$ °C† (unless otherwise noted)

PARAMETER	TEST CONDITIONS		μA7805Y MIN	TYP	MAX	UNIT
Output voltage‡				5		V
Input voltage regulation	V_I = 7 V to 25 V			3		mV
	V_I = 8 V to 12 V			1		
Ripple rejection	V_I = 8 V to 18 V,	f = 120 Hz		78		dB
Output voltage regulation	I_O = 5 mA to 1.5 A			15		mV
	I_O = 250 mA to 750 mA			5		
Output resistance	f = 1 kHz			0.017		Ω
Temperature coefficient of output voltage	I_O = 5 mA			–1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz			40		μV
Dropout voltage	I_O = 1 A			2		V
Bias current				4.2		mA
Short-circuit output current				750		mA
Peak output current				2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, $V_I = 11$ V, $I_O = 500$ mA, $T_J = 25$°C† (unless otherwise noted)

PARAMETER	TEST CONDITIONS		μA7806Y MIN	TYP	MAX	UNIT
Output voltage‡				6		V
Input voltage regulation	V_I = 8 V to 25 V			5		mV
	V_I = 9 V to 13 V			1.5		
Ripple rejection	V_I = 9 V to 19 V,	f = 120 Hz		75		dB
Output voltage regulation	I_O = 5 mA to 1.5 A			14		mV
	I_O = 250 mA to 750 mA			4		
Output resistance	f = 1 kHz			0.019		Ω
Temperature coefficient of output voltage	I_O = 5 mA			–0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz			45		μV
Dropout voltage	I_O = 1 A			2		V
Bias current				4.3		mA
Short-circuit output current				550		mA
Peak output current				2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, $V_I = 14\ V$, $I_O = 500\ mA$, $T_J = 25°C$† (unless otherwise noted)

PARAMETER	TEST CONDITIONS	µA7808Y MIN	TYP	MAX	UNIT
Output voltage‡			8		V
Input voltage regulation	V_I = 10.5 V to 25 V		6		mV
	V_I = 11 V to 17 V		2		
Ripple rejection	V_I = 11.5 V to 21.5 V, f = 120 Hz		72		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		12		mV
	I_O = 250 mA to 750 A		4		
Output resistance	f = 1 kHz		0.016		Ω
Temperature coefficient of output voltage	I_O = 5 mA		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		52		µV
Dropout voltage	I_O = 1 A		2		V
Bias current			4.3		mA
Short-circuit output current			450		mA
Peak output current			2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, $V_I = 15\ V$, $I_O = 500\ mA$, $T_J = 25°C$† (unless otherwise noted)

PARAMETER	TEST CONDITIONS	µA7885Y MIN	TYP	MAX	UNIT
Output voltage‡			8.5		V
Input voltage regulation	V_I = 10.5 V to 25 V		6		mV
	V_I = 11 V to 17 V		2		
Ripple rejection	V_I = 11.5 V to 21.5 V, f = 120 Hz		70		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		12		mV
	I_O = 250 mA to 750 mA		4		
Output resistance	f = 1 kHz		0.016		Ω
Temperature coefficient of output voltage	I_O = 5 mA		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		55		µV
Dropout voltage	I_O = 1 A		2		V
Bias current			4.3		mA
Short-circuit output current			450		mA
Peak output current			2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

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electrical characteristics at specified virtual junction temperature, V_I = 17 V, I_O = 500 mA, T_J = 25°C† (unless otherwise noted)

PARAMETER	TEST CONDITIONS	µA7810Y MIN	µA7810Y TYP	µA7810Y MAX	UNIT
Output voltage‡			10		V
Input voltage regulation	V_I = 12.5 V to 28 V		7		mV
	V_I = 14 V to 20 V		2		mV
Ripple rejection	V_I = 13 V to 23 V, f = 120 Hz		71		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		12		mV
	I_O = 250 mA to 750 mA		4		mV
Output resistance	f = 1 kHz		0.018		Ω
Temperature coefficient of output voltage	I_O = 5 mA		–1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		70		µV
Dropout voltage	I_O = 1 A		2		V
Bias current			4.3		mA
Short-circuit output current			400		mA
Peak output current			2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 500 mA, T_J = 25°C† (unless otherwise noted)

PARAMETER	TEST CONDITIONS	µA7812Y MIN	µA7812Y TYP	µA7812Y MAX	UNIT
Output voltage‡			12		V
Input voltage regulation	V_I = 14.5 V to 30 V		10		mV
	V_I = 16 V to 22 V		3		mV
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz		71		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		12		mV
	I_O = 250 mA to 750 mA		4		mV
Output resistance	f = 1 kHz		0.018		Ω
Temperature coefficient of output voltage	I_O = 5 mA		–1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		75		µV
Dropout voltage	I_O = 1 A		2		V
Bias current			4.3		mA
Short-circuit output current			350		mA
Peak output current			2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

electrical characteristics at specified virtual junction temperature, $V_I = 33$ V, $I_O = 500$ mA, $T_J = 25°C$† (unless otherwise noted)

PARAMETER	TEST CONDITIONS	μA7824Y MIN	μA7824Y TYP	μA7824Y MAX	UNIT
Output voltage‡			24		V
Input voltage regulation	V_I = 27 V to 38 V		18		mV
	V_I = 30 V to 36 V		6		
Ripple rejection	V_I = 28 V to 38 V, f = 120 Hz		66		dB
Output voltage regulation	I_O = 5 mA to 1.5 A		12		mV
	I_O = 250 mA to 750 mA		4		
Output resistance	f = 1 kHz		0.028		Ω
Temperature coefficient of output voltage	I_O = 5 mA		–1.5		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		170		μV
Dropout voltage	I_O = 1 A		2		V
Bias current			4.6		mA
Short-circuit output current			150		mA
Peak output current			2.1		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.
‡ This specification applies only for dc power dissipation permitted by absolute maximum ratings.

APPLICATION INFORMATION

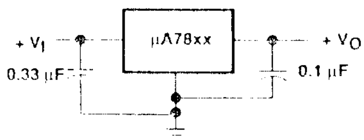


Figure 3. Fixed Output Regulator

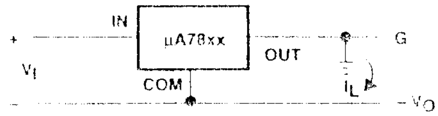
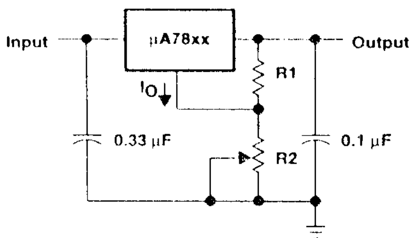


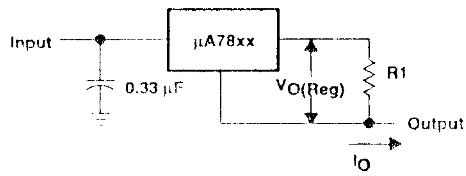
Figure 4. Positive Regulator in Negative Configuration (V_I Must Float)



NOTE A. The following formula is used when Vxx is the nominal output voltage (output to common) of the fixed regulator.

$$V_O = V_{xx} + \left(\frac{V_{xx}}{R1} + I_Q\right) R2$$

Figure 5. Adjustable Output Regulator



$I_O = (V_O/R1) + I_O$ Bias Current

Figure 6. Current Regulator

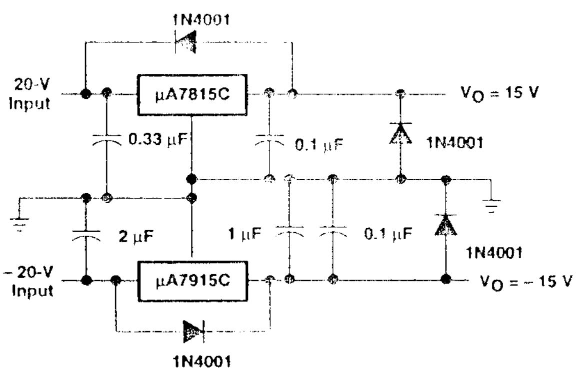
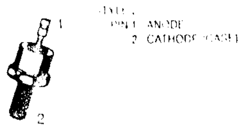
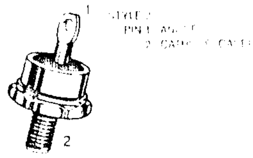


Figure 7. Regulated Dual Supply

Case 56
(DO-203AA)



Case 257
(DO-203AB)



Case 11-03
(TO-204AA)

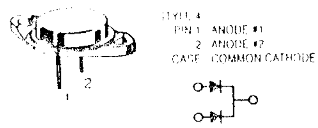


Table 9. TO-204AA (formerly TO-3), DO-203AA and DO-203AB (formerly DO-4 and DO-5) Schottky Rectifier Metal Packages

V_{RRM} (Volts)	I_O (Amperes)	I_O Rating Condition	Device	Max V_F @ i_F T_C = 25°C (Volts)	I_{FSM} (Amperes)	T_J Max (°C)	Case
20	15	T_C = 85°C (V_R = 4 V)	***1N5826***	0.44 @ 15 A	500	125	56
30	15	T_C = 85°C (V_R = 6 V)	***1N5827***	0.47 @ 15 A	500	125	56
40	15	T_C = 85°C (V_R = 8 V)	***1N5828***	0.50 @ 15 A	500	125	56
20	25	T_C = 85°C (V_R = 4 V)	***1N5829***	0.44 @ 25 A	800	125	56
30	25	T_C = 85°C (V_R = 6 V)	***1N5830***	0.46 @ 25 A	800	125	56
40	25	T_C = 85°C (V_R = 8 V)	***1N5831***	0.48 @ 25 A	800	125	56
30	25	T_C = 70°C	***1N6095***	0.86 @ 78.5 A T_C = 70°C	400	125	56
40	25	T_C = 70°C	***1N6096***	0.86 @ 78.5 A T_C = 70°C	400	125	56
45	30	T_C = 105°C	*SD41*	0.55 @ 78.5 A T_C = 125°C	600	150	56
45	35	T_C = 110°C	***MBR3545***	0.63 @ 35 A	600	150	56
20	40	T_C = 75°C (V_R = 4 V)	***1N5832***	0.052 @ 40 A	800	125	257
30	40	T_C = 75°C (V_R = 6 V)	***1N5833***	0.55 @ 40 A	800	125	257
40	40	T_C = 75°C (V_R = 8 V)	***1N5834***	0.59 @ 40 A	800	125	257
30	50	T_C = 70°C	***1N6097***	0.86 @ 157 A T_C = 70°C	800	125	257
40	50	T_C = 70°C	***1N6098***	0.86 @ 157 A T_C = 70°C	800	125	257
30	60	T_C = 120°C	***MBR6030L***	0.42 @ 30 A 0.48 @ 60 A	1000	150	257
45	60	T_C = 90°C	*SD51*	0.70 @ 60 A	800	150	257
45	60	T_C = 100°C	***MBR6045***	0.70 @ 60 A	800	150	257
45	65	T_C = 120°C	***MBR6545***	0.78 @ 65 A	800	175	257
45	75	T_C = 90°C	***MBR7545***	0.60 @ 60 A T_C = 125°C	1000	150	257
45	80	T_C = 120°C	***MBR8045***	0.72 @ 80 A	1000	175	257
45	30	T_C = 105°C	***MBR3045CT***	0.76 @ 30 A	400	150	11-03
45	30	T_C = 105°C	*SD241*	0.60 @ 20 A T_C = 125°C	400	150	11-03

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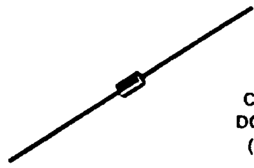
Devices listed in bold, italic are Motorola preferred devices.

Zener Diodes
Voltage Regulator Diodes (continued)

Table 13. Axial Leaded for Through–hole Designs – 500 mW (continued)

Nominal Zener Breakdown Voltage	500 mW Cathode = Polarity Band	500 mW Low Level Cathode = Polarity Band	500 mW Cathode = Polarity Band					500 mW Low Level Cathode = Polarity Band	500 mW Cathode = Polarity Band	
(*Note 1)	(*Note 2)	(*Note 3)	(*Note 4)	(*Note 5)	(*Note 6)	(*Note 7)	(*Note 8)	(*Note 9)	(*Note 10)	(*Note 8)
Volts	 Glass Case 299 DO–204AH (DO–35)									
19		1N4706	1N5249B							
20	1N968B	1N4707	***1N5250B***	1N6007B	BZX55C20RL	BZX79C20RL	BZX83C20RL			ZPD20RL
22	1N969B	1N4708	1N5251B	1N6008B	BZX55C22RL	BZX79C22RL	BZX83C22RL			ZPD22RL
24	1N970B	1N4709	1N5252B	1N6009B	BZX55C24RL	BZX79C24RL	BZX83C24RL			ZPD24RL
25		1N4710	1N5253B							
27	1N971B	1N4711	1N5254B	1N6010B	BZX55C27RL	BZX79C27RL	BZX83C27RL			ZPD27RL
28		1N4712	1N5255B							
30	1N972B	1N4713	1N5256B	1N6011B	BZX55C30RL	BZX79C30RL	BZX83C30RL			ZPD30RL
33	1N973B	1N4714	1N5257B	1N6012B	BZX55C33RL	BZX79C33RL	BZX83C33RL			ZPD33RL
36	1N974B	1N4715	1N5258B	1N6013B	BZX55C36RL	BZX79C36RL				
39	1N975B	1N4716	1N5259B	1N6014B	BZX55C39RL	BZX79C39RL				
43	1N976B	1N4717	1N5260B	1N6015B	BZX55C43RL	BZX79C43RL				
47	1N977B		1N5261B	1N6016B	BZX55C47RL	BZX79C47RL				
51	1N978B		1N5262B	1N6017B	BZX55C51RL	BZX79C51RL				
56	1N979B		1N5263B	1N6018B	BZX55C56RL	BZX79C56RL				
60			1N5264B							
62	1N980B		1N5265B	1N6019B	BZX55C62RL	BZX79C62RL				
68	1N981B		1N5266B	1N6020B	BZX55C68RL	BZX79C68RL				
75	1N982B		1N5267B	1N6021B	BZX55C75RL	BZX79C75RL				
82	1N983B		1N5268B	1N6022B	BZX55C82RL	BZX79C82RL				
87			1N5269B							
91	1N984B		1N5270B	1N6023B	BZX55C91RL	BZX79C91RL				
100	1N985B		1N5271B	1N6024B		BZX79C100RL				
110	1N986B		1N5272B	1N6025B		BZX79C110RL				
120	1N987B		1N5273B			BZX79C120RL				
130	1N988B		1N5274B			BZX79C130RL				
140			1N5275B							
150	1N989B		1N5276B			BZX79C150RL				
160	1N990B		1N5277B			BZX79C160RL				
170			1N5278B							
180	1N991B		1N5279B			BZX79C180RL				
190			1N5280B							
200	1N992B		1N5281B			BZX79C200RL				
220										
240										
270										
300										
330										
360										
400										

*See Notes on page 5.2–20.

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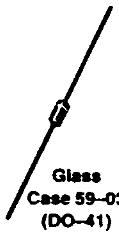
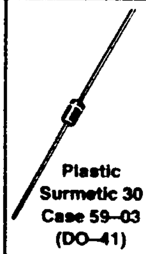
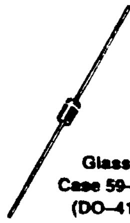
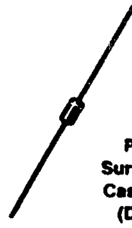
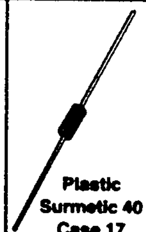
Devices listed in bold, italic are Motorola preferred devices.

Zener Diodes
Voltage Regulator Diodes (continued)

Table 14. Axial Leaded for Through–hole Designs – 1, 1.3, 1.5, 3 and 5 Watt

Nominal Zener Breakdown Voltage	1 Watt Cathode = Polarity Band		1.3 Watt Cathode = Polarity Band			1.5 Watt Cathode = Polarity Band	3 Watt Cathode = Polarity Band	5 Watt Cathode = Polarity Band
(*Note 1)	(*Note 11)	(*Note 12)	(*Note 13)	(*Note 14)	(*Note 15)	(*Note 16)	(*Note 17)	(*Note 18)
Volts	 Glass Case 59–03 (DO–41)	 Plastic Surmetic 30 Case 59–03 (DO–41)	 Glass Case 59–03 (DO–41)			 Plastic Surmetic 30 Case 59–03 (DO–41)		 Plastic Surmetic 40 Case 17
3.3	1N4728A	MZP4728A	BZX85C3V3RL			1N5913B		1N5333B
3.6	1N4729A	MZP4729A	***BZX85C3V6RL***			1N5914B		1N5334B
3.9	1N4730A	MZP4730A	BZX85C3V9RL	MZPY3.9RL	MZD3.9RL	1N5915B	3EZ3.9D5	1N5335B
4.3	1N4731A	MZP4731A	BZX85C4V3RL	MZPY4.3RL	MZD4.3RL	1N5916B	***3EZ4.3D5***	1N5336B
4.7	1N4732A	MZP4732A	BZX85C4V7RL	MZPY4.7RL	MZD4.7RL	1N5917B	3EZ4.7D5	1N5337B
5.1	***1N4733A***	MZP4733A	BZX85C5V1RL	MZPY5.1RL	MZD5.1RL	***1N5918B***	3EZ5.1D5	1N5338B
5.6	***1N4734A***	MZP4734A	BZX85C5V6RL	MZPY5.6RL	MZD5.6RL	1N5919B	3EZ5.6D5	1N5339B
6.0								1N5340B
6.2	***1N4735A***	MZP4735A	BZX85C6V2RL	MZPY6.2RL	MZD6.2RL	***1N5920B***	3EZ6.2D5	1N5341B
6.8	***1N4736A***	MZP4736A	BZX85C6V8RL	MZPY6.8RL	MZD6.8RL	1N5921B	3EZ6.8D5	1N5342B
7.5	1N4737A	MZP4737A	BZX85C7V5RL	MZPY7.5RL	MZD7.5RL	1N5922B	3EZ7.5D5	1N5343B
8.2	***1N4738A***	MZP4738A	BZX85C8V2RL	MZPY8.2RL	MZD8.2RL	1N5923B	3EZ8.2D5	1N5344B
8.7								1N5345B
9.1	1N4739A	MZP4739A	BZX85C9V1RL	MZPY9.1RL	MZD9.1RL	1N5924B	3EZ9.1D5	1N5346B
10	***1N4740A***	MZP4740A	BZX85C10RL	MZPY10RL	MZD10RL	1N5925B	3EZ10D5	1N5347B
11	***1N4741A***	MZP4741A	BZX85C11RL	MZPY11RL	MZD11RL	1N5926B	3EZ11D5	1N5348B
12	***1N4742A***	MZP4742A	BZX85C12RL	MZPY12RL	MZD12RL	1N5927B	3EZ12D5	1N5349B
13	1N4743A	MZP4743A	BZX85C13RL	MZPY13RL	MZD13RL	1N5928B	3EZ13D5	1N5350B
14							3EZ14D5	1N5351B
15	***1N4744A***	MZP4744A	BZX85C15RL	MZPY15RL	MZD15RL	***1N5929B***	3EZ15D5	1N5352B
16	***1N4745A***	MZP4745A	BZX85C16RL	MZPY16RL	MZD16RL	1N5930B	3EZ16D5	1N5353B
17							3EZ17D5	1N5354B
18	***1N4746A***	***MZP4746A***	BZX85C18RL	MZPY18RL	***MZD18RL***	1N5931B	3EZ18D5	1N5355B
19							3EZ19D5	1N5356B
20	***1N4747A***	MZP4747A	BZX85C20RL	MZPY20RL	MZD20RL	1N5932B	3EZ20D5	1N5357B
22	***1N4748A***	MZP4748A	***BZX85C22RL***	MZPY22RL	MZD22RL	1N5933B	3EZ22D5	1N5358B
24	***1N4749A***	***MZP4749A***	***BZX85C24RL***	MZPY24RL	MZD24RL	1N5934B	3EZ24D5	1N5359B
25								1N5360B
27	***1N4750A***	MZP4750A	BZX85C27RL	MZPY27RL	MZD27RL	1N5935B	3EZ27D5	1N5361B
28							3EZ28D5	1N5362B
30	***1N4751A***	***MZP4751A***	BZX85C30RL	MZPY30RL	MZD30RL	***1N5936B***	3EZ30D5	1N5363B
33	***1N4752A***	MZP4752A	BZX85C33RL	MZPY33RL	MZD33RL	1N5937B	3EZ33D5	1N5364B
36	1N4753A	MZP4753A	BZX85C36RL	MZPY36RL	MZD36RL	1N5938B	3EZ36D5	1N5365B
39	1N4754A	MZP4754A	BZX85C39RL	MZPY39RL	MZD39RL	1N5939B	3EZ39D5	1N5366B
43	1N4755A	MZP4755A	BZX85C43RL	MZPY43RL	MZD43RL	1N5940B	3EZ43D5	1N5367B
47	1N4756A	MZP4756A	BZX85C47RL	MZPY47RL	MZD47RL	1N5941B	3EZ47D5	1N5368B
51	1N4757A	MZP4757A	BZX85C51RL	MZPY51RL	MZD51	1N5942B	3EZ51D5	1N5369B
56	1N4758A	MZP4758A	BZX85C56RL	MZPY56RL	MZD56	1N5943B	3EZ56D5	1N5370B
60								1N5371B
62	1N4759A	MZP4759A	BZX85C62RL	MZPY62RL	MZD62	1N5944B	3EZ62D5	1N5372B
68	1N4760A	MZP4760A	BZX85C68RL	MZPY68RL	MZD68	1N5945B	3EZ68D5	1N5373B

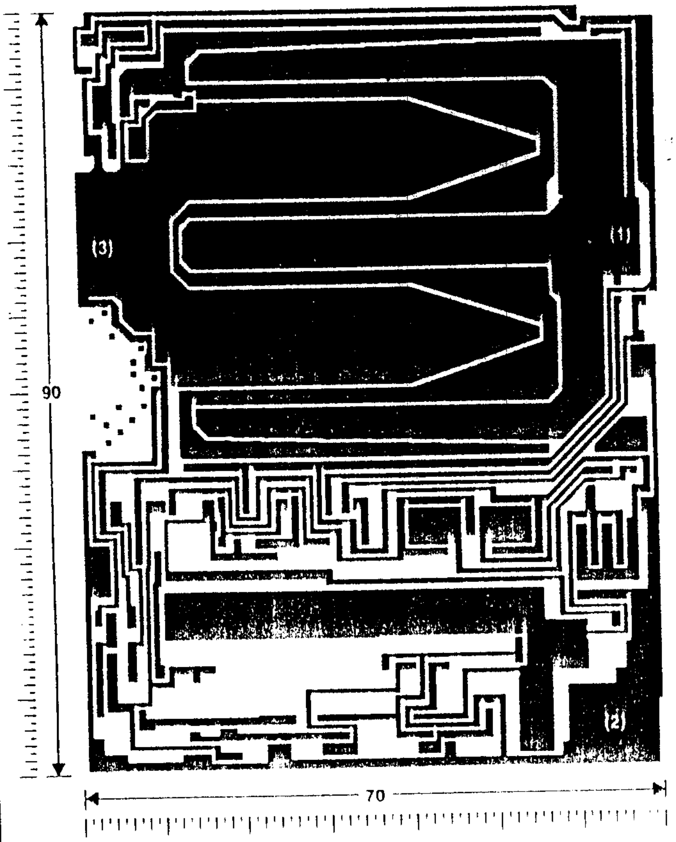
*See Notes on page 5.2–20

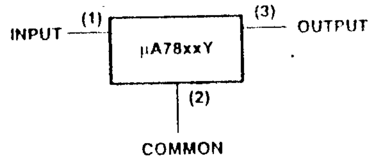
Devices listed in bold, italic are Motorola preferred devices

µA78xxY chip information

These chips, when properly assembled, display characteristics similar to the µA78xxC. Thermal compression or ultrasonic bonding may be used on the doped aluminum bonding pads. The chips may be mounted with conductive epoxy or a gold-silicon preform.

BONDING PAD ASSIGNMENTS





CHIP THICKNESS: 15 MILS TYPICAL

BONDING PADS: 4 × 4 MILS MINIMUM

$T_J$max = 150°C

TOLERANCES ARE ± 10%.

ALL DIMENSIONS ARE IN MILS.