THE UNIVERSAL VOLTAGE REGULATOR
Type A4 10 084-2

NEW ZEALAND BROADCASTING CORPORATION

HEAD OFFICE ENGINEERING DIVISION

WELLINGTON

Application Manual

for

The Universal Voltage Regulator

Type A4-10,084/2

TV STUDIOS
DEVELOPMENT GROUP

NZBC Report ~~F10505~~ 10084/5

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INDEX

1.0 INTRODUCTION

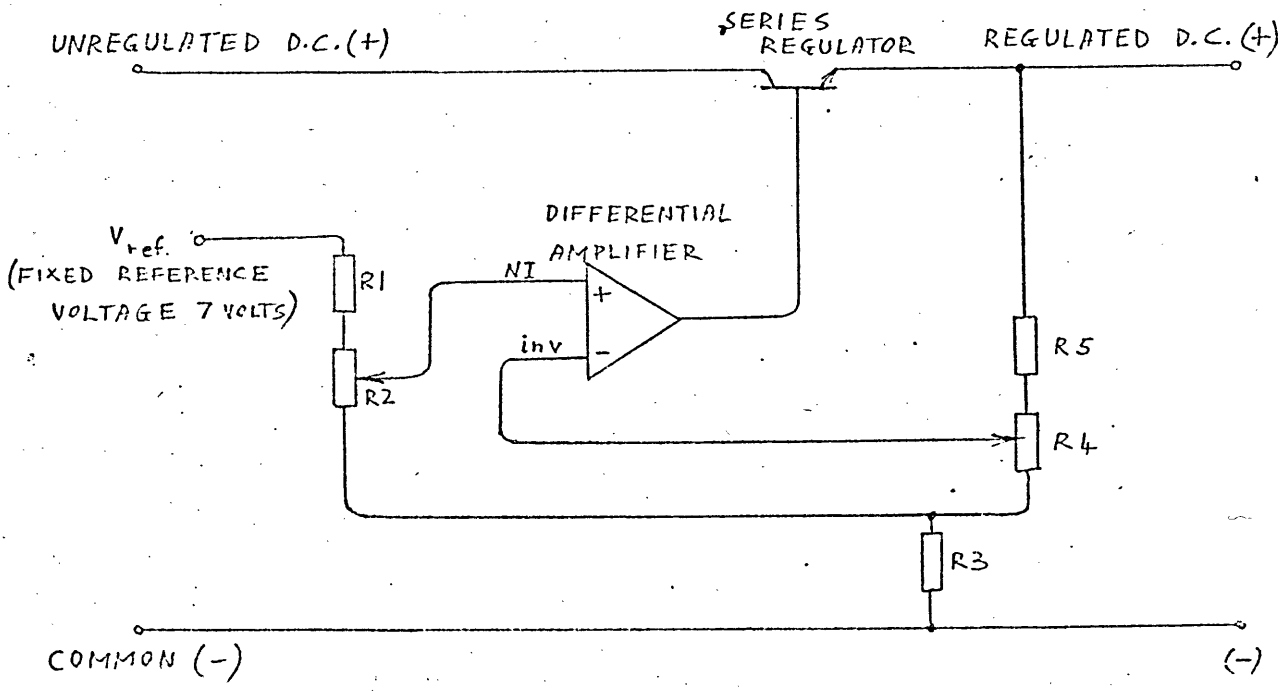
1.1 General

This Manual is intended to be of practical assistance to the user of the Universal Voltage Regulator, Type A4-10,084/2. Details relating to development are to be found in the NZBC Report No. F10291, "The Development of an I.C. Regulated Power Supply" (referred to as "ref. 1" in this Manual). Ref. 1 also covers the selection of transformers, filter capacitors and rectifiers (section 3.0).

The Universal Voltage Regulator, which is in the form of a plug-in printed card, may be used either as a completely self-contained voltage regulator capable of handling currents up to 300 mA or as the basis of a larger power supply with virtually unlimited current capacity. Facilities such as Current Foldback, Auto-Parallel and Auto-Series operation, Remote Sensing and Remote Programming are readily available.

1.2 Circuit Description

A differential amplifier is used to compare the output voltage of the regulator (or a fixed fraction of it) with the reference voltage (or a fixed fraction of it). Any difference between the two voltages is used to apply negative feedback to the series regulator thus tending to keep the two voltages equal (ref. 1. section 5.1).



The reference voltage (V ref) and the differential amplifier are both contained within the UA723C integrated circuit (see diagram A4-10,084/4 section 1.2). Terminal 4 (marked V ref) provides a very stable temperature compensated reference voltage of approximately 7 volts. If the power supply is to operate at a voltage less than 7 volts then V ref must be reduced by a divider consisting of R1, R2 and R3. The reduced reference voltage is applied to the non-inverting input (NI) of the differential amplifier. The inverting input (inv) is connected directly to the output via R5.

If the power supply is to provide a voltage in excess of 7 volts then V ref will be connected directly to NI via R1. The inverting terminal (inv) will be connected to the output via the voltage divider R5, R4 and R3.

The differential amplifier (inputs inv and NI) will adjust the series regulator until the voltages at inv and NI are equal. This will tend to keep the output voltage constant, i.e. to regulate the output voltage.

The output voltage of supplies under 7 volts may be varied by adjusting potentiometer R2 and the output voltage of supplies over 7 volts may be varied by adjusting potentiometer R4.

The series regulator may consist either of TR1 or of TR1 and TR2 forming a "super-alpha" pair (ref. 1, section 9.0). It is also possible to add other transistors in parallel with TR2 (ref. 1, section 15.4).

C1 and C2 are filter capacitors used to improve ripple rejection (ref. 1 section 6.1).

C4 is used to reduce output noise and also to reduce output impedance at high frequencies (ref. 1, section 6.2).

C3 is used to provide frequency compensation for the IC (see Fairchild UA723C data sheet).

Resistors R6, R7, R8, R10 and R11 provide Current Foldback by making the voltage at CL a function of the output current (see section 5.0).

1.3 The Current Rating of the Universal Regulator

The product of the d.c. voltage drop across the Universal regulator and the d.c. current through the Universal Regulator must not exceed 3 watts at 50°C ambient. The minimum voltage drop required across the Universal Regulator to give satisfactory regulation is about 9 volts (ref. 1, section 10.4). This means that the maximum output current obtainable is about 300 mA. If greater currents are required, it is necessary to use an external transistor. In most of the following sections the use of the Universal Regulator both with and without an external transistor is considered.

1.4 Resistor Specification

All resistors used on the Universal Regulator P.C. board are 0.25 watts (NZBC stock 267-..) except for R11 and R15 which are 0.5 watts (NZBC stock 261-..). When the value of a resistor is specified as being 0 ohms a wire link is used.

1.5 Potentiometer Connections

Potentiometers R2, R4 and R6 may be mounted either on the PC board or off the PC board. (Diagram, section 1.2).

If R2 is mounted off the PC board it is connected to terminals S, P and R. The wiper is connected to P.

If R4 is mounted off the PC board it is connected to terminals M, N and R. The wiper is connected to N.

If R6 is mounted off the PC board it is connected to terminals D, E and L. The wiper is connected to E. R8 is mounted off the PC board between terminal L and R6.

1.6 Replacing Potentiometers with Fixed Resistors

If no variation in voltage or Current Foldback setting is required, the potentiometers R2, R4 and R6 may be replaced by fixed resistors either on the PC board or off the PC board. (diagram, section 1.2).

R2 may be replaced by choosing suitable values of R1 and R3 and then joining S, P and R.

R4 may be replaced by choosing suitable values of R5 and R3 and then joining M, N and R.

R6 may be replaced by choosing a suitable value for R7 and then joining E and L via a suitable value for R8.

The values of the resistors must be determined experimentally for specific applications.

2.0 COMPONENTS USED IN ALL APPLICATIONS

Those components which are used on the PC board in all applications are listed. The component locations are shown in the component layout drawing (section 1.2).

Item	Description	Stock No.
R15	270 ohms, 0.5 watt	261-47
d	0 ohms, wire link	N.S
C1	100 UF40V (Philips 2222.023.17101)	N.S
C2	16 UF10V (Philips 2222.001.14169)	N.S
C3	0.0047UF NCC Mylar 50V	N.S
C4	16 UF 40V (Philips 2222.001.17169)	N.S
TR1	RCA 40409 transistor	N.S
IC1	FUA723C Voltage Regulator	191-78
D1	Philips BZY95-C39 Zener	N.S

Note: D1 is used to protect the IC from d.c voltages in excess of 40V. D1 is not used for filtering. If 40V is unlikely to be reached then D1 may be omitted (Ref. 1. Section 5.4).

3.0 COMPONENTS USED FOR ALL STANDARD MODULAR POWER SUPPLIES

The standard NZBC "PS" series of modular power supplies is designed so that the same PC board components are used throughout. This is made possible by mounting all the voltage - determining and Current Foldback components external to the PC board.

In addition to the components listed in section 2.0 the following are required:

Item	Description	Stock No.
R1	0 ohms	N.S
R3	0 ohms	N.S
R5	0 ohms	N.S
R9	100 ohms 0.25 watt	267-37
R10	0 ohms	N.S
R11	62 ohms 0.5 watt	261-32
R12	100 ohms 0.25 watt	267-37
R15	270 ohms 0.5 watt	261-47
b	0 ohms	N.S

4.0 CONTROLLING THE OUTPUT VOLTAGE

4.1 Selecting Resistors

The output voltage is determined by R1, R2, R3 and R4 and R5. R13 and R14 are necessary when an external reference voltage is used. R2 and R4 are normally 1K potentiometers. R2 is used to adjust voltage in power supplies under 7 volts and R4 is used in power supplies over 7 volts. These potentiometers may be mounted either on the PC board or off the PC board (section 1.5). The potentiometer is mounted off the PC board in the standard "PS" modular power supplies (section 3.0).

Some useful resistor values are tabulated in this section, for methods of calculating other resistor values see ref. 1, section 5.0.

Nominal Voltage Range	Actual Voltage Range	R1	R2	R3	R4	R5	R13	R14
0-7	2-7	0	1K	390	**	330	-	-
7-14	7-15	360	*	910	1K	0	1K	910
14-21	14-22	1.3K	*	1.8K	1K	2.7K	3.6K	1.8K
21-28	21-29	2.2K	*	2.7K	1K	7.5K	8.2K	2.7K
5,6,7	4.5-7	0	1K	1.6K	**	390	-	-
17	16-19	3.9K	*	6.2K	1K	9.1K	10K	6.2K
24	23-26	5.6K	*	7.5K	1K	20K	20K	7.5K
28	27-30	6.8K	*	8.2K	1K	27K	27K	8.2K

** Omit the 1K potentiometer R4. Link N & M.

* Omit the 1K potentiometer R2. Link S & P.

When using these tabulated resistor values it is wise to ensure that the potentiometer has a tolerance which is better than 10%.

4.2 Operation without an External Transistor

If the transistor on the PC board (TR1) is not likely to be required to dissipate more than 3 watts it is not necessary to use an external transistor (section 1.3).

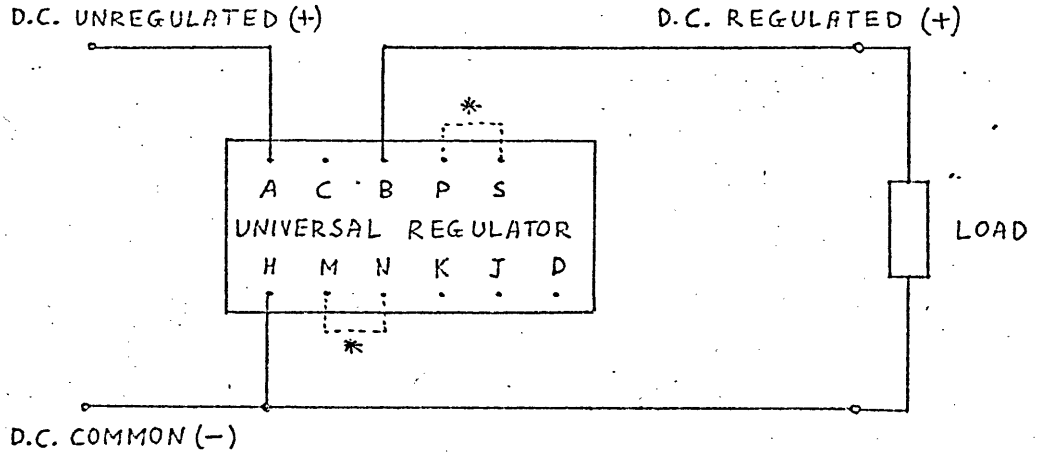
The components listed in section 2.0 are used.

The voltage-determining components are selected as described in section 4.1 except that R13 and R14 are omitted.

Other components on the PC board:

R6	omit	R11	omit
R7	omit	R12	0 ohms
R8	omit	a	0 ohms
R9	0 ohms	b	omit
R10	0 ohms	c	omit

External connections:-



* Note: Link MN for supplies under 7 volts.
Link PS for supplies over 7 volts.

4.3 Operation with an External Transistor

An external transistor is necessary in all supplies dissipating more than 3 watts (section 1.3).

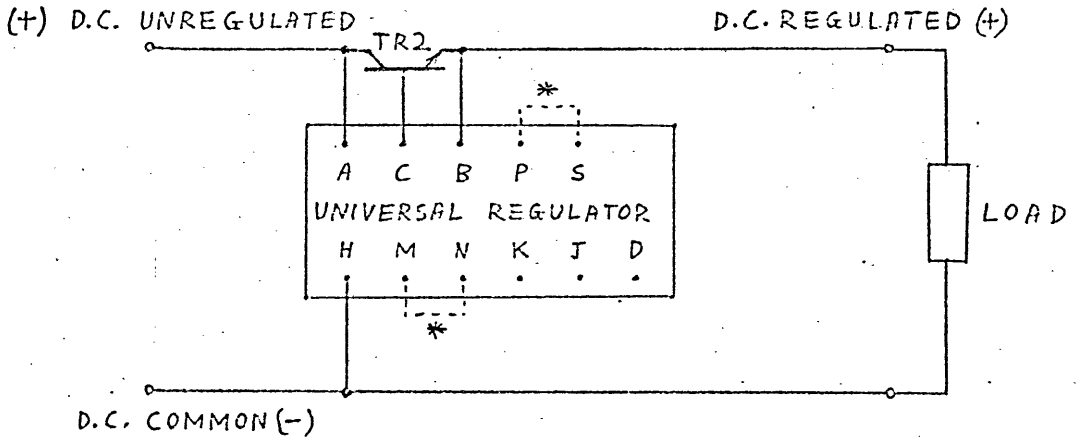
The components listed in section 2.0 are used.

The voltage-determining components are selected as described in section 4.1 except that R13 and R14 are omitted.

Other components on the PC board:-

R6	omit	R11	0 ohms
R7	omit	R12	0 ohms
R8	omit	a	omit
R9	0 ohms	b	omit
R10	0 ohms	c	omit

External connections:-



* Note: Link MN for supplies under 7 volts.
Link PS for supplies over 7 volts.

5.0 CURRENT FOLDBACK

5.1 General

An introduction to Current Foldback is given in section 10.2 of reference 1. With Current Foldback it is necessary to use a higher d.c. input voltage. (ref. 1, section 10.4). The current is self-restoring when the fault is removed.

5.2 When no External Transistor is used

The components listed in section 2.0 are used.

The voltage-determining components are selected as described in section 4.1 except that R13 and R14 are omitted.

Other components on the PC board:-

R6	1K pot.	R11	omit
R7	omit	R12	0 ohms
R8	1K	a	0 ohms
R9	0 ohms	b	omit
R10	1.3K	c	0 ohms

External connections are as shown in section 4.2.

5.3 When an External Transistor is used

The components listed in section 2.0 are used.

The voltage-determining components are selected as described in section 4.1 except that R13 and R14 are omitted.

Other components on the PC board:-

R6	1K pot.	R11	*
R7	omit	R12	0 ohms
R8	1K	a	omit
R9	0 ohms	b	0 ohms
R10	0 ohms	c	omit

* R11 is 62 ohms if TR2 is a 2N3772 and 33 ohms if TR2 is a 2N3055. Values of R11 for other power transistors must be determined experimentally if satisfactory Current Foldback is to be achieved.

External connections are as shown in section 4.3.

6.0 AUTO PARALLEL OPERATION

6.1 General

An introduction to Auto Parallel operation is given in ref. 1, section 2.8.

Auto Parallel operation incorporating both Current Foldback and the use of an external transistor TR2 is considered in the following sections.

Auto Parallel operation without Current Foldback and without an external transistor is possible using the Universal Regulator but is not described in this Manual. It is thought that in most situations where Auto Parallel operation is desirable there will also be a need for Current Foldback and an external transistor.

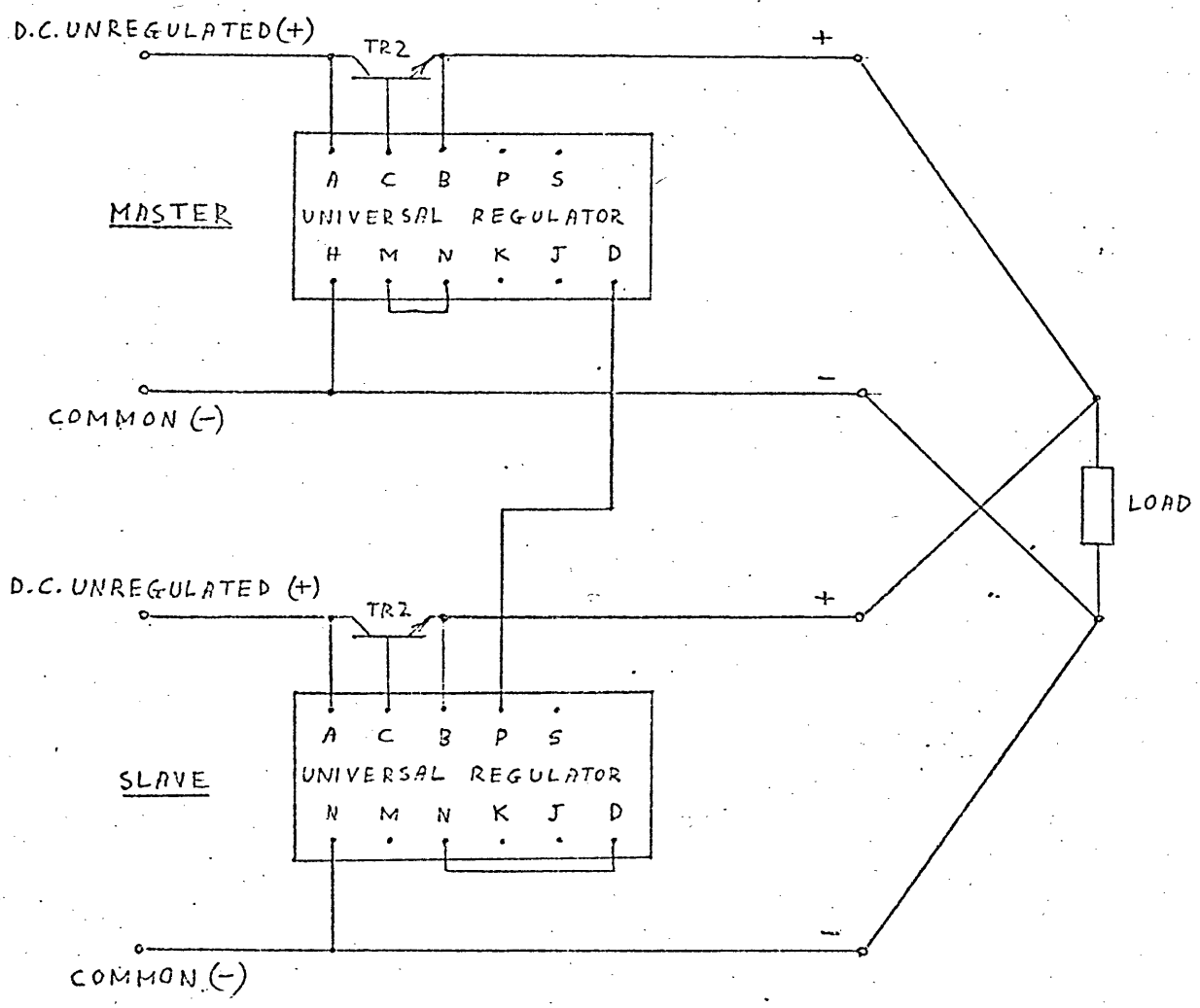
6.2 Supplies under 7 volts

Prepare the Master Universal Regulator PC board as in section 5.3.

The Slave Universal Regulator is the same except that potentiometer R2 is omitted.

Under no circumstances should more than 7 volts be applied to terminal P.

External connections:



6.3 Supplies over 7 volts

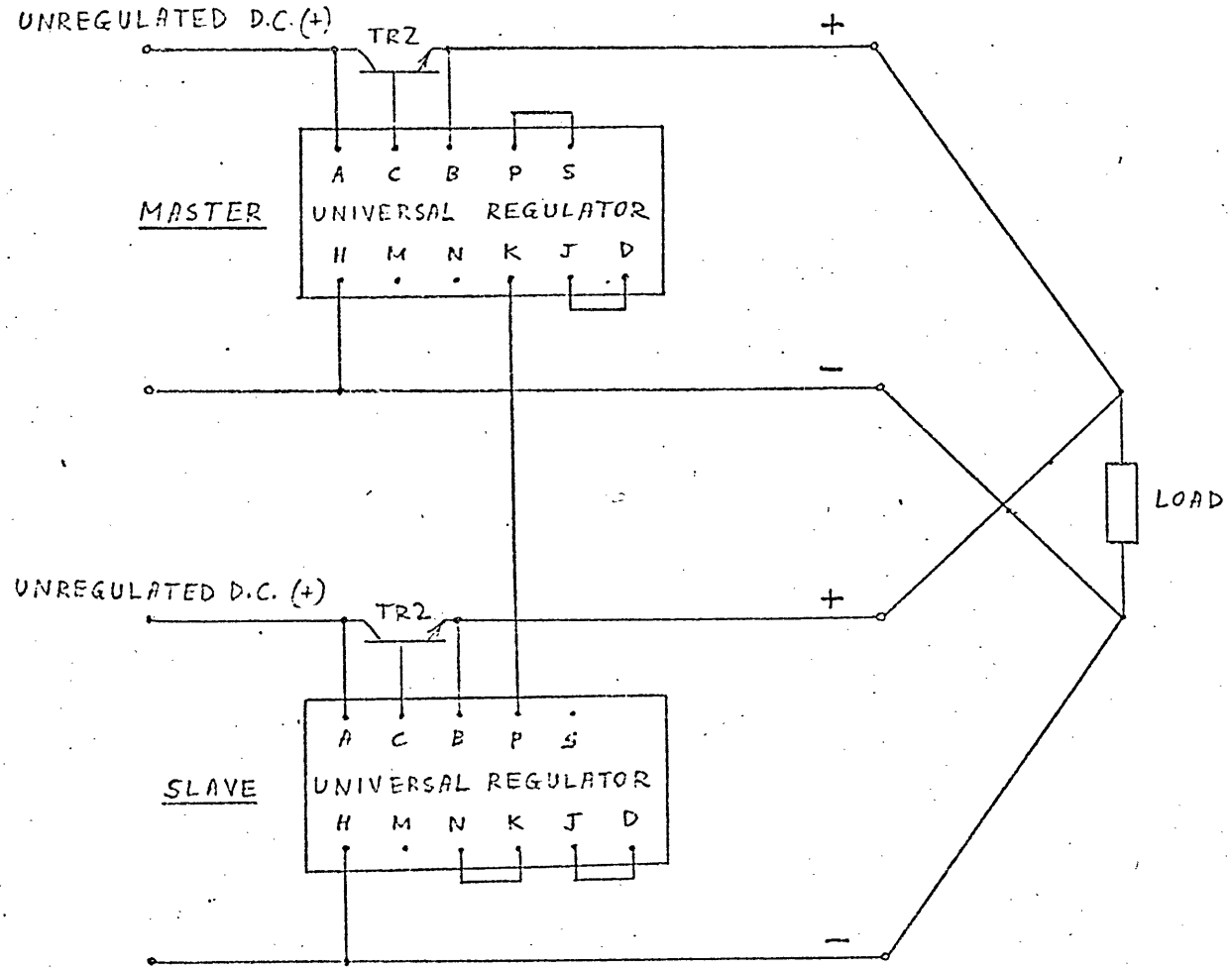
Prepare the Master Universal Regulator PC board as in section 5.3.

Add resistors R13 and R14 as specified in section 4.1.

The Slave Universal Regulator is the same except that potentiometer R4 is omitted.

Under no circumstances should more than 7 volts be applied to terminal P.

External connections:



It is possible to vary the division of current between the two supplies by altering R13 and R14.

7.0 AUTO SERIES OPERATION

7.1 General

An introduction to Auto Series operation is given in ref. 1, section 2.9.

Auto Series operation incorporating both Current Foldback and the use of an external transistor TR2 is considered in the following sections.

Auto Series operation without Current Foldback and without an external transistor is possible using the Universal Regulator but is not described in this Manual. It is thought that in most situations where Auto Series operation is desirable there will also be a need for Current Foldback and an external transistor.

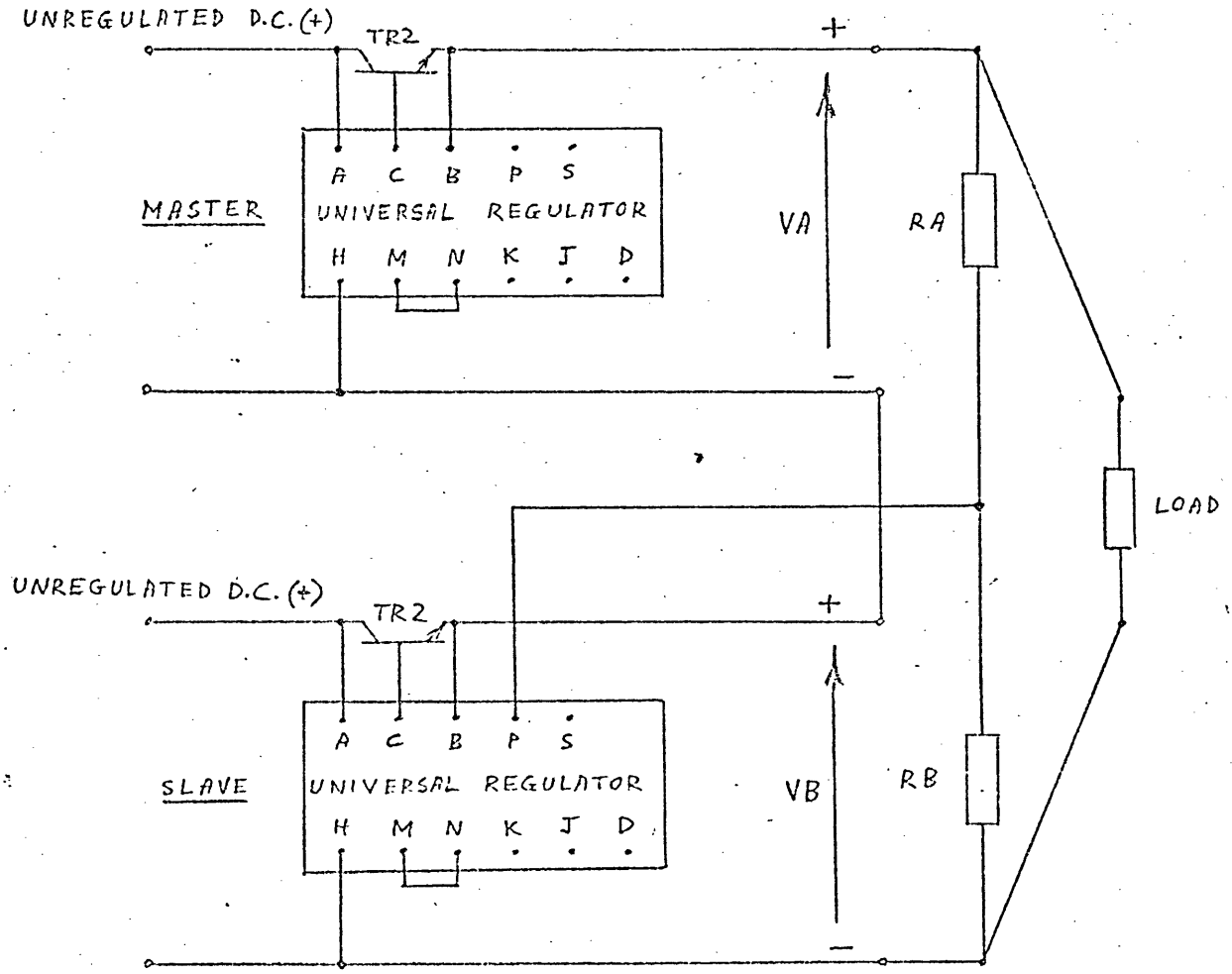
7.2 Supplies under 7 volts

Prepare the Master Universal Regulator PC board as in section 5.3.

The Slave Universal Regulator PC board is the same except that potentiometer R2 is omitted.

Under no circumstances should more than 7 volts be applied to terminal P.

External connections:-



Voltage VA is set by adjusting R4 on the Master. The ratio VA:VB is approximately equal to the ratio RA:RB. Resistors RA and RB should have a power rating at least 10 times their actual dissipation and should be selected so that the current through them will be in the order of 1-5 mA. Resistors RA and RB may be replaced by a suitable potentiometer.

7.3 Supplies over 7 volts

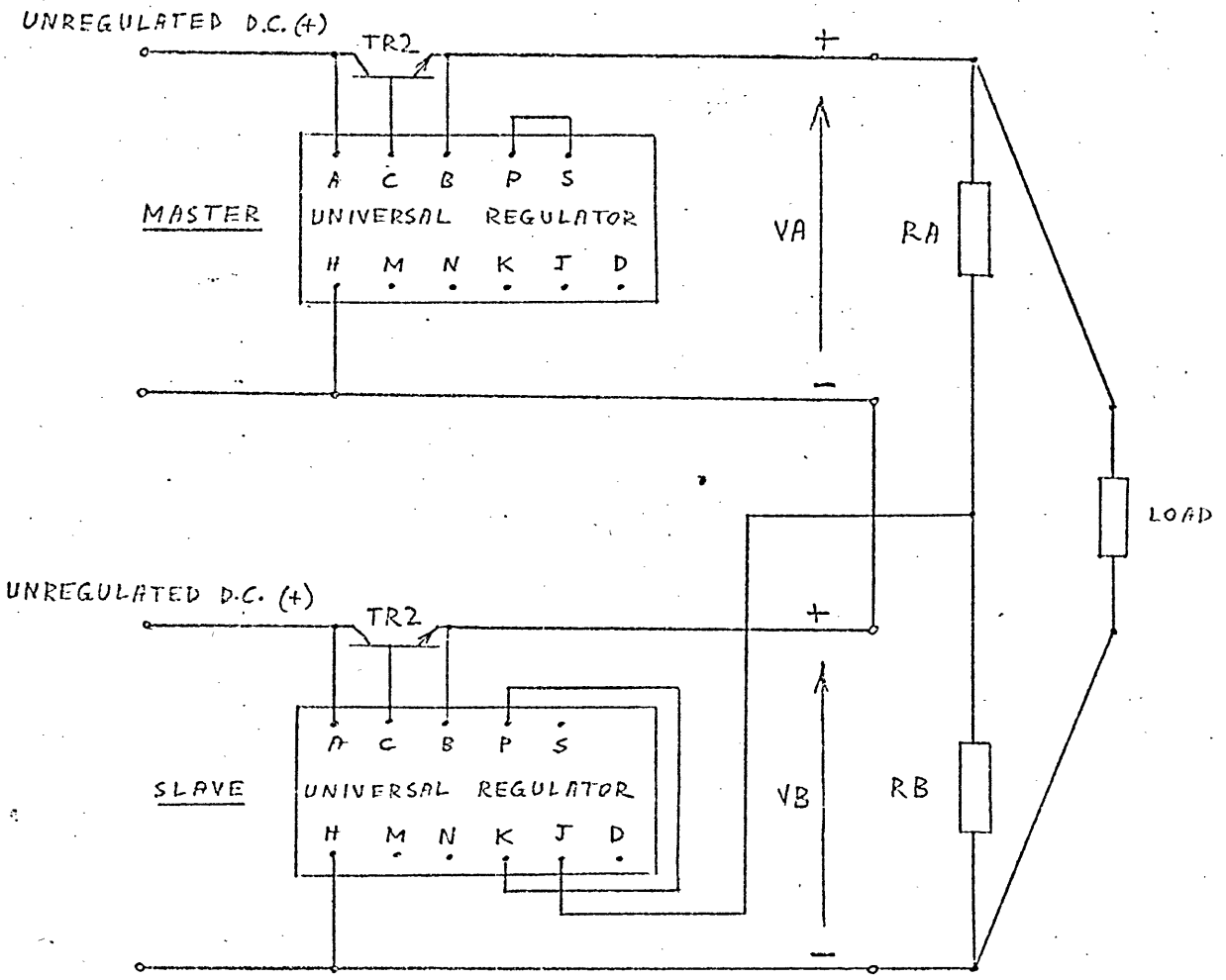
Prepare the Master Universal Regulator PC board as in section 5.3.

Add resistors R13 and R14 as specified in section 4.1.

The Slave Universal Regulator is the same as the Master Universal Regulator.

Under no circumstances should more than 7 volts be applied to terminal P.

External connections:



The voltage VA is set by adjusting R4 on the Master. The ratio VA:VB is approximately equal to the ratio RA:RB. For additional adjustment use R4 on the Slave. Resistors RA to RB should have a power rating at least 10 times their actual dissipation and should be selected so that the current through them will be in the order of 1-5 mA. Resistors RA and RB may be replaced by a suitable potentiometer.

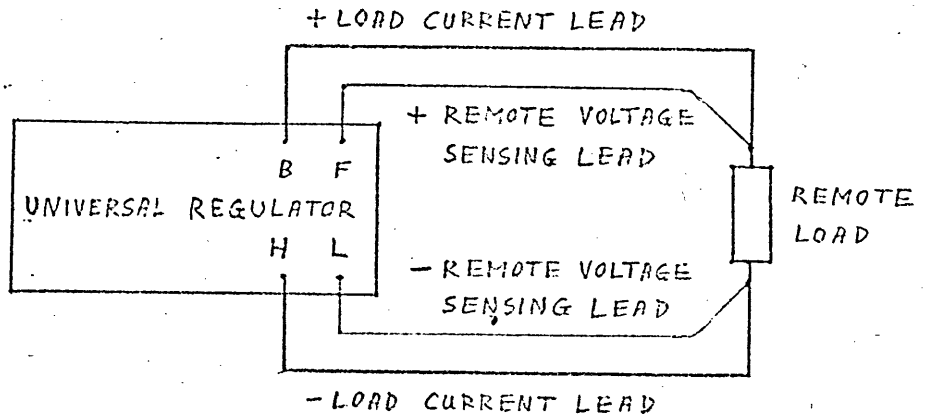
8.0 REMOTE SENSING

The function of Remote Sensing facilities is explained in ref. 1, section 2.10.

The Universal Voltage Regulator PC board is prepared as outlined in sections 2.0, 4.0, 5.0, 6.0, 7.0 and 9.0 with the exception that R9 and R12 are 100 ohm resistors.

When the Remote Sensing facilities are not being used it is necessary to link B to F and H to L. When the Remote Sensing facilities are being used the links are removed.

External connections:-



Note: The remote voltage sensing leads carry a very small current and will sense the load voltage accurately as they will suffer no significant voltage drop; this means that the voltage drops in the long load current leads will not impair the performance of the Universal Regulator.

9.0 REMOTE PROGRAMMING

9.1 General

An introduction to the concept of Remote Programming (remote control of power supply output voltage) is contained in ref. 1, sections 2.11 and 7.4. Remote Programming may be achieved either by varying a resistance or by varying a voltage.

9.2 Remote Programming with Resistance Control

The Universal Voltage Regulator PC board is prepared as in sections 2.0, 4.0, 5.0, 6.0, 7.0 and 8.0 with the exception that the voltage control potentiometer (R2 for supplies under 7 volts, R4 for supplies over 7 volts) is removed to the required remote location and attached by wires to the Universal Regulator as described in section 1.5.

This form of Remote Programming uses the reference voltage within the Universal Regulator.

9.3 Remote Programming with Voltage Control

This form of Remote Programming does not use the reference voltage within the Universal Regulator. A d.c. reference voltage must be supplied at the required remote location. The remote reference voltage should not exceed 7 volts. It may be varied using a resistive divider.

The PC board is prepared as described in sections 2.0, 4.0, 5.0, 6.0, 7.0 and 8.0 with the exception that R2 is omitted.

Terminal P is disconnected from terminal S and connected to the remote reference voltage.

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