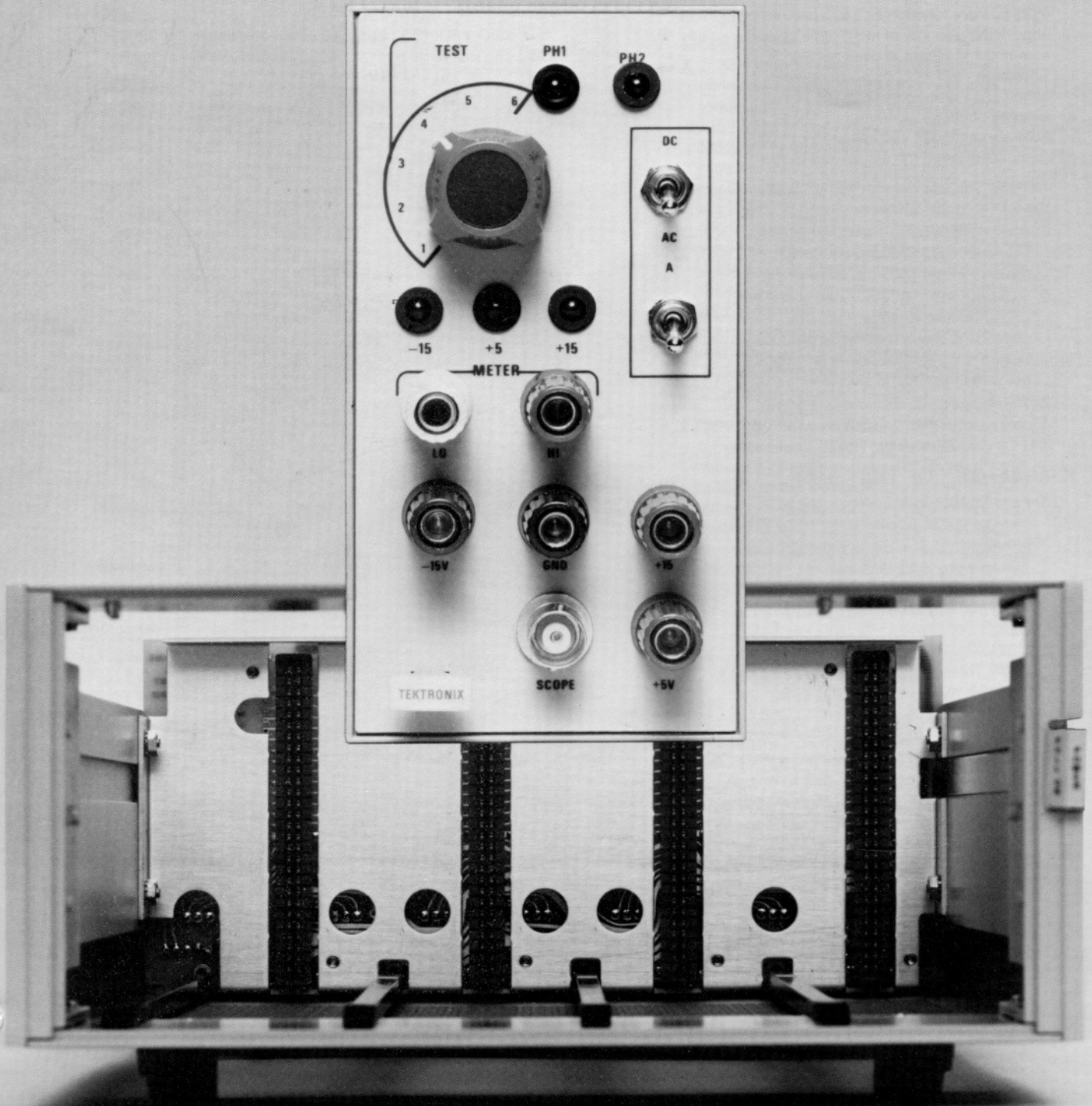


TM 500 POWER MODULE TESTER AND UTILITY POWER SUPPLY

Construction Note



TM500 POWER MODULE TESTER AND UTILITY POWER SUPPLY

By Warren Collier, Program Supervisor
TM 500 Marketing, Tektronix, Inc.

I. INTRODUCTION

This note describes the construction of a single-width TM 500 plug-in utilizing the blank plug-in kit, P/N 040-0652-02. The plug-in's primary purpose is to test TM 500 series power modules (mainframes). It is also useful as a limited performance power supply for breadboard or student use.

In its primary function as a test unit, it checks the integrity of mainframe power supply components. It does not check "interface" connections; these checks (when applicable) may be made with a simple ohmmeter or continuity tester. This note also includes instructions for mainframe tests using the completed plug-in.

As a utility power supply, the unit supplies the following voltages:

1. +5 V dc nominal at 1 amp. Suitable for TTL or similar logic, and compatible displays. (Type 7805 regulator.)
2. +15 V dc and -15 V dc rated at 400 mA, with short circuit protection. The common of these supplies is grounded. Output voltage and current limiting are not variable.

NOTE: When using this unit as a power supply, set the rotary switch to position 3 and the AC/DC switch to the DC position.

II. ASSEMBLY OF TEST UNIT

1. Parts location is not critical, but care must be taken to provide low impedance ground paths.
2. To minimize ripple in the output, be sure to sense output voltage at the front panel binding posts. This means that a separate wire should go from the +15 V post to R126 and from the -15 V post to R226. The ground post should be provided with a low impedance path to the plug-in frame. Avoid ripple at ground points of CR121, CR221, R128, and R228.
3. The 7805 regulator may be heat sunk by mounting as shown in Figure 1. This amount of heat sinking will be adequate for use as a test unit and for general use as an auxiliary power supply in most environments. For heavy duty service, additional heat sinking may be desirable.
4. A suggested front panel layout is shown in Figure 2.

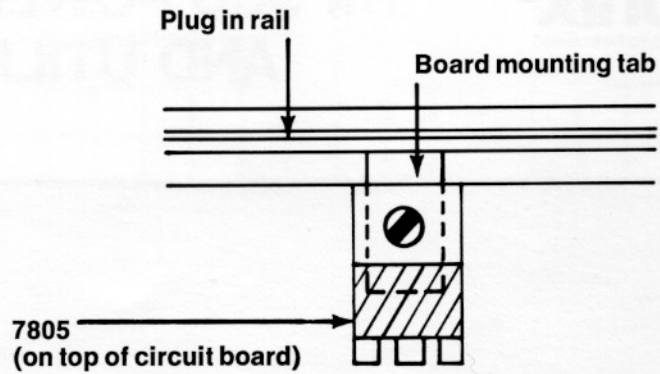


Figure 1

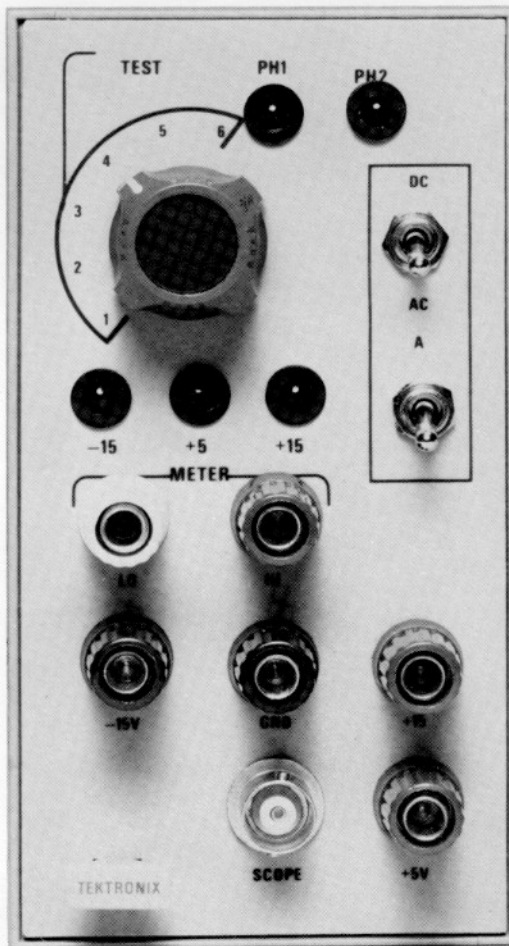


Figure 2

III. PARTS LIST—MAINFRAME TESTER

ICs

2 ea	μ A741C: μ 1, μ 2
1 ea	μ A7805 μ 5

Transistors

1 ea	2N2219A: Q121
1 ea	2N2222A: Q122
1 ea	2N2905A: Q221
1 ea	2N2907A: Q222

Diodes

2 ea	1N751A: CR121, CR221
6 ea	1N4004: CR1, CR2, CR123, CR223, CR501, CR502
4 ea	1N4152: CR2, CR102, CR122, CR222

LEDs

2 ea	Monsanto MV5C24	(red LED): DS1, DS2
3 ea	Monsanto MV5253	(green LED): DS120, DS220, DS501

Capacitors

2 ea	1000 μ F/50 V	Alum
2 ea	50 μ F/50 V	Alum
1 ea	100 μ F/15 V	Alum
2 ea	22 μ F/15 V	Tant

Resistors, fixed

4 ea	1 Ω	2 w	5%	ww
2 ea	300 Ω	3 w	5%	ww
4 ea	22 k Ω	$\frac{1}{4}$ w	5%	comp
2 ea	1.5 k Ω	$\frac{1}{2}$ w	5%	comp
2 ea	1.0 k Ω	$\frac{1}{2}$ w	5%	comp
2 ea	4.99 k Ω	$\frac{1}{8}$ w	1%	metal film
2 ea	7.5 k Ω	$\frac{1}{8}$ w	1%	metal film
2 ea	1.8 k Ω	$\frac{1}{2}$ w	5%	comp
2 ea	10 k Ω	$\frac{1}{4}$ w	5%	comp
5 ea	5.1 k Ω	$\frac{1}{4}$ w	5%	comp
2 ea	12 k Ω	$\frac{1}{4}$ w	5%	comp
4 ea	1.5 k Ω	$\frac{1}{4}$ w	5%	comp
1 ea	360 Ω	$\frac{1}{4}$ w	5%	comp

Resistors, variable

2 ea	5 k Ω	20% linear cermet trimmer
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Switches

1 ea	DPDT	3 A	panel mount
1 ea	SPDT	$\frac{1}{4}$ A	panel mount
1 ea	4 pole, 6 position, non-short Centralab PSA-211		

Fuses

2 ea	0.8 A, medium blow with circuit board mounting hardware	
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Connectors

3 ea	Binding post, red
1 ea	Binding post, white
1 ea	Binding post, black
1 ea	Binding post, green
1 ea	BNC, Female, panel mount

IV. POWER MODULE (MAINFRAME) TEST PROCEDURES

Introduction

Since the TM 500 power modules do not contain regulated supplies, test procedures are intended simply to assure that power supply components are functional; that is, that they have neither failed catastrophically, nor suffered appreciable degradation. Although test limits are given, they are intended as maintenance guidelines rather than formal specifications. The mainframe contains no adjustments and doesn't require "calibration" as the term is usually applied.

Circuit Analysis

1. \pm 33.5 V dc supplies. These dc supplies consist of a pair of transformer windings (equivalent to a tapped winding) feeding a full wave bridge rectifier which is followed by filter capacitors and bleeder resistors. Since there is no regulation circuitry, the plus and minus voltages increase and decrease as the primary line voltage increases and decreases.

When the line voltage is at its nominal value and there is no external load on the supply, the dc voltages are nominally plus and minus 33.5 V. The effect of load current is to decrease output dc voltage and increase peak-to-peak ripple voltage. These supplies are connected in parallel to all compartments.

2. NPN and PNP pass transistors. The pass transistors are isolated units whose collector, emitter, and base leads are brought to the interface connector, allowing each plug-in to utilize them as desired. In this test unit, the NPN is used as a series regulator in the +15 V supply and the PNP as a series regulator in the -15 V supply. There is a separate pair of transistors for each compartment.

3. 25 V ac rms floating windings. Each compartment has two such windings supplied to it; they are secondary windings of the main power transformer. They should be connected so that pins 1A, 5A, and 13A are in phase. This allows their voltages to be additive when series-connected. The test unit connects pins 1A and 13A to ground and compares the phase of 1B and 13B to the phase of 5B. The test unit also half-wave rectifies both floating windings. One winding produces a positive voltage and the other a negative voltage. These voltages are substituted for the \pm 33.5 V supplies when the AC/DC switch is in the AC position, allowing a test of voltage and current capacity.

4. +12 V dc supply. This supply consists of a pair of transformer windings (equivalent to a tapped winding) feeding a 2-diode full wave rectifier, followed by a filter capacitor and bleeder resistor. This supply is connected in parallel to all standard (low power) compartments. The common is isolated from ground in the mainframe by a one-kilohm resistor but is grounded by the TM 500 plug-ins.

The high power compartment (far right hole of a TM 504 or TM 506) has a separate 12 V supply for itself which may or may not be grounded by the plug-in.

The test unit uses the 12 V dc supply as the raw voltage which is regulated by the Type 7805 5 V regulator.

The unrectified voltage from these windings is connected to pins 5A and 5B. Except for the phase comparison previously described, these connections are not checked. Any winding failure will be detected in the check of the 12 V supply. Lack of ac voltage at pins 5A and 5B (when the 12 V dc supply is working) would be due to a broken run or connector.

General Instructions

- The test procedure for the mainframe assumes that the test load is properly assembled and in good working order.
- Two external load resistances are required. The recommended wattage ratings are the minimum required for adequate performance. At these wattage ratings, the surface temperature under load may be too great for safe handling. Therefore, the loads should be encased or shielded. As an alternative, a wattage rating five to ten times the minimum value will produce lower surface temperatures. The loads are:
 - 30 ohms, 10 W minimum; used with +15 V and -15 V supplies.
 - 5 ohms, 5 W minimum; used with +5 V supply.
- The HI and LO meter terminals are for connection to an external test meter. In some tests, the HI terminal is positive relative to the LO terminal, and in some it is negative. The unit is designed for use with an autopolarity DVM having an input resistance of at least 10 megohms. The DM 502 is a good choice for this application.
- The BNC connector in parallel with the HI meter terminal is for use with an oscilloscope. It is expected that an oscilloscope will be used to monitor ripple voltage on certain tests. These are low frequency tests and the bandwidth

of the instrument is not important. The scope will be used mostly ac-coupled and should have a calibrated vertical scale and time base. If an oscilloscope is not available, checkout can be accomplished with the meter.

- Several of the bused supply terminals have multiple connections:
 - +33.5 V, pins 12A and 12B
 - 33.5 V, pins 8A and 8B
 - ±33.5 V common, pins 9A and 9B
 - +12 V, pins 2A and 2B
 - +12 V common, pins 3A, 3B, 4A, and 4B

The circuit board for the blank plug-in kit parallels each of these sets. However, a given plug-in may use only one contact. The test unit can show the compartment to be good, whereas one contact of a pair may be broken or have an open run, producing trouble with some particular plug-in unit other than the test unit.

- In most instances, steps IIIA, IIIB, VIA, and VIB of the power module test procedure are necessary in only one compartment of a mainframe. However, it is possible that another compartment would lack voltage due to a broken run or contact. Step VIII should always be performed in a high power compartment (far right of TM 504 or TM 506) as well as at least one of the standard compartments.

DETAILED TEST PROCEDURE

Step I—NPN Short/Leakage

Presets:

Meter Switch	Position 1
AC/DC Selector	AC
A/B Selector	A
External Load	Disconnected

Procedure:

Check to see that +15 V indicator LED is extinguished and that the meter reading drifts down to zero (or nearly zero) as the output filter capacitor in the -15 V supply discharges. A residual reading greater than 10 mV indicates that the NPN pass transistor in the mainframe is leaky (or shorted) from collector to emitter.

A base-emitter short will result in a loss of regulation (reduced output voltage) in Step IIIB. This will cause the +15 V indicator light to dim. Another symptom of a base-emitter short is that the output voltage of the +15 V supply goes to zero more rapidly than normal when switching from position 2 to position 1.

NPN base-collector leakage will be evidenced by an output voltage (+15 V supply) greater than normal in position 2 or 3. A base-collector short should

produce the same symptom and will also result in a blown fuse F1 in position 1. Fuse F1 will also blow if the NPN collector is shorted to the chassis.

Step II—NPN Beta

Presets:

Meter Switch	Position 2
AC/DC Selector	AC
A/B Selector	A
External Load	30 ohm load connected to -15 V

Procedure:

CAUTION: Surface temperature of test load resistors may become too hot for safe handling. Refer to general instruction no. 2.

The meter displays a voltage which is proportional to the base current of the NPN pass transistor in this mainframe compartment. A high reading means low beta, and a low reading means high beta. Consider replacement of any transistor that shows a reading greater than 3.0 V. Removing the external load should cause the reading to reduce to a much smaller value.

A zero (or extremely low) reading may be due to low output from the +15 V supply. Check raw dc and pass transistor.

Step IIIA—+33.5 V dc Supply (unloaded)

Presets:

Meter Switch	Position 3
AC/DC Selector	AC
A/B Selector	A
External Load	Disconnected

Procedure:

The meter displays the raw dc voltage supplied by the mainframe to pins 12A and 12B, and the scope displays the ripple voltage. If a variable auto transformer is available, set the primary line voltage to the center value of the tap in use. Refer to Table 1 for the appropriate values. Inadequate performance is most likely due to a defective rectifier or filter capacitor in the +33.5 volt supply. A defective power transformer is another possibility. If no voltage is present, a blown fuse in the mainframe or in the test unit is a possibility.

Step IIIB—+33.5 V dc Supply (loaded)

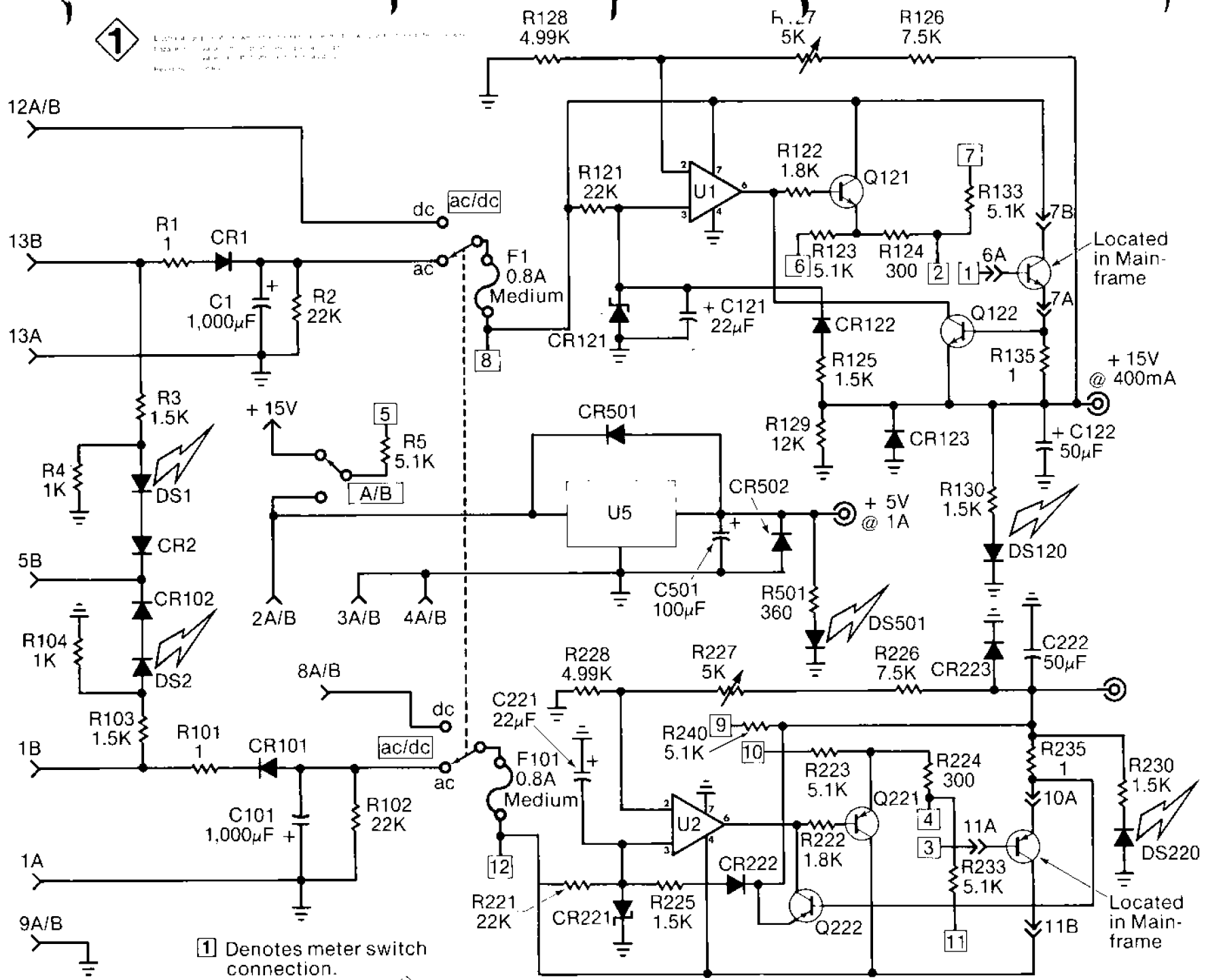
Procedure:

CAUTION: Surface temperature of test load resistors may become too hot for safe handling. Refer to general instruction no. 2.

With the controls still set as in Step IIIA, connect the 30 ohm load to the +15 V supply. There will be a decrease in the

1

LOCATED IN MAIN-FRAME



1 Denotes meter switch connection. See switch detail 2

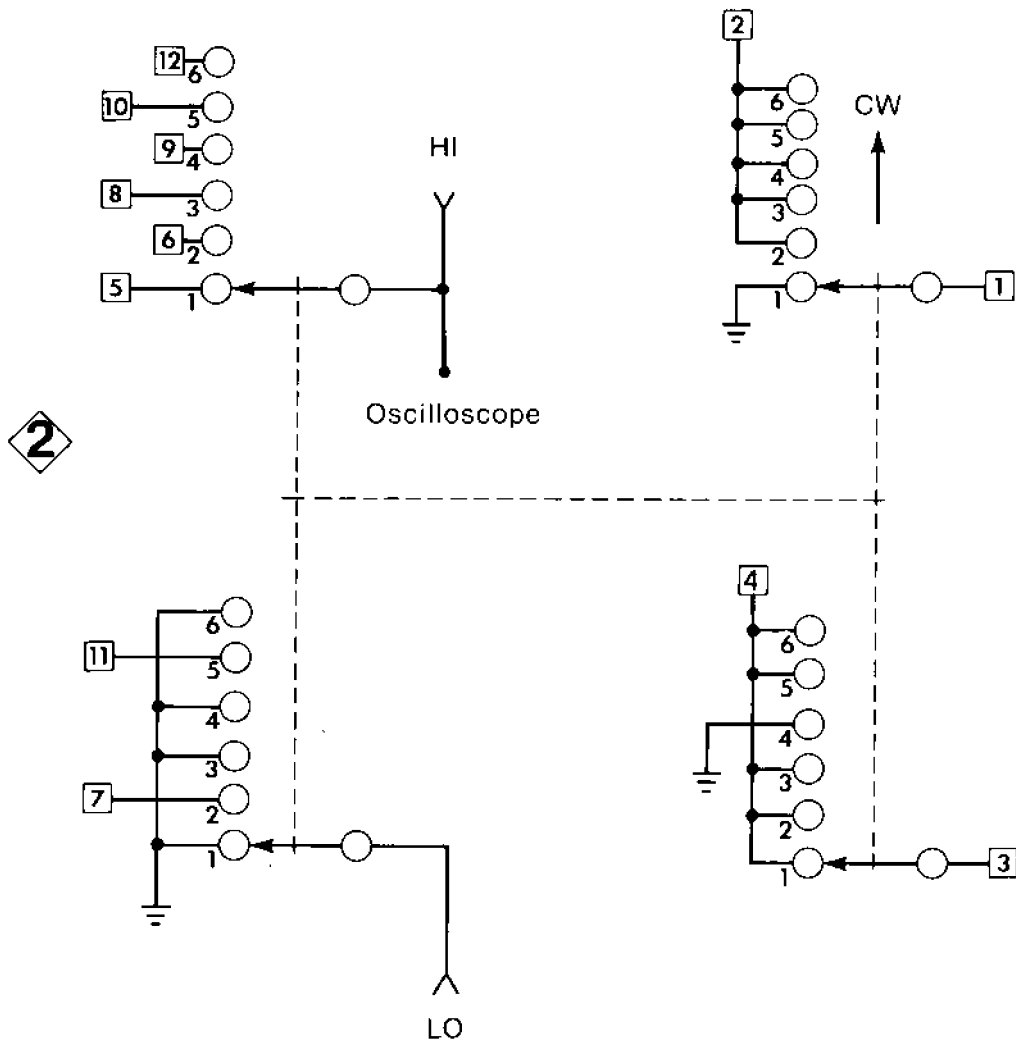
Located in Main-frame

+15V @ 400mA

+5V @ 1A

Located in Main-frame

Meter Switch Detail



dc voltage displayed by the meter, and an increase in the peak-to-peak ripple displayed by the oscilloscope. Refer to Table 2. Inadequate performance is likely due to the same causes listed above.

Step IIIC—AC Winding (pins 13A/13B)

Procedure:

With the controls still set as in Step IIIB (and with the 30 ohm load still connected), throw the AC/DC switch to the AC

position. There will be a further decrease in the dc voltage displayed by the meter, and an increase in the peak-to-peak ripple displayed by the oscilloscope. Typical value is 22-28 V, with a peak-to-peak ripple of 6-11 V. The ripple voltage is a function of the filter capacitors in the test unit and will be fairly constant. See Table 1 and Table 2 for other considerations. (The ripple frequency will also change from 120 Hz to 60 Hz.) These changes are due to the half wave rectifier and the smaller filter capacitor

in the test unit. Disconnect the 30 ohm load; the dc voltage should increase to approximately 32-35 V. Return the AC/DC switch to the DC position. Failure to supply adequate voltage in this step implies that the ac winding connected to pins 13A and 13B is defective.

Step IV—PNP Short/Leakage

Presets:

Meter Switch	Position 4
AC/DC Selector	AC
A/B Selector	A
External Load	Disconnected

Procedure:

Check to see that the -15 V indicator LED is extinguished and that the meter reading drifts down to zero (or nearly zero) as the output filter capacitor in the -15 V supply discharges. A residual reading greater than 10 mV indicates that the PNP pass transistor in this mainframe compartment has excessive leakage or may be shorted from collector to emitter.

A base-emitter short will result in a loss of regulation (reduced output voltage) in Step VIB. This will cause the -15 V indicator light to dim.

Another symptom of a base-emitter short is that the output voltage of the -15 V supply goes to zero more rapidly than normal when switching from position 5 to position 4.

PNP base-collector leakage will be evidenced by an output voltage $> -15\text{ V}$ supply; greater than normal in positions 5 or 6. A base-collector short should produce the same symptom and will also result in a blown fuse in position 4. Fuse F2 will also blow if the PNP collector is shorted to the chassis.

Step V—PNP Beta

Presets:

Meter Switch	Position 5
AC/DC Selector	AC
A/B Selector	A
External Load	30 ohm load connected to -15 V

Procedure:

The meter displays voltage which is proportional to the base current of the PNP pass transistor in this mainframe compartment. A high reading means low beta, and a low reading means high beta. Consider replacement of any transistor that shows a reading greater than 3.0 V . Removing the external load should cause the reading to reduce to a much smaller value.

CAUTION: Surface temperature of test load resistors may become too hot for safe handling. Refer to general instruction no. 2.

A zero (or extremely low) reading may be due to low output from the -15 V supply. Check raw dc and pass transistor

Step VIA— -33.5 V dc Supply (unloaded)

Presets:

Meter Switch	Position 6
AC/DC Selector	AC
A/B Selector	A
External Load	Disconnected

Procedure:

The meter displays the raw voltage supplied by the mainframe to pins 8A and 8B, and the scope displays the ripple voltage. If a variable auto transformer is available, set the primary line voltage to the center value of the tap in use. Refer to Table 1 for the appropriate values. Inadequate performance is most likely due to a defective rectifier or filter capacitor in the -33.5 V supply. A defective power transformer is another possibility. If no voltage is present, a blown fuse in the mainframe or in the test unit is a possibility.

Step VIB— -33.5 V dc Supply (loaded)

Procedure:

CAUTION: Surface temperature of test load resistors may become too hot for safe handling. Refer to general instruction no. 2.

With the controls still set as in Step VIA, connect the 30 ohm load to the -15 V supply. There will be a decrease in the dc voltage displayed by the meter, and an increase in the peak-to-peak ripple displayed by the oscilloscope. Refer to Table 2. Inadequate performance is likely due to the same causes listed above.

Step VIC—AC Winding (pins 1A and 1B)

Procedure:

With the controls still set as in Step VIB (and with the 30 ohm load still connected), throw the AC/DC switch to the AC position. There will be a further decrease in the dc voltage displayed by the meter, and an increase in the peak-to-peak ripple displayed by the oscilloscope. Typical value is $22\text{--}28\text{ V}$, with a peak-to-peak ripple of $6\text{--}11\text{ V}$. The ripple voltage is a function of the filter capacitors in the test unit, and will be fairly constant. See Table 1 and Table 2 for other considerations. (The ripple frequency will also change from 120 Hz to 60 Hz .) These changes are due to the half wave rectifier and the smaller filter capacitor in the test unit. Disconnect the 30 ohm load; the dc voltage should increase to approximately $32\text{--}35\text{ V}$. Return the AC/DC switch to the DC position. Failure to supply adequate voltage in this step implies that the ac winding connected to pins 1A and 1B is defective.

Step VII—Phasing of AC Windings

By now, both ac floating windings supplied to the compartment have been checked for adequate voltage and current. If their phasing relative to each other and to the windings connected to pins 5A and 5B is correct, DS1 and DS2 will be extinguished. If DS2 is lit, reverse the transformer leads to pins 1A and 1B. If DS1 is lit, reverse the transformer leads to pins 13A and 13B.

Step VIII— $+12\text{ V}$ dc Supply

Presets:

Meter Switch	Position 1
AC/DC Selector	AC
A/B Selector	B
External Load	Disconnected

Procedure:

The meter displays the raw 12 V dc voltage supplied to pins 2A and 2B. Refer to Table 3 for proper values.

CAUTION: Surface temperature of test load resistors may become too hot for safe handling. Refer to general instruction no. 2.

Connect the 5 ohm load to the $+5\text{ V}$ supply. There will be a decrease in dc voltage displayed by the meter, and an increase in peak-to-peak ripple displayed by the oscilloscope, as shown by Table 4. Inadequate performance is probably due to a defective diode or filter capacitor in the mainframe supply. A defective transformer winding or a blown fuse is another possibility. This completes the tests for this compartment.

TABLE 1

TM 501	TM 503	TM 504	TM 506	TM 515
34.3 ± 0.5	33.3 ± 0.5	33.5 ± 0.5	33.6 ± 0.5	33.7 ± 0.5

Plus and minus 33.5 V dc bused supplies. Typical no load voltage at 60 Hz, and with line voltage adjusted for center of range. These voltages are quite dependent on line voltage and are sensitive to line voltage waveform distortion.

TABLE 2

TM 501	TM 503	TM 504	TM 506	TM 515
-28.0 V	-29.5 V	-31.5 V	-31.6 V	-30.5 V
- 2.6 V	- 1.4 V	- 650 mV	- 600 mV	- .600 mV

Plus and minus 33.5 V dc bused supplies. Dc voltage with 500 mA load (upper) and peak-to-peak ripple with 500 mA load (lower). These are approximate worst-case values at 60 Hz and with line voltage adjusted for center of range. At 50 Hz, ripple will increase by about 25%, with a corresponding decrease in dc voltage. (Dc voltage will decrease by about 60% of the increase in peak-to-peak ripple.) The dc voltage is quite sensitive to line voltage, including waveform distortion.

TABLE 3

TM 501	TM 503	TM 504	TM 506	TM 515
12.8 ± 0.5	11.7 ± 0.5	13.2 ± 0.5	13.7 ± 0.5	14.0 ± 0.5
N/A	N/A	13.2 ± 0.5	13.7 ± 0.5	N/A

12 V dc supply. Typical no load voltage at 60 Hz and with line voltage adjusted for center of range. These voltages are quite dependent on line voltage and are sensitive to line voltage waveform distortion. Upper number is supply bused to standard compartments. Lower number is for high power compartment.


TABLE 4

TM 501	TM 503	TM 504	TM 506	TM 515
-9.3 V	-9.7 V	-11.7 V	-12.5 V	-12.2 V
N/A	N/A	-11.7 V	-12.5 V	N/A
- 1.8 V	- 1.0 V	- 600 mV	- 600 mV	- .600 mV
N/A	N/A	- 600 mV	- 600 mV	N/A

12 V dc supply. Dc voltage and peak-to-peak ripple with 1.0 A load. First row is dc voltage at standard compartment; second row is dc voltage at higher power compartment; third row is peak-to-peak ripple at standard compartment; fourth row is peak-to-peak ripple at high power compartment. These are approximate worst-case values at 60 Hz and with line voltage adjusted for center of range. At 50 Hz, ripple will increase by about 25% with a corresponding decrease in dc voltage. (Dc voltage will decrease by about 60% of the increase in peak-to-peak ripple.) The dc voltage is quite sensitive to line voltage, including waveform distortion.

IMPORTANT NOTE

It is the user's responsibility to follow good engineering practice, including the observance of all applicable safety procedures, in designing, constructing, and using any device described in this Construction Note. And while the suggested circuits for TM 500 blank plug-in kits are believed to be suitable for the described application, Tektronix does not guarantee their performance or warrant that they are useful for any particular purpose, and no such warranty should be implied. Finally, because Tektronix has no control over the construction or use of equipment built using TM 500 Construction Notes, it follows that Tektronix can accept no responsibility whatsoever for any claim or loss arising either directly or consequently from such construction or use.

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