TRANSFORMER RATIOMETER
TR700/TR800

CAT. NO. 820110/820130

OPERATING AND INSTRUCTION MANUAL

P/N 820111/820131
S/N 8470 & UP
910624

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1. GENERAL INFORMATION

1.1 GENERAL DESCRIPTION

The TR800 is a portable instrument designed for the accurate ratio measurement of transformers and all devices with AC ratiometric dividers associated with them.

Built into the TR800 is a current meter for the measurement of the exciting current of the transformer under test. Keeping a history of excitation current has proved to be a reliable way of detecting problems in transformers.

The phase deviation feature of the TR800 gives the operator the phase difference between primary and secondary voltages, which is useful in determining if there are shorted turns or whether the winding has an unequal number of turns connected in parallel.

Three-phase switching on the TR800 simplifies test procedures, saves time and greatly reduces the risk of electric shock.

1.2 FEATURES

- Built-in three-phase lead switching.
- High ratio range; 1:1 to 2021:1.
- Ratio's all types of C.T.s.
- Full internal protection from over-voltage and shorted output conditions.
- True four terminal measurements for high accuracy.
- Direct reading of percent deviation of transformer ratio.
- Phase angle measurement provided to give more accurate indication of transformer condition.
- Durable transport case provided for longer instrument life.
- Built-in current meter for performing excitation tests.

1.3 SPECIFICATIONS

Specifications: 25°C ±5°C 6 months 50 or 60Hz ±2Hz.

Bridge: Transformer ratio arm bridge circuit with phase sensitive null detector.

Bridge Output Test Voltage: 120V, 1A isolated, line dependent.
12V, 1A isolated, line dependent.
Frequency: 50 or 60Hz depending on line frequency.

Ratio Measurements:
(Exclusive of % Deviation Dial)

Multiplier	Resolution	Maximum Range
0.1	0.001	2.000:1
0.2	0.002	4.000:1
0.5	0.005	10.00:1
1.0	0.01	20.00:1
2.0	0.02	40.00:1
5.0	0.05	100.0:1
10.0	0.1	200.0:1
20.0	0.2	400.0:1
50.0	0.5	1000.0:1
100.0	1.0	2021.0:1

Accuracy: ±0.1% of ratio.

NOTE: Display by TR800 is ratio at test voltage (12 or 120V) and may not be ratio of device at its rated voltage or current.

% Deviation Dial

Maximum Range: +0.5 to -0.5 percent of ratio reading.
Resolution: 0.02% of ratio reading.
Accuracy: ±2% of dial reading.

1.3 SPECIFICATIONS (continued)

1.3 SPECIFICATIONS (continued)

Phase Deviation Dial

Multiplier	Resolution	Maximum Range
0.1	0.02CR	±0.5CR
1.0	0.2CR	±5.0CR

Accuracy: ±2% reading.

NOTE: 1 centiradian (CR) = 34.5 minutes.
60 minutes = 1 degree.

Excitation Meter

Multiplier	Resolution	Maximum Range
1.0	2mA	50mA
10.0	20mA	500mA

Accuracy: ±3% full scale.

Protection

"X" Input: 150V RMS maximum before protection shorts X0 to X1. Energizing X side of transformer instead of H side) will usually try to develop in excess of 150V on X side of TR800 thereby enabling protection to short X0 to X1. This prevents any damaging voltage from entering the instrument.

Resettable Circuit Breaker:
2A maximum fast acting; 0.1 second turn-off time. Prevents any circuit damage due to high currents created when the output supply is shorted or test transformer is connected backwards.

Physical:	Instrument and accessories supplies with portable foam-lined carrying case. Case has hinged opening from above with a lockable latch.	

Sizes:	Instrument:	400 x 220 x 250mm (15 x 9 x 10 inches)
	Case:	480 x 530 x 370mm (19 x 21 x 14 inches)
Weight:	Instrument:	9kg (20 lbs)
	Shipping:	12kg (27 lbs)

1.4 ACCESSORIES FURNISHED

The TR700 Transformer Ratiometer is supplied complete with:

820111	Instruction Manual
820112	Set of 10m leads
	Transport Case
	AC Line Cord

The TR800 Transformer Ratiometer is supplied complete with:

820131	Instruction Manual
820132	Set of 10m Leads
	Transport Case
	AC Line Cord

1.5 ACCESSORIES AVAILABLE

820111	Operating and Instruction Manual, TR700
820112	10M Test Leads
820113	25M Test Leads
820116	Range Extension Transformer, 5:1/2:1, Step-up
820118	CCVT Ratio Test Extension Adaptor
820131	Operating and Instruction manual, TR800
820132	10M Test Leads
820133	25M Test Leads
820134	Invertor, 12VDC to 120VAC
820135	10M Test Lead Extension
820136	25M Test Lead Extension

1.6 CHANGES

Please note that this instrument is subject to continuous development and improvement. This instrument may therefore incorporate minor changes in detail from the information contained herein.

1.7 WARRANTY

Multi-Amp warrants this instrument sold by us or our authorized agents, to be free from defects in material and workmanship for a period of 12 months from date of shipment. During the warranty period, Multi-Amp will, at our option, repair or replace the Instrument or part thereof which proves to be defective providing:

(1) The Instrument is returned properly packed and transportation prepaid with prior authorization from us or our appointed agent,

(2) The Instrument has not been altered, modified or repaired by unauthorized personnel and,

(3) That our examination discloses to our satisfaction that any improper operation or failure was the result of defective material or workmanship and was not the result of improper use, negligence or accident, exceeding environmental limits, or connecting the instrument to incompatible equipment.

This warranty is exclusive and is given and accepted in lieu of all other warranties, express or implied, and constitutes fulfillment of all our liabilities to the purchaser. Multi-Amp specifically disclaims the implied warranties of merchantability and fitness for a specific purpose. We assume no liability, in any event, for consequential damages, for anticipated or lost profits, for personal injury due to use or accident, for incidental damages or loss of time or other losses incurred by the purchaser or any third party in connection with instruments covered by this warranty or otherwise.

2. INSTALLATION

2.1 UNPACKING AND INSPECTION

Prior to shipment this instrument was electrically tested and mechanically inspected and found to meet specifications and be free of mechanical defects.

After unpacking the instrument, visually inspect the instrument and accessories for damage. If evidence of damage is present YOU must contact the carrier who transported the unit and file a claim in writing. The shipping container and packing material should be retained for inspection by the carrier's agent. Electrical operation per section 3 should be checked as soon as possible after shipment.

2.2 PREPARATION FOR USE

INSURE THAT THE APPARATUS TO BE TESTED IS CLEARED AND DE-ENERGIZED PRIOR TO TEST. It is highly recommended that the user familiarize himself with the controls, functions and features detailed in section 3 prior to use.

2.3 LINE SUPPLY VOLTAGE

This instrument is shipped from the factory for operation on either 120V, 60Hz line or 220V, 50Hz. Voltage is noted on the test report. To prevent damage to the instrument, ensure that the voltage on the test report matches your particular line voltage.

2.4 REPACKING AND SHIPMENT

To insure proper shipment of this instrument it is recommended that the original reusable container and packing material be retained. If being returned for calibration or service, please attach a card to the instrument specifying the owner, model and serial number and service required.

3. OPERATING INSTRUCTIONS

3.1 PANEL CONTROLS AND OPERATING FUNCTIONS

This section details and describes the operating features of the TR700 and TR800. (Refer to Figures 1 and 2).

1. Line Input Socket - Standard input for line cord provided.

2. Instrument ON - Flipping this switch upwards activates the instrument, immediately sending voltage to the "H" output terminals. This switch is also a fast-acting circuit breaker, therefore, protecting the instrument by shutting itself off. To reset, simply flip switch upwards.

3. Power ON Indicator - This red L.E.D. is illuminated when instrument is energized.

4. Detector Phasing Switch - State of bridge balance of ratio or phase deviation. Null meter (17) is indicator for balance condition.

5. Detector Sensitivity - The sensitivity of null meter (17) is controlled with this adjustment. As a general rule, the higher ratio's require higher sensitivity. eg. A 1:1 ratio, therefore would require the lowest gain and a 2000:1 ratio would require a high sensitivity setting.

6. Phase Multiplier Switch - The approximate range of phase deviation is determined with this switch.

7. Phase Deviation Dial - The precise value of phase deviation is determined by this setting in conjunction with the phase multiplier switch (6).

8. Ratio Multiplier Switch - The approximate range of the ratio being tested is determined with this switch.

9. Ratio Switches - These switches determine the "Ratio" of the test transformer, when used in conjunction with ratio multiplier (8).

3.1 PANEL CONTROLS AND OPERATING FUNCTIONS (continued)

10. Ratio Deviation Dial - Once the calculated transformer ratio is entered into the ratio switches (9) and ratio multiplier (8), this dial gives a direct reading of percent deviation of the test transformer versus the entered ratio. When balancing ratio switches, this dial should ALWAYS be in "0" position.

11. "X" Input - This connector couples with the provided leads marked "X0 to X3".

12. "H" Input - This connector couples with the provided leads marked "H0 to H3".

13. "X" Selector - This switch selects input to be measured from "X Lead" connections.

14. "H" Selector - This switch selects input to be measured from "H Lead" connections.

15. Polarity - This switch reverses the polarity of measured ratio and also acts as a polarity indicator.

16. Test Voltage Selector - This switch applies 12V or 120V to the test transformer. 12V is generally used for C.T.s where cores saturate at low voltages.

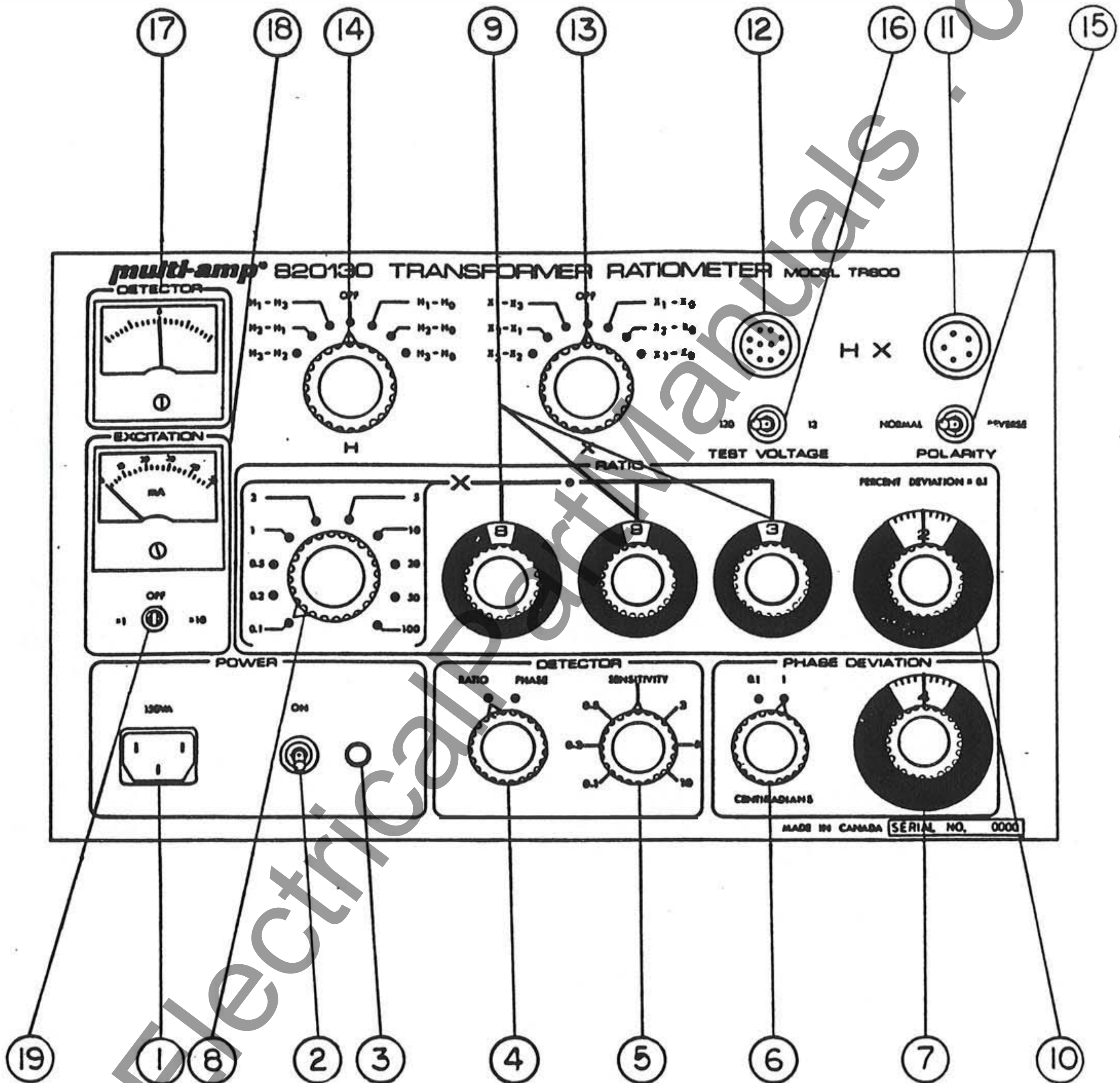
17. Null Meter - Indicator for balance of ratio and phase. Detector phasing switch (4) determines which is being balanced.

18. Excitation Ammeter - This meter indicates the amount of current required to excite the test transformer at the selected test voltage (16) under no load conditions.

19. Excitation Range Switch - The appropriate range of excitation current (18) is determined with this switch.

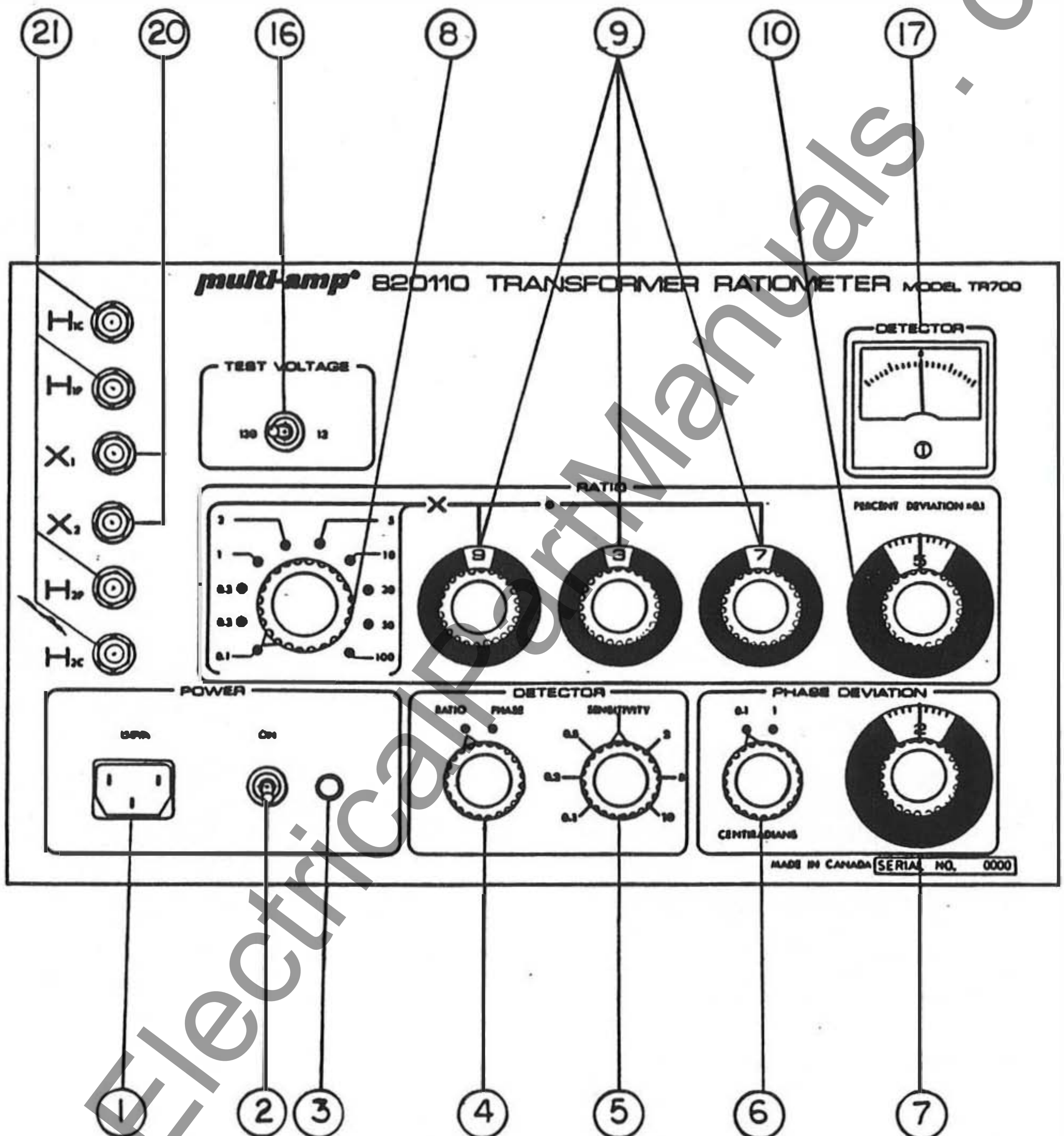
20. "X" Input - These binding posts couple with the provided leads.

21. "H" Input - These binding posts couple with the provided leads.



PANEL CONTROLS AND OPERATING FUNCTIONS - TR800

FIGURE 1



PANEL CONTROLS AND OPERATING FUNCTIONS - TR700

FIGURE 2

3.2 GENERAL OPERATING INSTRUCTIONS USING A SELF-CHECK PROCEDURE (Ratio 1:1)

TR800 (Refer to Figure 1)

1. Insure that instrument power switch (2) is in down position.

2. Connect high side leads(H markings on alligator clips) to "H" input(12). Connect low side leads (X markings on alligator clips) to "X" input(11).

3. Short all alligator ends as follows:

H0 to X0	H1 to X1
H2 to X2	H3 to X3

4. If line cord is not plugged into instrument, do so now.

5. Set the TR800 instrument controls as follows

Detector phasing switch:	Ratio.
Detector sensitivity:	Midway.
Phase multiplier switch:	0.1.
Phase deviation dial:	0.
Ratio multiplier switch:	0.1.
Ratio switches:	10. - 0 - 0.
Percent deviation dial:	0.
"X" Selector switch:	X3 - X2.
"H" Selector switch:	H3 - H2.
Polarity switch:	Normal.
Test voltage selector:	12V.
Excitation range switch:	x 10.

6. Ensure that personnel are kept clear of alligator clips. Clips should be clear of ground or any metal objects, as they will be at a potentially lethal voltage.

7. Turn power switch ON.

8. Observe "Null Detector" needle. It should be pointing towards "0". If not, obtain centre balance by adjusting "Percent Deviation Dial". Dial should remain at approximately "0" (±1 division) with needle balanced at centre "0" position.

9. The excitation meter should read approximately "0". If not, just above the "0" line.

10. Set "Test Voltage Selector" to "120V". Re-adjust "Percent Deviation Dial". It should still balance at approximately "0". If needle movement is too sensitive, set "Detector Sensitivity" back until needle movement is comfortable to operator (this does not affect accuracy).

If all of the above goes accordingly, the instrument has been balanced to a ratio of 1.000:1.

11. Switch detector phasing switch to "Phase".

12. Observe "Null Detector" needle. It should point towards centre "0", if not, obtain centre balance by adjusting phase deviation dial (7). Dial should remain at approximately "0" (±1 division) with needle balanced at centre "0" position.

If all of steps 11 and 12 go accordingly, the instrument has been balanced to a phase deviation of 0.0 CR (centiradians) which indicates the internal reference transformer is okay. The following steps will verify the correct operation of the "X" and "H" selector switches (13 & 14) and the corresponding H and X leads.

13. Turn instrument OFF.

14. Set "H" selector to "H2 - H1". Set "X" selector to "X2 - X1".

15. Turn instrument ON.

16. "Null Detector" needle should be balanced with detector phasing switch on "Ratio" and "Phase.

17. Repeat steps 13 to 15. Exchanging the following:
    a. H2 - H1 to H1 - H3.
       X2 - X1 to X1 - X3, then,
    b. H1 - H3 to H1 - H0.
       X1 - X3 to X1 - X0, then,
    c. H1 - H0 to H2 - H0.
       X1 - X0 to X2 - X0, then,
    d. H2 - H0 to H3 - H0.
       X2 - X0 to X3 - X0.

This should fully complete a self-test of the instrument as well as the test leads.

3.2 GENERAL OPERATING INSTRUCTIONS USING A SELF-CHECK PROCEDURE (continued)

<u>TR700</u> (Refer to Figure 2)

1. Insure that instrument power switch (2) is in down position.

2. Connect high side leads ("H" markings on alligator clips) to "H" input (21) (H1C, H1P, H2C and H2P).

3. Connect low side leads ("X" markings on alligator clips) to "X" input (20) (X1 and X2).

4. Short all clip ends as follows:
   H1 to X1
   H2 to X2

5. If line cord is not plugged into instrument, do so now.

6. Set the TR700 instrument controls as follows

Detector phasing switch:	Ratio.
Detector sensitivity:	Midway.
Phase multiplier switch:	0.1.
Phase deviation dial:	0.
Ratio multiplier switch:	0.1.
Ratio switches:	10. - 0 - 0.
Percent deviation dial:	0.
Test voltage selector:	12V.

7. Ensure that personnel are kept clear of alligator clips. Clips should be clear of ground or any metal objects, as they will be at a potentially lethal voltage.

8. Turn power switch ON.

9. Observe "Null Detector" needle. It should be pointing towards "0". If not, obtain centre balance by adjusting "Percent Deviation Dial". Dial should remain at approximately "0" (±1 division) with needle balanced at centre "0" position.

3.2 GENERAL OPERATING INSTRUCTIONS USING A SELF-CHECK PROCEDURE (continued)

10. Set "Test Voltage Selector" to "120V". Re-adjust "Percent Deviation Dial". It should still balance at approximately "0". If needle movement is too sensitive, set "Detector Sensitivity" back until needle movement is comfortable to operator (this does not affect accuracy).

If all of the above goes accordingly, the instrument has been balanced to a ratio of 1.000:1.

11. Switch detector phasing switch to "Phase".

12. Observe "Null Detector" needle. It should point towards centre "0", if not, obtain centre balance by adjusting phase deviation dial (7). Dial should remain at approximately "0" (±1 division) with needle balanced at centre "0" position.

If all of steps 11 and 12 go accordingly, the instrument has been balanced to a phase deviation of 0.0 CR (centiradians) which indicates the internal reference transformer is okay.

This should fully complete a self-test of the instrument as well as the test leads.

3.3 MEASUREMENT OF SINGLE-PHASE, TWO-WINDING TRANSFORMERS (Refer to Figures 1 and 2)

1. Insure that instrument power switch (2) is in down position.

2. Connect high side leads ("H" marking on alligator clips) to "H" input (12 & 21).

3. Connect low side leads ("X" markings on alligator clips) to "X" input (11 & 20).

4. Assuming the transformer under test has the following markings:

FIGURE 3

Connect the TR800 leads to the corresponding markings:

"H" Leads	- H1 to H1.	"X" Leads	- X1 to X1.
	- H2 to H2.		- X2 to X2.

5. Ensure that the remaining leads (H3, H0, X3, X0) are free and clear of the test transformer and any grounded points, as they may accidentally be energized.

6. Set the instrument controls as follows:

Detector phasing switch:	Ratio.
Detector sensitivity:	Midway.
Phase multiplier switch:	0.1.
Phase deviation dial:	0.
Ratio multiplier switch:	0.1.
Ratio switches:	8. - 0 - 0.
Percent deviation dial	0.
"X" Selector switch:	X2 - X1.
"H" Selector switch:	H2 - H1.
Polarity switch:	Normal.
Test voltage selector:	12V.
Excitation range switch:	x 10.

3.3 MEASUREMENT OF SINGLE-PHASE, TWO-WINDING TRANSFORMERS (continued)

It should be noted that the test voltage, 12V is used in this application to achieve an approximate balance, and therefore ratio, unless test specimen is a current transformer where upon 12V is used to achieve final balance as well

7. Ensure that personnel are kept clear of alligator clips and test transformer.

8. Turn power switch ON.

9. Observe "Null Detector" needle (17). It will be pointing to the left side of the meter. (If not, check polarity switch (normal) and lead connections ("H" on high side and "X" on low side)).

10. While still observing "Null Detector", turn ratio multiplier switch clockwise until null detector (17) swings to the right. Turn ratio multiplier switch counter-clockwise one position.

    eg. Needle swings right on "10" multiplier. Switch should be placed in "5" multiplier before continuing to next step.

11. With the ratio in approximate range (needle pinned to left), rotate left most ratio switch (9) clockwise (start on "8") until null indicator swings right. Turn ratio switch back one position.

12. Rotate middle ratio switch clockwise (start on "0") until null indicator swings right. Turn ratio switch back one position.

13. Rotate right most ratio switch clockwise until needle either swings right or comes to a balance in the centre of the meter.

14. If null detector needle is still settled either left or right of centre, rotate percent deviation dial (10) until needle balances to zero.

15. Switch detector phasing switch to "Phase".

16. Adjust phase deviation dial (7) until "Null Detector" (17) balances to centre "0".

3.3 MEASUREMENT OF SINGLE, TWO-WINDING TRANSFORMERS (continued)

17. If balance is not possible, switch phase multiplier switch to "1" and re-attempt step 16.

18. Once balance is achieved, set "Test Voltage Selector" to "120V" and re-balance. (Adjustments should be minimal). 120V should only be used for C.T.s that have sufficient core to handle this voltage. Otherwise, 12V is used on CT's.

EXAMPLES OF DIAL INTERPRETATION

After the ratiometer is balanced, the ratio of the transformer under test is determined as follows:

If ratio deviation dial is not used, i.e. set at 0, then;

Ratio = Multiplier x Reading on Ratio Dials

Examples:

1. If multiplier is 0.1 and ratio dials read 17.32, then:

   Ratio = 0.1 x 17.32 = 1.732 or 1.732:1

2. If multiplier is 0.5 and ratio dials read 10.02, then:

   Ratio = 0.5 x 10.02 = 5.01 or 5.01:1

If ratio deviation dial (10) is used for balancing, determine ratio as on previous page and multiply obtained ratio by a factor $\frac{1000 + D}{1000}$ to obtain exact value.

Examples:

1. If ratio dial reads 10.00, multiplier is 2.0 and deviation dial reads +1.5, then:

$$\text{Ratio} = 2 \times 10.00 \times \frac{1000 + 1.5}{1000}$$

$$= 20.00 \times \frac{1001.5}{1000}$$

$$= 20.03$$

The ratio deviation dial is most useful when percent deviation from a predetermined value has to be determined. If the deviation dial reads positive then the ratio of the transformer under test is higher than the preset value. Similarly, if the ratio of the transformer under test is lower than the preset value, then the deviation dial will read a negative value.

Examples:

Name plate ratio 4800 volts to 120 volts.
Ratio = 40.00
Set multiplier and ratio dials to obtain a ratio of 40.
Two possibilities exist: M = 2, R = 20.00 (19 + 1 + 0) or,
M = 5, R=8.0 (8 + 0 + 0)

Now balance only with ratio deviation dial. Deviation dial reads in mils (1 mil = 1/1000 or 0.1%) as to how high or low the ratio is from nameplate.

When obtaining ratio readings, the second and third ratio dials may exceed 9. If that occurs they should be read in the following manner:

8 + 10 + 9 = 9.09
19 + 11 + 10 = 20.20
10 + 0 + 10 = 10.10

3.3 MEASUREMENT OF SINGLE-PHASE, TWO-WINDING TRANSFORMERS (continued)

PHASE ANGLE BALANCE

The phase deviation dial reads directly in centiradians regardless of ratio, as long as proper multiplier (0.1 or 1.0) is applied. In normal testing, phase deviation should be minimal. Excessive dial readings from normal should be investigated because they indicate possible shorted turns, presence of circulating current paths, or other errors.

One centiradian is equal to 34.37 minutes. To convert the phase angle deviation dial from centiradians to minutes, multiply the dial reading by 3.437 when operating on the 0.1 multiplier and by 34.37 when operating on the 1.0 multiplier.

3.4 SINGLE PHASE AUTO TRANSFORMERS AND REGULATORS

TEST USING TR700

1. Auto Transformers (See Figure 4)

   Make connection as shown in figure 4, connecting:
   - i. H1 to (H1C + H1P)
   - ii. X1 to X1
   - iii. H0 to (H2C + H2P) + X2

   Follow steps of section 3.3 to complete the test.

2. Regulators (See Figure 5)

   Make connection as shown in figure 5, connecting:
   - i. S to X2
   - ii. L to (H2C + H2P)
   - iii. SL to (H1C + H1P) + X1

   Follow steps of section 3.3 to complete the test.

TEST USING TR800

1. Auto Transformers (See Figure 4)

   Make connection as shown in figure 4, connecting:
   - i. H1 to H1
   - ii. X1 to X1
   - iii. H0 to H0 + X0

   Follow steps of section 3.3 to complete the test.

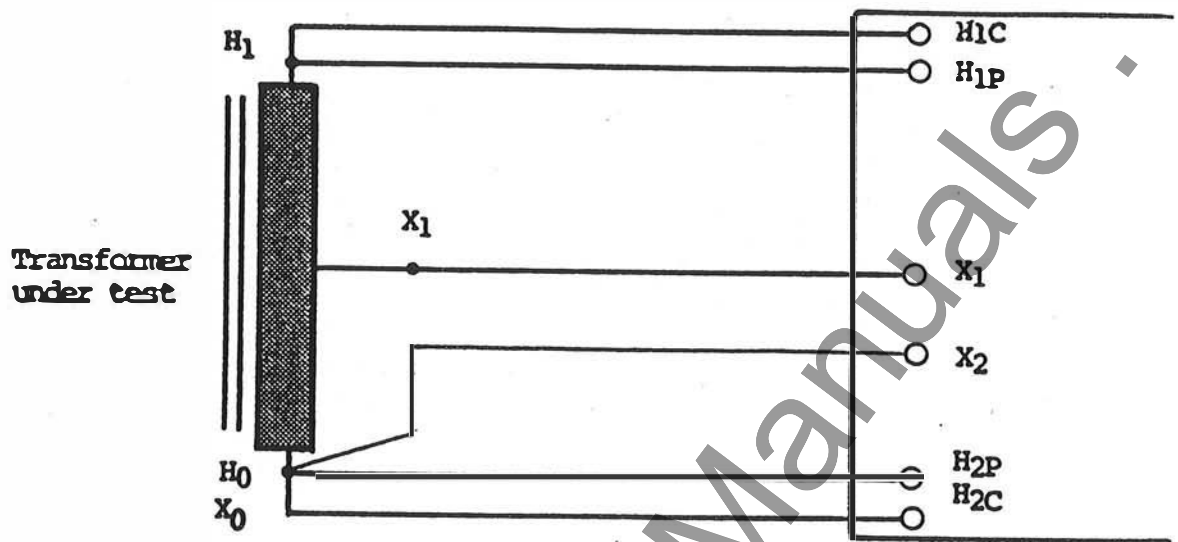
2. Regulators (See Figure 5)

   Make connection as shown in figure 5, connecting:
   - i. S to X2
   - ii. L to H2
   - iii. SL to H0 + X0

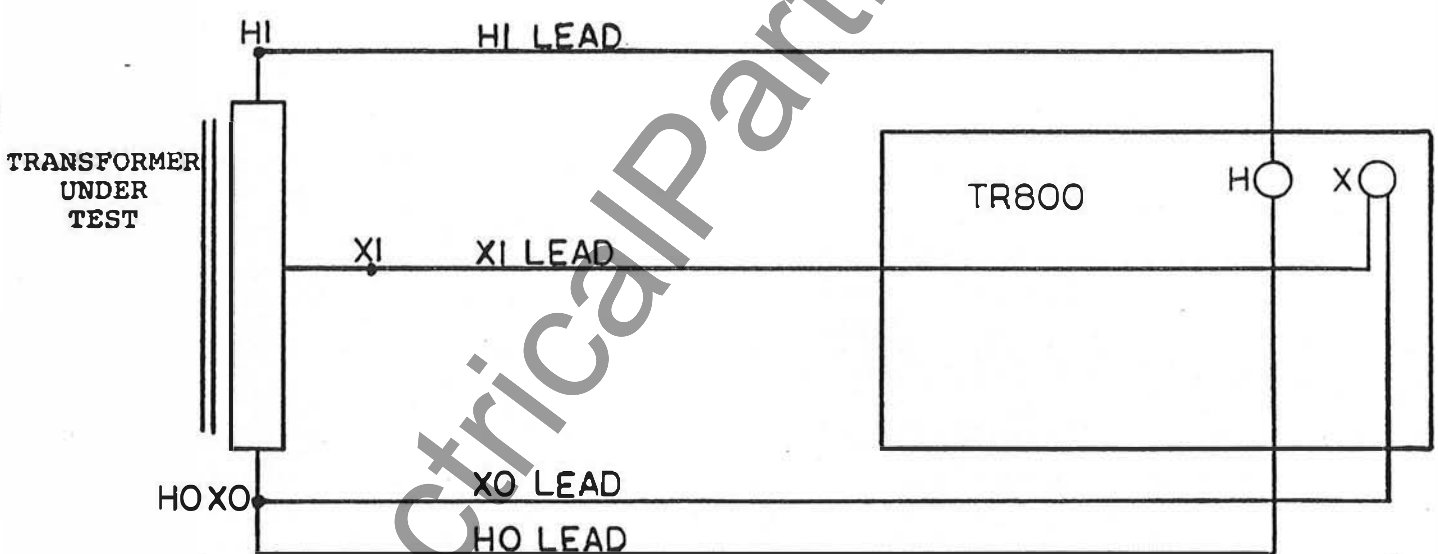
   Follow steps of section 3.3 to complete the test.

3.4 SINGLE PHASE AUTO TRANSFORMERS AND REGULATORS (continued)

TR700



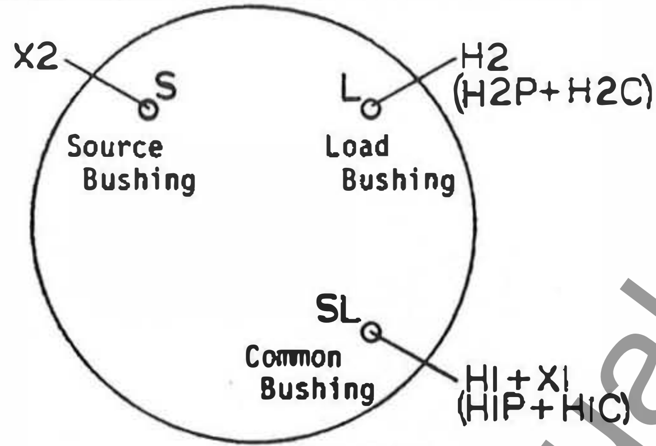
TR800

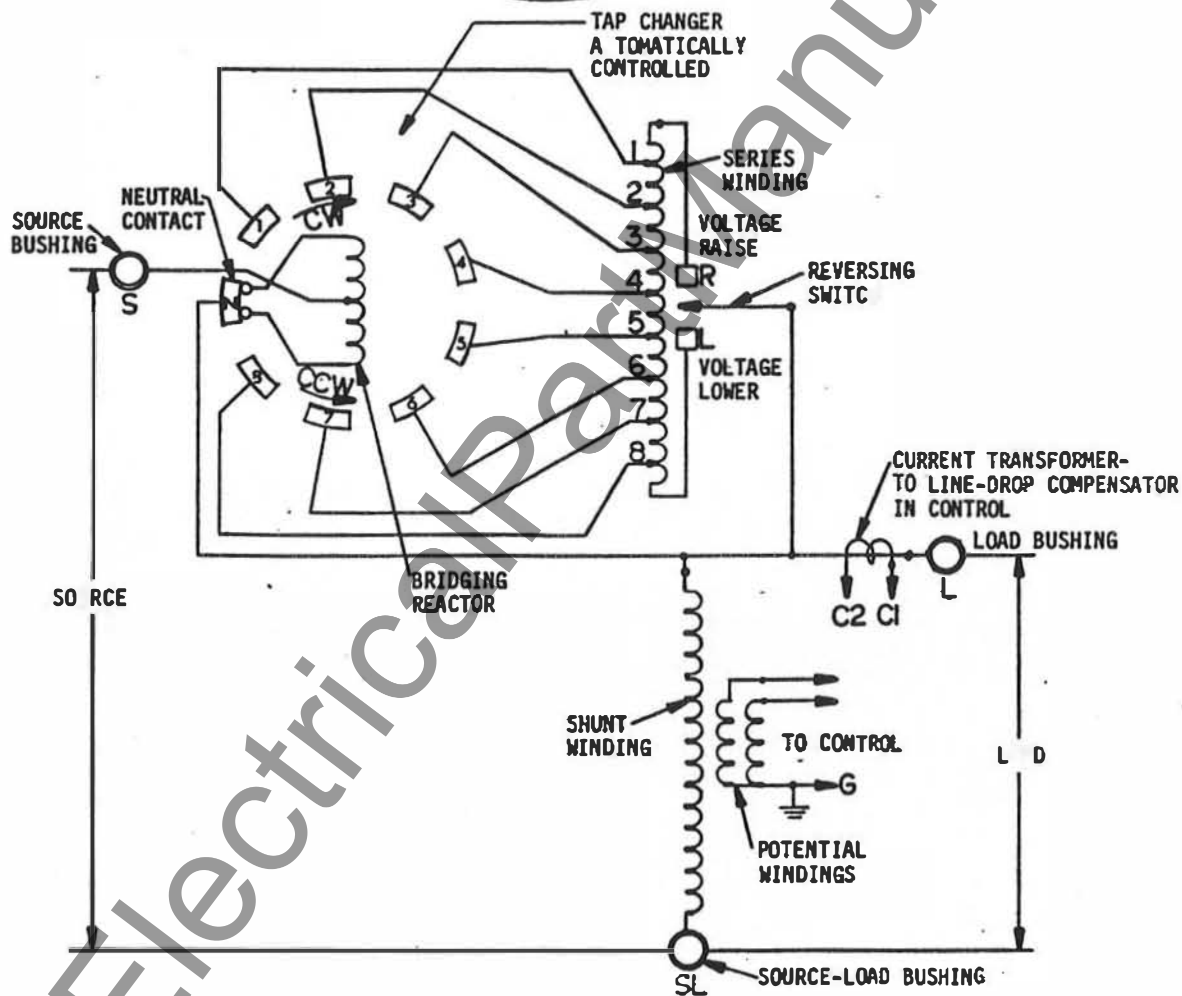


CONNECTION OF A SINGLE PHASE AUTO TRANSFORMER

FIGURE 4

3.4 SINGLE PHASE AUTO TRANSFORMERS AND REGULATORS (continued)





ONE STEP VOLTAGE REGULATOR

FIGURE 5

3.5 DETERMINING TRANSFORMER CONNECTIONS USING ONLY NAMEPLATE DATA

For most transformers, a connection diagram is available from our Table I, for these transformers, one needs only match the correct figure from the nameplate with the corresponding figure on our chart and follow the instructions.

For many utilities, different nameplate diagrams make it impossible to always find a corresponding figure on our Table I. To assist in determining the correct connection and testing of any transformer, the following explanation will assist in self checking one's work.

EXAMPLE 1: DETERMINING IN-PHASE "X" AND "H" VECTORS

For this diagram, one must determine two lines which are PARALLEL to each other. For example, H1-H3 is parallel to X2-X1. Only H1-H3 will ratio against X2-X1. The polarity is also important and is noted by the order of the phase mentioned i.e. H1-H3 is opposite polarity to H3-H1.

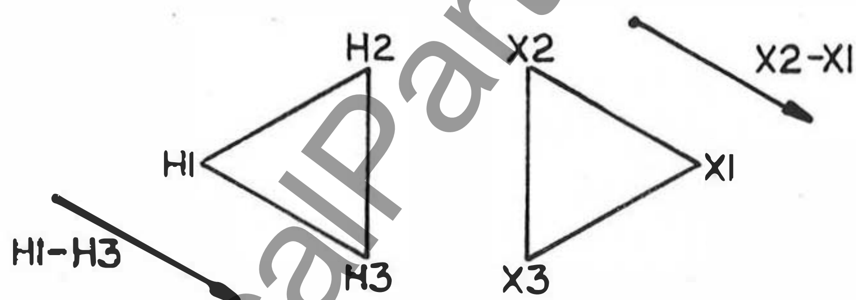


FIGURE 6

In connection to the TR800, an operator would typically connect the leads as marked to the corresponding bushings i.e. H1 to H1, H2 to H2 etc. therefore in testing this transformer, the following test positions on the "X' and "H" switches of the TR800 would be used:

"H" SWITCH	"X" SWITCH	POLARITY
H1-H3	X2-X1	Normal
H2-H1	X1-X3	Normal
H3-H2	X3-X2	Normal

For the TR700, each connection is made as a single phase transformer.

EXAMPLE 2: USE OF JUMPERS (i.e. no neutral accessible)

In some cases, parallel lines on a transformer diagram are not apparent, or as is most often the case, a neutral connection is not available and hence no test appears possible.

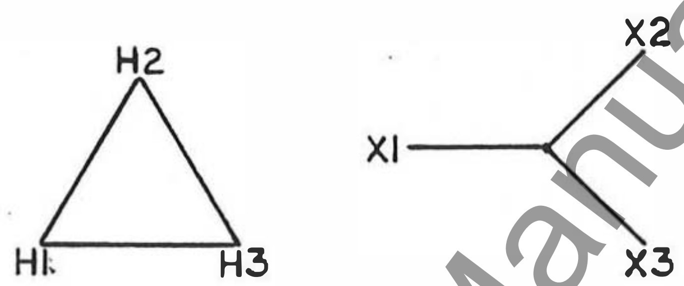


FIGURE 7

In the above diagram, H1-H3 is parallel to X1-X0, but with no X0 available, an alternative method must be used. By jumpering X2 to X3, a cancelling effect of the upward action of X2 with the downward action of X3 is obtained and a resultant direction is parallel to X1-X0.

H1-H3 can now be compared to X1-(X2 jumpered to X3). The ratio measured by the TR800 will be higher than the nameplate ratio. To obtain the multiplier, refer to Table I for a similar configuration.

3.6 THREE PHASE TRANSFORMERS (Two Windings)

In testing three phase transformers it is necessary to pay special attention to the relative phase relationships and winding connections.

Table I has been devised to simplify taking the ratio measurements of three phase transformers with single phase excitation. The nameplate voltage ratio (R) is the ratio of the HV line-to-line voltage and the LV line-to-line voltage. Table I shows the relationship between the measured ratio and the actual ratio based on line-to=line voltages. Even though neutrals may not be accessible, it is possible to determine ratios with only minor changes in the test method. This also permits the testing of zigzag windings without available neutrals.

It should also be noted that if the connections are made according to Table I, the relative phase rotation of the HV and LV can be verified.

The step by step procedure described in section 3.3 should be followed for checking ratio, polarity and phase rotation.

3.7 THREE PHASE AUTO TRANSFORMERS

Ratio tests on three phase auto transformers are carried out on a single phase basis following the same general procedure as described for single phase auto transformers. Connections shown in Table I between the ratiometer and transformer being tested should be observed with care. The step by step procedure for obtaining ratio, phase rotation and polarity is similar to that described in the previous sections. Make sure that while conducting the tests with Model TR800 (with 3 phase switching) X0 lead from the instrument lead bundle is not connected to H0-X0 terminal of transformer being tested.

CONNECTIONS USING TRANSFORMER NAMEPLATE

FIGURE	HIGH VOLTAGE (H)	LOW VOLTAGE (L)		JUMPER	SWITCH		MEASURED VALUE OF RATIO	VDE NOTATION	NOTES
		DIRECT	(REVERSE)		H	X			
1	H1 H2	X1 X2	X2 X1	--	2 - 1	2 - 1	R	--	Single Phase Transformer
2	S H1 L X1 H0 SL X0			--	1 - 0	1 - 0	R	--	Voltage Regulator
3	H2 H1 H3	X2 X1 X3	X3 X1 X2	--	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	R	Yy0 (Yy6)	No Accessible Neutral
4	H2 H0 H1 H3	X2 X0 X1 X3	X3 X1 X0 X2	--	1 - 0 2 - 0 3 - 0	1 - 0 2 - 0 3 - 0	R	Yy0 (Yy6)	
5	H2 H1 H3	X1 X2 X3	X3 X1 X2	H1 - H2 H2 - H3 H3 - H1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{\sqrt{3}}{2}$ R	--	<30° (<210°)
5a	H2 H1 H3	X1 X2 X3	X3 X1 X2	X3 - X2 X1 - X3 X2 - X1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{2}{\sqrt{3}}$ R	--	<30° (<210°)
6	H2 H0 H1 H3	X3 X1 X2	X1 X2 X3	--	1 - 0 2 - 0 3 - 0	2 - 1 3 - 2 1 - 3	$\frac{R}{\sqrt{3}}$	--	<210° (<30°)
7	H2 H1 H3	X1 X2 X3	X3 X1 X2	X3 - X2 X1 - X3 X2 - X1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{2}{\sqrt{3}}$ R	--	No Accessible Neutral <30° (<210°)
7a	H2 H1 H3	X1 X2 X3	X3 X1 X2	H1 - H2 H2 - H3 H3 - H1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{\sqrt{3}}{2}$ R	--	No Accessible Neutral <30° (<210°)
8	H2 H1 H3	X1 X2 X0 X3	X3 X1 X0 X2	--	1 - 3 2 - 1 3 - 2	1 - 0 2 - 0 3 - 0	$\sqrt{3}$ R	--	No Accessible Neutral on H.V. Side <30° (<210°)
9	H2 H1 H3	X2 X1 X3	X3 X1 X2	--	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\sqrt{3}$ R	Dd0 (Dd6)	
10	H2 H1 H3	X1 X2 X3	X3 X1 X2	X3 - X2 X1 - X3 X2 - X1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{2}{\sqrt{3}}$ R	--	No Accessible Neutral on L.V. Side <30° (<210°)
10a	H2 H1 H3	X1 X2 X3	X3 X1 X2	H1 - H2 H2 - H3 H3 - H1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{\sqrt{3}}{2}$ R	--	No Accessible Neutral on L.V. Side <30° (<210°)
11	H2 H1 H3	X1 X2 X0 X3	X3 X1 X0 X2	--	1 - 3 2 - 1 3 - 2	1 - 0 2 - 0 3 - 0	$\sqrt{3}$ R	--	<30° (<210°)

TABLE I

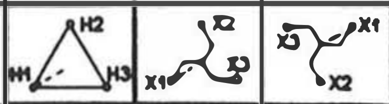
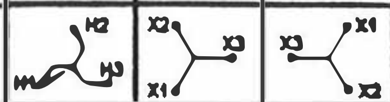
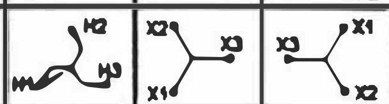
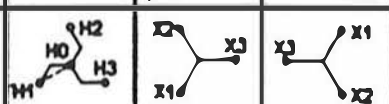
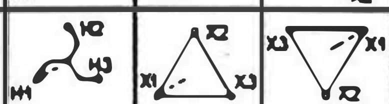
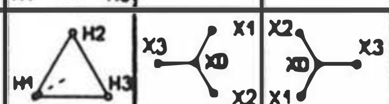
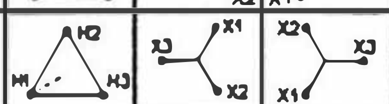
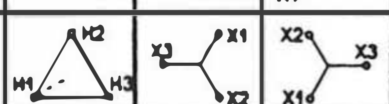
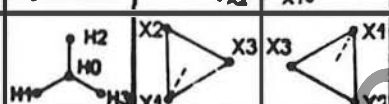
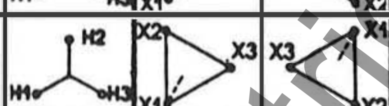
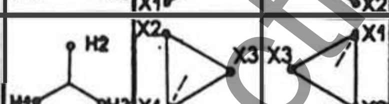
FIGURE	HIGH VOLTAGE (H)	LOW VOLTAGE (L) DIRECT	LOW VOLTAGE (L) (REVERSE)	JUMPER	SWITCH H	SWITCH X	MEASURED VALUE OF RATIO	VDE NOTATION	NOTES
12				--	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	R	Dz0 (Dz6)	
13				H3 - H2 H1 - H3 H2 - H1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{2}{\sqrt{3}}$ R	--	No Accessible Neutral <30° (<210°)
13a				X1 - X2 X2 - X3 X3 - X1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{\sqrt{3}}{2}$ R	--	No Accessible Neutral <30° (<210°)
14				--	1 - 0 2 - 0 3 - 0	1 - 3 2 - 1 3 - 2	$\frac{R}{\sqrt{3}}$	--	No Accessible Neutral on L.V. Side <30° (<210°)
15				--	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	R	--	No Accessible Neutral on H.V. Side
16				--	1 - 0 2 - 0 3 - 0	1 - 0 2 - 0 3 - 0	R	--	Three-Phase Auto-Transformer
17				--	1 - 3 2 - 1 3 - 2	3 - 0 1 - 0 2 - 0	$\sqrt{3}$ R	Dy5 (Dy11)	
18				X2 - X1 X3 - X2 X1 - X3	1 - 3 2 - 1 3 - 2	3 - 2 1 - 3 2 - 1	$\frac{2}{\sqrt{3}}$ R	Dy5 (Dy11)	
18a				H3 - H2 H1 - H3 H2 - H1	1 - 3 2 - 1 3 - 2	3 - 2 1 - 3 2 - 1	$\frac{\sqrt{3}}{2}$ R	Dy5 (Dy11)	
19				--	1 - 0 2 - 0 3 - 0	1 - 3 2 - 1 3 - 2	$\sqrt{3}$ R	Yd11 (Yd5)	
20				H3 - H2 H1 - H3 H2 - H1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{\sqrt{3}}{2}$ R	Yd11 (Yd5)	
20a				X1 - X2 X2 - X3 X3 - X1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{2}{\sqrt{3}}$ R	Yd11 (Yd5)	
21				--	2 - 1 3 - 2 1 - 3	1 - 0 2 - 0 3 - 0	$\sqrt{3}$ R	Yz5 (Yz11)	
22				H3 - H2 H1 - H3 H2 - H1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{2}{\sqrt{3}}$ R	Yz11 (Yz5)	
22a				X1 - X2 X2 - H3 X3 - X1	1 - 3 2 - 1 3 - 2	1 - 3 2 - 1 3 - 2	$\frac{\sqrt{3}}{2}$ R	Yz11 (Yz5)	

TABLE I (continued)

3.8 INTERPRETATION AND PROPER USE OF THE RATIO DEVIATION DIAL

PURPOSE OF DIAL

The Deviation Dial simplifies the determination of % ratio error for transformers. ANSI specifications allow a maximum of ±0.5% error or deviation from nameplate ratio.

Instead of using nameplate vs measured ratio and calculating the % deviation, one need only set the nameplate ratio of the TR800 dials (see example below) and adjust only the deviation dial until balance is obtained. This gives the operator an immediate indication of magnitude of the deviation and simplifies his written entry on his test report.

EXAMPLE

Nameplate Ratio: 4800 volts to 120 volts
Ratio = 40:1

1. Set multiplier and ratio dials to obtain nameplate ratio.

2. Mult. = 5 Ratio Dials = 8 + 0 + 0

3. Now balance only Ratio Deviation Dial. Dial balances at -1.2.

NOTE: The Deviation Dial reading must be multiplied by 0.1 to obtain % ratio error (indicated on front panel).

4. This indicates the ratio error is -0.12% from nameplate.

In the old method of testing, the Ratiometer would balance at 39.95 to 1. Operator would apply formula:

$$\frac{\text{Marked Ratio - Measured Ratio}}{\text{Marked Ratio}} \times 100$$

therefore, $\frac{40.0 - 39.95}{40.0} \times 100 = -0.12\%$

3.8 INTERPRETATION AND PROPER USE OF THE RATIO DEVIATION DIAL (continued)

3.8 INTERPRETATION AND PROPER USE OF THE RATIO DEVIATION DIAL (continued)

When filling out test sheets, much less written work using the deviation dial is required. e.g.:

TAP POSITION	NAMEPLATE RATIO	PERCENT DEVIATION			PHASE DEVIATION			EXCITATION CURRENT mA		
		A	B	C	A	B	C	A	B	C
1	40.0	-1.2	-1.0	-0.2	-	-	-	-	-	-
2	40.5	0.8	0.6	-0.1	-	-	-	-	-	-
3	41.0	3.5	-0.4	-0.2	2.9	-	-	25	8	8
4	41.5	0.0	0.1	0.1	-	-	-	-	-	-
5	42.0	-1.0	-0.8	-0.8	-	-	-	-	-	-
6	42.5									
7	43.0									
8	43.5									
9	44.0									

Only high readings of phase and excitation current are recorded.

3.9 CURRENT TRANSFORMERS

BUSHING CURRENT TRANSFORMERS

Bushing current transformers (BCT'S) can be tested for their ratio and phase angle characteristics with the TR700 and TR800 ratiometers. This checking is particularly useful for the following applications:

1. Receiving inspection of Bushing Current Transformers.
2. Testing of BCT's after they are mounted on transformer or circuit breaker covers, before cover is assembled to the main tank. This test is normally done to:
   a. Check whether the CT's are mounted with proper polarity with respect to the bushing lead, and;
   b. To make sure that the secondary leads from the CT are brought out to the proper terminals.
3. Testing BCT's after they are installed in transformers if their performance is suspected.

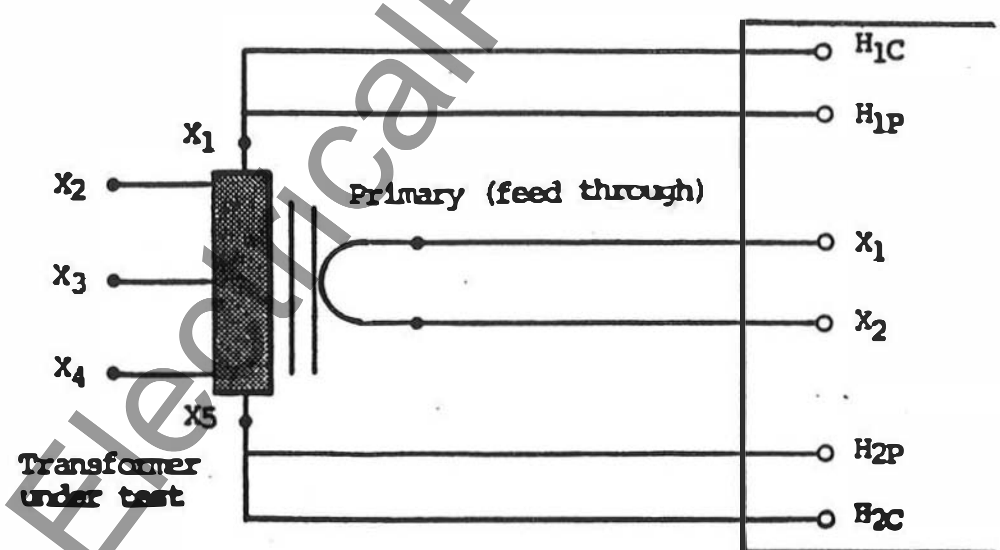


FIGURE 8

3.9 CURRENT TRANSFORMERS (continued)

NOTE: While testing with Model TR800 Ratiometer, H and X selector switches should be set in position H2-H1, and X2-X1. Use HV and LV leads marked H1-H2, and X1, X2 for this test. Reversing switch should be in normal position.

A current transformer is connected backwards, as compared to a potential transformer. That is, the H leads of instruments are connected to the X (secondary) terminals of the current transformer.

Procedure:

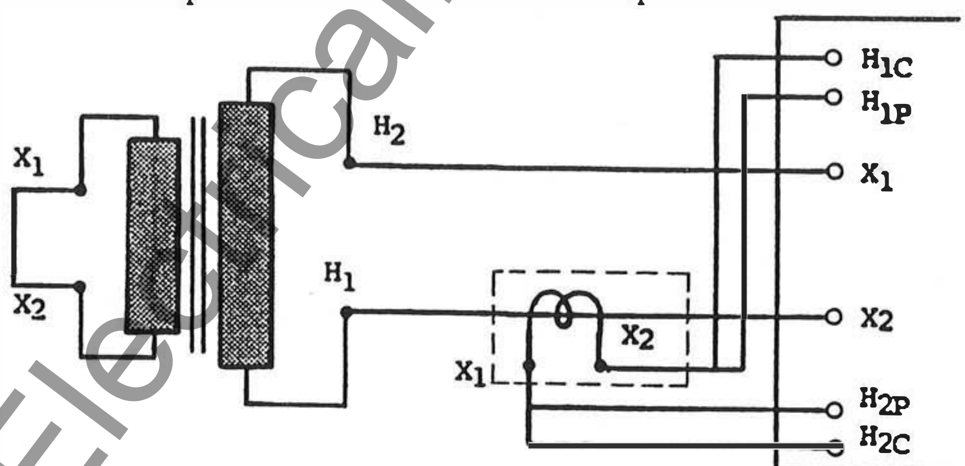
1. Run a lead (10 AWG wire) through the centre of the BCT/CT or to the buss terminals.

2. Connect one end of this lead to terminal X1 and the other end to terminal X2 on the ratiometer.

3. Connect the secondary winding of the BCT to the H1P, H1C and H2P, H2C terminals on the ratiometer.

4. Set the test voltage switch to 12 volts.

5. Use procedure in section 3.3 to complete test.



BUSHING CURRENT TRANSFORMERS, WHEN MOUNTED

FIGURE 9

3.9 CURRENT TRANSFORMERS (continued)

In order to test the BCT without removing it from the transformer:

1. De-energize and disconnect the main power transformer from the source so that it can be worked on.

2. Short circuit the X1, X2 terminals on the main power transformer.

3. Connect the X1 terminal of the instrument to the H1 terminal of the power transformer and the X2 terminal of the instrument to the H2 terminal of the power transformer.

4. Connect the H1 terminal of the instrument to the X1 terminal of the current transformer and the H2 terminal of the instrument to the X2 terminal of the current transformer.

5. Conduct the ratio measurement as described in section 3.3.

NOTE: It is important to short circuit all the windings on the same core limb except the one which includes the current transformer being tested.

METERING CURRENT TRANSFORMERS

Metering current transformers (CT's) can be tested for their no load ratio and phase angle characteristics with the Model TR700 and TR800 Ratiometers. This checking is particularly useful for the following application.

1. Receiving inspection of new CT's from the manufacturer or recycled units from the field for incorrect nameplate ratings.

2. Discovering if internal damage has occurred on field units which may have been subjected to lightning or fault currents.

3. Check for correct polarity.

NOTE: Connection diagram is the same as Figure 4. Testing procedure is the same as in section 3.3.

3.10 INSTRUMENT VOLTAGE TRANSFORMERS

POTENTIAL TRANSFORMERS

These transformers can be tested following the same procedure as for single phase, two winding transformers (Section 3.3). It is important to determine both the ratio and phase angle deviation to know the characteristics and correction factors for PT applications. In determining the compliance of PT characteristics for its accuracy class it is advantageous to use the % deviation dial for ratio and to convert the phase deviation dial reading to minutes.

1 centiradian = 34.37 minutes
0.1 centiradian = 3.437 minutes
or, 1 minute = 0.029 centiradians,
therefore, multiply bridge reading by 34.37 to get a dial reading in minutes.

For determining high voltage PT characteristics an auxiliary 40:1 step-up transformer is available as an option (Multi-Amp Cat. No. 820118).

It should be pointed out that a ratiometer test cannot be substituted for a full accuracy test conducted at rated voltage, using real burdens and a suitable comparator.

CAPACITIVE VOLTAGE DIVIDERS

This information is valid for the Capacitive Dividers and Capacitive Voltage Dividers (CVT).

Due to the high interference and rather high impedance of the CVT, it is not a recommended policy to test the ratio of a CVT in a station using an ordinary ratiometer. However, the TR700/800 ratiometers together with an auxiliary 40:1 step-up transformer can be used to measure accurately the overall ratio of the EVT in the shop or in the field if reduced accuracy is acceptable.

The auxiliary transformer (CVT Ratio Adaptor) increases the test voltage to 4800 volts and increases the range of the ratiometer to 80, 800:1. This ratio is large enough to test CVT's on the highest voltages used for power transmission at the present time.

3.10 INSTRUMENT VOLTAGE TRANSFORMERS (continued)

Figure 10 shows the connection for a typical measurement using the auxiliary transformer. It should be noted that the ratio of the CVT may be different when tested at 1200 volts than at the operating voltage due to the non-linearity of the components used in the CVT.

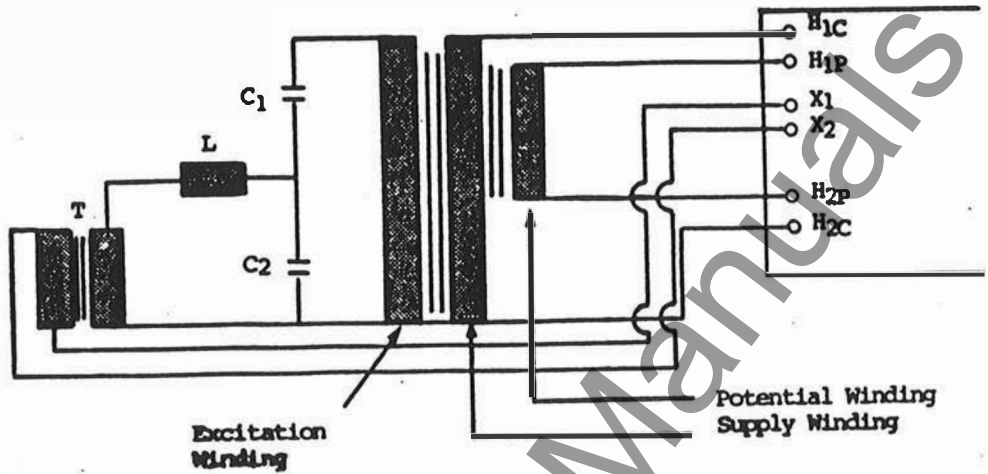
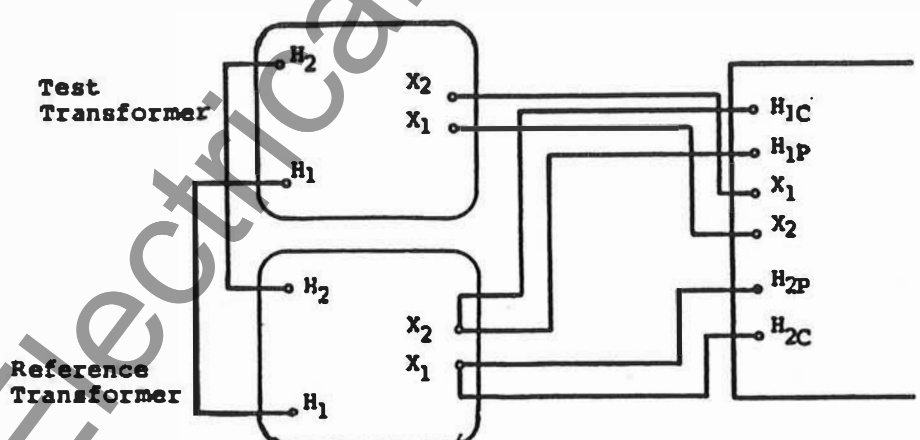


FIGURE 10

Alternatively, the TR700/800 Ratiometers may be used to test separately, first the divider and then the intermediate voltage transformer. This test, however, is limited to CVT's with accessible intermediate voltage connections.



TRANSFORMER COMPARATOR

FIGURE 11

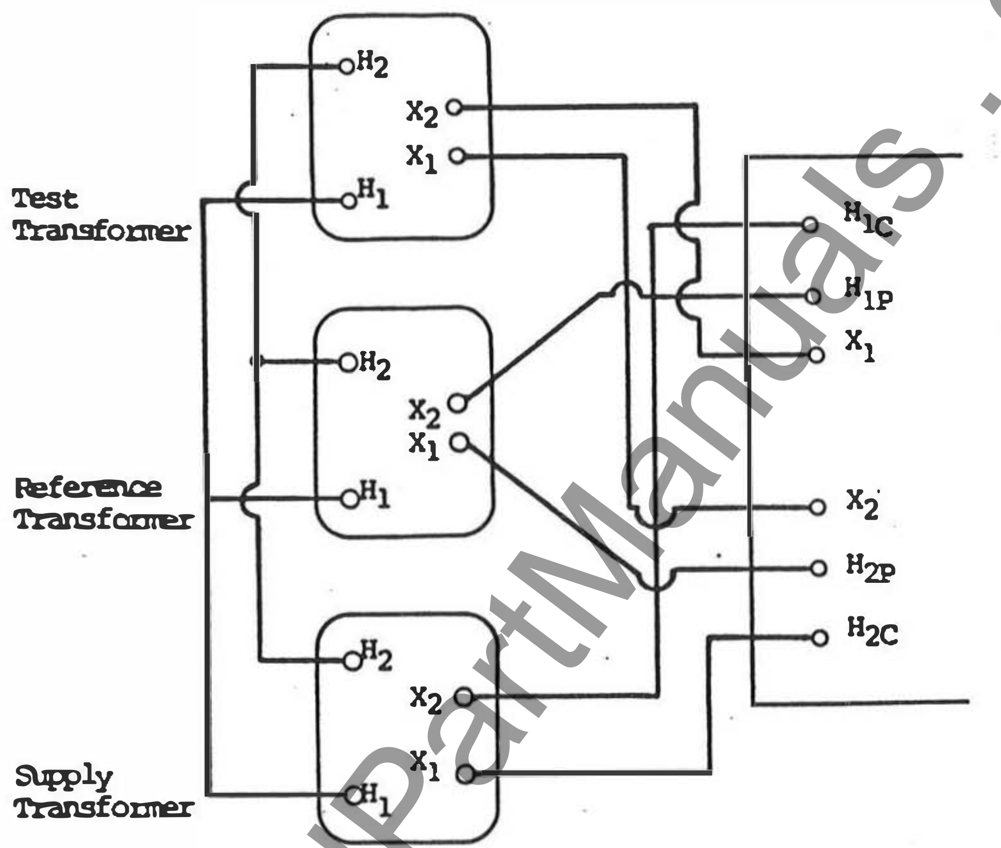


FIGURE 12

This connection is equivalent to the tests of an instrument transformer at rated voltage using a calibrated reference transformer.

When applying the transformer ratiometer as a comparator, make the connections between the reference or standard transformer, ratiometer, and transformer being tested as shown in Figure 12. Conduct the balancing for ratio and phase as described in section 3.3.

NOTE: It may be desirable to supply X1-X2 of the Supply Transformer from a separate and variable source. This is especially true if the tested transformers are of higher voltage and required many VA for excitation.

4. TROUBLE SHOOTING

4.1 SETTING OF DEVIATION DIALS

If the self check procedure (see Section 3.2) indicates that the calibration may be out, then a simple field adjustment can be implemented.

1. Observe the instructions as per Section 3.2, 1 through 10.

2. Remove the plastic caps on the deviation and phase angle variable dials, and loosen the nuts which secure the knob to the pot shaft.

3. With the phase selection switch in the appropriate position, set the dial to zero on the scale and with a screw driver, turn the pot shaft such that the null detector is halanced.

4. Check both phase pointers (ratio and phase angle) then secure the nuts, replace the plastic caps.

5. This adjustment is for minor calibration changes, which should be expected occasionally. Major adjustment should be performed by a qualified technician or at our factory.

4.2 QUICK REFERENCE TROUBLE CHECK

TYPICAL PROBLEMS

A - Self-check fails completely.
B - High phase angle reading.
C - Transformer hums or vibrates.
D - Leads heat above the norm.
E - Excitation meter pins.
F - Breaker blows.
G - Bridge will not balance.

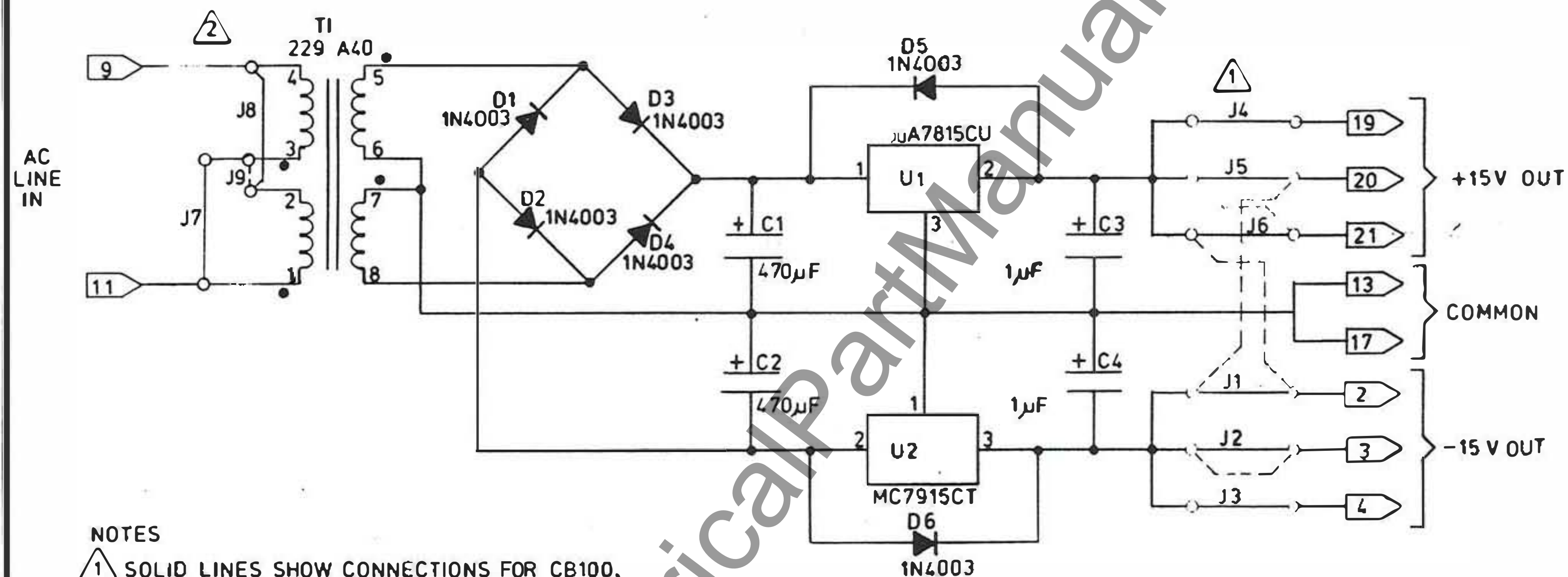
TYPICAL PROBLEMS							
A	B	C	D	E	F	G	POSSIBLE CAUSES
	x					x	Wrong polarity of Tx or leads reversed.
	x					x	Leads open circuited - check continuity.
	x					x	Poor lead contact on Tx.
						x	Open winding on H or X of Tx.
	x					x	Ratio greater than 2021:1.
		x	x	x	x		Leads reversed primary and secondary on Tx.
	x		x	x	x		Mechanical short on Tx (link closed)
	x			x			Could be normal check expected value.
	x	x	x	x	x		Severe problem on Tx.
	x	x	x				Test voltage is too high.
	x				x		Incorrect main supply 120/240.
	x				x		Internal damage to bridge
		x			x	x	Connect instrument for "self-check"
	x						Loose circuit card or mechanical damage to instrument wiring.
	x				x		Instrument has incorrect internal wiring (120/240V).

5. SERVICE AND MAINTENANCE

5.1 DOCUMENTATION

The following drawings are included for reference purposes only:

DRAWING NO.	DESCRIPTION
B10130-109	Schematic, PWR PCB
B20110-102	Schematic, DTH PCB
A20110-104	Connection Diagram, Range Extension Transformer
B20110-105	Schematic, RPH PCB
A20110-106	Schematic, OVH PCB
C20110-107	Schematic, TR700
C20130-102	Schematic, TR800
A10130-706	Component Assembly, PWR PCB
A20110-707	Component Assembly, DTH PCB
A20110-708	Component Assembly, RPH PCB
A20110-709	Component Assembly, OVH PCB



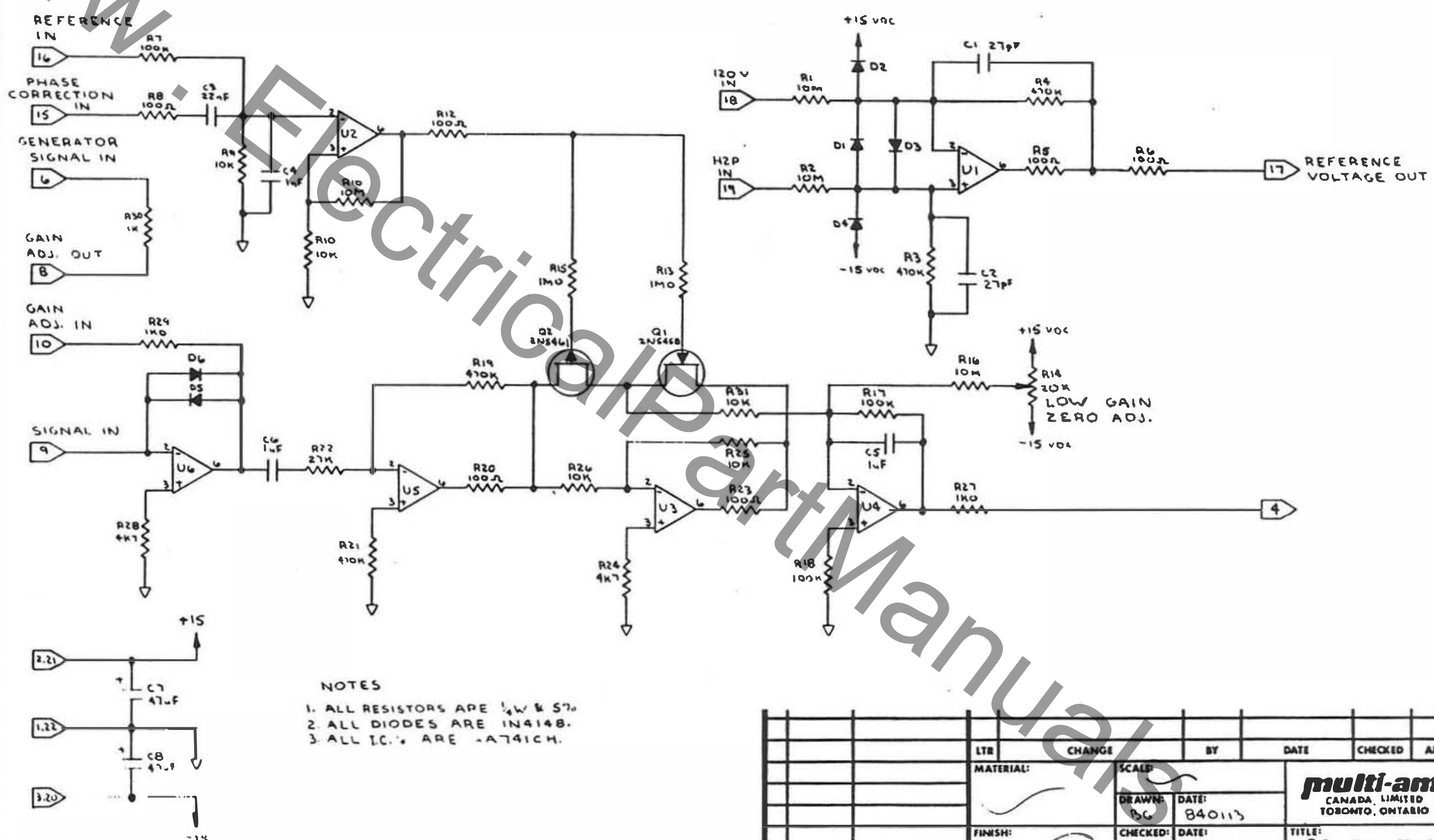
NOTES

1. SOLID LINES SHOW CONNECTIONS FOR CB100, TR700, AND TR800
DOTTED LINES SHOW CONNECTIONS FOR CB78, M400, AND MTB

2. SOLID LINES SHOW CONNECTIONS FOR 120V, 60Hz SERVICE
DOTTED LINE SHOWS CONNECTION FOR 240V, 50 Hz SERVICE

		LTR	CHANGE	BY	DATE	CHECKED	APPR.
MTB		MATERIAL:	SCALE:		multi-amp CANADA, LIMITED TORONTO, ONTARIO		
M400			DRAWN: R P	DATE: 83 06 21			
CB78							
TR800		FINISH:	CHECKED: GS	DATE: 830622	TITLE: PWR PCB SCHEMATIC		
TR700							
CB100	S/N 39904 4 P.		APPR: JDS	DATE: 830622			
USED ON	NEXT ASSEMBLY		SUPERCEDES: A10130-101A		DRAWING NO: B10130-109		

ALL DIMENSIONS ARE IN INS. DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE:
DEBURR AND BREAK SHARP EDGES



NOTES

1. ALL RESISTORS ARE ¼W & 5%
2. ALL DIODES ARE IN4148.
3. ALL I.C.'s ARE µA741CH.

LTR	CHANGE	BY	DATE	CHECKED	APPR.

MATERIAL:

FINISH:

USED ON | NEXT ASSEMBLY

SCALE:

DRAWN: BC | DATE: 840113

CHECKED: TI | DATE: 84-01-16

APPR: ADS | DATE: 840116

SUPERCEDES:

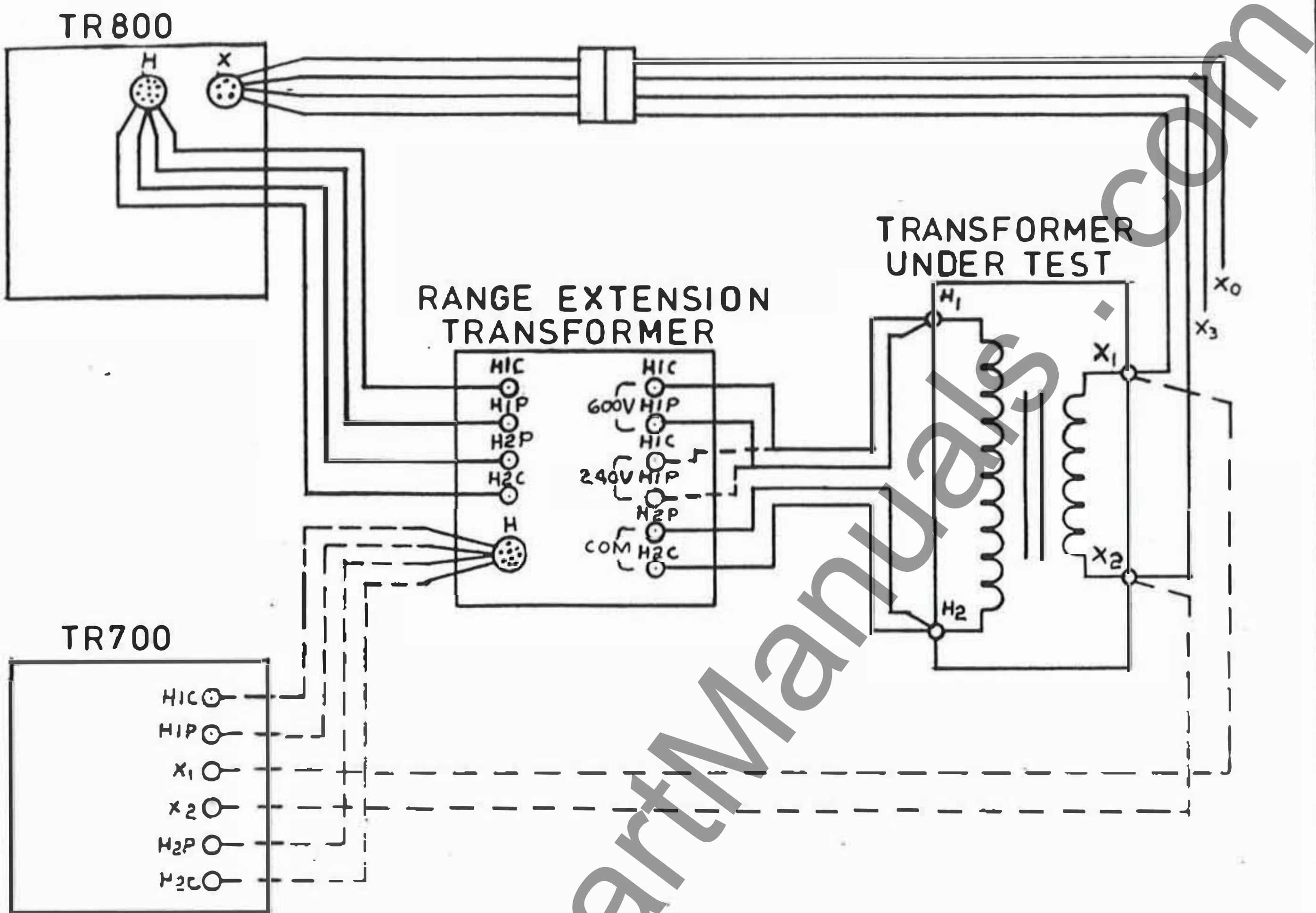
multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: SCHEMATIC DTH PCB

DRAWING NO: B2010-102

REV

ALL DIMENSIONS ARE IN INS./mm DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.030 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES



NOTES
1. CONNECTION DIAGRAM FOR RANGE EXTENSION TRANFORMER USING EITHER TR700 OR TR800

A	CORRECTED	BG	86 10 23	R.P. RD
LTR	CHANGE	BY	DATE	CHECKED / APPR.

A	SN 4380 & UP
USED ON	NEXT ASSEMBLY

MATERIAL:

FINISH:

SCALE:

DRAWN: R.P. DATE: 83 10 12

CHECKED: G.L. DATE: 83 10 12

APPR: GJS DATE: 831013

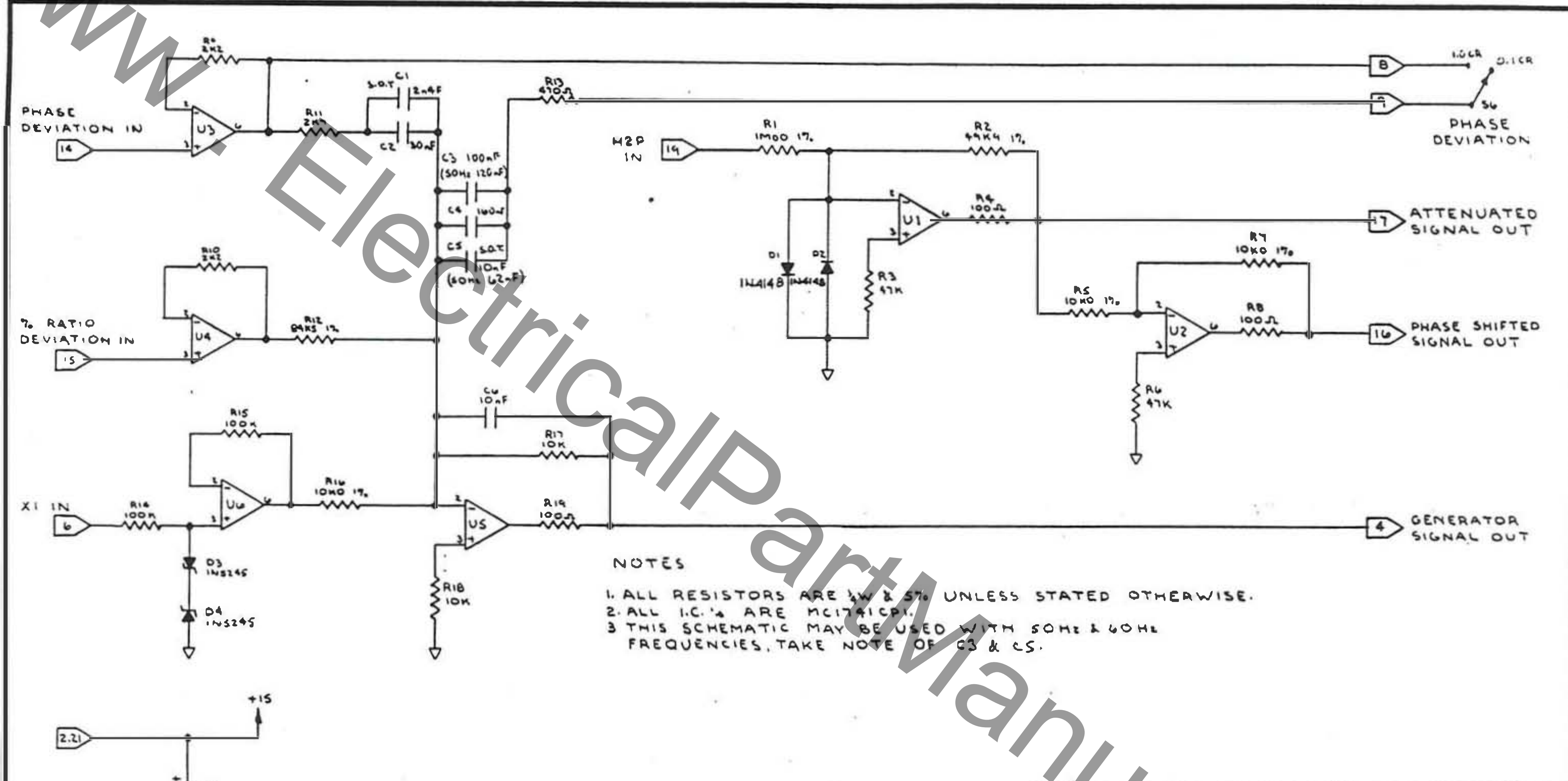
multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: CONNECTION DIAGRAM: RANGE EXTENSION TRANS.

SUPERCEDES:

DRAWING NO: A20110-104 REV A

ALL DIMENSIONS ARE IN INS[redacted] DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES



NOTES

1. ALL RESISTORS ARE ¼W & 5% UNLESS STATED OTHERWISE.
2. ALL I.C.'s ARE MC1741CP1.
3. THIS SCHEMATIC MAY BE USED WITH 50Hz & 60Hz FREQUENCIES, TAKE NOTE OF C3 & C5.

LTR	CHANGE	BY	DATE	CHECKED	APPR.
B	ADDED 1N4148 TO D1 & D2	M.S.	91 01 24		
A	C5 CHANGED TO 10nF FROM 120nF ...	O.C.	85 07 01	DG	

B	20110	S/N 8470 + UP
A	20110 20130	S/N 5735 + UP
-	TR700 TR800	
USED ON		NEXT ASSEMBLY

MATERIAL:

FINISH:

SCALE:

DRAWN: DG DATE: 840112

CHECKED: T.I. DATE: 84-01-16

APPR: DATE: 840118

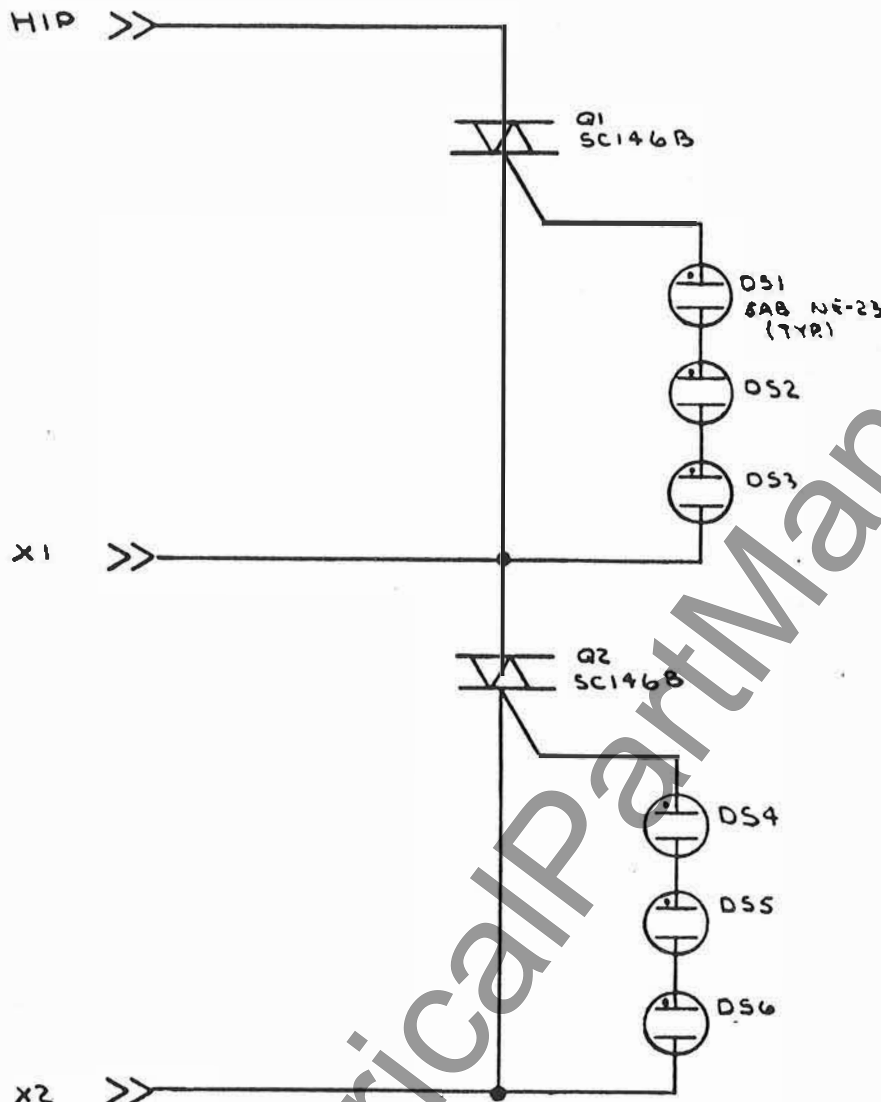
SUPERCEDES:

multi-amp CANADA LIMITED TORONTO, ONTARIO

TITLE: SCHEMATIC RPH PCB

DRAWING NO: B20110-105 REV B

ALL DIMENSIONS ARE IN INS./mm. DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES



LTR	CHANGE	BY	DATE	CHECKED	APPR.

USED ON | NEXT ASSEMBLY

MATERIAL: ~

FINISH: ~

SCALE: ~

DRAWN: BG | DATE: 840113

CHECKED: T. I. | DATE: 84-01-16

APPR: AJS | DATE: 840118

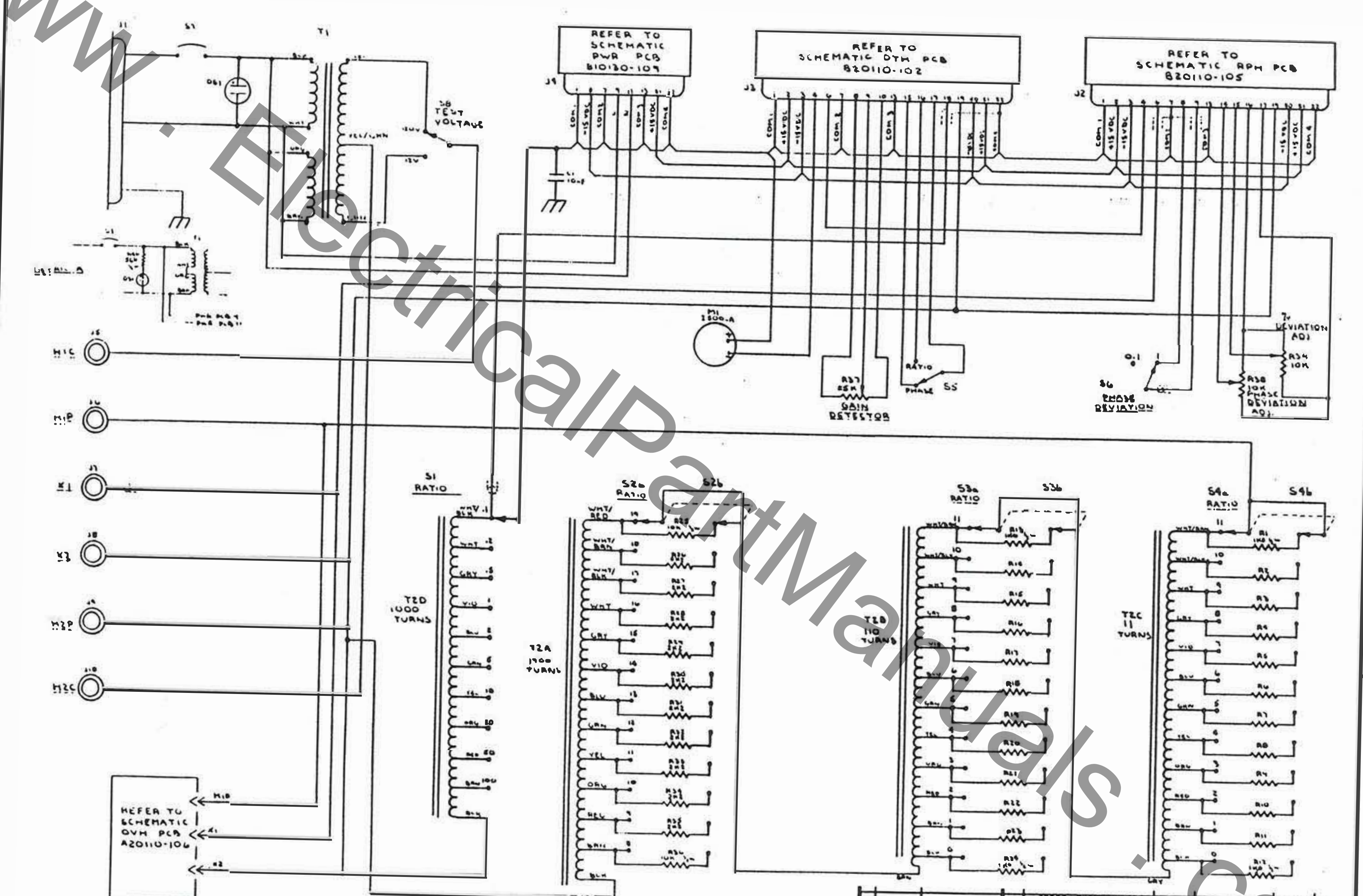
SUPERCEDES: ~

multi-amp
CANADA, LIMITED
TORONTO, ONTARIO

TITLE: SCHEMATIC OVH PCB

DRAWING NO: A20110-106 | REV

ALL DIMENSIONS ARE IN INS./mm. DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES



NOTES

1. ALL RESISTORS ARE 220Ω, ¼ & 5%, UNLESS STATED OTHERWISE.
2. DETAIL A SHOWS 50Hz OPERATION.

LTR	CHANGE	BY	DATE	CHECKED	APPR.
B	ADDED PHASE CHECK ... SPECS	BG	86 06 03		

MATERIAL:

FINISH:

SCALE:

DRAWN: B.G. DATE: 840119

CHECKED: T.J. DATE: 84/01/20

APPR: DATE: 840126

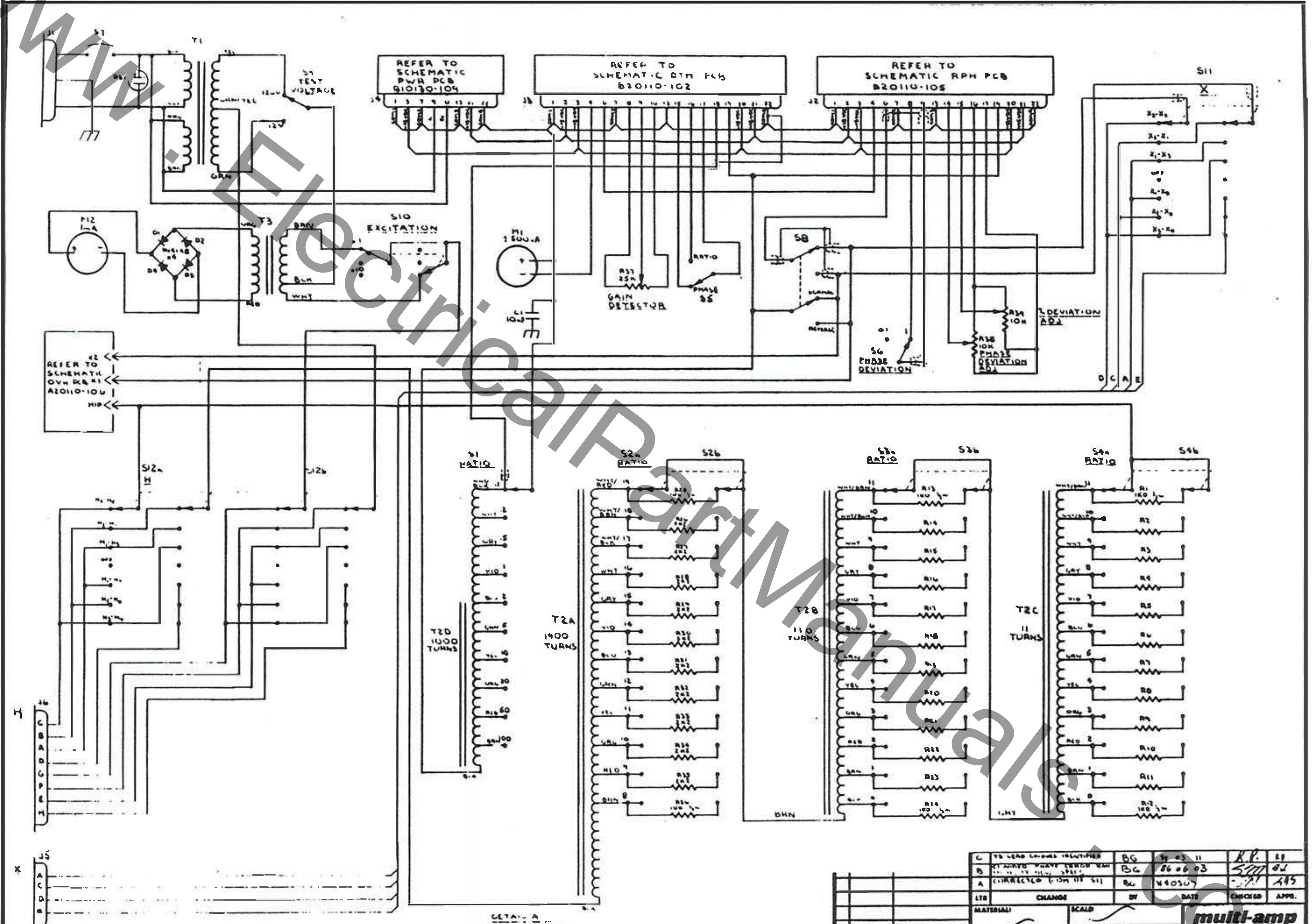
SUPERCEDES:

USED ON | NEXT ASSEMBLY

multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: SCHEMATIC TR700

DRAWING NO: C20110-107 REV B



NOTES:
1. ALL RESISTORS ARE 220Ω ¼W 5% UNLESS STATED OTHERWISE
2. S10 IS SHOWN IN IT'S 'OFF' POSITION.
3. DETAIL 'A' SHOWS 50Hz OPERATION.

LTR	CHANGE	BY	DATE	CHECKED	APPR.
C	T2 LEAD COLOURS IDENTIFIED	BG	86 03 11	K.P.	
B		BG	86 06 03		
A	CORRECTED ... S11	BG	840507		

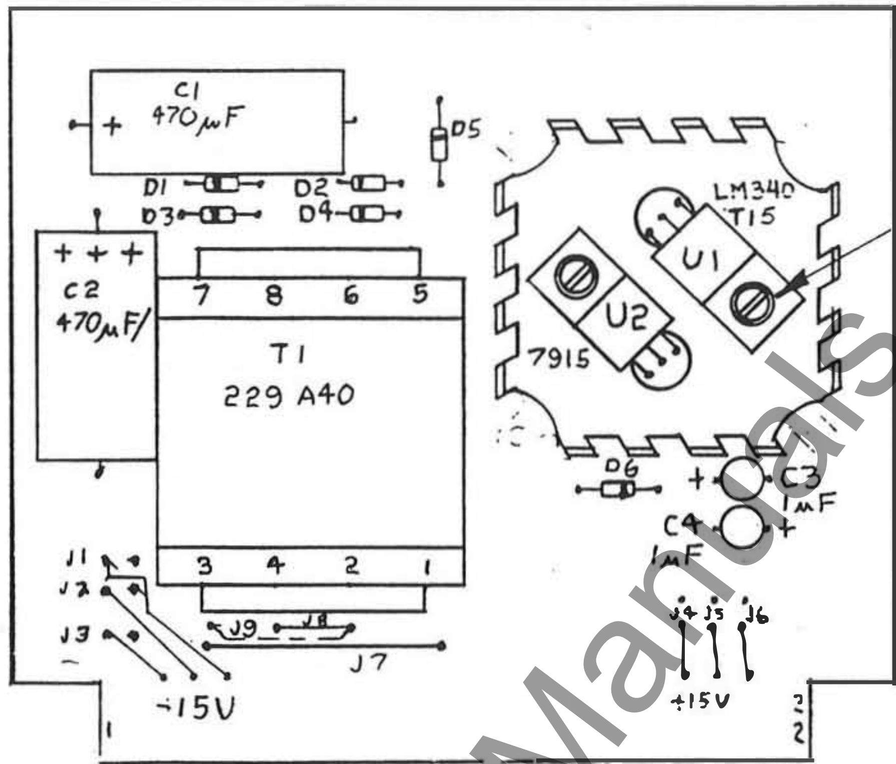
multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: SCHEMATIC TR800

DRAWN: BG — DATE: 840120
CHECKED: T.I — DATE: 81/4/20
APPR.: — DATE: 840126

DRAWING NO: C20130-102 — REV C

20130	S/N 5343 & UP
20130	
USED ON	NEXT ASSEMBLY



NOTES:

1. FOR 120V, 60Hz SERVICE OMIT J9 AND FOR 240V, 50Hz INSTALL J9 AND OMIT J7 AND J8

2. ASSEMBLE I.C.S IN FOLLOWING ORDER
   - 445-030 MACHINE SCREW
   - I.C.
   - K4-58 INSULATOR
   - BOARD AND HEATSINK
   - 1750 LOCKWASHER AND 727 NUT
3. INSTALL T1 AFTER BOARD IS DEFLUXED.
4. CUT THE TRACES OF PINS 13 AND 17 FOR CB 100 ONLY.
5. ALL DIODES ARE 1N4003,

J		S/N 8847 & UP
H	10130	S/N 7343 & UP.
G		
F	10130,20110 10130-1	S/N 4652 & UP
E	10130,20110 20130	SN 4380 & UP
D	10130,20110 20130	
C	10130,20110 20130	SN 3761 & UP
	USED ON	NEXT ASSEMBLY

LTR	CHANGE	BY	DATE	CHECKED	APPR.
J	ADDED NOTE 5.	A.S			
H	ADDED NOTE 4.	M.S.	90 08 01	E.J.	E.J.
G	NOTE 2 REMOVED. [illegible] PN CHANGED.	O.C.	79 10 05	RD	RD

MATERIAL: ______

FINISH: ______

SCALE: NONE

DRAWN: B G — DATE: 80 10 28

CHECKED: ______ — DATE: ______

APPR: G J S — DATE: 80 10 28

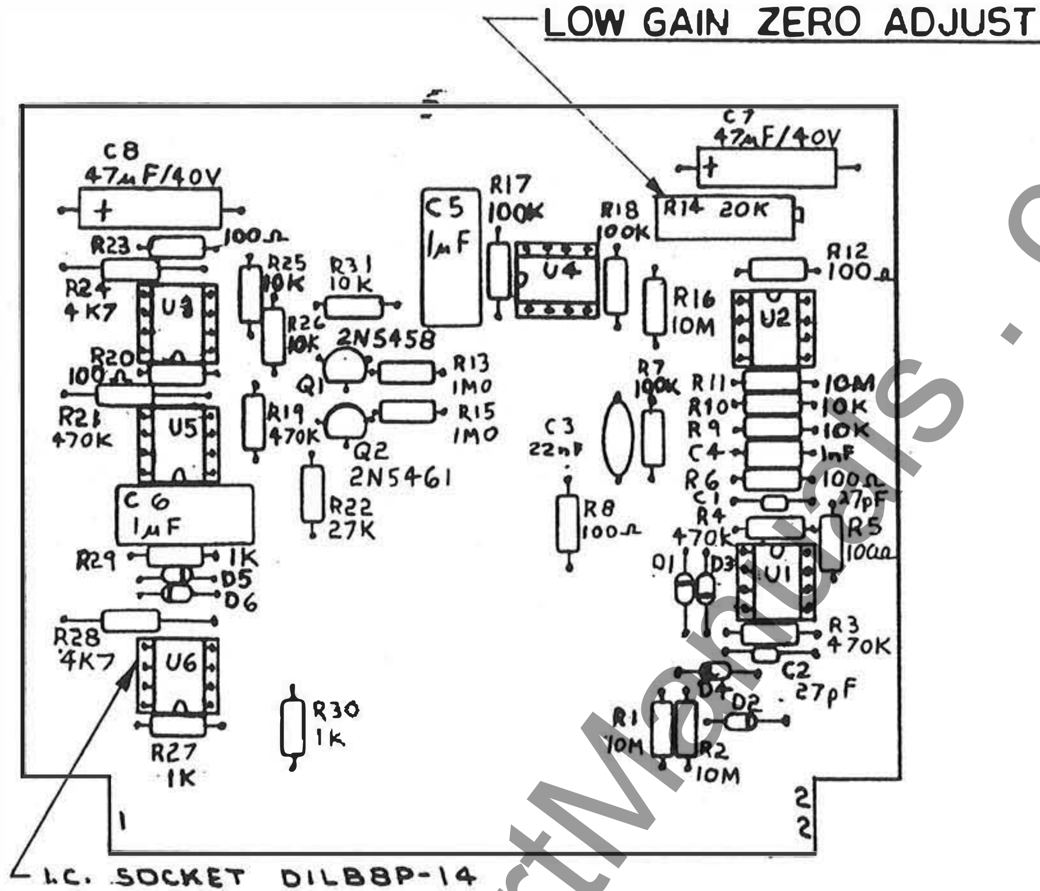
SUPERCEDES: ______

multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: COMPONENT ASSEMBLY PWR PCB

DRAWING NO: A10130-706 — REV J

ALL DIMENSIONS ARE IN INS.[redacted] DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES



NOTE:
1. ALL I.C.'S ARE MC1741CP1.
2. ALL RESISTORS ARE $\frac{1}{4}$ WATT AND 5%
3. ALL DIODES ARE IN4148
4. INSTALL C4 ON PCB AFTER DEFLUXING PROCESS.

LTR	CHANGE	BY	DATE	CHECKED	APPR.
A	I.C. SOCKETS SHOWN AND NOTE FOUR ADDED	BG	86 10 23	R.L.	RD

A	S/N 4380 & UP	
USED ON	NEXT ASSEMBLY	

MATERIAL: ______
FINISH: ______

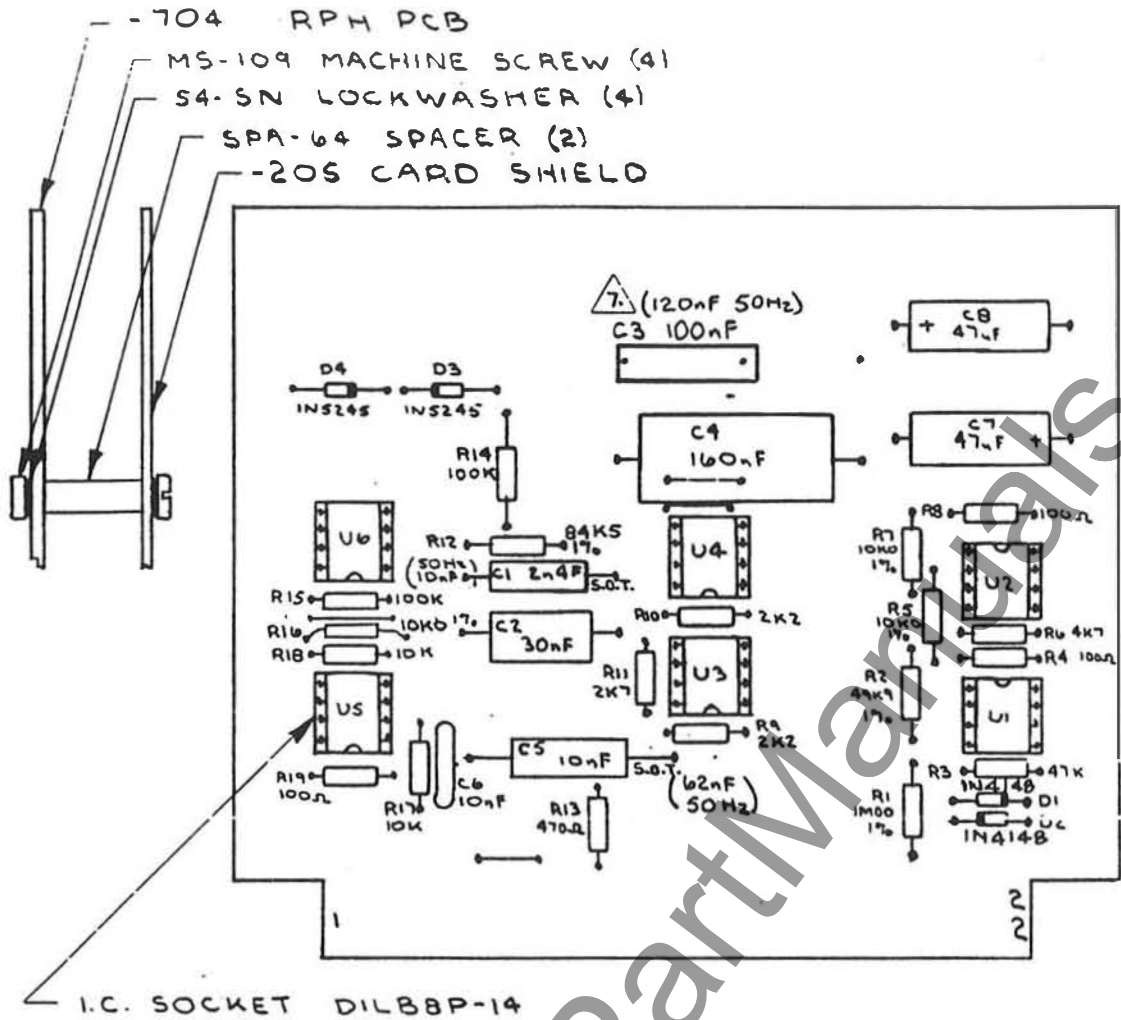
SCALE: FULL
DRAWN: R.P. DATE: 82 11 08
CHECKED: BG DATE: 821118
APPD: AES DATE: 821118
SUPERCEDES: ______

multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: COMPONENT ASSEMBLY DTH PCB

DRAWING NO: A20110-707 REV A

ALL DIMENSIONS ARE IN INS.[redacted] DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES



NOTES

1. ALL RESISTORS ARE ¼W & 5% UNLESS STATED OTHERWISE.
2. CARD SHIELD TO BE MOUNTED ON COMPONENT SIDE WITH HARDWARE AS SHOWN IN SIDE VIEW.
3. INSTALL JUMPERS BEFORE INSTALLING C4.
4. THE COMPONENTS ON THIS PCB ARE SUITED FOR 50 Hz & 60 Hz FREQUENCIES EXCEPT FOR C1, C3 & C5.
5. THE FOLLOWING COMPONENTS ARE INSTALLED ON PCB AFTER BOARD IS DEFLUXED, C1 THROUGH C6.
6. ALL I.C.'s ARE MC1741CP1.
7. C3 50Hz VERSION - A RADIAL CAPACITOR 120nF/63VDC IS USED.

LTR	CHANGE	BY	DATE	CHECKED	APPR.
D	ADDED IN4148 MARKING TO D1+D2.	M.S.	91 06 24	RD	RD
C	C3 CHANGED TO 100nF FROM 120nF. NOTE 4 CHANGED, 7 ADDED	O.C.	88 09 01	BG	RD

D	20110	S/N 8470 + UP
C	20110 20130	S/N 5735 & UP
B		S/N 4380 & UP
	USED ON	NEXT ASSEMBLY

MATERIAL: ~

FINISH: ~

SCALE: FULL

DRAWN: BG DATE: 840112

CHECKED: T.I. DATE: 84 01 16

APPR: [illegible] DATE: 840116

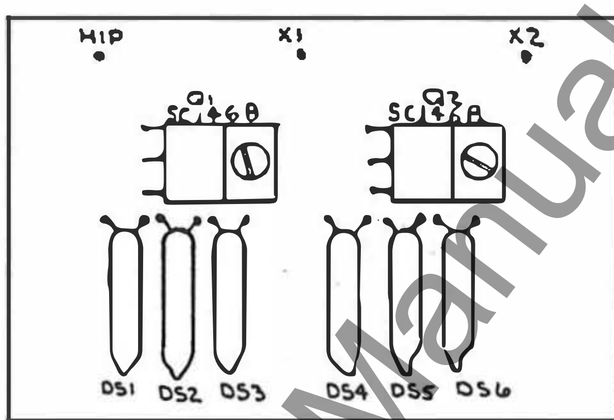
multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: COMPONENT ASSEMBLY RPH PCB

ALL DIMENSIONS ARE IN INS. DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES

SUPERCEDES: ~

DRAWING NO: A20110-708 REV D



NOTES

1. SECURE Q1 & Q2 TO PCB WITH MS-109 MACHINE SCREW, 54-SN LOCKWASHER, & B-753 HEX NUT.
2. USE 'DOW CORNING' 3145 RTV ON ALL DISPLAYS TO GUARD AGAINST DAMAGE.

LTR	CHANGE	BY	DATE	CHECKED	APPR.
C	ON NOTE 2: 3145 RTV WAS 1345 RTV.	M.S.	91 06 24	RD	RD
B	MS-109 WAS MS-428	O.C.	89 10 06	RD	RD
A	MS-428 WAS MS-167 Q1+Q2 PART NUMBER ADDED	R.P.	87 07 31	SM	RD

	USED ON	NEXT ASSEMBLY
C	20110	S/N 8470+UP.
B	20110 20130	S/N 6578+UP

MATERIAL:	
FINISH:	
SCALE:	FULL
DRAWN: BG	DATE: 840116
CHECKED: T.I.	DATE: 84 01 16
APPR: SYS	DATE: 840116
SUPERCEDES:	

multi-amp CANADA, LIMITED TORONTO, ONTARIO

TITLE: COMPONENT ASSEMBLY OVH PCB

DRAWING NO: A20110-709 REV C

ALL DIMENSIONS ARE IN INS./[redacted] DO NOT SCALE DRAWING
UNLESS NOTED TOLERANCES ARE: .X ±.100 .XX ±.020 .XXX ±.005 ±0.5°
DEBURR AND BREAK SHARP EDGES