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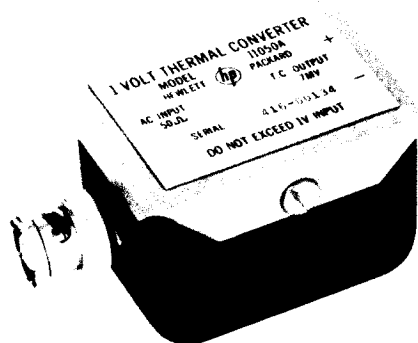
Agilent Technologies

THERMAL CONVERTERS

11049A

11050A

11051A





OPERATING AND SERVICE MANUAL

Manual Part No. 11049-90005

Microfiche Part No. 11049-90055

MODEL 11049A, 11050A, 11051A THERMAL CONVERTERS

Serials Prefixed 0416A

If other serial prefixes require modification of this manual, the changes will appear in an associated "Manual Changes" supplement.

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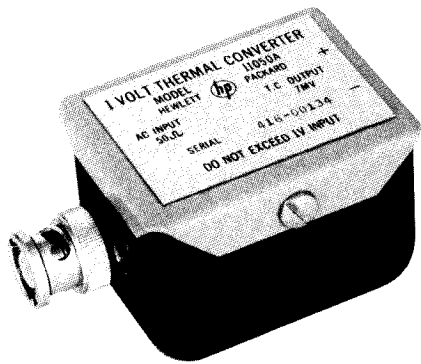


Figure 1. -hp- Model 11050A Thermal Converter

1. GENERAL

2. The -hp- Model 11049A, 11050A, 11051A Thermal Converters are used to accurately compare the rms value of ac input voltages at a specified frequency to the rms value of input voltages at one or more different frequencies. Two versions of these Thermal Converters are available: a standard and an Option 003 version. Each standard version is tested at the specified frequencies listed in Table 1. The Option 003 versions have correctional data supplied for specific frequencies up to 100MHz. Refer to paragraph 5 for more information on Option 003 converters. The operating characteristics for both versions of the converters are shown in Table 2.

Table 1. 11049A, 11050A, and 11051A Specifications

Frequency	Input Error with Respect to 1kHz ($\pm\%$)	Measurement Uncertainty ($\pm\%$)
30kHz	.03	.02
100kHz	.03	.02
300kHz	.03	.06
1MHz	.03	.06
3MHz	.06	.12
8MHz	.06	.12
10MHz	.06	.12

Table 2. 11049A, 11050A, and 11051A Characteristics

Maximum Input Voltage:
11049A: 3 volts rms 11050A: 1 volts rms 11051A: 0.5 volts rms
Input Resistance:
50 ohms $\pm$.15 ohms
Output Resistance:
less than 10 ohms
Output Voltage (with Full Range Input):
Nominal 7.0mV

3. Refer to Table 1. The column labeled "Input Error with Respect to 1kHz" shows the maximum difference between the input voltage at 1kHz and the input voltage at the specified frequency that develops the same Thermal Converter output voltage. This difference is given in percentage of the rms value of the input voltage. The "Measurement Uncertainty" column lists the inaccuracies (or uncertainties) involved in measuring the Input Errors previously described. You cannot reduce this uncertainty to obtain better absolute accuracies.

4. The accuracy of the standard Thermal Converter is calculated by algebraically summing the columns in Table 1 labeled "Input Error with Respect to 1kHz" and "Measurement Uncertainty". For example, the difference between a 1kHz signal level and a 30kHz signal level that develops the same Thermal Converter dc output voltage as the 1kHz level, can be as much as " $\pm 0.03\%$ " plus " $\pm 0.02\%$ " or " $\pm 0.05\%$ ". This takes into account the inaccuracies of the Thermal Converter itself and the measurement. For specific frequencies up to 10MHz, the actual percentage difference between the rms value of the 1kHz input and the rms value of an input at another frequency (that develops the same dc output), will never exceed the sum of the two columns for each specified frequency.

5. OPTION 003 DESCRIPTION

6. If the accuracies of a standard Thermal Converter are insufficient for your application, Option 003 is recom-

mended. Option 003 Thermal Converters are supplied with measured Input Error data at the frequencies listed in Table 1 plus the following frequencies: 20MHz, 30MHz, 50MHz, 70MHz, 80MHz, and 100MHz. This data allows you to enhance the accuracy of a standard Thermal Converter. The Input Error measurements are obtained by direct comparison to a similar Thermal Converter that has data traceable to NBS (National Bureau of Standards in the USA). This data gives you the characteristics of your particular Thermal Converter by comparing ac voltage levels at different frequencies. For example, if the measured data of an Option 003 converter is "+.01%" at 30kHz, the Input Error with respect to 1kHz would then be ".01%" high at 30kHz. (Note: Option 003 has replaced both Options 001 and 002 listed in earlier manuals.)

7. Each Option 003 comes with a certificate containing a table similar to Table 1, but with measured data instead of the maximum limits for the "Input Error with Respect to 1kHz" column. This data is for the following frequencies: 30kHz, 100kHz, 300kHz, 1MHz, 3MHz, 8MHz, 10MHz, 20MHz, 30MHz, 50MHz, 70MHz, 80MHz, and 100MHz. The "Measurement Uncertainty" column in Table 1 is the same for Option 003, because these uncertainties cannot be reduced. Option 003 therefore provides Input Error data whose uncertainties are bounded by the percentages in the "Measurement Uncertainty" column in Table 1. For example, the uncertainty at 30kHz in the table is " $\pm 0.02\%$ " which represents the uncertainties for

both standard and Option 003 converters.

8. CIRCUIT DESCRIPTION

9. Refer to Figure 2. The Thermal Converter consists of a 90 ohm UHF thermoelement containing a heater filament and a thermoelectric junction. When a voltage is

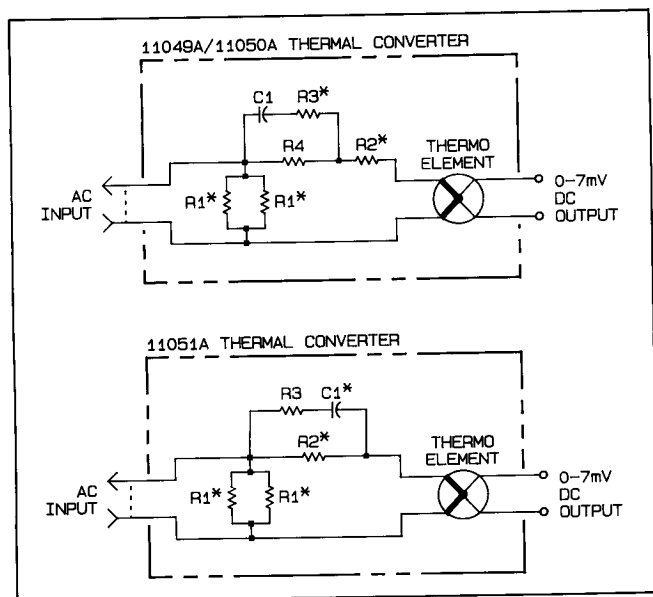


Figure 2. Thermal Converter Schematic Diagram

applied to the Thermal Converter, the resultant current into the thermoelement heats the filament. The thermoelectric junction then develops a voltage value proportional to the filament heat (i.e., the output voltage value is proportional to the input power).

10. For the 11049A and 11050A, resistors R2 and R4 develop the 5mA current through the thermoelement for full scale inputs and resistor R1 develops the 50 ohm input resistance of the converter. Resistors R3 and R4, and capacitor C1 form a filter to optimize the high frequency response (1MHz to 10MHz) of the converter.

11. For the 11051A, resistor R2 develops the 5mA current through the thermoelement for full scale inputs and resistor R1 develops the 50 ohm input resistance of the converter. Resistors R2 and R3, and capacitor C1 form a filter to optimize the high frequency response (1MHz to 10MHz) of the converter.

12. The input/output relationship of a typical Thermal Converter is shown in Figure 3.

13. MAINTENANCE

14. The following paragraphs show how to calibrate and repair the Thermal Converter, and how to select the necessary components after repair.

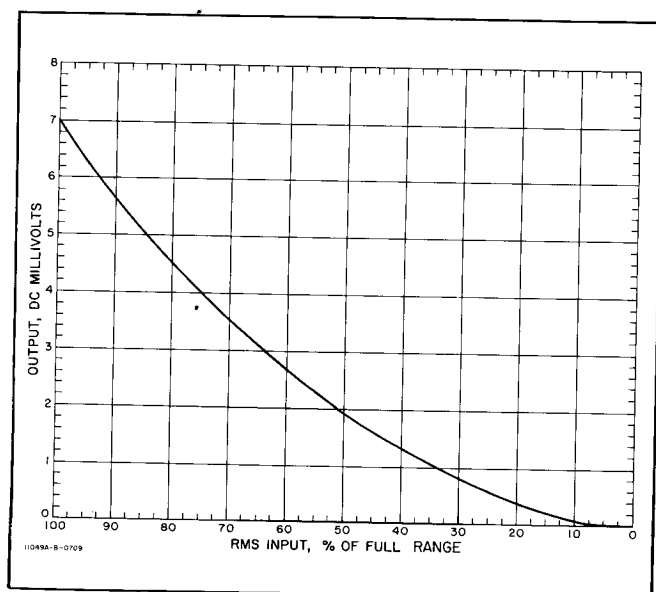


Figure 3. Input/Output Relationship

15. Thermal Converter Calibration

16. The Thermal Converter is calibrated using a reference Thermal Converter that has correctional data available. Since the Option 003 11049A, 11050A, and 11051A Thermal Converters have correctional data, you can use them as reference converters.

17. A typical Thermal Converter calibration setup is shown in Figure 4. In the setup, the Thermal Converter under test is compared to the reference Thermal Converter. Using the known correctional data of the reference converter, the error data of the converter under test is calculated. If during the test it is determined that the error data exceeds the limits listed in the "Error with Respect to 1kHz" column of Table 1, the Thermal Converter is not within specifications.

18. A Thermal Converter failure is most likely caused by an open UHF thermoelement, or if the glass bead separating the heater and thermocouple inside the thermoelement is defective. This can be determined by the failure. For example, if the readings at all frequencies are inaccurate, the thermoelement is most likely open. If the readings at 1MHz and above are inaccurate, the glass bead is most likely the cause. Before replacing the thermoelement, check and make sure capacitor C1 is installed. If the capacitor is installed, it may be worthwhile to select a new C1 (see paragraph 27). If it is necessary to replace a thermoelement, resistors R1 and R2, and capacitor C1 may have to be changed. The procedures to select these components starts in paragraph 20.

19. To calibrate the Thermal Converter, do the following:

NOTE

The Thermal Converter should be checked against a reference Thermal Converter at least once every six months the first year, and once a year thereafter.

- a. Set the test oscillator to 1kHz and set its output to minimum.
- b. Connect the equipment as shown in Figure 4. Keep all leads and cables as short as possible.
- c. Adjust the oscillator output for a 6mV reading, as shown on the digital multimeter connected to the reference Thermal Converter. This reading is called the 1kHz Reference reading. Make sure it is exactly 6mV or note the reading to the nearest microvolt if other than 6mV.
- d. Note the reading on the digital multimeter connected to the Thermal Converter under test. This reading is called the 1kHz Test reading.
- e. Set the oscillator amplitude to minimum.
- f. On the reference Thermal Converter, determine the lowest frequency that has correctional data available. Set the oscillator to that frequency. For example, if you are

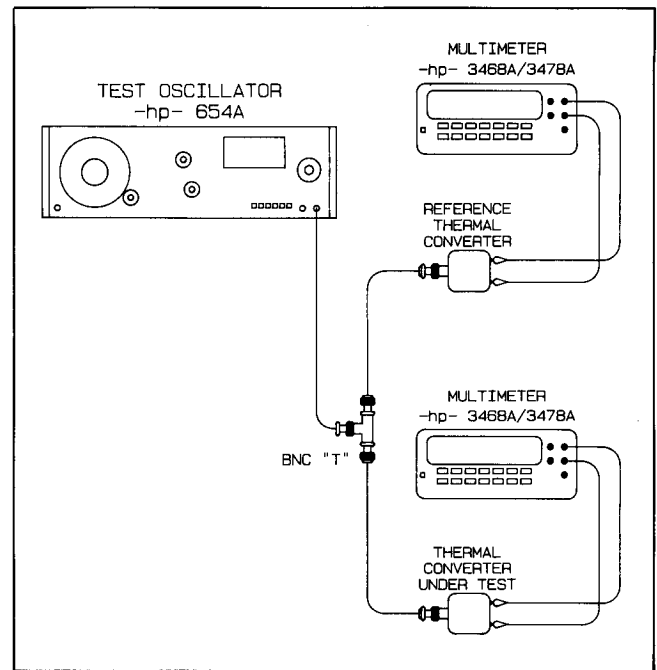


Figure 4. Thermal Converter Calibration

using an Option 003 11049A, 11050A, or 11051A Thermal Converter with correctional data, use 30kHz as the lowest frequency.

g. While observing the digital multimeter connected to the Thermal Converter under test, readjust the oscillator output to the 1kHz Test reading taken in step d.

h. Note the reading on the digital multimeter connected to the reference Thermal Converter. Subtract the 1kHz Reference reading taken in step c from this reading. For example, if the present reading is 5.997mV and the 1kHz Reference reading is 6.000mV, the result is 5.997mV minus 6.000mV which equals -.003mV or $-3\mu\text{V}$.

i. Change the result from microvolts to percent. If the Option 003 converter is used, 1uV corresponds to .01% (for 6mV full scale outputs). Using the numbers of the example in step h, the result is -.03%. (Note: Derivation of the 1uV to .01% conversion is shown in Figure 5.)

j. Refer to the reference Thermal Converter correctional data and determine the error at the present frequency. Algebraically add the error in percent of the reference Thermal Converter to the results in percent calculated in step i. For example, if the correctional data shows an error of +.02%, the result, using the numbers of the previous example, is +.02% plus -.03% which equals -.01%.

k. The resultant error in percent is the actual error of the Thermal Converter under test. Record this error. (Note: If the resultant error is negative, it means the converter under test requires less input at the test frequency

The formula for thermal conversion is as follows:

$V_{out} \approx K \cdot V_{in}^{1.7}$ where K is a constant therefore:

$$\Delta V_{out} = K \cdot 1.7 V_{in}^{-.7} \cdot \Delta V_{in}$$

$$\frac{\Delta V_{out}}{V_{out}} = \frac{K \cdot 1.7 V_{in}^{-.7} \cdot \Delta V_{in}}{K \cdot V_{in}^{1.7}}$$

$$\frac{\Delta V_{out}}{V_{out}} = 1.7 \frac{\Delta V_{in}}{V_{in}}$$

A numerical example using a 6mV output value is as follows:

$$\frac{1\mu\text{V}}{6\text{mV}} = 1.7 \frac{\Delta V_{in}}{V_{in}}$$

OR

$$\frac{\Delta V_{in}}{V_{in}} = \frac{1\mu\text{V}}{6\text{mV}} \cdot \frac{1}{1.7} \approx 10^{-4} = .01\%$$

therefore a change of 1uV at a 6mV output corresponds to a change of .01% (i.e., 10^{-4})

Figure 5. Microvolt/Percent Conversion for 11049A, 11050A, and 11051A Converters

than at 1kHz to develop the same output. Similarly, a positive error indicates that more input is needed at the test frequency.)

1. Repeat steps e through k for each frequency of the reference Thermal Converter that has correctional data available. In each case, record the error of the converter under test.

20. Selection of R2

21. Resistors R2 and R4 sets the 5mA current through the thermoelement for all full scale inputs which results in a 7mV dc output. Since there is no R4 in the 11051A converter, only R2 sets the current in that converter. In the 11049A, the nominal value of R2 is 460 ohms. The R2 value in addition to a fixed R4 value of 50 ohms gives a total nominal value of 510 ohms. In the 11050A, the nominal value of R2 is 100 ohms. The R2 value in addition to a fixed R4 value of 20 ohms gives a total nominal value of 120 ohms. In the 11051A, R2 is a single resistor with a nominal value of 7 ohms. Remember, there is no R4 in the 11051A. All resistors should be 1/8 watt, $\pm 1\%$ metal film resistors.

22. A test setup for selecting R2 is in Figure 6. In the figure, the power supply outputs a known input (3V, 1V, or 0.5V for the 11049A, 11050A, or 11051A, respectively) and the digital multimeter monitors the output. The

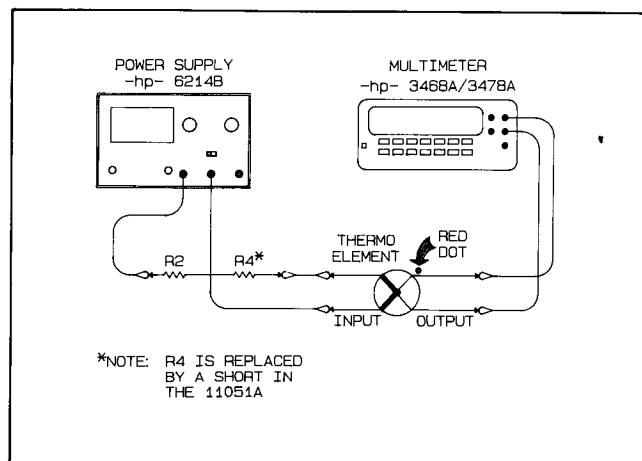


Figure 6. Selection of R2

correct value of R2 is selected when the converter output is 7mV dc. Remember, the resistor R4 value for the 11049A and 11050A is fixed, and there is no R4 in the 11051A. Do the following:

a. With the power supply set to minimum, connect it, the thermoelement, the digital multimeter, and an initial value of R2 (see paragraph 21) as shown in Figure 6.

b. Adjust the power supply to either 3V (for the 11049A), 1V (for the 11050A), or 0.5V (for the 11051A).

c. The output, as read on the digital multimeter, should be $7\text{mV} \pm .05\text{mV}$. If the output is high, increase the value of R_2 and if low, decrease R_2 . (Note: Do not use the thermoelement if the R_2 value for the 11051A falls below 5 ohms.)

23. An alternate but not as accurate method to select R_2 is to assume a thermoelement resistance of 90 ohms. Then select an R_2 value of 460 ohms for the 11049A, 100 ohms for the 11050A, or 7 ohms for the 11051A. If this method is used, the 7mV output may be high or low by as much as 10%.

24. Selection of R_1

25. Resistor R_1 shunts the series combination of the thermoelement, and resistors R_2 and R_4 (R_2 only for the 11051A), to bring the converter's input resistance to 50 ohms, ± 0.15 ohms. Resistor R_1 is made up of two resistors connected in parallel. The nominal values for the 11049A are two 121 ohms resistors. The nominal values for the 11050A are a 121 ohms and a 150 ohms resistor. The nominal values for the 11051A are two 215 ohms resistors. All the resistors should be $1/8$ watt, $\pm 1\%$ metal film resistors.

26. A bridge test setup for selecting R_1 is in Figure 7. In the figure, R_1 is selected for a zero volts indication on the digital multimeter. Do the following:

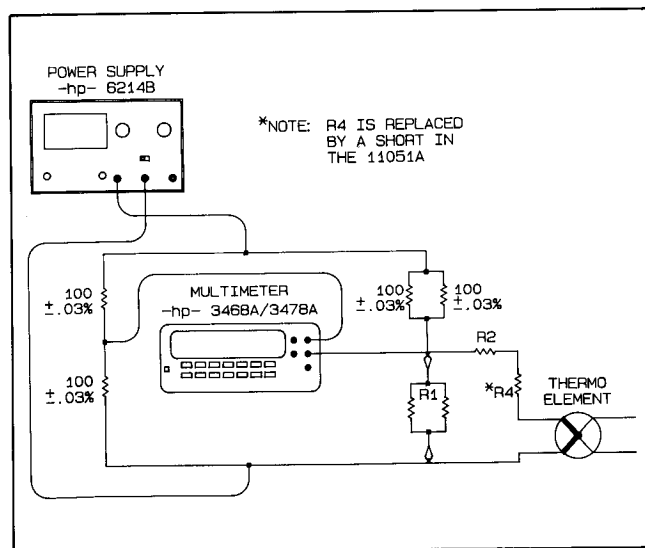


Figure 7. Selection of R_1

a. With the power supply output set to minimum, construct the bridge shown in Figure 7.

b. Connect the initial value of R_1 as shown in Figure 7. For the 11049A, use two 121 ohms resistors in parallel. For the 11050A, use a 150 ohms plus a 121 ohms resistor in parallel. For the 11051A, use two 215 ohms resistors in parallel.

c. Adjust the output voltage of the power supply to the following level:

11049A5.0V
 11050A1.5V
 11051A0.6V

d. Change the value of R1 until a zero reading is noted on the digital multimeter. Maximum deviations on the multimeter should be as follows:

11049A $\pm 10.0\text{mV}$
 11050A $\pm 3.0\text{mV}$
 11051A $\pm 1.2\text{mV}$

e. For a final close adjustment, a larger value resistor may be added in parallel with R1. Use a 1/4 watt, 5% carbon resistor ranging from 900 ohms to 500K ohms.

27. Selection of C1

28. Capacitor C1 is selected to level out the Thermal Converter's frequency response above 10MHz. It is best to select the capacitor after all the resistors and the thermoelement are mounted in the Thermal Converter case. Go to the following paragraphs to select the correct capacitor for the different converters.

29. **C1 Selection for the 11049A Converter.** Use a variable capacitor with a nominal value of 9-35pF for C1 (-hp-

Part Number: 0121-0105). Adjust the capacitor for the best high frequency response. If unable to level out the response, try placing a capacitor in parallel with C1. Any mica or ceramic capacitor ranging from 1pF to 50pF can be used.

30. **C1 Selection for the 11050A Converter.** Use a variable capacitor with a nominal value of 7-25pF for C1 (-hp- Part Number: 0121-0114). Adjust the capacitor for the best high frequency response. If unable to level out the response, try placing a capacitor in parallel with C1. Any mica or ceramic capacitor from 1pF to 50pF can be used.

31. **C1 Selection for the 11051A Converter.** The capacitor is selected by noting the resistor R2 value and then choosing the correct C1 value, as shown in Table 3. If unable to level out the high frequency response after installing C1, try placing a variable capacitor in parallel with C1. A good choice is a 9-35pF capacitor (-hp- Part Number 0121-0105).

Table 3. C1 Selection for the 11051A

R2 Value in Ohms	Capacitor C1	
	Value	-hp- Part Number
11 to 12	30pF	0160-2199
10 to 11	33pF	0160-2150
8 to 10	39pF	0160-0190
7 to 8	43pF	0160-2200
6 to 7	51pF	0160-0205
5 to 6	62pF	0140-0205
5	82pF	0140-0193

32. Installation of Components

33. The orientation of the components within the Thermal Converter case is critical. Improper spacing may cause serious degradation, especially at higher frequencies. Refer to Figure 8 for the correct placement of the components. Observe the following precautions when installing the components.



Use an adequate heat sink when soldering connections to the thermoelement. Excessive heat can damage the element.

- a. Keep all leads as short as possible.
- b. Make sure the components are mounted as shown in Figure 8.
- c. Avoid bending the thermoelement leads any more than absolutely necessary. Excessive bending may weaken the glass seal.
- d. The red (positive lead) is to be connected to the thermoelement's lead with the red dot.

34. REPLACEABLE PARTS

35. All the replaceable parts for the Thermal Converters are listed in Table 4. The mechanical parts are shown in Figure 9. Included with each part is its -hp- part number, total quantity, check digit, and description.

Table 4. Replaceable Parts

Ref. No.	-hp- Part Number	C D	Qty	Description
1	1250-0045	5	1	Connector: Male BNC
2	2190-0016	3	3	Lock Washer
3	0360-0024	2	2	Lug: Grounding
4	2950-0001	8	1	Nut: Hex, 3/8
5	0340-0039	7	2	Bushing: Insulator
6	0340-0038	6	2	Terminal: Output
R3	0698-3122	2	1	Resistor: 412 ohms, 1%, 1/8W (11049A)
R3	0757-0421	4	1	Resistor: 825 ohms, 1%, 1/8W (11050A)
R3	0757-0407	6	1	Resistor: 200 ohms, 1%, 1/8W (11051A)
R4	0757-0277	8	1	Resistor: 49.9 ohms, 1%, 1/8W (11049A)
R4	0757-0384	3	1	Resistor: 20 ohms, 1%, 1/8W (11050A)
	0853-0001	0	1	Thermoelement: UHF, 90 ohms, 5mA
	11049-00021	1	1	Can: Shield
	11049-00031	3	1	Cover: Top
	2360-0113	2	2	Screw: 6/32 for top cover

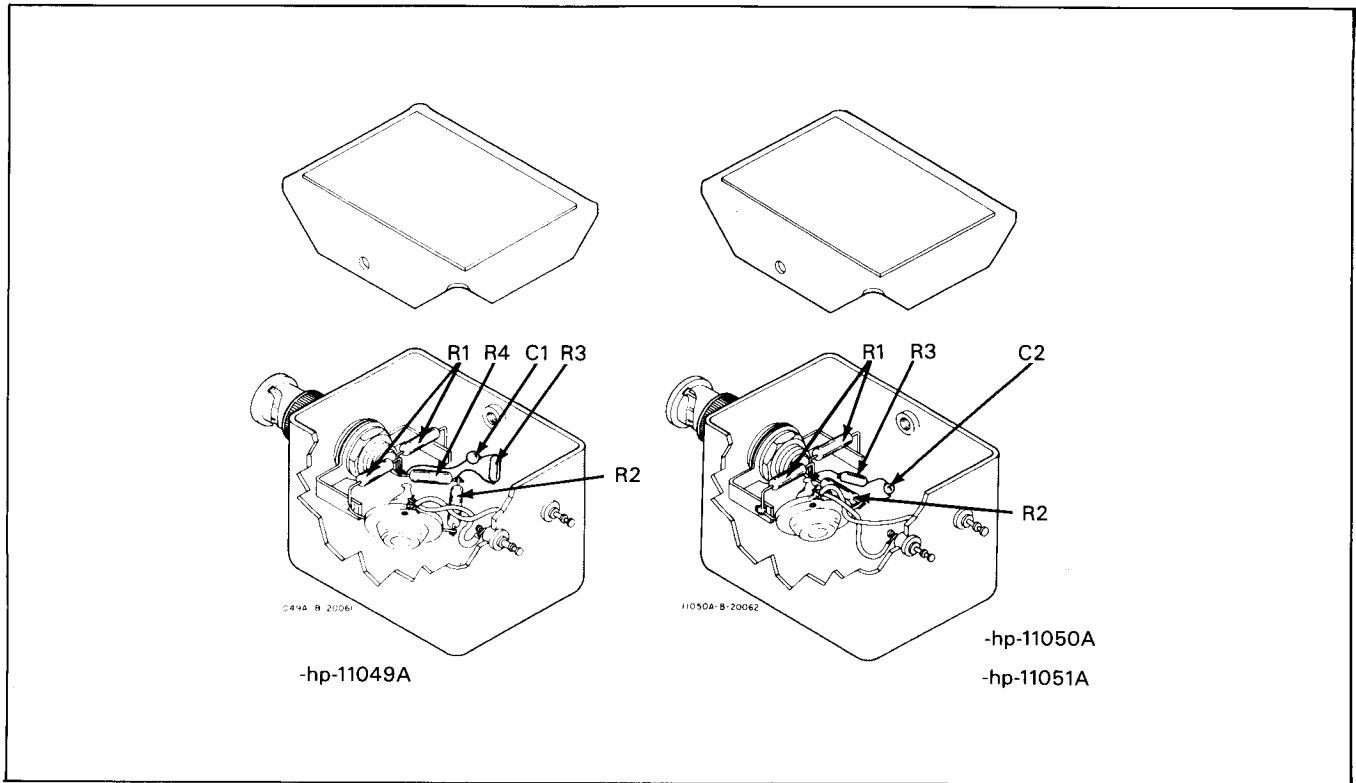
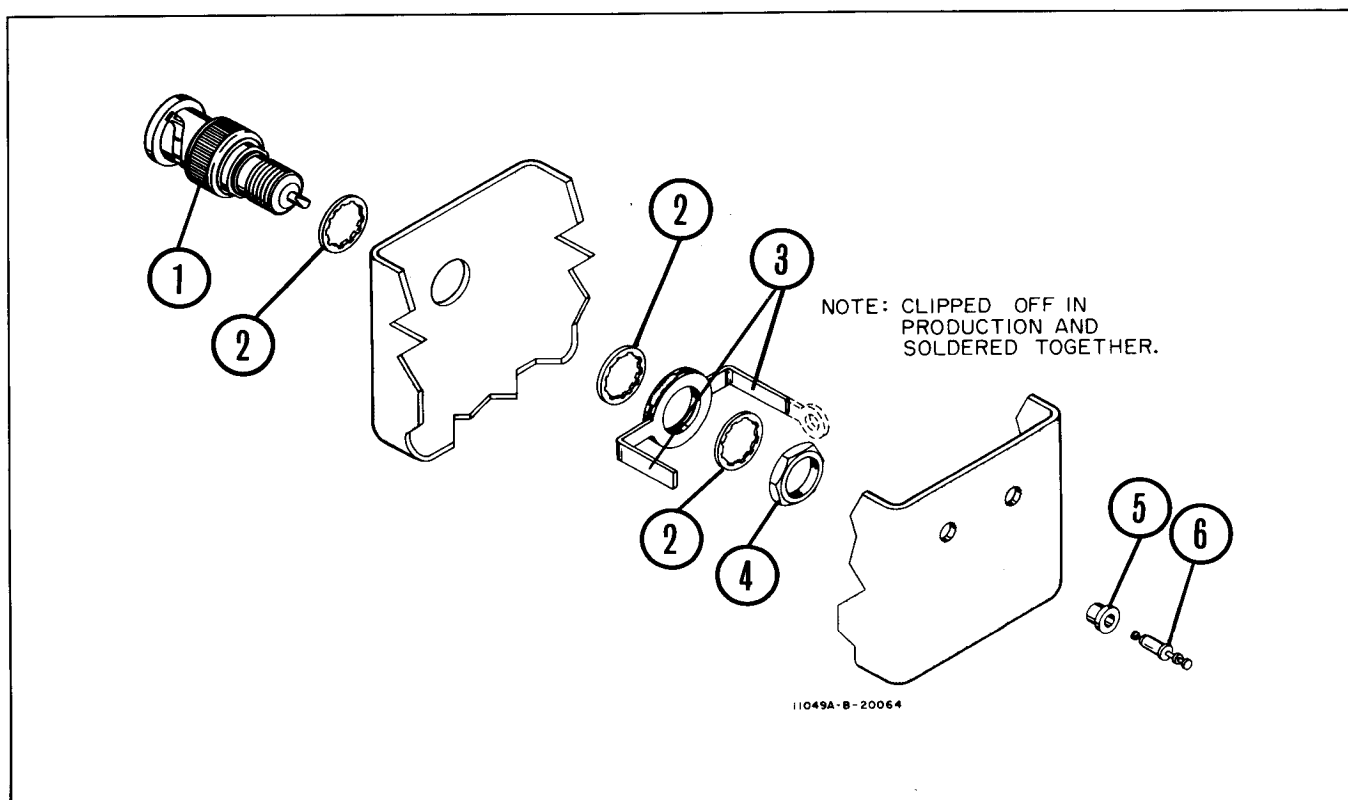


Figure 8. Proper Orientation of Components

**Figure 9. Mechanical Parts**



Product Line Sales/Support Key

Key Product Line

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- CH Computer Systems Hardware Sales and Services
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