

# ***FLUKE 51,52***

*K/J Thermometer*

## **Service Manual**

PN 768234

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Fluke Corporation  
P.O. Box 9090  
Everett WA 98206-9090

Fluke Europe B.V.  
P.O. Box 1186  
5602 B.D.  
Eindhoven  
The Netherlands

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# Section 1

## Introduction and Specifications

### 1-1. INTRODUCTION

This manual presents service information for the Fluke 51 and 52 K/J Thermometers. Included are a theory of operation, general maintenance procedures, performance tests, calibration procedures, troubleshooting information, a list of replacement parts, and schematic diagrams.

### 1-2. OPERATING INSTRUCTIONS

For operating instructions, refer to the Operator's Manual provided with the instrument at the time of purchase, or order Fluke P/N 769026 for the 51 K/J Thermometer

Operator's Manual or Fluke P/N 764712 for the 52 K/J Thermometer Operator's Manual.

### 1-3. SUMMARY OF CONTROLS AND MODES

For information regarding controls and modes of the 51/52, refer to the Operator's Manual provided with the instrument at the time of purchase, or turn to the Theory of Operation section in this manual.

### 1-4. SPECIFICATIONS

For instrument specifications, refer to the Operator's Manual provided with the instrument at the time of purchase.

## Section 2

# Theory of Operation

### 2-1. INTRODUCTION

This section of the manual describes the theory of operation of the Fluke 51 and 52 K/J Thermometers. The main features of the 51/52 are first presented at an overall functional level, followed by a detailed description using the schematic diagrams for reference. Instrument control and calibration modes are also discussed in this section. These modes may be used during performance testing and during calibration of the units.

### 2-2. FUNCTIONAL OVERVIEW

The Fluke 51 and 52 K/J Thermometers take nonlinear voltages from thermocouples and convert the voltages to meaningful temperature readings. These thermometers are actually microvoltmeters with additional features to compensate for the reference junction and non-linearities of thermocouples.

The heart of these instruments is an analog-to-digital converter (a/d converter) that develops a numerical representation of an analog voltage. The a/d converter (U1) works in the range of -10 mV to +55 mV. For the Fluke 52, three signals must be measured: thermocouple 1, thermocouple 2, and the signal that represents the temperature of the reference junctions. To measure the three signals, the a/d converter is connected to each of these signals one at a time. A microcomputer (U2) coordinates the switching and a/d activity performed by U1. U2 also interprets the numbers sent by the a/d converter, including reference junction compensation, linearization, and degrees Celsius and Fahrenheit conversion. U2 also monitors the instrument control buttons and drives the liquid crystal display (LCD). See Figure 2-1 for a functional overview of the 51 and 52.

### 2-3. DETAILED DESCRIPTION

The following information describes the 51 and 52 K/J Thermometers simultaneously. Refer to the schematic diagrams in Section 6 while reading this description.

#### NOTE

*Reference designations used here, such as "R7,13" mean that R7 appears on both the 51 and 52 instruments, and R13 appears only on the 52 dual thermocouple instrument.*

### 2-4. Power Supply and Switching

Vdd is the positive terminal of the battery. When the instrument is turned on (ON/OFF and U4 pin 4), Vss is regulated by an on-board regulator consisting of Q2, Q3, CR7, R31 and R32. The output of the regulator, Vss, is provided to pin 46 of U1. A "common" voltage of approximately 3.1V below Vdd is generated by pin 14 of U1. This Vdd-common voltage provides the power supply for the microcomputer (U2), the band gap reference (VR1), and the reference junction sensor (Q1). C8 provides compensation and bypassing for the Vdd-to-common regulator. U1 (pin 46) and U4 (pin 4) are the only components that use Vss. Vss-to-common changes as the battery discharges, whereas Vdd-to-common is regulated and does not change (except slightly with ambient temperature changes).

U4 and its surrounding components form two toggle flip-flops that function as instrument power switching and F/C display control button memory. Pin 4 of U4, controlled by the ON/OFF button, provides the input to the Vss regulator consisting of Q2, Q3, CR7, R31 and R32. The output of

this regulator, Vss, is provided to U1 pin 46. Pin 11 of U4 signals U1 (which in turn signals U2) indicating whether degrees Fahrenheit or Celsius is chosen by the user. The F/C flip-flop state is maintained, and cannot be changed, when the instrument is turned off. C5 and C6 provide a reverse charge to change the state of the F/C and on/off flip-flops when the buttons are depressed. C4 ensures that the F/C flip-flop does not change when the instrument is turned on or off. C13 ensures that the instrument does not turn on or off when the thermocouples experience an electrostatic discharge.

R23 and R24 provide an intermediate voltage level for the multiplexed LCD drive signals.

**2-5. Analog Circuitry**

**NOTE**

*In the following text, TnLO refers to either T1LO or T2LO, TnHI refers to either T1HI or T2HI, etc.*

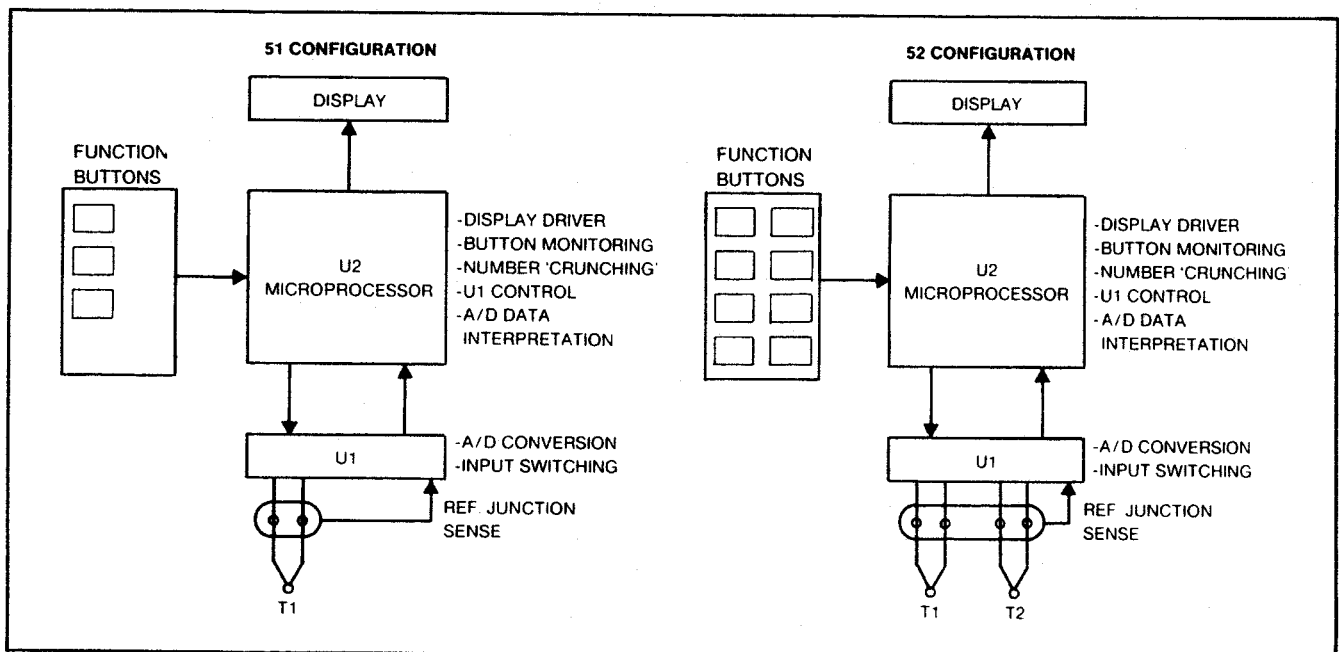
Each thermocouple connection to U1 consists of four pins (refer to the schematics and the block diagrams). TnLO ties the low side of the thermocouple to instrument common. TnHI connects the high-side thermocouple input to the positive-sensed a/d converter input. TnPU provides approximately 70 mV to a 22-MΩ pull-up resistor (R2,8) to force the a/d converter into overload if the thermocouple is open or not plugged in. R19 and R20 provide the pull-up voltage source, approximately 70 mV. The VPU input, pin 35 on U1, is connected internally to TnPU when the particular thermocouple

input is being read by U1. R7,13 provide small offset voltages to the TnOS input(s) to compensate for slight errors in thermocouples being used. The range of adjustment as seen by TnOS is approximately 0.4 mV.

The TnPU, TnHI, TnLO, and TnOS pins on U1 are continuously switched signals from within U1. When U1 is commanded by U2 to read a thermocouple input, a switch on each of the four pins closes, and the thermocouple is connected to the a/d converter. When U1 is measuring another signal (i.e., the other thermocouple or the reference junction temperature sensor), U1 opens all four switches and effectively allows the thermocouple to float within a positive limit controlled by the clamp voltage (approx. 1.23V) at pin 32 of U1. Voltages greater than 1 volt that are applied between two thermocouples (Fluke 52) can cause improper instrument operation. If this voltage exceeds 60V dc or 24V ac, the instrument can be damaged. R3,9 and R4,10 provide current limit protection.

Pins 4 through 9 of precision resistor network Z1 divide down VR1 reference voltage (approximately 1.23V) and provide various stable voltages to generate Vdd-common, establish the a/d reference voltage, and form part of the reference junction temperature-sensing circuit as described below.

Q1 is thermally connected to, but electrically isolated from, the reference junction(s) at the input connector(s). The voltage across the base and emitter is about 567 mV at 25°C, and becomes smaller as temperature increases



**Figure 2-1. Functional Overview**



(about  $-2.24 \text{ mV}/^\circ\text{C}$ ). The voltage is divided down by R17 and R18 and applied to RJS LO ( $482 \text{ mV}$  at  $25^\circ\text{C}$  and  $-1.90 \text{ mV}/^\circ\text{C}$ ). Another temperature-stable voltage that matches the voltage divided by R17 and R18 when Q1 is at room temperature ( $482 \text{ mV}$  at  $25^\circ\text{C}$ ) is available from pin 6 of Z1, and is tied to RJS HI. RJS LO and RJS HI are measured by the a/d converter inputs when U2 commands U1 to read the reference junction temperature. R16 adjusts the current through Q1 for calibration of the reference junction sensing circuit.

C10 is the dual slope integrator capacitor, C11 is the auto-zero capacitor, and pins 1, 2, and 3 of Z1 form the integrate-ranging resistors.

## 2-6. Digital Circuitry

Crystal Y1 is the frequency-determining element for the instrument's clock source that is generated in U1. The clock signal is used by both U1 and U2 and appears on pin 56 of U1 and pin 12 of U2.

C7 resets the microcomputer when the instrument is turned on.

Connections leaving U1 called D0, D1, D2, D3 and A0, A1, A2, A3 are the data and address buses that form the communications link between U1 and U2. NRD, NWR, and NDAV are data-direction and data-availability signaling lines.

The pins labeled B0, B1, and B2 on U1 communicate operation modes to the instrument and are read just after the instrument is turned on. B0 controls display resolution and is strapped (or not strapped) to Vdd by R22, or is actuated by the elastomeric switch grid labeled TP0. B1/TP1 brings up the TC CAL (Thermocouple Calibration) mode that allows easy calibration of R7,13 initially (offset adjustments for each thermocouple channel), and allows easy calibration of R21, the a/d converter reference adjust (overall scaling adjustment). B2/TP2 brings up the RJS CAL (Reference Junction Sensor Calibration) mode and allows easy calibration of R16. The pin labeled B3 is read continuously during operation and is the F/C display control. If degrees Celsius ( $^\circ\text{C}$ ) is selected, B3 is pulled to Vdd through CR6. CR6 blocks battery drain if degrees Fahrenheit ( $^\circ\text{F}$ ) is selected when the instrument is turned OFF.

## 2-7. INSTRUMENT CONTROL MODES

The operation of the instrument can be altered to change default modes and access calibration functions.

## 2-8. Secondary Functions

The operation of the instrument may be modified by holding down the following buttons, or any combination of buttons, as the instrument is turned on. Holding down any of the buttons listed below holds all of the display segments on until the button(s) are released, which allows time to inspect the display. The full display is held on longer than the normal "self-test" display flash, indicating the unit has recognized a request for the secondary function (see Operator's Manual).

T1	Overrides resolution as selected by the absence or presence of R22.
T2	Enter Scan Mode.
HOLD	Overrides thermocouple type as selected by the absence or presence of W1.

The following is a list of strapped options.

W1	When installed, the microprocessor linearizes for K-type thermocouples. If the jumper is cut or removed, J-type linearization is used unless this action is reversed by pressing HOLD during power-on.
R22	When installed, the microprocessor causes the display to show $0.1^\circ\text{C}$ or $0.2^\circ\text{F}$ resolution. If the jumper is cut or removed, $1^\circ$ resolution is displayed for both F and C unless this action is reversed by holding down T1 during power-on.

## 2-9. Calibration Modes

In the normal operating mode, the reference junction signal is measured every 13 to 20 seconds (depending on how many thermocouples are being used on the 52, and always about 13 seconds on the 51). Thermocouple samples are combined with the reference junction samples to give a display reading. It is desirable to separate the effects of these separate readings for calibration and troubleshooting purposes. Two modes are available for these purposes (TC CAL mode and RJS CAL mode).

To enter these modes, it is necessary to short the TP1 or TP2 switch grid near the ON/OFF switch grid on the printed circuit assembly (pca) with the front cover of the instrument removed. Otherwise, these modes are activated in the same manner as the secondary functions of the user button. However, the display test interval does not stay frozen while the connection is held on test points TP1 or TP2. Because of this, it is not immediately obvious that you are in a calibration mode.

**CAUTION**

**When shorting out the switch grids, use only the soft conductive pads supplied with the service manual and called out in the required equipment list. Hard metal tools should not be used to touch the switch grid as they may damage the pca and switch contact points.**

The following is a list of the test points and their functions.

- TP0 Not effective if R22 is installed. Brings up high resolution for calibration purposes if R22 is not installed.
- TP1 (TC CAL mode)  
Offset potentiometer(s) (R7, 13) and a/d

reference (R21) calibration. The thermocouple inputs are the only signals that affect the display in this mode.

In this mode, the reference junction circuit compensation is ignored; the microcomputer simulates the reference junction circuit at room temperature.

**TP2 (RJS CAL mode)**

Reference Junction Sensor Calibration (R16). Since the thermocouple inputs are ignored in this mode, the reference junction compensation can be calibrated without interference from the thermocouple inputs.

In this mode, the thermocouple inputs are ignored; the microcomputer simulates zero output from the thermocouples.

## Section 3 Maintenance

### WARNING

**THESE SERVICE INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATOR'S MANUAL UNLESS YOU ARE QUALIFIED TO DO SO.**

### 3-1. INTRODUCTION

This section contains maintenance information for the Fluke 51 and 52 K/J Thermometers, including performance tests, calibration, general maintenance procedures, and troubleshooting. For operator maintenance and instrument specifications, refer to the Operator's Manual.

The performance tests are recommended as a preventive maintenance tool to verify proper instrument operation. A one-year calibration cycle is recommended to maintain the specifications given in the Operator's Manual.

### 3-2. SERVICE INFORMATION

The Fluke 51 and 52 are warranted for a period of 3 years upon shipment of the instrument to the original purchaser. Conditions of the warranty are described on the registration card. Malfunctions that occur within the limits of the warranty will be corrected at no cost to the purchaser. For in-warranty service, ship the instrument post-paid to the Fluke Service Center nearest you. A list of service centers is included at the back of the Operator's Manual provided with the instrument at the time of purchase.

Fluke Service Centers are also available for calibration or repair of instruments that are beyond the warranty period. Upon request, a cost estimate will be provided before work is performed on instruments that are beyond the warranty period.

For application or operation assistance or information on Fluke products, call:

800-44-FLUKE (800-443-5853) in U.S.A. and Canada  
31 40 723-220 in Europe  
206-356-5500 from other countries

If reshipment is necessary, please use the original shipping container. If the original container is not available, be sure that adequate protection is provided to prevent damage during shipment. It is recommended that the instrument be surrounded by at least 3 inches of shock-absorbing material in the shipping container.

### 3-3. GENERAL MAINTENANCE

#### 3-4. Instrument Disassembly

### WARNING

**TO AVOID ELECTRICAL SHOCK, REMOVE THERMOCOUPLES BEFORE OPENING THE CASE, AND CLOSE THE CASE BEFORE OPERATING THE METER.**

### CAUTION

**To avoid contaminating the pca with oil from the fingers, handle it by the edges or wear gloves. PCA contamination may not cause immediate instrument failure in controlled environments. Failures typically show up when contaminated units are operated in humid areas.**

Use the following procedure for removing the pca from its case.

1. Turn the instrument off and remove the thermocouples.
2. Remove the four case screws from the bottom cover with a #2 Phillips screwdriver.
3. Turn the meter face up, grasp the top cover, and pull the top cover from the meter.
4. Remove the Phillips screw that holds the pca to the back cover.
5. The pca may now be removed from the bottom cover.

**CAUTION**

To prevent damage to the case, care should be taken when reassembling the unit to not over-torque the screws (6 to 7 inch pounds is sufficient).

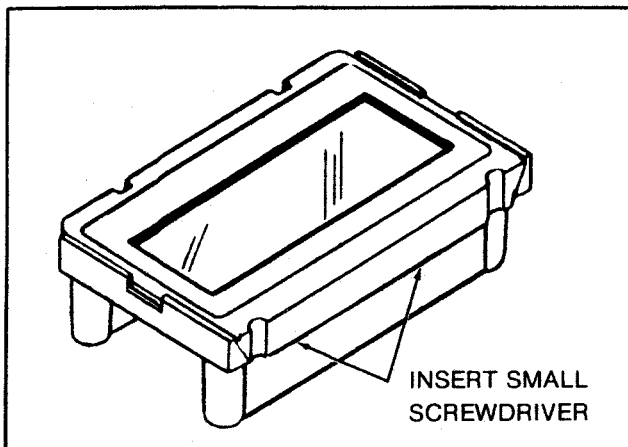
**3-5. Display Access**

**CAUTION**

Do not handle the conductive edges of the LCD or LCD interconnects. If the edges are contaminated, clean them with alcohol.

While referring to Figure 3-1, use the following procedure to remove the LCD from the display holding bracket.

1. Remove the four Phillips screws from the back side of the pca.



**Figure 3-1. Display Assembly**

2. Remove the LCD mounting bracket.
3. Insert a small screwdriver under the edges of the display holding bracket, and gently pry the bracket loose from the snaps.
4. Turn the bracket upside down to remove the LCD.
5. Before installing a new LCD, make sure that all connector contact points are clean.

**3-6. Cleaning**

**CAUTION**

To avoid damaging the meter, do not use aromatic hydrocarbons or chlorinated solvents for cleaning. These solutions will react with the plastics used in the instrument.

Do not allow the liquid crystal display to get wet. Remove the display assembly before washing the pca, and do not install until the pca is completely dry.

Do not use detergent of any kind for cleaning the pca.

Avoid removal of lubrication from the thermocouple connectors when cleaning the pca.

To relubricate the thermocouple connectors, slide the white isothermal block up and off the metal connectors. Apply a conservative amount of Amoco Rykon® PN 344572, Premium Grease, type EP-2, on the side of the connectors nearest the battery as shown in Figure 3-2.

Clean the instrument case with a mild detergent and water.

The pca may be washed with isopropyl alcohol or deionized water and a soft brush. Remove the display assembly before washing. Dry with clean dry air at low pressure and then bake at 50°C for 24 hours.

**3-7. PERFORMANCE TEST**

The following procedure refers to the Fluke 51 or 52 instruments as the Unit Under Test (UUT).

Performance tests are recommended for incoming inspection, periodic maintenance, and for verifying the specifications in the Operator's Manual. If the instrument fails any part of the test, calibration and/or repair is indicated.

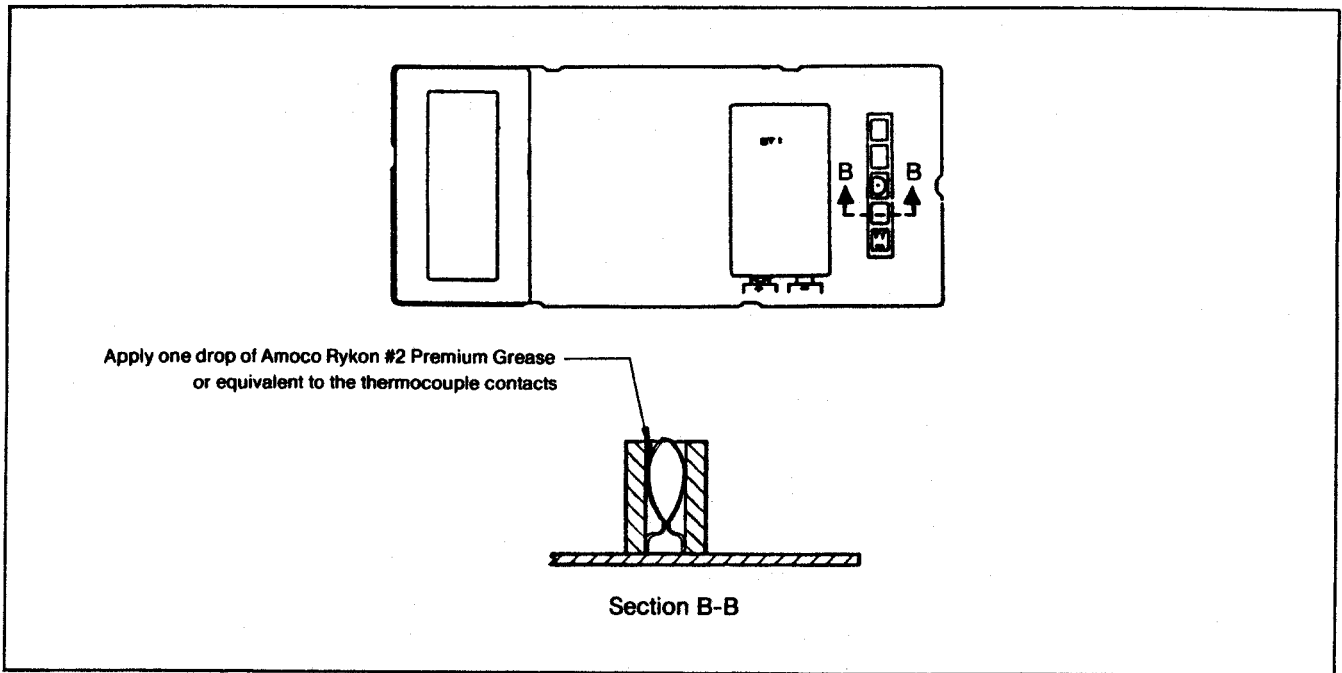


Figure 3-2. Lubricating the Thermocouple Connectors

**3-8. Initial Procedure**

Use the following procedure to prepare the UUT before beginning the Performance Tests or Calibration Procedures.

1. Allow the UUT to stabilize to room temperature,  $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $73^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).
2. Check the battery and replace it if necessary.

**3-9. Display Test**

Turn the instrument on while continuously pressing the HOLD button. Check that all the display segments come on as shown in Figure 3-3. The entire display stays on as long as the HOLD button is pressed.

*NOTE*

*Since pressing the HOLD button during power-up activates one of the instruments secondary functions (see Secondary Functions in Section 2-8), take care to return the instrument to its normal function (if required).*

**3-10. WIDE RANGE PERFORMANCE TEST PROCEDURE**

The performance test listed here verifies instrument performance to its specifications. This test may be used for initial acceptance, for verifying calibration, or as an aid in troubleshooting. If the thermometer fails to meet

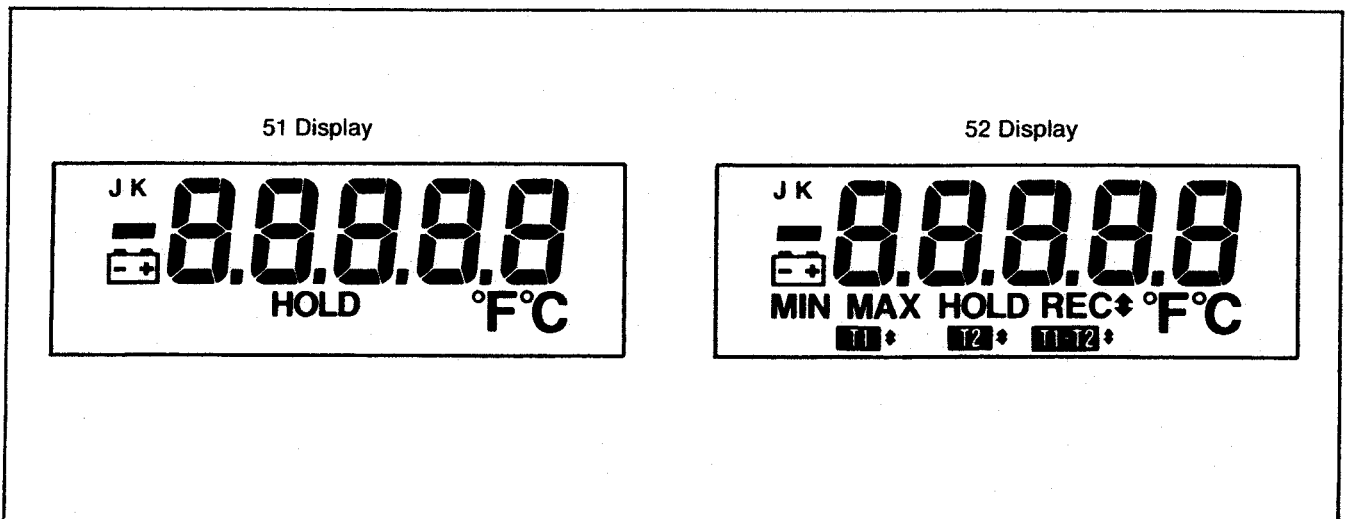


Figure 3-3. Display Test

specifications in this test, the calibration adjustment procedure or troubleshooting should be performed as determined by qualified personnel.

Test equipment required for the performance test and calibration is listed in Table 3-1. If the recommended equipment is not available, instruments with equivalent specifications may be used. The test should be conducted with an ambient temperature of  $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $73^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).

### 3-11. Ice Bath Construction

To begin the Performance Test, first construct an ice bath using the following steps.

1. Prepare a Dewar Flask by drilling two holes in its cap to accept the thermometer and thermocouple wires, or use a standard laboratory cork.
2. Fill the Dewar Flask with shaved or crushed ice made from distilled water.
3. Fill the Dewar Flask with enough distilled water so that the ice becomes slush, but do not add enough water to float the ice.

### NOTE

*As the ice melts, siphon off the excess water and add more ice. Allow approximately 5 to 10 minutes for the water to drop back to the freezing point.*

4. Replace the Dewar Flask cap or cork, and insert thermocouple wires as shown in Figure 3-4.

### 3-12. Ice Bath Test

Use the following procedure to test the instrument. This test should be conducted on both thermocouple inputs on the 52.

1. Connect the equipment as shown in Figure 3-4.
2. Insert the Mercury Thermometer to the same depth as the thermocouple wires, verify that the Ice Bath temperature is  $0.0^{\circ}\text{C} \pm 0.3^{\circ}\text{C}$ .
3. Short (or apply 0 mV) to the copper wires at the 5440A Calibrator.
4. Verify that the UUT reads  $0.0^{\circ}\text{C} \pm 0.4^{\circ}\text{C}$ .

**Table 3-1. Recommended Test Equipment**

TEST EQUIPMENT	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
DMM	DC Voltage Accuracy: 0.5%	Fluke model 8060A
Temperature Probe	Accuracy: Certified to $\pm 0.2^{\circ}\text{C}$ ambient	Fluke Model 80T-150U
DC Voltage Calibrator	Output Voltage 0 to 10V Accuracy: 0.002% Resolution: 10 $\mu\text{V}$	Fluke 5440A
Elastometer Switch Pad		Fluke P/N 680686
Thermocouple Connector	For K-type thermocouple	Fluke 80CK-M
Thermocouple Wire (K or J Type)		Omega
Dewar Flask/Cap	1-pint capacity	Thermos
Mercury Thermometer (either $^{\circ}\text{C}$ or $^{\circ}\text{F}$ )	0.02 $^{\circ}\text{C}$ resolution 0.05 $^{\circ}\text{F}$ resolution	Princo Model ASTM56C Princo Model ASTM56F

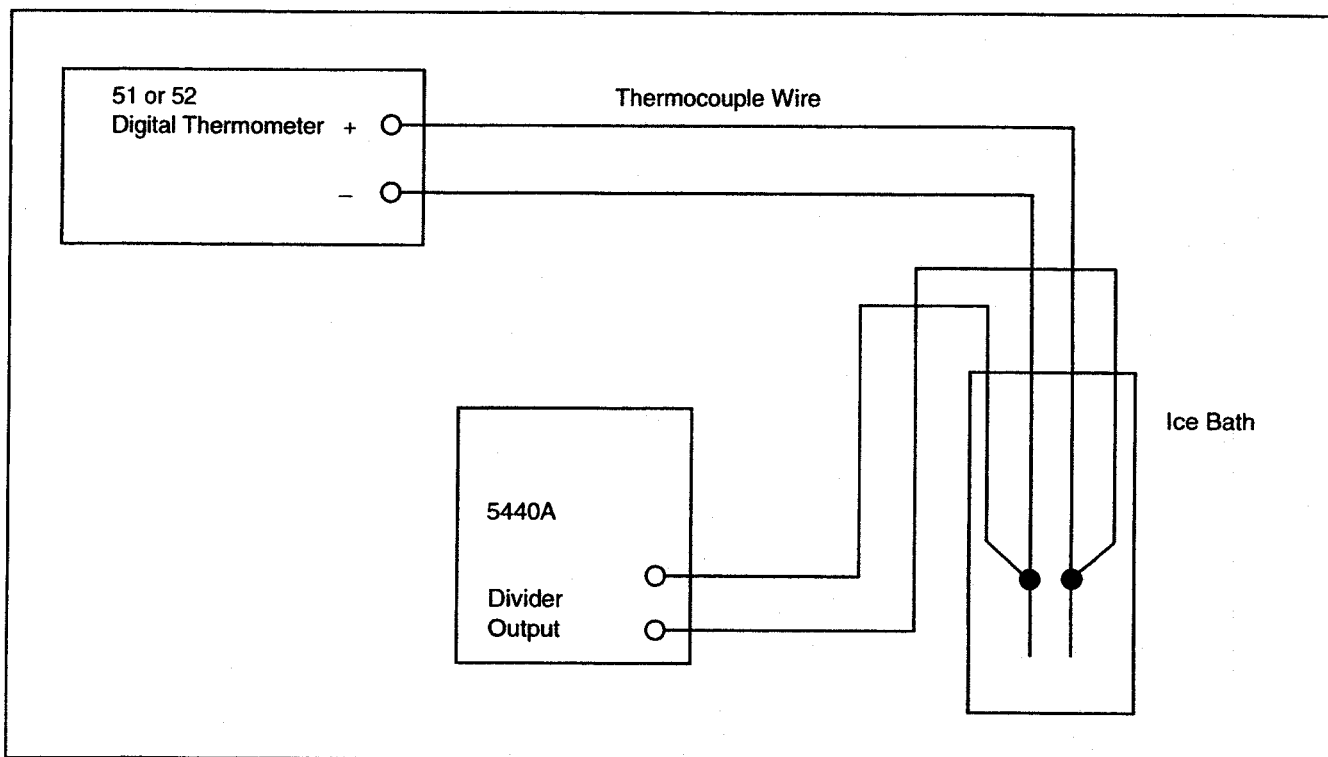


Figure 3-4. Equipment Connections

Table 3-2. Performance Test Values

THERMOCOUPLE TYPE	INPUT VOLTAGE (mV DC)	DISPLAY READING	
		DEGREES C	DEGREES F
K	-5.587	-182.0 ±(0.9)	-295.6 ±(1.6)
K	-3.211	-89.0 ±(0.8)	-128.2 ±(1.4)
K	21.919	530.0 ±(1.2)	986.0 ±(2.3)
K	54.297	1355.0 ±(2.1)	2471.0 ±(3.8)
J	-7.824	-197.0 ±(1.0)	-322.6 ±(1.7)
J	13.997	258.0 ±(1.1)	496.4 ±(1.9)
J	39.442	705.0 ±(1.5)	1301.0 ±(2.7)

If this test fails, reposition the thermocouple wires and Mercury Thermometer in the Ice Bath and repeat Step 2-4. If the test continues to fail then perform the Calibration Procedure, earlier in this section.

5. Remove the short applied in step 3.
6. Using Table 3-2 (for the corresponding thermocouple type), obtain a divided output from the 5440A equal to the first value of the "Input Voltage (mVDC)" column, and verify that the UUT reads within the limits specified.
7. Repeat step 2 for the remaining voltages in the "Input Voltage (mVDC)" column.

8. Disconnect the thermocouple from the input terminals. This completes the Ice Bath Test.

### 3-13. CALIBRATION PROCEDURE

The following procedure refers to the Fluke 51 or 52 instruments as the Unit Under Test (UUT).

#### CAUTION

**When you are directed to short a switch grid below, use only the elastomeric switch pad that is supplied, as pca damage could occur if a hard tool is used.**

Wire the Thermocouple Connector to the 5440A with a length of ordinary 22-gauge wire. Polarity is important, so connect the positive side to the narrow thermocouple blade and the negative side to the wide blade. When using this connector with the UUT case top removed, make sure that the wide blade is oriented the same as the case top would normally allow. Connect the equipment as shown in Figure 3-5.

### 3-14. Instrument Calibration

Use the following procedure to calibrate the 51 and 52 K/J Thermometers.

1. Turn UUT off and remove the top case leaving the pca in the bottom case.
  2. Simultaneously short the TP1 grid and turn on the UUT by shorting the ON/OFF switch grid. Hold the elastomeric switch pad on TP1 for at least 3 seconds after turn on. This puts the UUT into the Thermocouple Calibration mode.
  3. Allow the UUT to stabilize at room temperature,  $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $73^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).
  4. Select  $^{\circ}\text{C}$  mode. Select T1 if the UUT is a Fluke 52.
  5. Adjust the 5440A for 0.00000V. Connect the 5440A divider output to the TP1 input.
  6. Allow the meter reading to settle and then adjust the T1 offset adjustment (R7) for a display reading of  $25.2^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ .
- Skip the next two steps if you are calibrating the Fluke 51.
7. Leave the 5440A adjusted for 0.00000V. Connect the 5440A divider output to the T2 input and select the T2 function.
  8. Allow the reading to settle and adjust the T2 offset adjustment (R13) for a display reading of  $25.2^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ .
  9. Adjust the 5440A for 53.807 mV output (5.3807V on the 343A).
  10. Allow the reading to settle and adjust (R21) for a display reading of  $+1370.0^{\circ}\text{C} \pm 0.4^{\circ}\text{C}$ .
  11. Disconnect the UUT from the 5440A. Power down the UUT by shorting the ON/OFF switch grid.
  12. With an elastomeric switch pad in both hands, use the left one to short out the TP2 grid, and use the right one to first turn on the instrument and then quickly short out the VIEW switch grid. Hold this position until the display is held in self-test. This puts the UUT into the Reference Junction Sensor calibration mode, and the VIEW

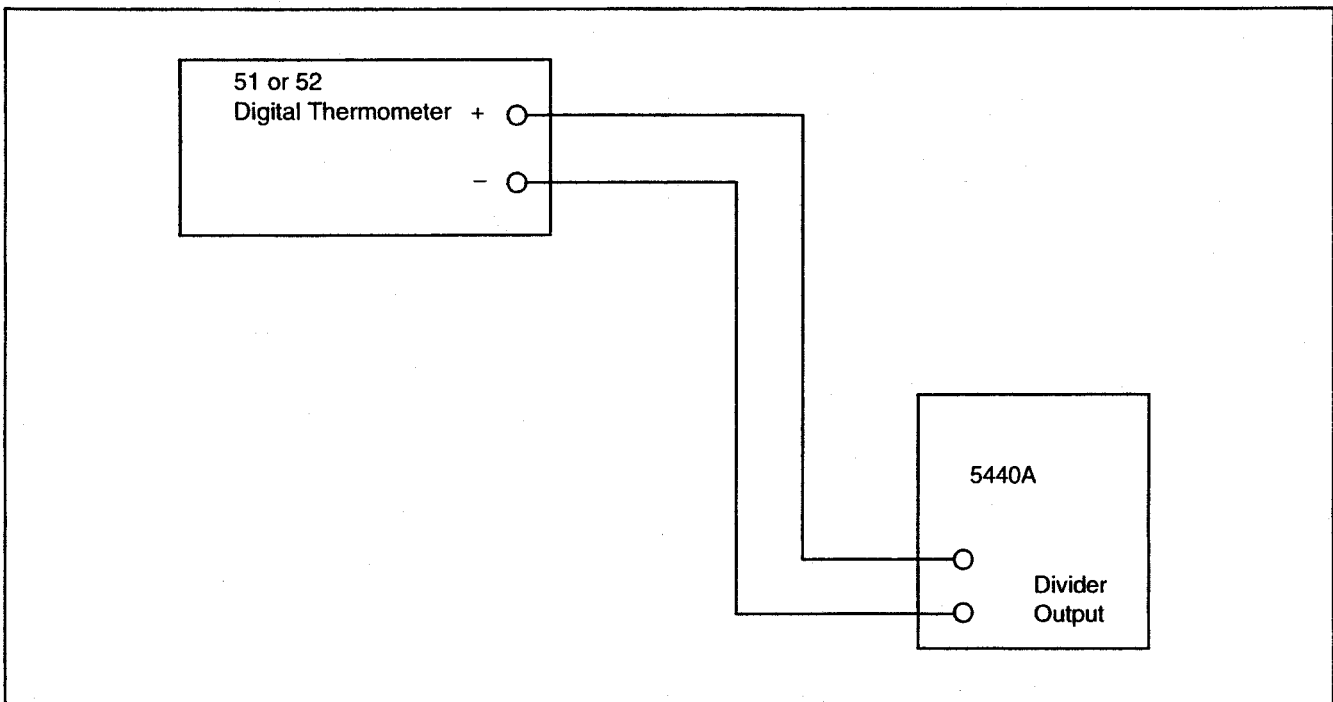


Figure 3-5. Calibration Adjustment Connections



- maneuver turns off a filter so that the reading settles immediately.
13. Using the 80T-150U and the 8060A DMM, measure the reference junction transistor temperature by placing the 80T-150U probe tip against Q1, located in the middle hole of the isothermal block. Wait for the temperature reading to stabilize.
  14. Adjust R16 for a temperature reading that is the same as displayed on the 8060A DMM.
  15. Power down the UUT and reassemble.

The following steps optimize the UUT performance in the negative temperature range.

16. Put the UUT in normal operating mode. Normal operation can be achieved by turning the UUT OFF and then ON. No other UUT buttons should be pressed during the power cycle operation.
17. Insert a known good thermocouple in an Ice Bath (See Ice Bath Construction, earlier in this section).
18. Insert the Mercury Thermometer to the same depth as the thermocouple wires, verifying the Ice Bath temperature is  $0.0^{\circ}\text{C} \pm 0.3^{\circ}\text{C}$ .

19. Connect the other end of the thermocouple wire to the T1 input of the UUT and allow the instrument reading to settle.
20. Slowly and in small graduations, adjust R7 (T1 OFFSET) until the UUT reading matches the Mercury Thermometer reading. Allow the UUT reading to settle and repeat the adjustment as necessary until a stable and correct reading can be attained.
21. Repeat Steps 19 and 20 for the R13 (T2 OFFSET, Fluke 52 only).

### 3-15. Thermocouple Input Calibration

Perform the thermocouple input calibration using the following procedure.

#### NOTE

*This procedure optimizes the 51 or 52 for measurement with a specific thermocouple.*

1. Construct an ambient temperature lag bath as shown in Figure 3-6.
2. Connect the thermocouple to the 51/52 input terminals. Select the applicable switch position (T1 or T2) and temperature scale ( $^{\circ}\text{C}$  or  $^{\circ}\text{F}$ ). Insert the probe into a room temperature lag bath.

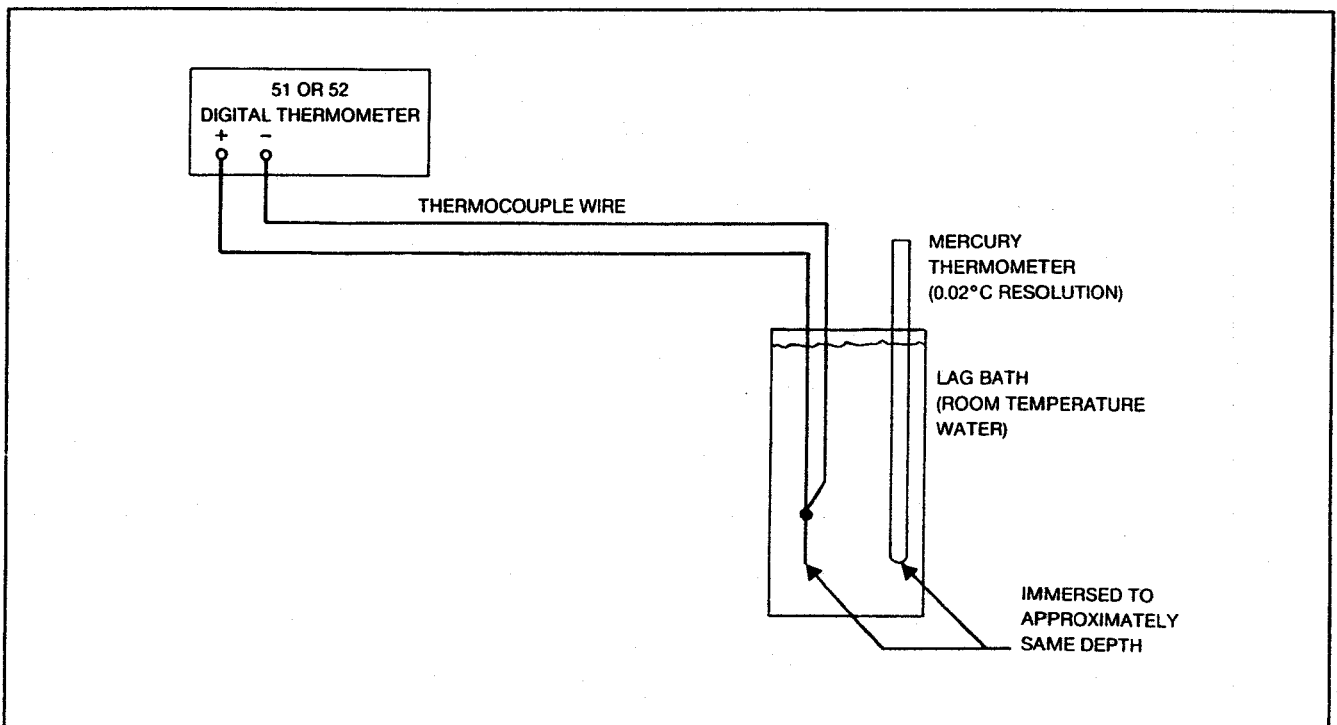


Figure 3-6. Room Temperature Lag Bath

3. Allow the system to stabilize, then adjust T1 or T2 offset adjustments for a temperature display equal to the reading of the lag bath reference thermometer.
4. Calibration of the 51/52 is complete. Disconnect all test equipment from the instrument.

### 3-16. TROUBLESHOOTING

#### CAUTION

**Static discharge can damage CMOS components U1, U2, and U4. Follow the handling precautions given previously for static-sensitive components. Never remove or install components without first disconnecting all inputs to the instrument.**

#### 3-17. Introduction

If the pca must be removed from the instrument, the board should be handled by the edges or the LCD bracket. This prevents improper operation due to electrical leakage caused by body fluids and salts. After any repair operation, the pca assembly must be cleaned by the procedure outlined in Section 3-6.

When the instrument is powered on, an approximate 1-second delay occurs during the microcomputer reset interval. After that, a short (1/3 second) period occurs that forces all LCD segments to appear while an internal self-test occurs. Secondary functions are also sought by the microprocessor during the power-on sequence, such as

alternate thermocouple type, alternate resolution, scan mode, TC calibration mode, and RJS calibration mode.

If the A/D converter within U1 is nonfunctional or if C10, C11 and Z1 are nonfunctional, the entire display flashes up to eight times as the instrument attempts to pass the A/D Self-Test. The instrument then exits the self-test phase and attempts to establish normal operation.

If a problem occurs, check the Operator's Manual to ensure proper operating procedures. If there is still a problem with the instrument, continue on with this section.

If U1 or U2 is defective, replacement should be left to experienced personnel. Service information is contained in Section 3-2 of this manual. For information on how to order replacement parts, refer to How To Obtain Parts in Section 4-2 of this manual. To obtain shipping information refer to the list of Fluke Service Centers in the Operator's Manual provided with the instrument at the time of purchase.

#### 3-18. Fault Diagnosis Guide

A fault guide for the 51 and 52 K/J Thermometers is given in Table 3-3. This guide can be helpful in isolating troubles to a component area. Unless otherwise specified, make all voltage measurements with respect to instrument common. Common is generated by U1 at pin 14 (COM).

#### 3-19. Using Calibration Modes for Troubleshooting

In the normal operating mode, the instrument obtains a reading from the combinations of the reference junction signal and the thermocouple signals. However, when troubleshooting, sections of the circuitry can be isolated.

Use TP1 to enter the TC CAL mode to eliminate the effect of the reference junction signal on the reading. In this mode, the reference junction compensation circuit is ignored; the microcomputer simulates the reference junction circuit as it would be at room temperature.

An example of the use of this mode is when the instrument displays an error indication (as shown in Figure 3-7) for T1, T2, and T1-T2. This may imply that the instrument is outside the allowable ambient operating temperature window (just below 0°C to just above 50°C). However, this display around room temperature either indicates all

thermocouples are open or the reference junction circuit is malfunctioning. If the TC CAL mode is selected and the readings are roughly correct and responsive to changes in thermocouple temperature, then the reference junction circuit may be malfunctioning.

Use TP2 to enter the RJS CAL mode to eliminate the effect of the thermocouple signals. This mode samples the reference junction more often than normal, which shortens the time between readings to show the immediate effect of an adjustment (normally up to 20 seconds).

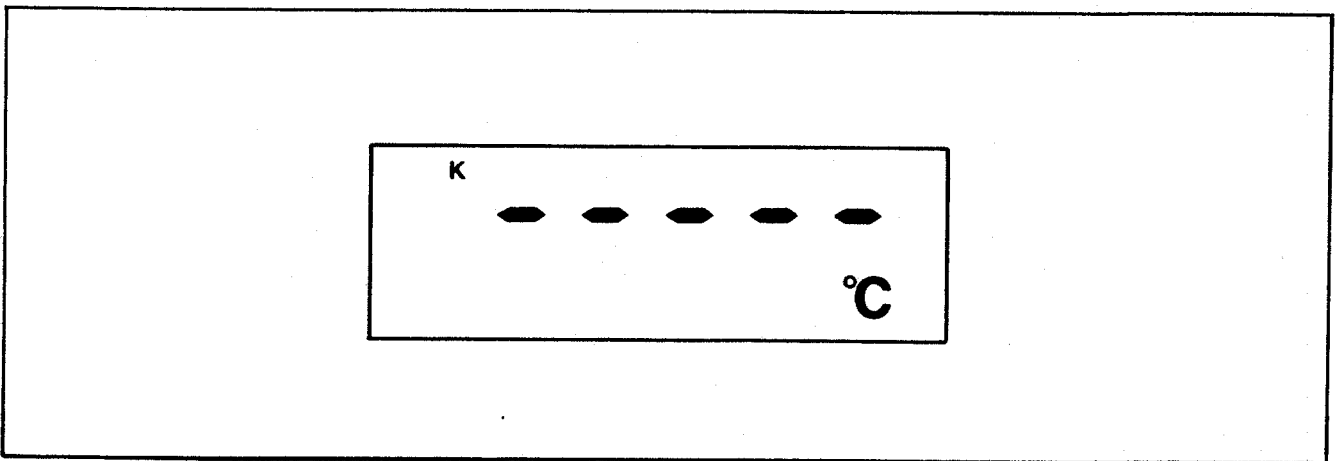


Figure 3-7. Error Indication

Table 3-3. Fault Guide

SYMPTOM	POSSIBLE CAUSE	ACTION
No display; unit fails to turn on	<p>Dead battery.</p> <p>U1 not generating Vcom.</p> <p>U4 defective.</p>	<p>Make sure CR5 is not shorted and that CR6 is not leaky.</p> <p>Check (+) side of battery relative to common for approximately 3.1V at room temperature (common appears on the grid pattern under the battery, VR1, pin 14, 15, and 16 of U1, etc.)</p> <p>Check to see if U4 is operating; pin 4 of U4 should toggle as pin 8 is momentarily shorted to the juncture of C6, R26. Also check C6, R26, and R27.</p>
Absent or dim and inactive display	<p>Very low battery (the battery symbol should be visible on the display).</p> <p>No clock.</p>	<p>Replace the battery.</p> <p>Check for approximately 32768 Hz, 3V peak-to-peak square-wave on U2 pin 12. If no signal is found, look for evidence of 32768 Hz on pin 54 of U1 and a lower level signal on pin 52 of U1. Also check U1, Y1, or C3.</p>
Some segments are missing on the display	<p>Contamination of LCD interconnects at pca or LCD (U3).</p> <p>Defective LCD.</p> <p>Defective U2.</p> <p>Damaged LCD interconnect.</p>	<p>Look for debris trapped under elastomeric interconnect. Clean as described in Section 3-6.</p> <p>Replace the LCD.</p> <p>Check for activity on U2 output strobes to the LCD.</p> <p>Examine interconnect and contacts for contaminants. Clean per Section 3-6.</p>
Inaccurate readings	<p>Damaged or open thermocouple.</p> <p>See if the wrong thermocouple type is installed or selected. Also see if the extension wire is of the proper thermocouple type.</p> <p>The thermocouple is installed backwards. If the measurement junction and the instrument are both at the same temperature, the reading appears to be correct. However, if the measurement junction is then heated, the meter shows a colder reading.</p> <p>Offset controls are misadjusted.</p>	<p>Replace the thermocouple.</p> <p>Refer to Table 1 in the Operator's Manual that describes how to identify thermocouple type and wire polarity.</p> <p>Refer to Table 1 in the Operator's Manual that describes how to identify thermocouple type and wire polarity.</p> <p>Recalibrate per Thermocouple Input Calibration in Section 3-15.</p>

Table 3-3. Fault Guide (cont)

SYMPTOM	POSSIBLE CAUSE	ACTION
Inaccurate readings(cont)	<p>Low battery (the low-battery annunciator should be on).</p> <p>Instrument is out of calibration.</p> <p>U1, VR1, Q1, or Z1 is defective.</p> <p>PCA contaminated around U1 and/or thermocouple input area.</p>	<p>Replace the battery.</p> <p>Execute calibration procedure in Section 3-13.</p> <p>Make the following measurements with a Fluke 8060A in the Hi-Z 2V DC range. All voltages are with respect to pin 4 of Z1 (instrument common). With reference junction sensor calibrated, the base of Q1 should be 567 mV at 25°C. If VR1 is operating properly, pin 9 of Z1 should be 1.23V (<math>\pm 0.03V</math>). With R21 calibrated, pin 7 of Z1 should be 1.00V, pin 6 should be 482 mV <math>\pm 3</math> mV, and pin 5 should be 170 mV <math>\pm 1</math> mV.</p> <p>Clean per Section 3-6.</p>
Noisy or erratic readings	<p>Exceeds common mode voltage specifications.</p> <p>The thermocouple may be damaged.</p> <p>Offset potentiometers R7 and R13 are worn or defective.</p> <p>High level electromagnetic field possibly caused by a radio transmitter nearby.</p> <p>Battery is very low.</p> <p>U1, VR1, C10, C11, or Z1 is defective.</p> <p>PCA contaminated around U1 and/or thermocouple input area.</p> <p>R3,9; R4,10; or R5,11 input-protection resistors damaged.</p> <p>Pull-up resistor open (R2,8) and thermocouple is not plugged in or is open.</p>	<p>Check to ensure that the common mode voltage on any thermocouple is not beyond specification for the instrument. Use isolated thermocouples where the possibility of voltage differences between T1 and T2 (for the 52) is greater than 1 volt (see specifications in the Operator's Manual).</p> <p>Check the welded measurement junction (bead) on the thermocouple. Also check all connector hardware.</p> <p>Set up the 51/52 per Section 3-15 and rotate R7 and R13 to see if the display shows erratic readings.</p> <p>Eliminate the suspected source and allow at least 20 seconds for the instrument to recover. C1, C2, and C12 alleviate disturbances from such EMI sources.</p> <p>Replace the battery.</p> <p>Substitute parts.</p> <p>Clean per Section 3-6.</p> <p>Check resistance values, replace if necessary.</p> <p>Check resistance values, replace if necessary.</p>

**Table 3-3. Fault Guide (cont)**

SYMPTOM	POSSIBLE CAUSE	ACTION
<p>No action from F/C button</p>	<p>U4 defective.</p> <p>Debris on switch grid.</p> <p>U1 defective.</p> <p>CR6 open.</p>	<p>Pin 11 of U4 should toggle as pin 1 is shorted to the juncture of R25-C5. The purpose of C4 is to ensure that the F/C flip-flop remains in the same state when the instrument is powered on and off.</p> <p>Clean per Section 3-6.</p> <p>Replace U1.</p> <p>Replace CR6.</p>
<p>Short battery life</p>	<p>High storage temperature. Batteries tend to self-discharge more rapidly when stored at elevated temperature.</p> <p>With the instrument ON, battery drain is approximately <math>350 \mu\text{A} \pm 50 \mu\text{A}</math> at room temperature.</p> <p>With the instrument OFF, battery drain is greater than <math>5 \mu\text{A}</math> at room temperature.</p>	<p>If high temperature storage is expected, use an alkaline-type battery, which exhibits longer shelf life than the carbon zinc type.</p> <p>Check U1 and U2 current drain.</p> <p>Check U4, CR5, and CR6 for leakage.</p>

## Section 4

# List of Replacement Parts

### TABLE OF CONTENTS

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Fluke 51 Final Assembly .....	4-1	4-3	4-1	4-4
Fluke 52 Final Assembly .....	4-1	4-3	4-2	4-5
Fluke 51 A1 Main PCA .....	4-2	4-6	4-3	4-7
Fluke 52 A1 Main PCA .....	4-2	4-6	4-4	4-8

#### 4-1. INTRODUCTION

This section contains an illustrated list of replaceable parts for the 51 and 52 K/J Thermometers. Parts are listed by assembly; alphabetized by reference designator. Each assembly is accompanied by an illustration showing the location of each part and its reference designator. The parts lists give the following information:

- Reference designator
- An indication if the part is subject to damage by static discharge
- Description
- Fluke stock number
- Manufacturers supply code (doe-to-name list at the end of this section)
- Manufacturers part number or generic type
- Total quantity
- Any special notes (i.e., factory-selected part)

#### CAUTION

**A \* symbol indicates a device that may be damaged by static discharge.**

#### 4-2. HOW TO OBTAIN PARTS

Electrical components may be ordered directly from the manufacturer by using the manufacturers part number, or from the Fluke Corporation and its authorized representatives by using the part number under the heading **FLUKE STOCK NO.** In the U.S., order directly from the Fluke Parts Dept. by calling 1-800-526-4731. Parts price information is available from the Fluke Corporation or its representatives. Prices are also available in a Fluke Replacement Parts Catalog which is available on request.

In the event that the part ordered has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

To ensure prompt delivery of the correct part, include the following information when you place an order:

- Instrument model and serial number
- Part number and revision level of the pca containing the part.
- Reference designator
- Fluke stock number
- Description (as given under the **DESCRIPTION** heading)
- Quantity

#### 4-3. MANUAL STATUS INFORMATION


The Manual Status Information table that precedes the parts list defines the assembly revision levels that are documented in the manual. Revision levels are printed on the component side of each pca.

#### 4-4. NEWER INSTRUMENTS

Changes and improvements made to the instrument are identified by incrementing the revision letter marked on the affected pca. These changes are documented on a supplemental change/errata sheet which, when applicable, is included with the manual.

#### 4-5. SERVICE CENTERS

A list of service centers is located at the end of this section.

**NOTE** 

*This instrument may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke service center for recycling information.*

#### MANUAL STATUS INFORMATION

Ref or Option number	Assembly name	Fluke Part Number	Revision Level
A1	FLUKE 51 Main PCA	778191	J
A2	FLUKE 52 Main PCA	778209	L



Table 4-1. FLUKE 51 AND 52 FINAL ASSEMBLY  
(SEE FIGURE 4-1.)

REFERENCE DESIGNATOR		FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT QTY	N O T
-A>-NUMERICS-->	S-----	NO--	CODE--	OR GENERIC TYPE----	QTY--	-E-
A	1					
A	1					
BT	1					
H	1					
H	2					
H	6					
MP	1					
MP	1					
MP	2					
MP	2					
MP	3					
MP	4					
MP	4					
MP	5					
MP	6					
MP	6					
MP	7					
MP	8					
MP	9					
MP	10					
MP	12					
MP	14					
MP	15					
MP	40					
TC	1, 2					
TM	1					
TM	1					
TM	2					
TM	2					
TM	3					
U	3					
U	3					

An \* in 'S' column indicates a static-sensitive part.

- NOTES: 1. FOR FLUKE 51, QTY = 1.  
2. FOR FLUKE 51, QYT = 1 (TC1).

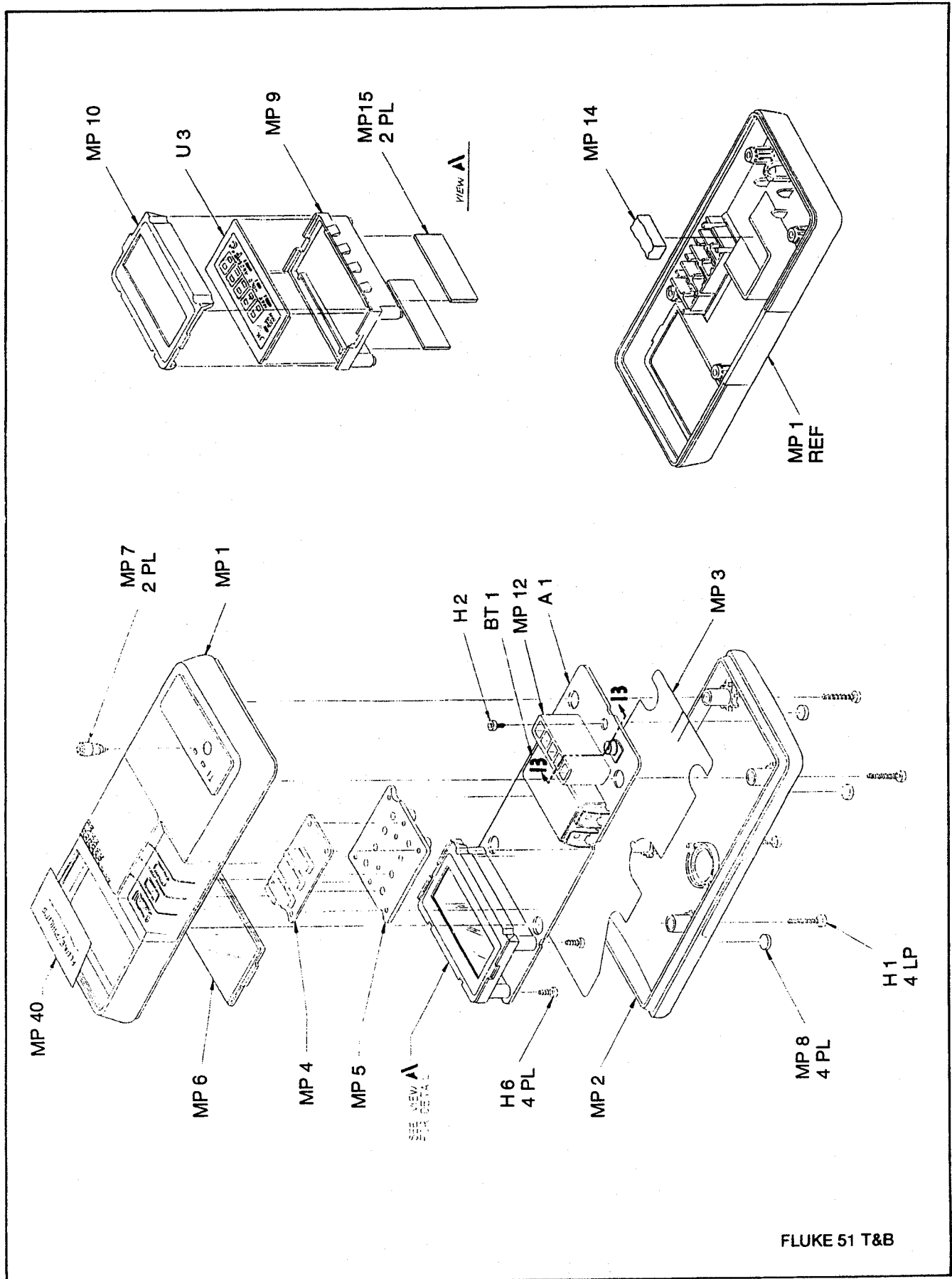


Figure 4-1. Fluke 51 Final Assembly

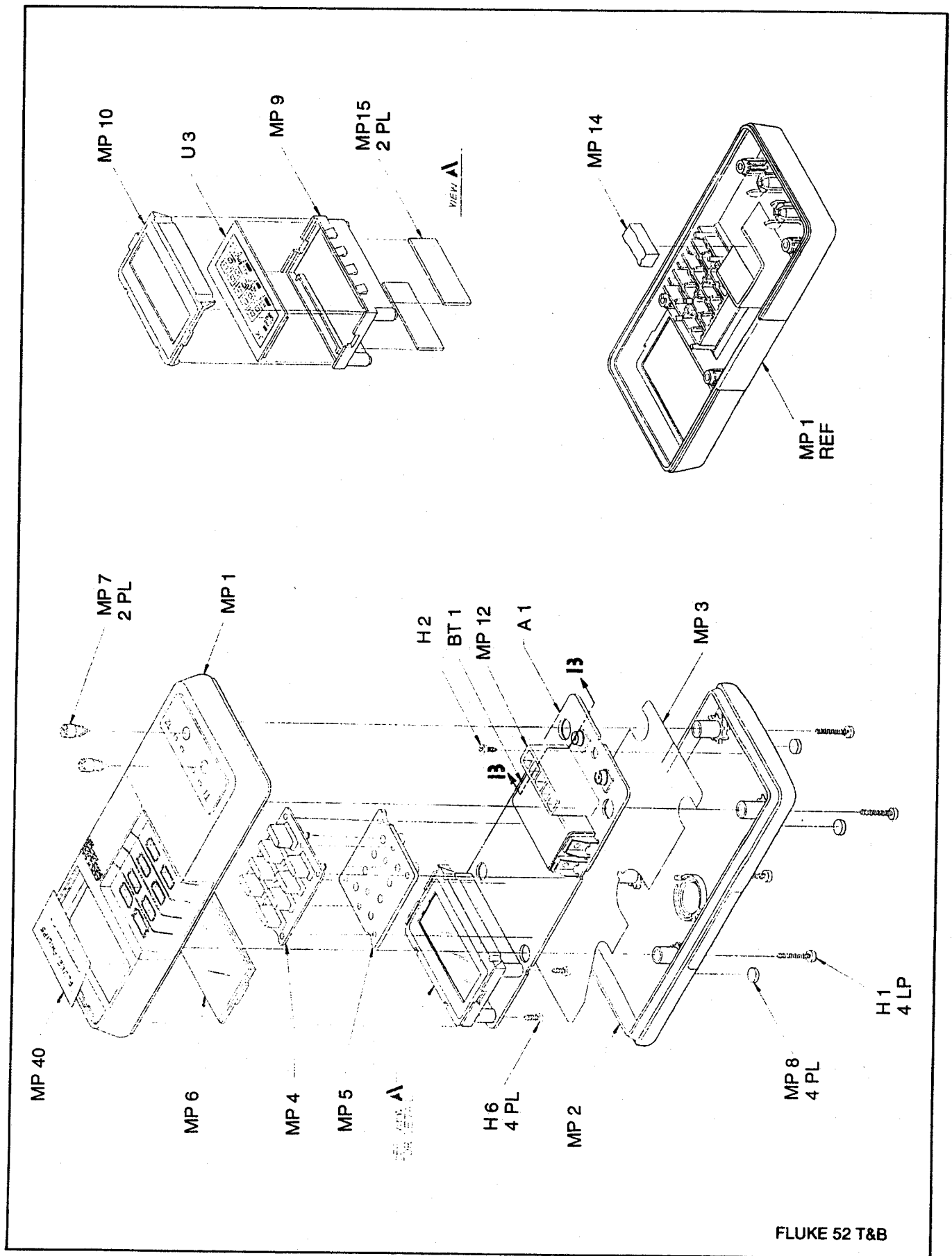


Figure 4-2. Fluke 52 Final Assembly

TABLE 4-2. A1 MAIN PCB  
(SEE FIGURE 4-3.)

REFERENCE DESIGNATOR	FLUKE STOCK	MFRS SPLY	MANUFACTURERS PART NUMBER	TOT	N
-A>-NUMERICS-----> S-----DESCRIPTION-----	--NO--	-CODE-	-OR GENERIC TYPE-----	QTY-	-E-
C 1, 2, 12	743427	04222	SR591A472MAA	3	1
C 3, 14	714543	04222	SR595A330JAA	2	
C 4, 13	740654	04222	SR595A221MAA	2	
C 5	697284	60705	562CZ5USE051EE103M	1	
C 6	733386	04222	SR595E224ZAA	1	
C 7, 9	769695	62643	KMA50474M4X7LL	2	
C 8	769687	62643	KMA50T2R2M45X85LL	1	
C 8	706804	56289	199D225X0016AE2	1	
C 10	721050	68919	MKP20333K63	1	
C 11	649913	68919	MKS2104K50	1	
C 15	423012	56289	199D226X0015DA2	1	
CR 1- 6	659516	15238	1N4448	6	2
CR 7	927392	89536	927392	1	
MP 1	753244	89536	753244	1	
MP 2, 5- 7	745802	89536	745802	4	3
MP 3	642967	89536	642967	1	
MP 4	654228	89536	654228	1	
Q 1	761908	89536	761908	1	
Q 2	698233	04713	2N3906	1	
Q 3	852111	17856	J6006	1	
R 1, 20	747550	59124	CF1/4 513J	2	
R 2, 6, 8,	757104	59124	CF1/4 226J	4	4
R 12	757104				
R 3, 5, 9-	658963	59124	CF1/4 104J	8	5
R 11, 22, 32	658963				
R 7, 13	772335	89536	772335	2	6
R 14, 31	757799	59124	CF1/4 123J	2	
R 15	772038	59124	MF50D1542F	1	
R 16	772905	89536	772905	1	
R 17	757807	59124	MF50D1003F	1	
R 18	757815	59124	MF50D5623F	1	
R 19	747543	59124	CF1/4 754J	1	
R 21	747592	89536	747592	1	
R 23	655274	59124	MF50D3013F	1	
R 24	655217	59124	MF50D3323F	1	
R 25, 26	649970	59124	CF1/4 105J	2	
R 27, 28	758219	59124	CF1/4 154J	2	
U 1	751552	89536	751552	1	
U 2	741520	89536	741520	1	
U 4	586727	04713	MC14070BCP	1	
VR 1	654707	27014	LM285BXZ-1.2D26Z	1	
W 1	682575	91637	FRJ-55	1	
Y 1	643031	61429	NC-26-32.768KHZ	1	
Z 1	824144	89536	824144	1	

An \* in 'S' column indicates a static sensitive part.

NOTES:

- FOR FLUKE 51, QTY = 2 (C1,12)
- FOR FLUKE 51, QTY = 2 (CR5,6)
- FOR FLUKE 51, QTY = 2 (MP2,5)
- FOR FLUKE 51, QTY = 2 (R2,6)
- FOR FLUKE 51, QTY = 7 (R3,5,28,29,30,32)
- FOR FLUKE 51, QTY = 1 (R7)

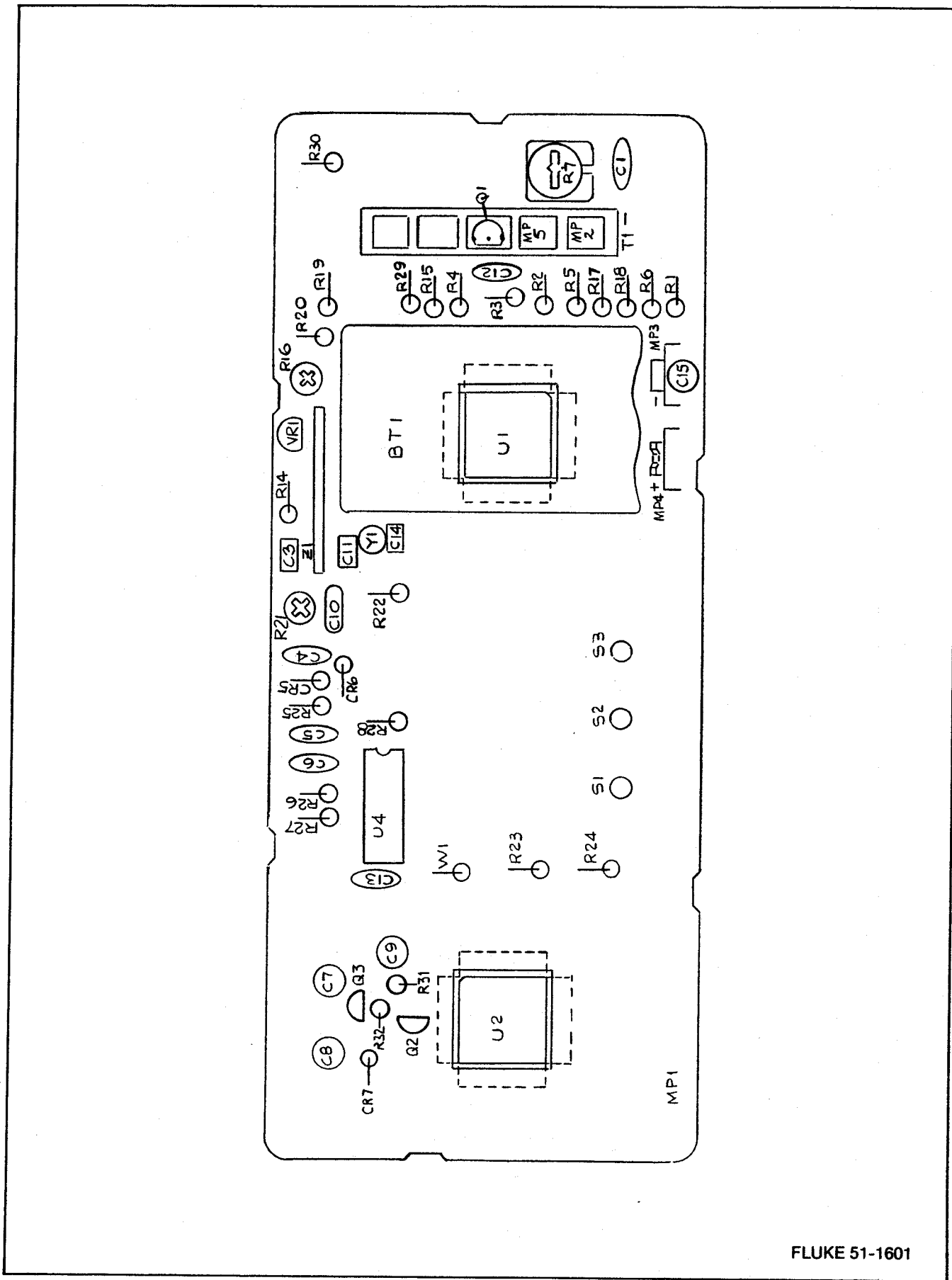
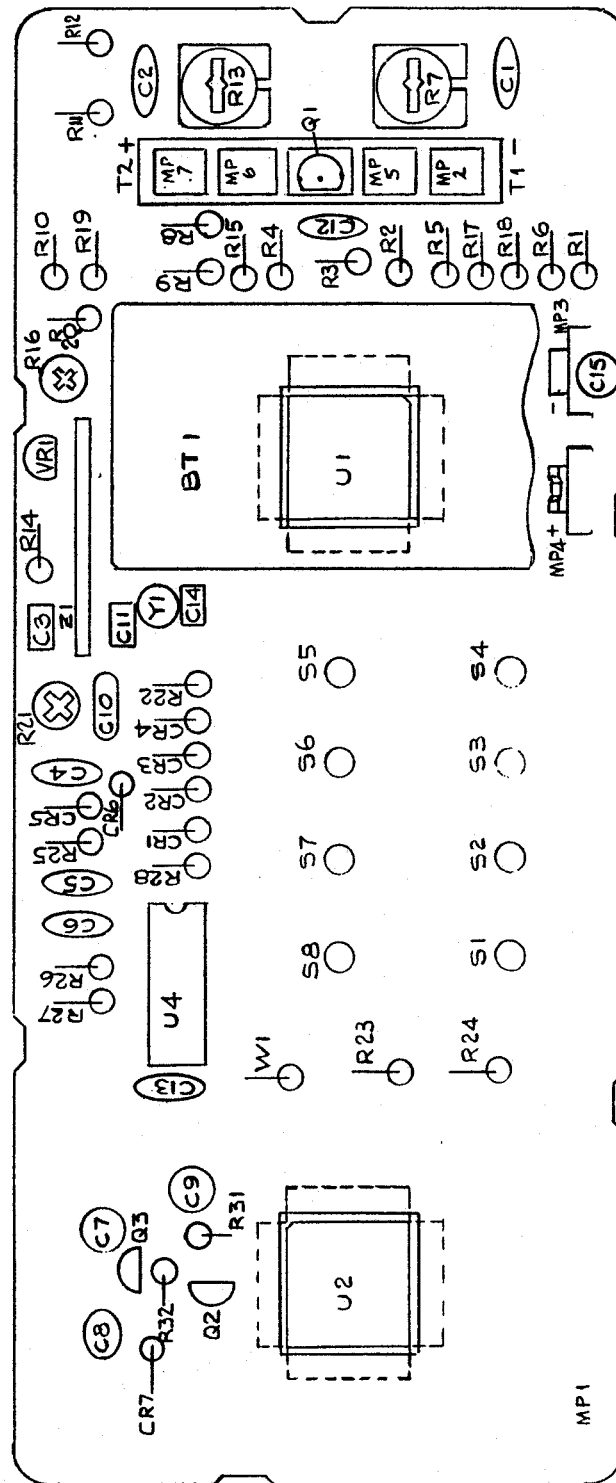


Figure 4-3. Fluke 51 A1 Main PCA

FLUKE 51-1601



FLUKE 52-1601

Figure 4-4. Fluke 52 A1 Main PCA

## Section 5 List of Abbreviations

### 5-1. INTRODUCTION

Table 5-1 in this section contains a list of definitions for abbreviations used in the schematic drawings for the Fluke 51 and 52 K/J Thermometers.

**Table 5-1. Abbreviations**

ABBREVIATION	DEFINITION
ACL	Auto Clear (Reset)
AZ	Auto Zero
CLAMP	Clamp Voltage Source
CLK	Clock
COM	Instrument Common
EC	Common Reference Voltage
INT	Integrator Output
K (kilo)	Multiple of 1000
K0	Buffer Output 0
K1	Buffer Output 1
M (mega)	Multiple of 1000000

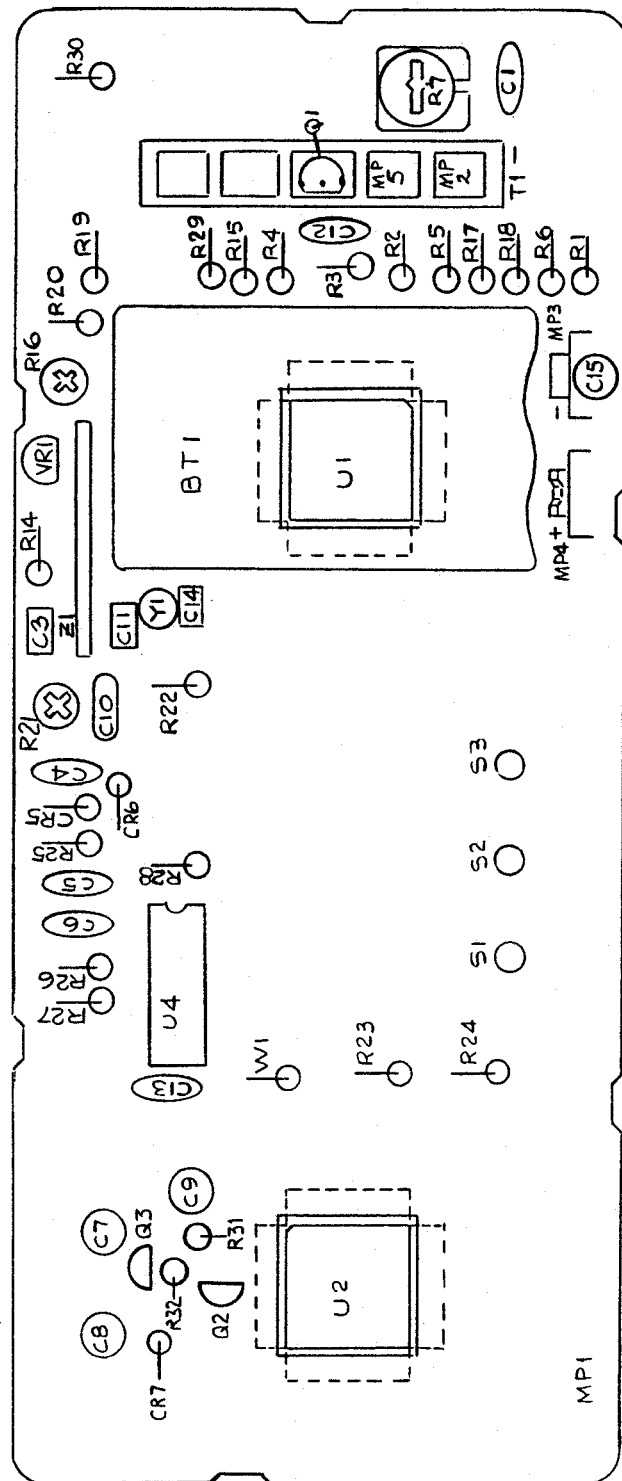
**Table 5-1. Abbreviations (cont)**

ABBREVIATION	DEFINITION
REF+	Positive A/D Reference
REF-	Negative A/D Reference
RJS HI	Reference Junction Sense High
RJS LO	Reference Junction Sense Low
TLO	Thermocouple Low
T1HI	+ Side of Thermocouple 1
T2HI	+ Side of Thermocouple 2
T1LO	- Side of Thermocouple 1
T2LO	- Side of Thermocouple 2
T1OS	Thermocouple 1 Offset
T2OS	Thermocouple 2 Offset
T1PU	Thermocouple 1 Pull-up
T2PU	Thermocouple 2 Pull-up
VDD	Positive Supply
VM	LCD Middle Voltage
VPU	Pull-up Voltage Source
VSS	Negative Supply
XTL	Crystal Oscillator
p (pico)	Multiple of .000000000001
μ (micro)	Multiple of .000001

# Section 6 Schematic Diagram

<b>FIGURE</b>	<b>TITLE</b>	<b>PAGE</b>
6-1.	Fluke 51 A1 Main PCA .....	6-2
6-2.	Fluke 52 A1 Main PCA .....	6-4





FLUKE 51-1601

Figure 6-1. Fluke 51 A1 Main PCA

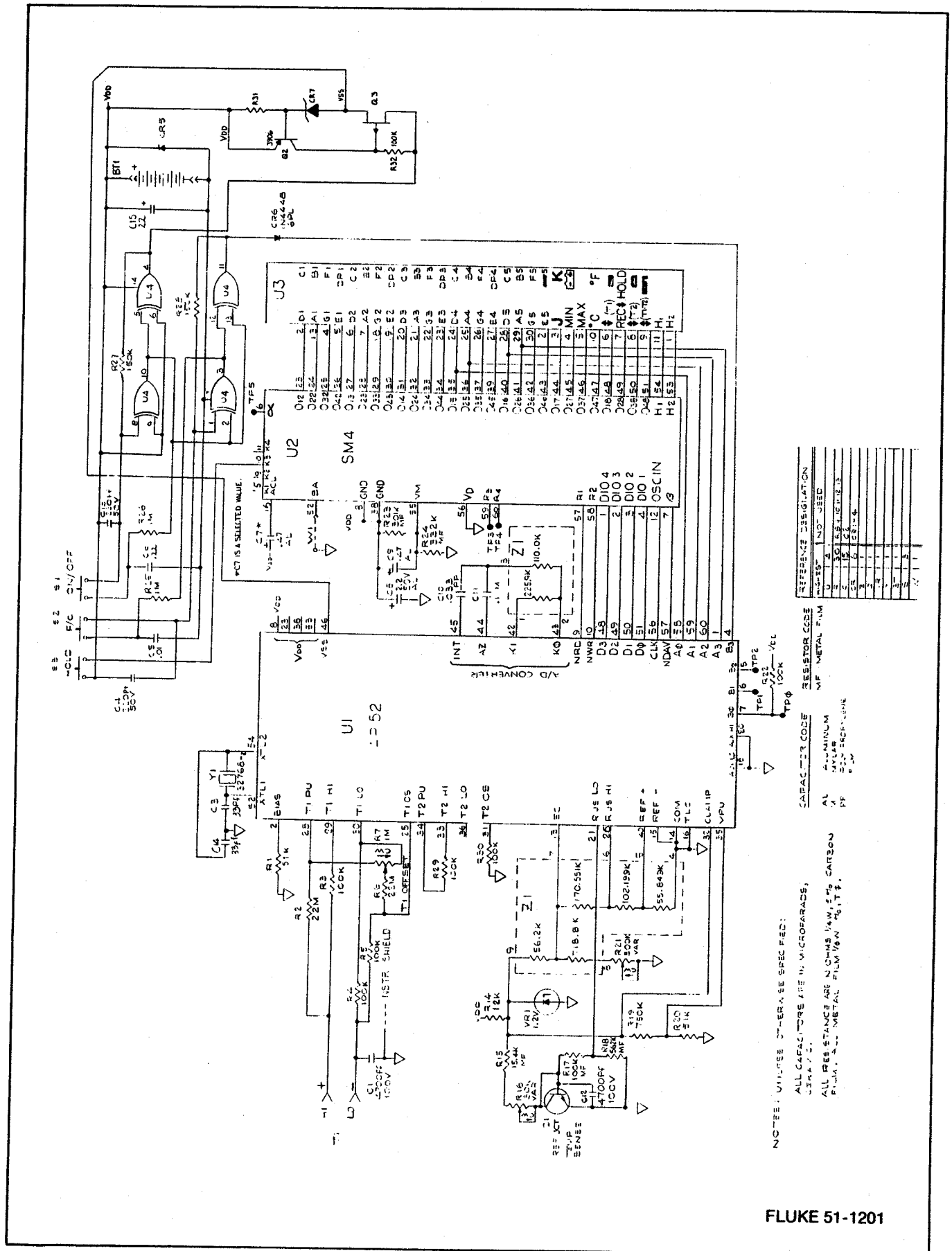
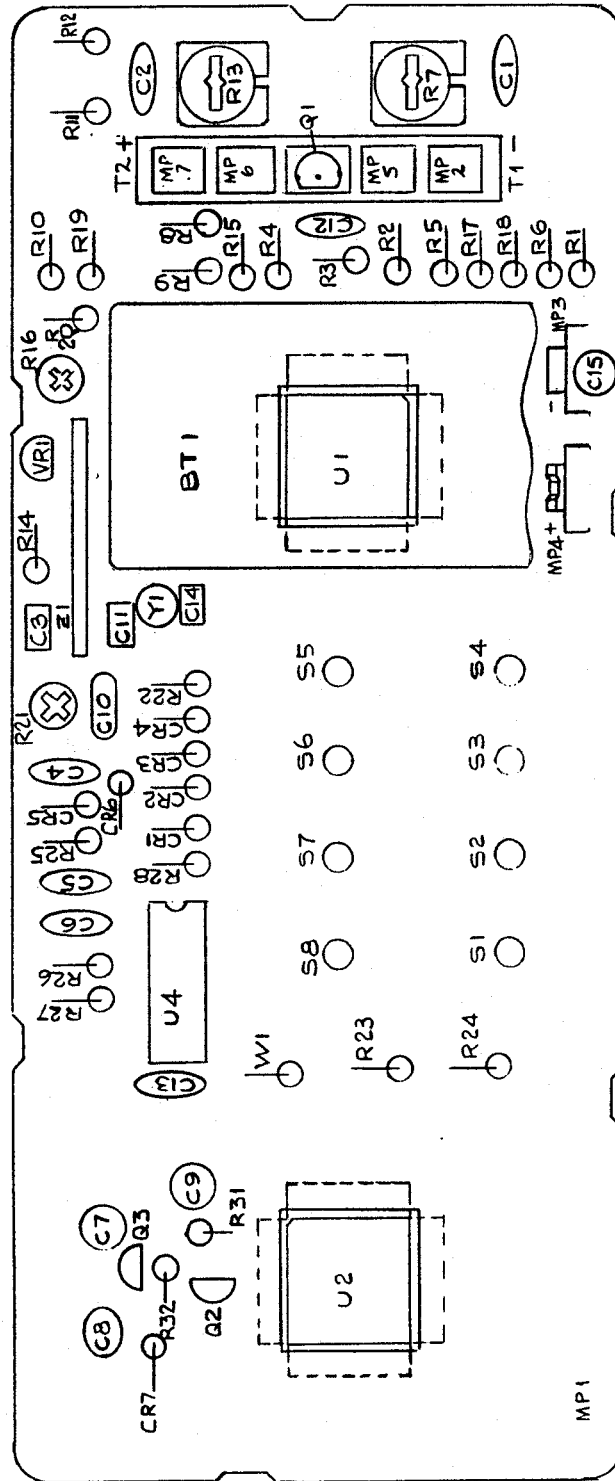


Figure 6-1. Fluke 51 A1 Main PCA (cont)



FLUKE 52-1601

Figure 6-2. Fluke 52 A1 Main PCA

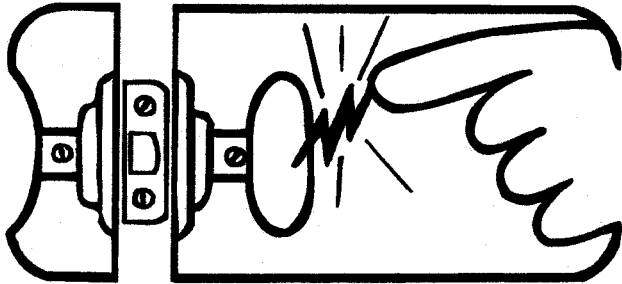




# static awareness



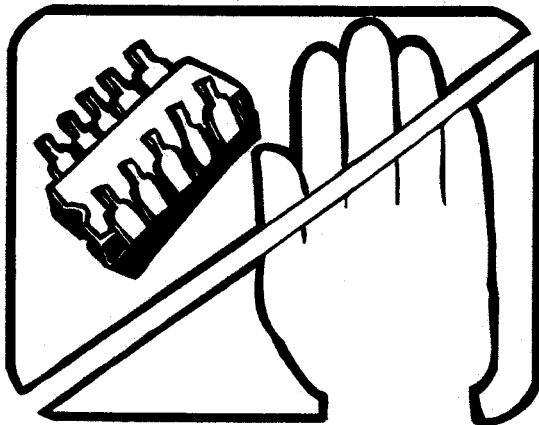
## A Message From Fluke Corporation



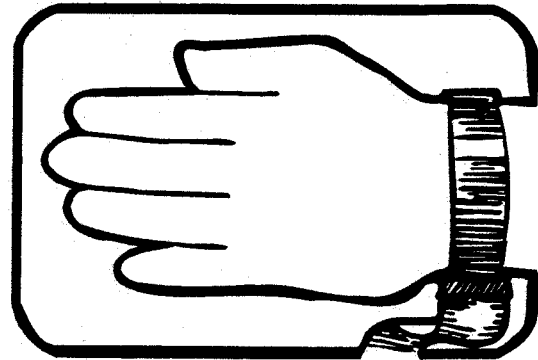
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, packaging, and bench techniques that are recommended.

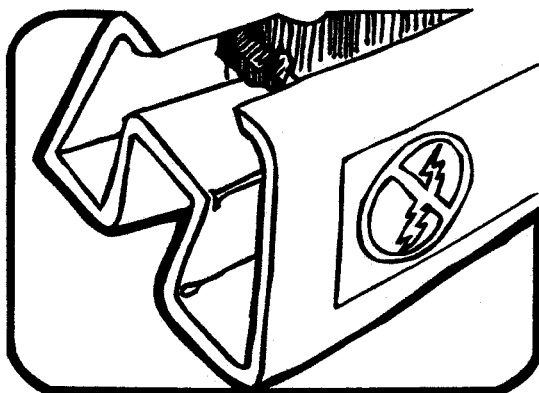
The following practices should be followed to minimize damage to S.S. (static sensitive) devices.



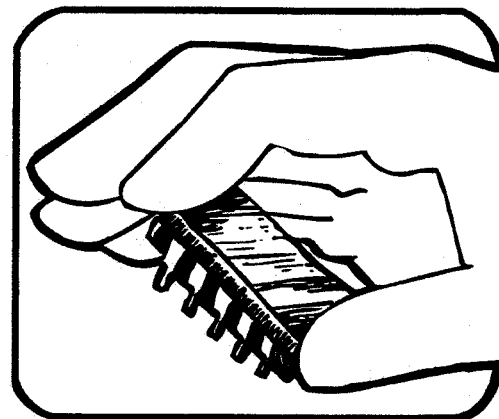
1. MINIMIZE HANDLING



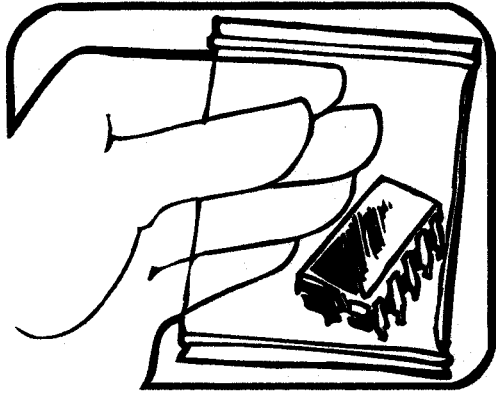
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



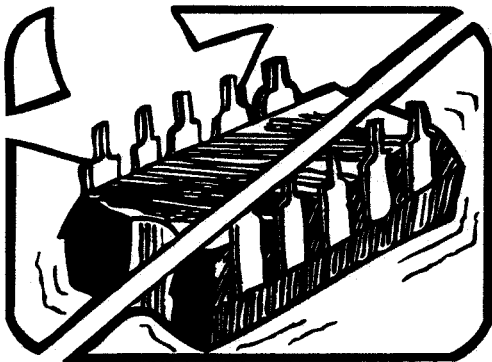
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



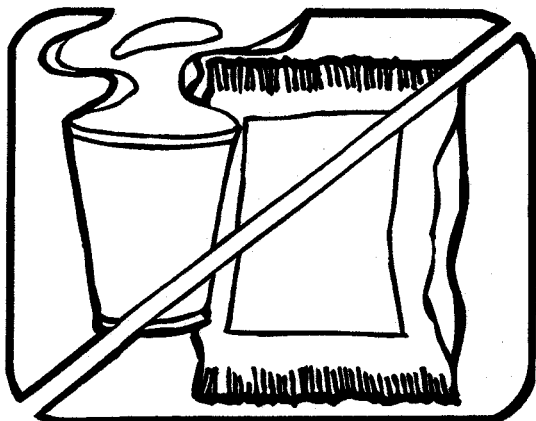
4. HANDLE S.S. DEVICES BY THE BODY.



5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.

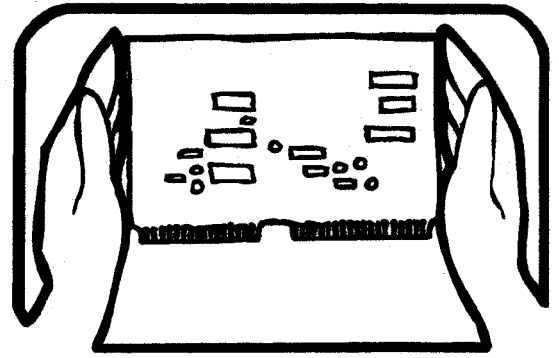


6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.

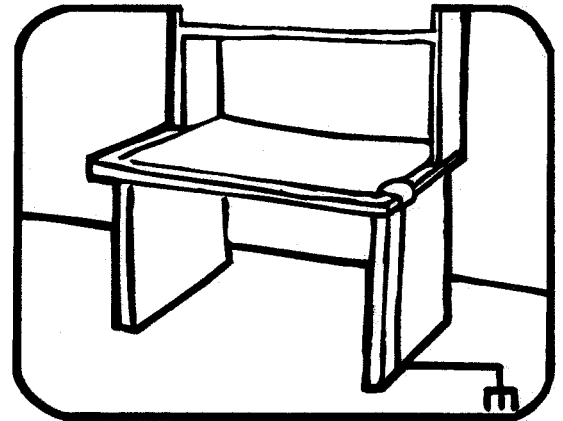


7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA.

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AND GENERAL DYNAMICS, POMONA DIV.



8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.

## Service Centers

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Fluke Calibration Center  
C/o FLW Service Corporation  
3505 Cadillac Ave., Bldg E  
Costa Mesa, CA 92626  
TEL: (714) 751-7512  
FAX: (714) 755-7332

#### Dallas

Fluke Service Center  
2104 Hutton Drive  
Suite 112  
Carrollton, TX 75006  
TEL: (214) 406-1000  
FAX: (214) 247-5642

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Fremont, CA 94538  
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FAX: (510) 651-4962

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FAX: (847) 705-9989

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Paramus, N.J. 07652-0930  
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FAX: (201) 599-2093

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Fluke Service Center  
Fluke Corporation  
Building #4  
1420 - 75TH St. S.W.  
Everett WA 98203  
TEL: (206) 356-5560  
FAX: (206) 356-6390

### INTERNATIONAL

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745 Springvale Road  
Mulgrave  
Victoria 3170  
TEL: 61-3-881-3666  
FAX: 61-3-881-3636

Phil. Sci. & Ind. Bk F, Centrect.  
34 Waterloo Road  
North Ryde, N.S.W. 2113  
TEL: 61-2-888-8222  
FAX: 61-2-888-0440

#### Austria

Fluke Vertriebsges. GMBH (GM)  
SudrandstraBe 7  
P.O. Box 10, A-1232 Vienna  
TEL: 43-1-614-100  
FAX: 43-1-614-1010

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Mohammed Fakhroo & Bros.  
P.O. Box 439  
Bahrain  
TEL: 973-253529  
FAX: 973-275996

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N.V. Fluke Belgium S.A.  
Sales & Service Dept.  
Langeveldpark - Unit 5 & 7  
P.Bastelousstraat 2-4-6  
1600 St. Pieters - Leeuw  
TEL: 218-2-331-2777 (ext 218)  
FAX: 32-2-331-1489

#### Bolivia

Casilla 7295,  
Calle Ayacucho No. 208  
Edificio Flores, Sto. Piso  
La Paz, Bolivia  
TEL: 591-2-317531 or 317173  
FAX: 591-2-317545

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Philips Medical Systems, LTDA  
Av. Interlagos North  
3493 - Campo Grande  
04661-200 Sao Paulo S.P.  
TEL: 55-11-523-4811  
FAX: 55-11-524-4873 (ID 2148)

Sigtron Instrumentos E. Servicios  
Rua Alvaro Rodrigues  
269 - Brooklin  
Sao Paulo, Sp  
TEL: 55-11-240-7359  
FAX: 55-11-533-3749

#### Sistest

Sist. Instr. Testes Ltda  
Av. Ataulfo De Paiva  
135 S/ 1117 - Leblon 22.449-900  
Rio De Janeiro, RJ, Brazil  
TEL: 55-21-259-5755 or 512-3679  
FAX: 55-21-259-5743

#### Bulgaria

Ac Sophilco, Cust. Supp. Serv.  
P.O. Box 42  
1309 Sofia, Bulgaria  
TEL: 359-2-200785  
FAX: 359-2-220910

#### C.S.F.R.

Eiso  
NA. Berance 2  
16200 Prahae 6  
TEL: 42-2-316-4810  
FAX: 42-2-364986

Data Elektronik BRNO  
Jugoslavka 113  
61300 Brno  
TEL: 42-5-57400-2  
FAX: 42-5-574002

#### Canada

Fluke Electronics Canada Inc.  
400 Britannia Rd East, Ut #1  
Mississauga, Ontario  
L4Z 1X9  
TEL: 905-890-7600  
FAX: 905-890-6866

#### Chile

Intronica, Instrumen Electronica,  
S.A.C.I.  
Guardia Vieja 181 Of. 503  
Casilla 16500, Santiago 9  
TEL: 56-2-232-6700

#### China

Fluke S.C., Room 2111  
Scite Tower  
Jiangumenwai Dajie  
Beijing 100004, PRC  
TEL: 86-10-512-6351, 6319, 3437  
FAX: 86-10-512-3437

#### Colombia

Sistemas E Instrument., Ltda.  
Calle 83, No. 37-07  
Po Box 29583  
Santa Fe De Bogota  
TEL: 57-1-287-5424  
FAX: 57-1-218-2660

#### Costa Rica

Electronic Engineering, S.A.  
Carretera de Circunvalacion  
Sabanilla Av. Novena  
P.O. Box 4300-1000, San Jose  
TEL: 506-253-3759 or 225-8793  
FAX: 506-225-1286

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Kaltim - Zagreb  
Fluke Sis & Serv. Draga 8  
41425 Sveta Jana  
TEL: 385-41-837115  
FAX: 385-41-837237

#### Denmark

Fluke Danmark A/S, Cust. Supp.  
Ejby Industrivej 40  
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TEL: 45-43-44-1900 or 1935  
FAX: 45-43-43-9192

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P.O. Box 17-03-228-A, Quito  
TEL: 593-2-230283 or 520005  
FAX: 593-2-561980

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Electronic Equipment Mktng Co.  
9 Hassan Mazher St.  
P.O. Box 2009  
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Cairo, Egypt  
TEL: 20-2-417-8296  
FAX: 20-2-417-8296

#### Fed. Rep. of Germany

Fluke Deutschland GmbH  
Customer Support Services  
Servicestutzpunkt VFN5  
Oskar-Messter-Strasse 18  
85737 Ismaning/Munich  
TEL: 49-89-9961-1260  
FAX: 49-89-9961-1270

Fluke Deutschland  
(CSS), Servicestutzpunkt VFN5  
Meiendorfer Strasse 205  
22145 Hamburg  
TEL: 49-40-679-6434  
FAX: 49-40-679-7653

#### Finland

Fluke Finland Oy  
Sinikalliontie 3, P.L. 151  
SF 02631 Espoo  
TEL: 358-0-6152-5600  
FAX: 358-0-6152-5630

#### France

Fluke France S.A.  
37 Rue Voltaire  
BP 112, 93700 Drancy, Cedex  
TEL: 33-1-4896-6300  
FAX: 33-1-4896-6330

#### Greece

Philips S.A. Hellenique  
Fluke Sales & Service Manager  
15, 25th March Street, P.O. Box  
3153, 177 78 Tavros Athens  
TEL: 30-1-489-4911 or 4262  
FAX: 30-1-481-8594

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Schmidt & Co, Ltd. 1st Floor  
323 Jaffe Road  
Wanchai  
TEL: 852-9223-5623  
FAX: 852-834-1848

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MTA MMSZ KFT, Srv. / Gen. Mgr  
Etele Ut. 59 - 61  
P.O. Box 58  
H 1502 Budapest  
TEL: 361-186-9589 or 209-3444  
FAX: 361-161-1021

#### Iceland

Taeknival HF  
P.O. Box 8294, Skeifunni 17  
128 Reykjavik  
TEL: 354-1-681665  
FAX: 354-1-680664

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33/44A 8th Main Road  
Raj Mahal Vilas Extension  
Bangalore 560 080  
TEL: 91-80-334-8266 or 0068  
FAX: 91-33-247-6844

Hinditron Services Pvt. Ltd  
Hinditron House, 23-B  
Mahal Industrial Estate  
Mahakali Caves Rd, Andheri East  
Bombay 400 093  
TEL: 91-22-836-4560, 6590  
FAX: 91-22-836-4682

Hinditron Services Pvt. Ltd  
Castle House, 5th Floor  
5/1 A, Hungerford Street  
Calcutta 700 017  
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FAX: 91-33-247-6844

Hinditron Services Pvt. Ltd  
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98 Nehru Place  
New Delhi 110 019  
TEL: 91-11-641-3675 or 643-0519  
FAX: 91-11-642-9118

Hinditron Services Pvt. Ltd.  
Field Service Center  
Emerald House, 5th Floor  
114 Sarojini Devi Road  
Secunderabad 500 003  
TEL: 91 40-844033 or 843753  
FAX: 91-40-847585

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P. T. Daeng Bro, Phillips House  
J/n H.R. Rasuna Said Kav. 3-4  
Jakarta 12950  
TEL: 62-21-520-1122  
FAX: 62-21-520-5189 or 62-21-520-5189

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Tel-Aviv 61580  
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FAX: 972-3-647-8908

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FAX: 52-5-687-8695

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Science Park Eindhoven 5108  
5692 EC Son  
TEL: 31-40-2678  
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Private Bag 41904,  
St. Lukes, 2 Wagener Place  
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Philips Projects Centre  
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8, Kofo Abayomi Street  
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TEL: 234-1-262-0632  
FAX: 234-1-262-0631

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Islamic Cham. of Commerce  
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FAX: 92-21-577-0348

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FAX: 51-14-31-0707

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60 188 Poznan  
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FAX: 48-61-682256

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1700 Lisboa  
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FAX: 351-1-795-1713

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FAX: 40-1-659-4468

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Proezd. 29  
103287 Moscow  
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FAX: 7-95-212-3838

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A. Rajab & Silsilah Co. S&S Dept.  
P.O. Box 203  
21411 Jeddah  
TEL: 966-2-661-0006  
FAX: 966-2-661-0558

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Fluke Singapore Pte., Ltd.  
Fluke ASEAN Regional Office  
#27-03 PSA Building  
460 Alexandra Road  
Singapore 119963  
TEL: 65-276-5161  
FAX: 65-\*276-5929

### South Africa

Spescom Measure. (PTY) Ltd.  
Spescom Park  
Cm. Alexandra Rd. & Second St.  
Halfway House, Midrand 1685  
TEL: 27-11-315-0757  
FAX: 27-11-805-1192

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Centro Empresarial Euronora  
c/Ronda de Poniente, 8  
28760-Tres Cantos  
Madrid, Spain  
TEL: 34-1-804-2301  
FAX: 34-1-804-2496

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Fluke Sverige AB, (CSS)  
P.O. Box 61  
S-164 94 Kista  
TEL: 46-8-751-0235 or 0230  
FAX: 46-8-751-0480

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Fluke Switzerland AG, (CSS)  
Rutistrasse 28  
CH 8952 Schlieren  
Switzerland  
TEL: 41-1-730-3310 or 730-3932  
FAX: 41-1-730-3932

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Schmidt Scientific Taiwan, Ltd.  
6th Floor, No. 109,  
Tung Hsing Street  
Taipei, Taiwan R.O.C.  
TEL: 886-2-767-8890 or 746-  
2720  
FAX: 886-2-767-8820

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Measuretronix Ltd.  
2102/31 Ramkamhang Road  
Bangkok 10240  
TEL: 66-2-375-2733 or 2734  
FAX: 66-2-374-9965

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Pestas Prof. Elektr. Sist. Tic. V  
Selcuklar Caddesi  
Meydan Apt. No. 49, Daire 23  
Akatlar 80630 Istanbul  
TEL: 90-212-282-7838  
FAX: 90-212-282-7839

### U.A.E.

Haris Al Afaq Ltd.  
P.O. Box 8141  
Dubai  
TEL: 971-4-283623 or 283624  
FAX: 971-4-281285

### United Kingdom

Fluke U.K. LTD. (CSS)  
Colonial Way  
Watford, Hertfordshire WD2 4TT  
TEL: 44-923-240511  
FAX: 44-923-225067

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Coasin Instrumentos S.A.  
Casilla de Correo 1400  
Libertad 2529, Montevideo  
TEL: 598-2-492-436, 659  
FAX: 598-2-492-659

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Coasin C.A.  
Calle 9 Con Calle 4, Edif. Edinurbi  
Piso-3  
La Urbina  
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TEL: 58-2-241-6214  
FAX: 58-2-241-1939

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Schmidt-Vietnam Co., Ltd.  
8/FI. Schmidt Tower  
Hanoi International Tech. Ctr  
KMB, Highway 32, Cau Giay  
Tu Liem, Hanoi  
Vietnam  
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FAX: 84-4-346-188

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Western Scientific Co., Ltd.  
Freeport Mission Road  
Freeport, Trinidad  
West Indies  
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FAX: 809-673-0767

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Jugoelektro Beograd  
T & M Customer Support  
Services  
Knez Mihailova 33  
11070 Novi  
TEL: 38-11-182470  
FAX: 38-11-638209

### Zimbabwe

Field Technical Sales  
45, Kelvin Road North  
P.O. Box Cy535 Causeway  
Harare, Zimbabwe  
TEL: 263-4-750381 or 750382  
FAX: 263-4-729970