SureTemp®

Model 678 & Model 679 Thermometer

Technical Manual

Welch Allyn

TABLE OF CONTENTS

LIST OF FIGURES

WARRANTY

3-YEAR LIMITED WARRANTY ON NEW M678 AND ON M679 ONE PER ROOM INSTRUMENTS. 1-YEAR LIMITED WARRANTY ON NEW M679 INSTRUMENT:

Instrumentation purchased new from Welch Allyn, Inc. (Welch Allyn) is warranted to be free from original defects in material and workmanship under normal use and service for a period of three years for the **M678 and one per room M679** and one year for the **M679** from the date of first shipment from Welch Allyn. This warranty shall be fulfilled by Welch Allyn or its authorized representative repairing or replacing at Welch Allyn's discretion, any such defect, free of charge for parts and labor.

Welch Allyn should be notified via telephone of any defective product and the item should be immediately returned, securely packaged and postage prepaid to Welch Allyn. Loss or damage in shipment shall be at purchaser's risk.

Welch Allyn will not be responsible for loss associated with the use of any Welch Allyn product that (1) has had the serial number defaced, (2) has been repaired by anyone other than an authorized Welch Allyn Service Representative, (3) has been altered, or (4) has been used in a manner other than in accordance with instructions.

THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTY OR MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. WELCH ALLYN WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

SPECIFICATIONS

• Case Dimensions (nominal):	2.25 in. x 3 in. x 7 in 5.7 cm x 7.6 cm. x 17.8 cm
• Case Material:	ABS Plastic
• Weight (nominal):	10.25 ounces with batteries and probe
• Input:	Welch Allyn Thermistor Probe. P/N 02678-000 (ORAL 4'), P/N 02678-100 (ORAL 9'), 02679-000 (RECTAL 4'), AND 02679 -100 (RECTAL 9')
• Display range:	28.9º C to 42.2º C (84.0º F to 108.0º F)
• Laboratory Accuracy:	± 0.2º F in the Monitor mode and in a water bath per Welch Allyn document number 90565-000
• Clinical Accuracy:	Meets the ASTM E1112-86 clinical test standard
• Push buttons:	Mode and Pulse Timer
• Mode Button:	Selects ºF/ ºC, Oral, Axillary and Monitor Modes
• Probes:	Interchangeable Oral (also used for Axillary) and Rectal
• Power Source:	Three "AA" Batteries
• Battery Operating Life:	Approximately 5,000 temperature measurements (At 72º F ambient temperature)
• Display Type:	Liquid Crystal Display, 3½ digits plus special icons
• Operating temperature:	16º C to 40º C (60.8 º F-104º F) @ 15% to 95% RH non-condensing per ASTM E1112-86
• Storage Temperature:	-20º C to 50º C (-4º F-120º F) @ 15% to 95% RH non-condensing per ASTM E1112-86

TERMINOLOGY

Many standard abbreviations are used in this Technical Manual.

Abbreviation	Definition
PCB	printed circuit board (the board itself)
PCA	printed circuit assembly (the board with all its components)
LCD	Liquid Crystal Display
BATT	Battery
DMM	Digital Multi-Meter
O-Scope	Oscilloscope

Component Reference Designators include:

Abbreviation	Definition
C	capacitor
D	diode
E	test point
J	connector jack
L	inductor
P	connector plug
Q	transistor
R	resistor
S	switch
T	transformer
U	integrated circuit
X	crystal, resonator

1. OPERATIONAL CHARACTERISTICS

Note: This manual describes both the Model 678 and the Model 679 thermometers. The bulk of the discussion is equally applicable to both products. Where there are differences, it will be noted as to which instrument the discussion applies.

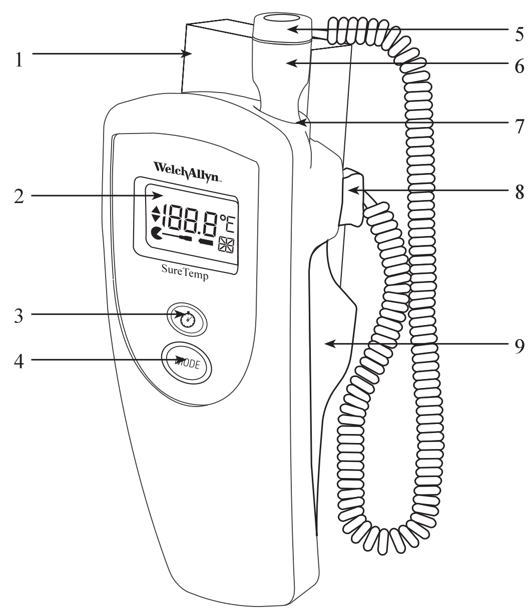
The Welch Allyn Model 678 and 679 Thermometers are the next generation of thermistor based medical grade thermometers providing the accuracy and ease of use of thermistor technology as in the well known Model 675. The Model 678 and Model 679 provide a Normal mode oral temperature in about 4 seconds, significantly faster than the typical 30-40 second average time to temperature in earlier products.

Basic end user operation of the Model 678 and Model 679 is covered in the *User's Manual* and this manual assumes an understanding of these operations. This chapter will help you determine if the Model 678/679 is functioning properly and, if it is not, refer you to the proper section to isolate the problem.

Note: There are many things that can be done to check operation before the unit is disassembled. This section will cover these normal operating actions.

Basic System Description

The thermometer system consists of five main components: The batteries, the thermometer instrument, the wall mount, the probe and the probe cover.



1. Probe cover box
2. Display
3. Timer button (678 only)
4. Mode button
5. Probe cover ejection button
6. Probe Handle
7. Probe storage well
8. Probe connector receptacle
9. Probe cover storage well/ Battery cover

Figure 1 - Thermometer Diagram

Batteries — The Model 678 and Model 679 thermometers use three standard alkaline “AA” cells. These batteries are readily available and provide long life for reduced down time. No battery charging is required.

Note: The use of Ni-Cad rechargeable batteries **is** allowed. The nominal cell voltage of 1.2 volts for Ni-Cad (vs. 1.5 volts for alkaline) combined with the lower actual capacity than alkaline will result in a much shorter time between battery charges than alkaline battery life.

Instrument — The main instrument operates very similarly to the Model 675. Basic operation has been kept similar to that of the Model 675 to ease learning and use.

Wall Mount — The wall holder is easily secured to a wall (or rolling stand). An optional locking mechanism with a removable key for securing the instrument is available. Through the use of available long probe cords, the thermometer can be used without removing it from the wall holder.

Probe — The probe is similar to earlier probes. Model 670/675 probes are incompatible with Model 678/Model 679 instruments, but Model 767 and Welch Allyn Vital Signs Monitor probes can be used in Model 678/Model 679 thermometers.

Probe Covers — The probe covers are unchanged from previous models and are compatible across all Welch Allyn and Diatek thermistor based thermometers.

Welch Allyn’s thermistor-based probes can be identified by color combinations as indicated in the following table.

Handle Color	**Top Color**	**Cord Color**	**Connector Color**	**Model #**	**Probe Type**
Green	Green	Green or Black	Green	M600	Oral
Red	Red	Green or Black	Green	M600	Rectal
Green	Green	Green	Modular Phone style	M650	Oral
Red	Red	Green	Modular Phone style	M650	Rectal
White	Blue	White	Blue	M670/M675	Oral
White	Red	White	Red	M670/M675	Rectal
White	Blue	White	White with latch	M678/679/767	Oral
White	Red	White	White with latch	M678/679/767	Rectal

Self Tests

Instrument Reset/Self Tests

If a problem is reported with an instrument, it is preferred that the user investigate operation *before* the unit is reset. However, resetting the electronics is the recommended starting point in the checkout process.

The batteries must be removed from the instrument to reset the internal microprocessor electronics. Follow the battery removal instructions in the **Preventive Maintenance** section.

Caution: After battery removal, any remaining charge due to internal capacitance must be discharged to achieve a proper reset. After the batteries are out, press the Mode or Timer button for about 5 seconds. The electronics will now properly reset upon new battery installation.

1. Remove the probe from the probe storage well and unplug the probe connector from the instrument by depressing the locking tab and pulling on the connector body. Do not pull on the cord.
2. While watching the display, install the batteries per the instructions in the **Preventive Maintenance** section and observe the power up self test.

The self test includes several internal microprocessor self tests, instrument electronics tests and the display test. If there are internal electronics problems detected by the self tests, the error "|X|" icon will be displayed and an audible tone will sound. Refer to the **Error Codes** in the **Troubleshooting** section for an explanation.

Display Test

The display test begins with each display segment and icon being individually lit in brief and rapid succession. Immediately after this, all display segments and icons are simultaneously illuminated briefly followed by a display of the software revision in this instrument. The beeper also briefly sounds at the beginning of the test. At the end of the test, the display goes blank.

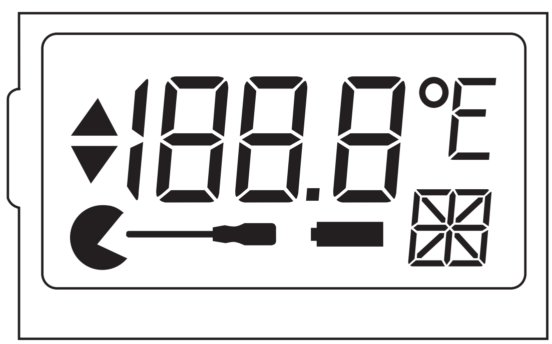


Figure 2 - M678 Display

Note: If a probe is installed during this power up time, the probe type will be displayed as the last item before the display blanks. At this point, there should be no probe connected to the instrument.

If there is no display, any missing segments, or no beeper, refer to the **Troubleshooting** section.

Probe Warmer Circuit Self Tests

Proper instrument functionality should be verified first as described in the **Instrument Reset/Self Tests** section (above) before a probe is installed. With a properly functioning instrument, the probe can be run through the self test. If the instrument is functioning properly and a probe is installed, the instrument will initiate the probe warmer self test during the instrument reset self test and whenever a probe is plugged in.

If an instrument has passed the **Instrument Reset/Self Tests** section, install the probe connector and observe the display of the probe type. For Models 678 and 679, the probe type will display for approximately 2 seconds.

- If the display does not show “OrL” or “Aly” with an Oral/Axillary probe plugged in, or “rEC” with a Rectal probe plugged in, there is a problem with either the probe or the probe connector in the instrument.
- If the display goes blank after the probe type display, the probe has passed its tests and the instrument is ready for use. Do not withdraw the probe during this self test.
- If the display shows the malfunction icon |**X**|, refer to the **Troubleshooting** section.

Note: Handle the probe only by the probe handle, not the metal shaft. When removing a probe, disconnect the connector by pressing the locking tab and pulling on the connector body. Do not pull it by the cord.

If there are any problems with probe initialization, refer to the **Troubleshooting** section.

Battery Life

Under normal use, battery life is expected to provide approximately 5,000 temperature measurements. This number is based on a 22.2°C (72.0°F) ambient temperature, with the security features turned off. Colder ambient temperatures, excessive security alarms, use of non-alkaline batteries, and other usage patterns can reduce battery life. Instruments are shipped with fresh batteries, but we cannot guarantee full life from the first set of batteries due to potential long storage times between shipping and actual use. Battery life can also be reduced by storage at elevated temperatures.

If you are experiencing short battery life, refer to **Battery Life Problems** in the **Troubleshooting** section.

Normal Mode

After instrument and probe warmer self tests, the system is ready for use. Normal mode operation is the rapid mode of temperature taking. This is the default mode and is automatically selected when the probe is withdrawn from the probe well.

1. Upon withdrawal of the probe from its storage well, every segment on the display will be illuminated. Watch for the display to change from the all segments test to the probe type display; "OrL/Aly" or "rEC", depending on the probe and algorithm type , followed by °C or °F, whichever is selected. This display might take several seconds to appear. At the same time that the probe type is displayed, a short beep will sound.
2. At this point, load a probe cover and take a temperature.

To change between the Oral and the Axillary algorithms; place the instrument in Ready mode as described above, and press the Mode button for approximately two seconds. Observe that the display changes between "Orl" and "Aly" every time the Mode button is pressed for more than two seconds.

Note: It is possible that the display will switch from the probe type display to the "walking segments" display and back again several times before the probe is inserted in the mouth. This is acceptable operation and will not adversely effect the temperature taken.

The thermometer will automatically switch to Monitor mode under some conditions. These are:

- If the prediction algorithm has not been activated for more than 60 seconds after taking the probe out of the storage well.
- If the instrument determines that room temperature is above 33.9°C (93.0°F).
- If the thermometer is unable to predict an oral temperature after 15 seconds due to improper technique such as excessive probe movement.

With correct use, the patient's temperature will be displayed in about 4 seconds for Model 678 and for Model 679. The instrument will beep to signal completion of the Normal mode temperature cycle.

Note: The thermometer reads the probe temperature immediately upon removal from the storage well. If the probe was just placed into the storage well from a previous temperature and immediately extracted, insufficient time may have passed to allow the probe to cool to room temperature. This will result in the instrument determining room temperature to be higher than actual. This could result in the instrument switching to Monitor mode immediately if it detects room temperature to be above 33.9°C (93.0°F). *For best results, the user should wait at least 30 seconds between Normal mode temperatures.*

If the probe is left out of the storage well after completion of a Normal mode temperature, the unit will shut down after 30 seconds to conserve power. Simply replace the probe in the storage well to prepare for the next temperature.

Monitor Mode

The instrument can be placed in Monitor mode by pressing and holding the Mode switch for two seconds after a predictive (normal) temperature has been taken. This mode will be indicated on the display by a capital M in the bottom right corner. Monitor mode provides a direct readout of the probe temperature.

This mode of operation has the ability to provide long term monitoring of a patient's temperature. Unlike Predictive mode, Monitor mode will follow a temperature as it rises or falls.

The typical slow rise in temperature when Monitor mode is used is due mainly to the mouth temperature slowly recovering from placement of the colder (room temperature) probe. The probe itself is actually very fast at rising to the temperature of its surroundings, usually within a few seconds. Because of this slow mouth recovery, the recommended time to wait before recording a Monitor mode oral temperature is 3 minutes. Similarly, the recommended waiting period for an axillary temperature taken in Monitor mode is 5 minutes.

Monitor mode is also useful in testing the accuracy of the combined probe/instrument system when the probe can be warmed to a known temperature, as with a Welch Allyn Model 9600 Calibration Tester or in a circulating water bath.

Note: The instrument will shut off automatically if the probe temperature remains below 28.9°C (84.0°F) or above 42.2 °C (108.0 °F) for more than 5 minutes.

If Monitor mode does not display expected temperatures or exhibits other problems, refer to the **Troubleshooting** section.

Pulse Timer Mode (Model 678 only)

Pulse Timer mode is activated from a Low Power or Recall mode by pressing the Timer button. Whenever the unit enters the Pulse Timer mode, it will emit an audio beep at 0, 15, 30, 45 and 60 seconds. The display will then count up one second at a time, "01", "02", ..., "60".

Pulse timer mode will be terminated automatically upon completion of a 60 second count and go back to low-power mode. The pulse timer can be shut off at anytime during the 0-60 count by pressing the Timer button, the Mode button or removing the probe from the probe holder. Connecting a probe will also terminate the pulse timer.

If the timer does not work or exhibits other problems, refer to **Timer Problems** in the **Troubleshooting** section.

Backlight (Model 678 only)

The backlight is turned on automatically in any mode except Low Power. Once the backlight is turned on, it will automatically shut off whenever the instrument goes into Low Power mode.

The backlight provides a display light for use in dark rooms. The LCD is backlit such that all readings are clearly readable in a darkened room from a distance of 18 inches.

If the backlight does not work or is showing other problems refer to the **Backlight Problems** section in the **Troubleshooting** section.

F/C Conversion

When a final temperature is displayed (in Normal, Recall, or Monitor mode), pressing and releasing the Mode button will toggle the temperature between °F/°C.

Note: A recalled temperature will be displayed in whichever scale (°F/°C) is selected at the time of recall. This can also be changed during display.

If pressing the Mode button does not change the scale of the displayed temperature, refer to **Mode Button Problems** in the **Troubleshooting** section.

Temperature Recall

Whenever the instrument is in Low Power or Pulse Timer mode, pressing and releasing the Mode button will cause the most recent predicted temperature to be displayed for 5 seconds. An "A", "O", or "R" will be displayed near the lower right corner of the LCD, designating Axillary, Oral and Rectal temperatures for the recalled temperature. Pressing the Pulse Timer button will interrupt the temperature recall function.

Note: No Monitor temperatures will be saved for recall. When a temperature is recalled, the mode in which it was obtained (axillary, oral or rectal) will be shown independent of the present mode.

If the last temperature can not be recalled, refer to **Temperature Recall Problems** in the **Troubleshooting** section.

Biotech Mode

To enter this special program mode:

1. Place the thermometer in the wall holder.
2. Press and hold the Mode button, and at the same time remove the probe from the probe well.

Press the Mode button approximately 2 seconds to move sequentially through the various program categories. Changes within each category can be made by momentarily pressing and releasing the Mode button.

Upon entering the Biotech mode, the following features and selections become available. A number is provided in the flag area to indicate which Biotech category is displayed.

To exit Biotech mode at any time, insert the probe into the probe well. Replacing the probe into the probe holder returns the unit to normal operation. The Biotech mode will automatically time out after 5 minutes of inactivity.

If you cannot enter the Biotech mode, refer to **Biotech Mode Problems** in the **Troubleshooting** section.

Function	Settings
1. Software Version	Observe the display, The display should show "r X.X" where "X.X" is a number such as 2.3. This can be helpful when discussing operation with Welch Allyn customer support. Press the Mode button for more than two seconds to advance to the Default Algorithm.
2. Default Algorithm Oral/Axillary Modes	Three settings are available to set the default predictive algorithm: oral, axillary or last prediction. To change the default algorithm, momentarily press the Mode button to advance to the next algorithm. The instrument will be placed in the selected algorithm after the probe has been returned to the probe well. When replacing the batteries, the power-up setting is the oral predictive algorithm. Press the Mode button for more than two seconds to advance to the Battery Voltage.
3. Battery Voltage	This section displays the current battery voltage with 10 mV resolution. The battery is considered acceptable if it measures higher than 3.4 volts. New batteries should produce 4.5 volts or more. Each thermometer is factory tested for accuracy down to a supply voltage of 2.9 volts. At 3.2 volts, the low battery indicator (battery icon) will flash. When the battery voltage is 3.0 volts or less, the low battery indicator will display without flashing. Three double beeps are generated, followed by a blank display. At this point temperature taking is disallowed.
4. Predictive Temperature Counter	This section displays the count of the number of predictive temperature actuations that have occurred since last cleared (in 100's). Replacing the batteries will clear the counter. The power-up setting is 0.
5. Anti-Theft Temperature Counter System (Model 678 only)	The user can select the anti-theft time out based upon a predictive temperature counter that can be set as 0, 25, 50, 100 and 200 (0=disabled). • The unit will not function when the predictive temperature counter has reached the user set parameter. The unit will display a warning consisting of a digit representing the last 5 counts (i.e. 5,4,...1,) and will display "SEC" on the LCD for five seconds when the probe is returned to the storage channel after the temperature is complete or after 30 seconds with the final temperature displayed. • When the unit enters the alarm state, it will double beep for approximately 10 seconds and display "SEC" on the LCD. This function is deactivated at power-up.

6. Instant Anti-Theft Audio Alarm System (Model 678 only)	The user can select an anti-theft option that instructs the instrument to beep continuously (beginning after approximately 5 seconds) whenever the unit is removed from the wall holder. • The user must defeat the Instant Anti-Theft Audio Alarm within 30 seconds after removal from the wall holder by holding the Mode button and removing the probe from the probe well, or by returning the unit to the wall holder. • After 30 seconds, the instrument must be returned to the wall holder to silence and reset the Instant Anti-Theft Audio Alarm. • Once in the Instant Anti-Theft Audio Alarm state, the instrument will continue the audio alarm until power is exhausted or until the unit is returned to the wall holder. **Note:** At power-up, this mode is deactivated.
7. Error Log (Function 5 in the Model 679)	The instrument will save the last 10 error messages that occur and display those messages in a last in first viewed sequence. While in error log, the display reads E x.x. To display the next error, momentarily press the mode button. **Note:** Battery removal will clear the error log of all error messages.

2. PREVENTIVE MAINTENANCE

The following preventive maintenance is recommended to maximize uninterrupted service with the M678 and M679 SureTemp Thermometers. Units which are in service on a regular basis should have the following preventive maintenance performed every 6 months:

1. Visually inspect the thermometer for physical damage which might cause future product failure.
2. Clean the unit per instructions in the *Directions for Use* manual supplied with the thermometer and/or per the instructions below.
3. Perform the Power-Up Display test, Startup Display test and Model 9600 Calibration Testing procedure found in the *Model 9600 Operation Manual*.

Units which are stored for an extended period and not used should have the following performed every 12 months:

1. Replace the batteries according to the procedures found in the *Directions for Use* manual.
2. Perform the Power-Up Display test, Startup Display test and Model 9600 Calibration Testing procedure found in the *Model 9600 Operation Manual*.

Cleaning and Sterilization

Routine Cleaning

Clean the exterior of both the Model 678 or Model 679 instrument, the wall mount and the probe as needed. Wipe all surfaces with a clean cloth dampened with warm water and a mild detergent, alcohol, or a nonstaining disinfectant such as Sporicidin® Spray and Towelettes[1] or MetriSpray™ cleanser[2]. Care should be taken to not scratch the LCD faceplate. Make sure that the cloth is damp, but not too wet.

Note: Do not allow cleaning solution to run inside the instrument. *Never* immerse the thermometer into the cleaning solution. *Never* autoclave the thermometer or probe.

ETO Gas Sterilization Procedure

When no other form of decontamination such as a germicidal wipe is acceptable, a low temperature (not to exceed 48.9°C [120°F]) ETO gas sterilization cycle may be used. Refer to your institution's standard operating procedure for the length of the cycle.

[1] Sporicidin® is a registered trademark of Sporicidin International (800) 424-3733.

[2] MetriSpray™ is a trademark of Metrex Research Corporation (800) 841-1428.

This type of sterilization may cause some hazing of glossy plastic surfaces and should be used only when absolutely necessary.

1. Ensure that the probe is removed from its storage well and disconnected from the instrument.
2. Remove any probe covers from the probe and from the probe cover storage well.
3. Remove the batteries following the instructions in the **Battery Removal and Replacement** section below.

WARNING: Leaving batteries in the thermometer during the sterilization procedure may present an explosion hazard.

4. Wrap the thermometer in a standard sterilization type packaging such as the Baxter Tower Dualpeel Sterilization Pouch.
5. ETO gas sterilize at a temperature not to exceed 48.9°C (120°F) and aerate.
6. Remove the sterilization packaging.
7. Before installing the batteries and probe, allow the probe and instrument to stabilize to room temperature for at least one hour.
8. Reinstall the batteries (see **Battery Removal and Replacement** below) and verify a successful self test.
9. Install the probe connector and insert the probe into the storage well to start the probe initialization process.
10. Verify proper calibration of the thermometer and probe using the Welch Allyn Model 9600 Calibration Tester.

Battery Removal and Replacement

1. Using a flat surface, lay the thermometer on its front panel.
2. Remove the **PROBE COVER BOX HOLDER** on the back of the instrument by pressing with thumb and middle finger on the “dimples” located in the sides of **PROBE COVER BOX HOLDER**. The batteries are located under the **PROBE COVER BOX HOLDER**.
3. Remove the batteries by pulling on the ribbon located under them.
4. Press either the Mode or the Timer button for approximately five seconds to discharge the electronics.
5. Install 3 new “AA” batteries according to the battery polarities marked inside the battery compartment. Verify that the thermometer completes self-test, then goes blank.

   CAUTION: Incorrect battery polarity may result in damage to the thermometer.
6. Reinstall the **PROBE COVER BOX HOLDER**.

3. CALIBRATION TESTING

The Calibration Key provides a convenient means of testing the thermometer.

Calibration Key Procedure

1. Extract the probe and disconnect it from the thermometer.
2. Insert the Calibration Key (part number 01637-000) into the probe connector receptacle on the thermometer and observe the display. The display should read CAL for two seconds, and then go blank.
3. Insert a probe shaft into the probe storage well and remove it to initiate a temperature taking cycle. Wait for the display test and then observe the display. The display must read between 97.1°F and 97.5°F inclusive for the calibration of the instrument to be correct.
4. Remove the Calibration Key and reinstall the probe connector plug.
5. Then install the probe into the probe storage well.

Note: This Cal Key test does *not* test the probe. To do so requires the use of the Welch Allyn Model 9600 Calibration Tester.

If the reading from the Cal Key is not within the specified range or you are having other problems with the use of the Cal Key, refer to **Cal Key Problems** in the **Troubleshooting** section.

Model 9600 Calibration Testing Procedure

The Model 9600 Calibration Tester provides a convenient means of testing the entire thermometer system (instrument and probe).

- The 9600 must be warmed up and stable at one of the two available temperature settings.
- The thermistor based instrument under test must be in Monitor mode and no probe cover loaded.

The probe is inserted into the small hole in the dry heat well of the 9600 and allowed to settle for a minimum of 2 minutes to the final temperature. The reading on the thermometer must be within the range specified on the 9600. Refer to the *Model 9600 Operation Manual* for complete instructions.

Note: All Welch Allyn and Diatek thermometers (thermistor and infrared ear thermometers) can be checked in the Model 9600.

If you are having problems with the use of the Model 9600, refer to the **Troubleshooting** section in the *Model 9600 Operation Manual*.

4. THEORY OF OPERATION

Technical Overview

The heart of the Model 678 and Model 679 is comprised of two integrated circuits which provide most of the microcontroller and analog circuit functions.

- All control and display functions are governed by the microcontroller (U1).
- All probe analog data interfacing to the microcontroller is provided by U2. U2 functions as an A/D converter.

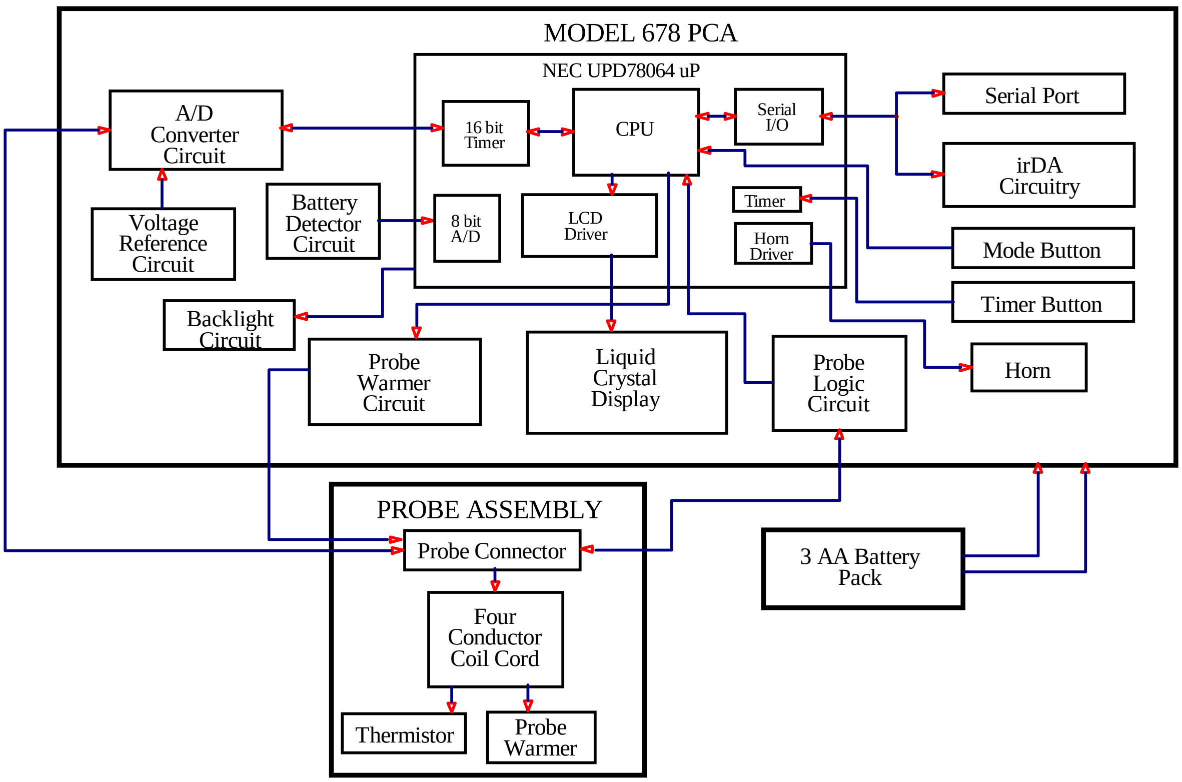


Figure 3 - System Block Diagram

Probe resistance measurements are made by ratioing pulse widths which are generated in U2 by sequentially switching in a calibration resistor and the probe thermistor. These pulse widths are measured by the microprocessor, which calculates the probe resistance. The actual probe temperature is then calculated from the probe resistance.

Probe Enhancements

The Model 678 and Model 679 thermometers have the capability to detect probe type - oral / axillary vs. rectal. This allows the oral temperature-taking to be as fast as possible by using different operating modes based on probe type. Axillary temperatures are measured with oral probes in combination with the axillary mode, providing a temperature reading in about 15 seconds. Rectal probes give a Normal mode temperature in about 15 seconds for both models.

Probe type recognition also allows the use of minor differences in prediction parameters tailored to the temperature taking site to help increase speed over previous products.

The probe type is communicated to the thermometer by the use of shorting jumpers between the ground and two of the probe connector contacts. Model 678 / 679 oral/axillary probes also incorporate a warming resistor in the tip to pre-warm the probe before placement in the mouth or axilla, thus speeding response even further.

Probe Switch

The probe switch (S4) is activated by the probe shaft when the probe is installed or removed from its storage well. Placing the probe into the storage well pulls processor pin 15 high via R6. When the probe is removed, this line is pulled low. This signal is also routed to test connector J4 pin 5 to allow automated testing of this function during factory test. R6 allows this line to be pulled high or low at J4 during factory test regardless of the actual switch position.

**CAUTION: For the technician, J4 serves as a convenient set of "test points" to monitor proper operation of all user switch functions.
BE CAREFUL WITH STATIC DISCHARGE! J4 TIES DIRECTLY TO CMOS PROCESSOR INPUTS WHICH ARE EASILY DAMAGED BY STATIC DISCHARGE. FOLLOW PROPER ESD HANDLING TECHNIQUES.**

Normal Mode

The Oral/Axillary probe is pre-warmed using a pulse width modulation (PWM) controller to 33.9°C (93°F) upon extraction from the storage well.

- When the probe is first extracted and colder than 33.9°C, the heater pulse widths are at a maximum percentage ON vs. OFF to warm the probe quickly.
- When the probe reaches 33.9°C, the pulse widths narrow to a duty cycle just enough to maintain temperature.
- When the probe is placed in the mouth, the heat supplied by the mouth makes the pulse widths reduce to zero. This reduction to zero (and the probe being at least up to 33.1°C / 91.6° F) triggers the start of the prediction algorithm.

The shape of the rising temperature curve is monitored and the best fit to a curve is found. When the curve fit is stable, the final predicted temperature is displayed.

- In the oral mode, if the prediction criteria is not met within 15 seconds of starting the prediction process, it will automatically switch to Monitor mode.
- In the axillary mode, if the prediction criteria is not met within 30 seconds of starting the prediction process, the thermometer displays a final temperature but also indicates that the probe is out of position.
- In the oral or axillary mode, if the ambient temperature is above 33.9°C (93.0°F) the unit will automatically switch to Monitor mode.
- Rectal probes are not prewarmed. Rectal temperature measurements will take about 15 seconds.
- Within 60 seconds after the probe is removed from the well, if the prediction process has not started, the thermometer will switch to Monitor mode.

Power Supply

The Model 678 contains a battery pack made up of 3 AA size batteries. This provides a maximum supply voltage of about 4.8 volts. Power is drawn from the three AA alkaline cells directly to the circuit electronics. The voltage from the batteries is unregulated but filtered by capacitor C25. The power supply voltage will range from about 4.8 volts with new batteries to 3.0 volts at shut down.

The thermometer has two low battery voltage indications.

- The first is a warning that batteries are getting low and is indicated by the battery icon flashing in the display. This begins when the batteries fall to about 3.2 volts. Accuracy is not affected during low battery warning indication.
- When the batteries fall to approximately 3.0 volts, the low battery error condition is defined to exist. Operation is halted and the E2.1 error message is stored in memory. At this point, the batteries must be replaced and the thermometer electronics reset. See **Reset Self/Tests** on page 4 and on page v.

Low Battery Detection

The Model 678 includes a low battery detector circuit which shuts the device off when the battery degrades to 3 volts. This ensures that erroneous temperature readings are not given due to a low battery. For this operation, the reference voltage (VREF) is measured by software using channel 1 of the 8 bit A/D in the microprocessor. The A/D is powered with the battery voltage (VCC) through Q12. A/D channel 1 is compared to the full scale on the A/D. As the battery voltage gets lower, channel 1 readings get higher. A reading above a fixed limit indicates a weak battery. Exceeding another limit indicates a dead battery and the device will shut off.

Microcontroller

A NEC UPD78064 or UPD78063 single chip microcontroller in a QFP package (U1) is used for signal digitizing, data processing, program memory addressing and storage, and I/O interfacing. The microcontroller also includes an LCD controller/driver which allows internal conversion of CMOS logic levels to a data format capable of driving the Model 678/679 LCD. In this application, the microcontroller is running at approximately 2.5 MHz, which is achieved by using a 4.9152 MHz Crystal (X1).

Reset/Self Tests

Upon battery installation, (assuming that the electronics have been discharged sufficiently by pressing a user button with batteries removed) the microprocessor receives a power up reset signal from the components associated with the reset line at U1-12. When power is applied continuously, C3 is charged slowly through R7, providing an active low reset to the microprocessor.

When the reset signal is complete, the microprocessor launches a series of self checks which include RAM test, ROM test, instruction set test, self calibration tests (electronics accuracy test, hi cal, low cal), probe warmer circuitry tests, probe test, battery voltage test and ambient temperature test. Any failures here will cause a specific error code to be displayed to assist debugging.

Microprocessor Clock

The clock for the microprocessor is generated by X1 and capacitors C26 and C27, which form a 4.9152 MHz. oscillator circuit. The microcontroller is running at approximately 2.5 MHz, which is achieved by internally dividing the frequency of oscillation by two.

Temperature Measurement and Display

The thermometer probes incorporate negative temperature coefficient thermistors. When the temperature of the probe is increased, its electrical resistance decreases. Model 678 and 679 use “20K” thermistors, so they are at approximately 20 Kohms at room temperature. At 37 °C (98.6 °F) they are near 12 Kohms. The change in resistance is nonlinear with temperature, and an equation describing this curve is programmed into the thermometer.

Temperature Measurement A/D Converter

The primary function of the temperature measurement A/D converter circuit is to convert a measured resistance into a 16-bit word, which is then used by the microprocessor to calibrate itself and calculate a temperature.

Theory of Operation

The A/D circuit is made up of 4 major parts:

- The resistance to be measured (either the probe thermistor, the PTBCAL resistor, or the HICAL resistor).
- The timing capacitor (C21, 0.33uF) and associated driver circuitry (Q1-Q4, Q9, R15, and R30).
- A low bias dual voltage comparator (U2, TLC555).
- A 16 bit timer internal to the microprocessor.

In effect, this is a single slope converter which measures the time constant of the measured resistance combined with a fixed capacitance. The time constant is measured by counting the time it takes for the voltage to decay from a fixed initial voltage level to a fixed lower voltage. The ratio of this pulse width and the pulse width corresponding to a known calibration resistance (R13, 11.55K) is used to calculate the measured resistance. Once the resistance is known, the corresponding temperature is calculated using the thermistor temperature equation. Because the M678 uses this 'ratio cal' method for measuring the thermistor resistance, the device is immune to a number of gain errors which can be measured and corrected using software.

Circuit Description

Initially, the microprocessor simultaneously discharges both sides of the capacitor. This is accomplished by bringing A/D TRIGGER high which turns on Q9, pulling one side of capacitor C21 to ground. This also turns on Q1, Q2, and Q3 via PROBE_SEL, PTBCAL_SEL, and HICAL_SEL, which allows the other side to discharge through the thermistor R8(12.1K) and R13(11.55K).

Once capacitor C21 has been fully discharged, the probe thermistor is then selected by switching the PTBCAL and the HICAL resistor paths off. The microprocessor then forces the A/D TRIGGER signal to go low turning on Q4, which lifts one end of capacitor C21 up to VREF(2.4v).

Because there can be no instantaneous voltage drop across capacitor C21, the other side of the capacitor immediately goes to 2.4v. This exceeds the threshold voltage(1.6v) of U2(TLC555), causing the output A/D_OUT to go low. At this point, the capacitor begins to discharge from 2.4v to 0v through the thermistor resistor.

The output of the comparator goes high again when its input reaches the trigger voltage(0.8 volts). This produces a pulse of length equal to the time it takes for the capacitor to discharge from 1.6v to 0.8v through the thermistor.

The microprocessor measures this pulse width using an internal 16-bit timer and then the same A/D conversion is performed using the HICAL resistor as the measurand resistance. The microprocessor performs the following calculation that ratios these two pulse widths to determine the exact resistance of the thermistor:

$$\text{Rthermistor} = \frac{(\text{PWthermistor})\cdot(\text{Rhical})}{\text{PWhical}}$$

The microprocessor then uses the following equation to convert the measured resistance into a temperature:

$$\text{Temperature\_in\_Kelvin} = \frac{1}{\text{Ra} + \text{Rb}\cdot\ln(\text{Rt}) + \text{Rc}\cdot(\ln(\text{Rt}))^3}$$

Q4 and Q5 and the base resistors R15 and R30 form the level shifter and drive circuit for the fixed end of the timing capacitor. R15 (4.7K) is selected to give adequate saturation on-resistance. R30 (10K) is selected so that a float on the input will not cause damage from cross-conduction if the input is left floating, yet supply enough current to the timing capacitor during recovery. Q4 and Q9 exhibit only a few millivolts of saturation voltage, which does not affect the accuracy of the A/D as described above.

- C21 is the surface mount timing capacitor. This capacitor is selected for low dielectric absorption, hence the high voltage rating (50V).
- D4 and R16 protect the comparator from input undervoltage when the timing capacitor (C21) is discharged. D4 also reduces the recovery time by limiting the voltage at the beginning of recovery to 0.6 volts instead of 2/3VREF.
- C5 provides the first line of defense from EMI (Electro Magnetic Interference) coming in on the probe. R33 and C18 protect Q1 from rectifying EMI in the substrate diode. R16 protects the comparator input from overcurrent.

Probe Identification Logic

Basic Function

The probe logic circuitry is needed to determine which type of probe is connected to the device. This allows the microprocessor to initiate the proper algorithm for converting a thermistor measurement into a temperature. Figure 4 lists the probe logic circuitry and Figure 5 shows the logic diagram.

PROBE LOGIC				
SIGNAL	**ORAL**	**RECTAL**	**CAL KEY**	**NO PROBE**
PROBE_0	0	0	1	1
PROBE_1	0	1	0	1

Figure 4 - Probe Logic Circuitry

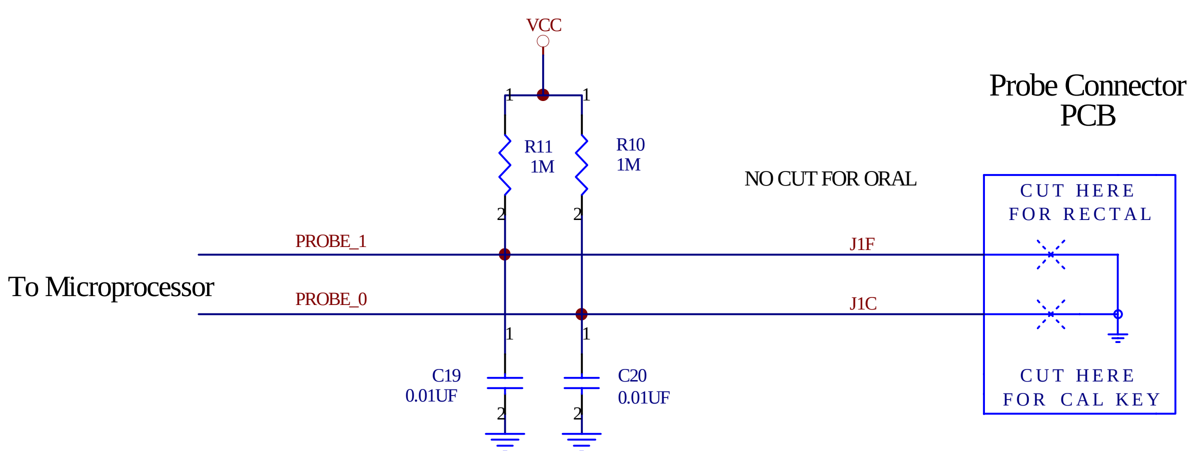


Figure 5 - Probe Logic Diagram

Circuit Operation

R10, R11 (both 1 MΩ pullup resistors to reduce battery drain), J1-F(PROBE_1), J1-C(PROBE_0) and J1-E(GND) are used to provide logic 0 or 1 inputs to U1-17 and U1-18 depending on whether a probe or cal key has been plugged into the Model 678 probe connector receptacle. When a probe has been plugged in, the software determines whether it is Oral, Axillary, Rectal, or a Cal Key as follows:

- When J1-C (CAL) and J1-F (RCTL) are both connected to J1-E (GND) (by jumpers installed in the Model 678 probe PCB), the software determines that the probe is an Oral probe;
- When J1-C (CAL) is connected to J1-E (GND), but J1-F (RCTL) is not connected to J1-E (GND), the software determines that the probe is Rectal probe;
- When J1-F (RCTL) is connected to J1-E (GND), but J1-C (CAL) is not connected to J1-E (GND), the software determines that the probe is a Calibration Key;
- When neither J1-C (CAL) or J1-F (RCTL) are connected to J1-E (GND), the software determines that no probe has been plugged in.

C19 and C20, both 0.01 uF capacitors, are bypass capacitors used to filter out spurious noise to the microprocessor on the probe input lines J1-F(PROBE_1) and J1-C(PROBE_2).

Probe Warming (Oral probes only)

Probe characteristics vary somewhat due to normal production process variations. It is desirable to warm the probe as efficiently as possible from a time-to-ready standpoint and from a temperature stability standpoint when the probe is up to temperature.

The probe warming process is a closed loop feedback control system incorporating PWM (pulse width modulation) control.

The probe warmer circuitry is used to heat the probe tip prior to taking a temperature reading in order to speed the convergence of the prediction algorithm. This allows quicker temperature readings. A fail safe hardware shutoff circuit is included to ensure the heater will shut off in the event of a software failure.

Theory of Operation

The microprocessor sends pulses via /HTRC to drive the probe heater resistor which heats the probe tip. A temperature of about 93°F is maintained prior to taking a temperature.

A software algorithm calculates the width of the HTRC pulse as a function of the difference between the probe temperature and 93°F, and as a function of the probe temperature rate of change. It provides an initial pulse to rapidly heat up the probe tip to the 90°F region and then supplies progressively shorter pulses as the probe temperature converges to about 93°F. Once 93°F is reached, software continues to send a “control” pulse to maintain the temperature.

Circuit Operation

The warmer circuitry consists of Q5, Q13, Q14, C1, C2, L1, D1, R1, R2, R3, R4, R5, R31, R32, and the heater resistor (27 ohms) connected across J1B and J1E.

Line /HTRQ is pulled low by the uP which enables Q13 to turn on. /HTRC is then pulsed low which brings the base of Q5 low via capacitor C1. Q5 turns on which in turn enables Q14 on. Base current from Q14 flows through R31 (1K) and R32 (1K). Most of this current flows through the emitter of Q5 while some flows through R1 (470K) to satisfy the diode drop of Q5's BE junction. The base current of Q5 along with the current through R1 flows into C1(1uF), charging it up. This sets up the mechanism for the hardware shutoff. As this capacitor charges up, the base voltage of Q5 approaches the emitter voltage and the transistor shuts off, thereby shutting down the probe warmer. As long as Q5 remains on, Q14 has a base current flowing which allows current to flow from its collector through R2 (4.7K) and the heater resistor. With about 150mA flowing through it ([VCC-2VCEsat]/29 ohms), the heater resistor heats up the probe tip.

During normal operation, software turns the warmer circuit on and off. The width of the pulse on HTRC determines how long Q5 is turned on, thereby determining how long the heater is heating. Once the HTRC pulse goes high again, the base of Q5 is pulled high turning it off, and the capacitor discharges to VCC through D1.

Q13 and Q14 are selected for their low saturation on voltage. D1 is a diode clamp used to keep the base of Q5 from attaining a much higher voltage than VCC. R4(47K) and R2(4.7K) in combination with R3(47K), serve as pull down resistors ensuring that the processor feedback lines (U1-34 and U1-35) go low immediately upon warmer component shut off. C2 serves as an RFI suppression component.

Other Components

Liquid Crystal Display

The model 678 and Model 679 use a liquid crystal display to display data to the user. Three communication lines and 18 segment lines connect the LCD to the display driver (U1-60 to U1-80) internal to the NEC microprocessor. The LCD is 3:1 multiplexed with 1/2 bias. The bias voltages (1.5 volts, and 3.0 volts) are supplied to the display driver by the voltage reference circuit

The LCD glass is electrically tied to the display PCB via an elastomeric connector sandwiched and compressed between the glass and the PCB by the frame. This assembly, if taken apart, cannot be reassembled without replacing the frame.

LCD Backlight (Model 678 Only)

The backlight is a low power LED which illuminates the back of the LCD display. The backlight will be turned on automatically in any mode except Low Power. Once the backlight is turned on, it will automatically shut off whenever the instrument goes into Low Power mode.

Battery power is applied to current limiter resistor R23 and LED D3. When microprocessor signal /BLIGHTCTL at pin 42 goes low, current is allowed to flow through the LED. The amount of current is approximately 2 milliamps, depending on the Battery voltage Vcc. When the instrument is in Low Power mode / BLIGHTCTL goes high, turning the LED backlight off to conserve power.

Probe Switch

When the probe has been inserted in the probe holder, the probe switch (S4) brings PROBE SW (U1-15) high (VCC). When the probe is removed from the probe holder, the probe switch brings PROBE SW (U1-15) low (GND). R6 (47K) allows the probe switch to be overridden by the test port.

Mode Button

The mode button (S2) is a momentary contact switch. A pullup internal to the microprocessor normally pulls /MODE (U1-25) high, placing a logic “1” at this input. When depressed, S2 provides a momentary contact to ground at /MODE giving it a logic level of “0”. The software continuously checks /MODE. If the thermometer is not in the process of taking a temperature, pressing the Mode button will wake up the thermometer and display the last recorded temperature.

Timer Button (678 Only)

The timer button (S1) is also a momentary contact switch. A pullup internal to the microprocessor normally pulls /PTIMER (U1-26) high, placing a logic “1” at this input. When depressed, S1 provides a momentary contact to ground at /PTIMER giving it a logic level of “0”. The software continuously checks /PTIMER.

Serial Communications Port

Transmit , receive data and control CMOS-level signals are made available for test or system integration via J4. The contacts of J4 are laid out so they are accessible through a slot in the rear of the case. Communications on a cable length of over one foot should be driven with external RS232 or other line driving circuitry.

Horn

The horn is activated at the start of a temperature taking cycle, at the end of a Normal mode temperature cycle, during timer operation at 0, 15, 30, 45 and 60 seconds, and for various error conditions.

- A short duration single beep is indicative of normal operation.
- A short duration double beep is used to indicate errors and warnings such as switching from Normal mode to Monitor mode during a temperature cycle.

The horn is a piezoelectric ceramic resonator driven by the processor square wave. The horn control signal comes from U1 pin 49. It directly drives the horn LS1.

5. TROUBLESHOOTING

Many thermometer operational parameters can be tested for proper operation before the unit is taken apart and without needing any tools. Refer to **Operational Characteristics** on page 1-1 and in particular to the **Setup** and **Biotech Mode** sections for guidance on preliminary checks.

If the trouble seems to be calibration related, refer to **Calibration Testing** on page 3-1.

If these sections do not prove useful in resolving the problem and you are sure that the instrument is not performing properly, the following sections should guide you through the debugging process given the proper tools and equipment.

Error Codes

Error codes are divided into four classes:

Probe	Probe errors are generated by the probe or the probe connector and are not errors generated by the thermometer. They do require that temperature measuring be inhibited until the error is cleared. There is no limit to the number of times a probe error can occur. All probe problems are considered by the thermometer to be recoverable. When a probe error occurs, the probe icon is displayed.
Ambient Temperature	Ambient Temperature errors occur when the ambient probe temperature is above 104.0° F or below 60.8° F. During an ambient temperature error, the display shows an ”A” with either the up or down arrow icon flashing.
Dead Battery	Dead Battery error occurs when the instrument detects a battery voltage of 3.0 volts or less. The battery icon is displayed without flashing when this error occurs.
Instrument Circuitry	Instrument Circuitry errors are generated from internal test failures and can be recoverable or non-recoverable. Error code numbers are only available in Biotech mode. • Recoverable errors require that temperature measuring be inhibited until the error is cleared. After displaying the error |X| icon, the instrument will shut itself off and store the error code in memory. • Non-recoverable errors are generated from internal ROM and RAM test failures. The error code will be stored in memory and the LCD will disply the error |X| Instrument Malfunction icon.The only way to recover from a ROM or RAM error is to reset the electronics by removing the batteries.

Note: Error codes E0.1, E0.2, E0.3, can sometimes be caused by a faulty probe. It is advisable to remove the probe completely from the instrument and check its functionality as described in the *Operational Characteristics* section before assuming an instrument problem instead of a probe problem. If another probe is available, this can prove useful in tracking down the source of the problem.

Instrument circuitry error codes are listed in the table below.

CLASS	ERR NUM	SELF-TEST DESCRIPTION
Probe	E0.1	Probe heater accumulation test.
Probe	E0.2	Probe a/d pulse width test.
Probe	E0.3	Adaptive probe gain too high or too low test.
Ambient	E1.1	Ambient temperature high test.
Ambient	E1.2	Ambient temperature low test.
Battery	E2.1	“Dead” battery test.
Internal	E3.1	RAM read/write test.
Internal	E3.2	ROM checksum test.
Internal	E3.3	CPU instruction test.
Internal	*	CPU Watchdog test. *Will cause hardware reset, but no error.
Internal	E4.0	PTB resistor a/d pulse width test.
Internal	E4.1	RatioCal resistor a/d pulse width test.
Internal	E5.0	Heater circuit test.
Internal	E5.1	Heater overheated test.
Internal	E5.2	Heater watchdog timeout test.
Internal	E6.0	PTB resistor “temperature” test.

Figure 6 - Self-Test /Error Table

Equipment Required

Most troubleshooting operations can be performed with standard tools and meters.

- A #1 Phillips screwdriver will remove all instrument screws.
- A standard lab 3.5 digit digital multi-meter (DMM) will provide sufficient accuracy for most tests. A needle-tipped pair of probes is recommended.
- For particularly difficult tasks, an oscilloscope is sometimes the only way to analyze high speed signals, but is not generally required.
- Standard electronic tools and supplies for small surface mounted and through hole component rework will be needed to perform any electronics repairs. Some surface mounted components are extremely small and present a challenge for rework by hand. A surface mount rework station is recommended.
- Power and ground are available at the battery terminals E2 (power) and E3 (ground).

Troubleshooting Table

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
No operation	Dead batteries, no batteries, battery missing, battery incorrectly installed	Refer to Battery Removal and Replacement on page 2-2. Check that all batteries are installed in proper direction. Reset electronics (see Instrument Reset/Self Tests on page 1-3). If battery voltage is within specifications, refer to Biotech Mode on page 1-7 and enter Biotech mode to measure battery voltage as seen by electronics.
	Broken battery wire	Open instrument case, install batteries, check for voltage on main PCB at battery wire connections.
	Short circuit preventing operation	Remove batteries, press mode button 5 seconds, set DMM to Ohms, measure resistance of electronics at battery contacts ("+" to bottom right corner, "-" to top left corner). Resistance should climb to more than 2 Megohms as C25 charges.
	Failed component	Check oscillator at U1-7 for 4.91 MHz sine wave. If not present, suspect X1 or U1.
Display problems	LCD frame loose	Check that all 4 plastic hooks for the LCD frame are tight and not broken. The frame should not be lifting off of the PCB.
	Dirty LCD elastomeric conductor strips	Have a new LCD frame handy. Remove old one by unlatching plastic hooks. Clean LCD elastomeric strips, LCD glass contacts, and PCB contacts with lint proof cloth dampened with alcohol.

Troubleshooting Table (continued)

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
Display problems (continued)	Cracked LCD	Inspect LCD for hairline cracks, especially in corners.
	Microprocessor failure	Check for improper soldering of pins, crystal operation on O-scope, proper reset.
No beeper sound	Defective horn	Replace horn.
	Broken connection	Check continuity from U1-49 to horn pin 2 and from ground to horn pin 1.
	Defective U1	Check for signal with O-scope at U1-49. Replace microcontroller U1.
No Timer function	Defective Timer button S1	Check for low level (gnd.) signal at U1-26 when timer button S1 is pressed. Replace button if signal is high.
	Broken trace	Check for low level (gnd.) signal at U1-26 when timer button S1 is pressed. Replace Button if signal is high.
No Backlight	Defective backlight	Check LED D3 and resistor R23.
	No /BLGTHCTL signal	Check that signal at U1-42 goes low when unit is in on.
Recalled temperature is not correct.	Unit switched to Monitor mode	If unit is in Monitor mode (whether by the user switch or automatically), the stored temperature is the last one seen by the instrument. This is usually lower than the patient temperature since the probe drops in temperature after removal from the patient.
Probe: Wrong type displayed	Missing Vcc power to R10 and/or R11	With no probe installed, check that probe connector pins J1-B and E are both pulled high when any function is active (recall or timer).

Troubleshooting Table (continued)

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
Probe: Wrong type displayed (continued)	Incorrect wiring of probe	Oral probes should have a short between pins B, E and F (refer to instrument PCB designators for probe pin definition). Rectal probes should have a short between pins E and F but open between pins B and E or F. Replace with new probe.
Normal/Monitor Mode switching problems	Ambient above 33.9°C (93.0°F)	Causes auto switch to Monitor mode.
	Switched to Monitor mode before probe in mouth	If 60 seconds pass after ready in Normal mode, unit switches to Monitor mode. If probe is still cooling from a previous temperature and used immediately, it might sense ambient to be above 33.9°C (93.0°F).
	Defective Mode button	Check mode button for proper function. Check U1-25 for low level signal when button is pressed.
	Deffective Probe	Replace probe.
Cannot enter Biotech Mode	Mode button not pressed, and or Instrument not in wall holder (678 only)	Mode button must be pressed while instrument is in the wall holder.
	Probe not connected and or probe shaft not inserted and removed from probe well	Must connect probe to instrument and remove the probe shaft from the probe well while the instrument is in wall holder and mode button is pressed.
	Failed component, broken trace	Check proper Mode button, Probe switch and security switch operation.

Troubleshooting Table (continued)

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
Battery Life Problems	Excessive alarms Excessive use in monitor mode	The horn draws significant current. During monitor mode the instrument is continously drawing current.
	Dead cell	If cell voltage is down significantly in only one cell, this battery is defective. All batteries should drain at the same rate.
	First set shelf life	Due to possibly long stocking times between fabrication and end use, the first set of batteries may have reduced life.
Cal Key doesn't activate thermometer	Probe switch not also activated	When the cal key is connected the display must read CAL for two seconds and then blank. The probe shaft must be inserted and removed from the probe well to activate the probe switch.
Cal Key shows OrL, rEC, or ALy	Defective Cal Key	Replace Cal Key.
Monitor mode temperature reading too low	Probe malfunction	Change probe. Test calibration of entire system (instrument and probe) with the M9600 Calibration Tester.
	Instrument malfunction	Check calibration with Cal Key.
	Improper placement of probe	Probe must be under the tongue and as far back as possible into the sublingual pocket.
	Temperature not stable.	Allow three minutes for Monitor mode reading to stabilize in mouth.

Troubleshooting Table (continued)

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
Monitor mode temperature reading too high	Probe malfunction	Change probe or test calibration of entire system (instrument and probe) with the M9600 Calibration Tester.
	Instrument malfunction	Check calibration with Cal Key.
Normal mode temperature reading too low	Probe malfunction	Recharacterize probe (remove completely from instrument and re-install). Or, change probe. Or, test calibration of entire system using 9600.
	Instrument malfunction	Check calibration with Cal Key.
	Improper placement of probe	Probe must be under the tongue and as far back as possible into the sublingual pocket.
Normal mode temperature reading too high	Probe malfunction	Recharacterize probe (remove completely from instrument and re-install). Or, change probe. Or, test calibration of entire system using 9600.
	Instrument malfunction	Check calibration with Cal Key.
	Improper technique	Movement in mouth after insertion and before final temperature is displayed can cause high readings. Place probe quickly into sublingual pocket and hold still.
	Improper technique	Do not place probe in mouth until the display is showing “OrL”.

Field Serviceable Repairs

Repairs are considered field serviceable if the repair will not alter the calibration or proper operation of the instrument.

- All probes designed to work with the thermometer are fully interchangeable.
- All components in the Model 678 and Model 679 can be replaced without affecting instrument operation or calibration. Some minor changes to the exact calibration point will be caused by changing R8, and R13, but as long as the proper type and tolerance resistors are used (0.1% and 0.05% as supplied by Welch Allyn), the unit will remain within specifications.
- Replacement of the LCD frame is somewhat difficult due to the need to assemble it while under pressure to assure proper compression of the elastomeric connector.

Note: Do not glue the LCD frame to the display PCB if the frame latching pins are broken. This will destroy the display. Replace with a new LCD frame.

Field Serviceable Parts

All parts are serviceable by qualified technicians.

Note: The following parts lists are current as of the date of publication. Parts and part numbers may be changed without notice. Check with Welch-Allyn prior to ordering parts to verify current parts for any replacement requirement.

Model 678/679 Replacement Parts

Part Number	Description
25228-0000 (678 Only)	SWITCH ARRAY, M678
25232-0000	HOUSING, FRONT, M678 (2 BTTNS)
25234-0000	HOUSING, REAR, M678/679
53009-000	BATTERY, ALKALINE 1.5V AA
70852-0000	LABEL, BLANK LASER 1.25 X 1.56
70866-0000 (678 Only)	LABEL, FRONT, M678
70867-0000 (678 Only)	LABEL, ICON, ID, M678
80128-1000	TUBING,SILICONE,125 X .25 X.3
83174-0000	SCREW,PLASTITE,2-28 X 1/2 P-PL
85259-0000	O-RING, 208 I.D.
70852-0007	SERIAL NUMBER LABEL, M678
70852-0008	SERIAL NUMBER LABEL, M679
25233-0990	HOUSING ASSY, MIDDLE 678/679
25228-1000 (679 Only)	SWITCH ARRAY, M679
25232-0001 (679 Only)	HOUSING FRONT, M679 (1 BTTN)
70866-1000 (679 Only)	LABEL, FRONT, M679
70867-2000 (679 Only)	LABEL, ICON, ID M679

Replacement Parts-Circuit Board Assemblies

Part Number	Description	Reference Designator
21001-0011	PCA MAIN M678 W/BCKLGHT	
46129-1050	CAP 1UF TANTCHIP 16V +/-20%	C1
46138-0000	CAP, 10UF, 20%, 16V ALUM	C17
46127-1030	CAP 0.01UF 100V X7R CHIP 0805-	C19, C2, C20, C22, C5, C6
46136-0000	CAP, .33UF, 10%, 50V TANTB	C21
46137-0000	CAP, CHIP, 1UF, 20%, 50V ALUM	C25
46140-0000	CAP, CHIP, 22PF, 5%, 50V 0805	C26, C27
46022-000	CAP 0.1UF 50V +80%-20% Z5U -	C3, C4
44047-0000	DIODE, DUAL, MMBD1203	D1, D2, D4
43010-0000	INDUCTOR 10UH LOWRES CHIP 1210	L1
50032-0000	TRANS BSS138 FET, SOT-23	Q1, Q2, Q3
50035-0000	TRANSISTOR, PNP W/BIAS RESTOR	Q12, Q15
50031-0000	TRANS BCX69 PNP SOT-89	Q13, Q14
50030-0000	TRANS XX5087 PNP SOT-23	Q4, Q5, Q6
50029-0000	TRANS XX2222A NPN SOT-23	Q9
40290-4740	RES, 470K, 5% 0805 SIZE	R1
40290-1050	RES 1M, 5% 0805 SIZE	R10, R11, R12
40320-0000	RES, 11.55K, 0.05% 25PPM 0805	R13
40290-4720	RES 4.7K SM 5% 0805 SIZE	R14, R15, R17, R2
40290-1020	RES 1K, 5% 0805 SIZE	R16, R23, R31, R32, R5
40290-1030	RES 10K, 5% 0805 SIZE	R21, R30
40290-1630	RES 16K SM 5% 0805 SIZE	R28
40290-4730	RES 47K S, 5% 0805 SIZE	R3, R4, R6
40290-1500	RES 15, 5% 0805 SIZE	R35
40290-1040	RES 100K SM 5% 0805 SIZE	R7
40301-2120	RES 12.1K SMO .1% 0805 SIZE	R8
54264-3000	IC, UP78PO64 M678/9 REV 2.3	U1
54258-0000	IC, TIMING, TLC555CD	U2
54266-0000	IC, 2.4V 2.5% LOW DROPOUT	U9
47021-0000	CRYSTAL, SMD, 4.9152 MHZ	X1

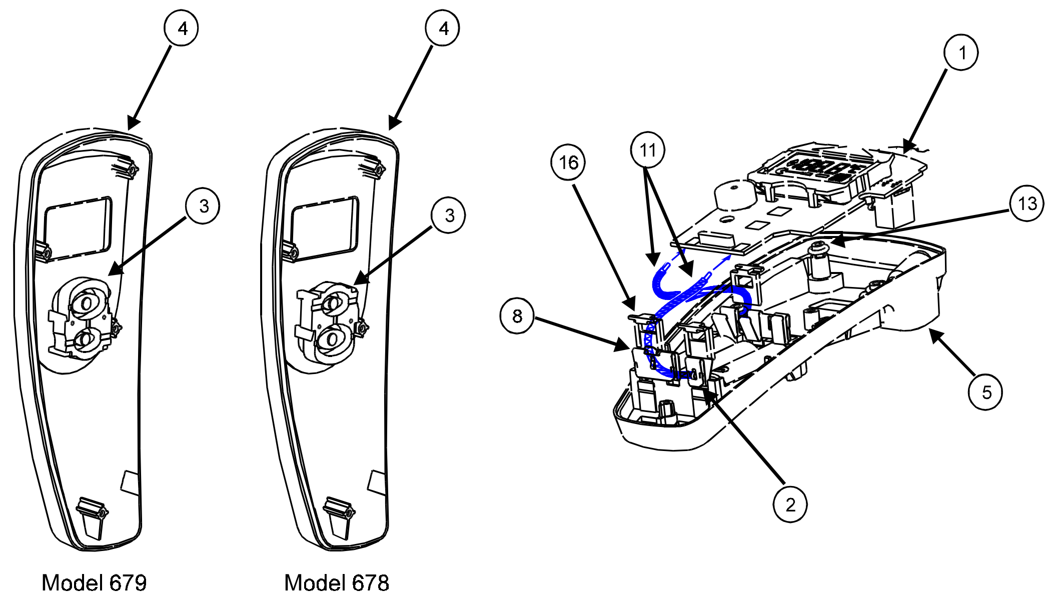
Part Number	Description	Reference Designator
21001-1010	PCA, MAIN, M678 F/C W/BCKLGHT	
25229-0000	FRAME, LCD, M678/679	
25230-0000 (678 Only)	LIGHT PANEL	
25231-0000	SPACER, EDAC, M678/679	
58536-0000	CONNECTOR, ZEBRA .255X1.82x.10	
70869-0000 (678 Only)	LABEL, REFLECTIVE, M678	
60026-0000 (678 Only)	LED, BACKLIGHT, YELLOW	D3
58524-0000	CONNECTOR,6 COND,EDGE REC	J1
60025-0000	LCD, M678	LCD1
58315-0000	SPEAKER,MINIATURE, PIEZOELECTRIC	LS1
58455-000 (678 Only)	SWITCH,REED,10 TO 20 A TURNS	S3
58540-0000	SWITCH, PROBE, M678/679	S4
85257-0001 (679 Only)	FOAM SPACER 3/16 THK	
40290-1500 (679 Only)	RES 15, 5% 0805 SIZE	R34

Thermometer Disassembly

Please note that if your thermometer is within the warranty period, you should return the unit to an authorized service representative for servicing; failure to do so will invalidate the warranty.

WARNING: This instrument contains microelectronic devices which are highly susceptible to damage by static discharge. Use proper handling and grounding techniques while working on the internal electronics.

1. Withdraw the probe from the probe storage well.
2. Unplug the probe connector from the thermometer.
3. Lay the thermometer on its front panel.
4. Remove the Probe Cover Holder /Battery Access Cover from the thermometer back case by firmly pressing on the indentations located on the sides of the Battery Access Cover.
5. Remove the batteries by pulling on the ribbon strap.
6. Remove the four screws from the thermometer back case.
7. Carefully remove the thermometer back case, keeping the thermometer electronics assembly and mid-frame in the front case.
8. Remove the neck strap or neck strap eyelet.
9. The electronics assembly can be removed from the mid-frame by desoldering the battery wires from the main PCA, and carefully removing the PCA out of the front housing.



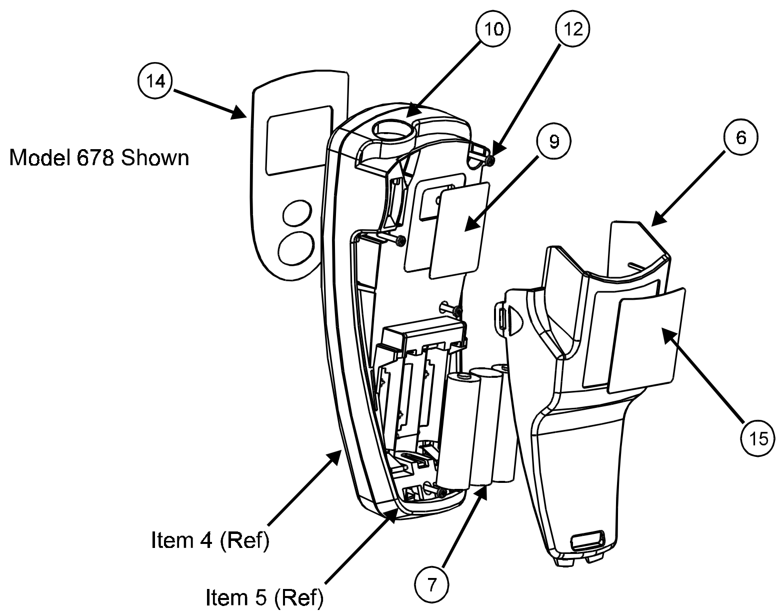


Figure 7 - Thermometer Assembly Drawing

1	Printed Circuit Assy.	7	Battery 3 "AA"	13	O rings (3)
2	Battery Clips (2)	8	Battery Clip Dual	14	Label Front
3	Push Button Switches	9	Label Caution Serial Number	15	Label Icons
4	Front Housing	10	Probe Well	16	Battery Limiter
5	Middle Housing	11	Battery Wires		
6.	Rear Housing	12	Screws (4)		

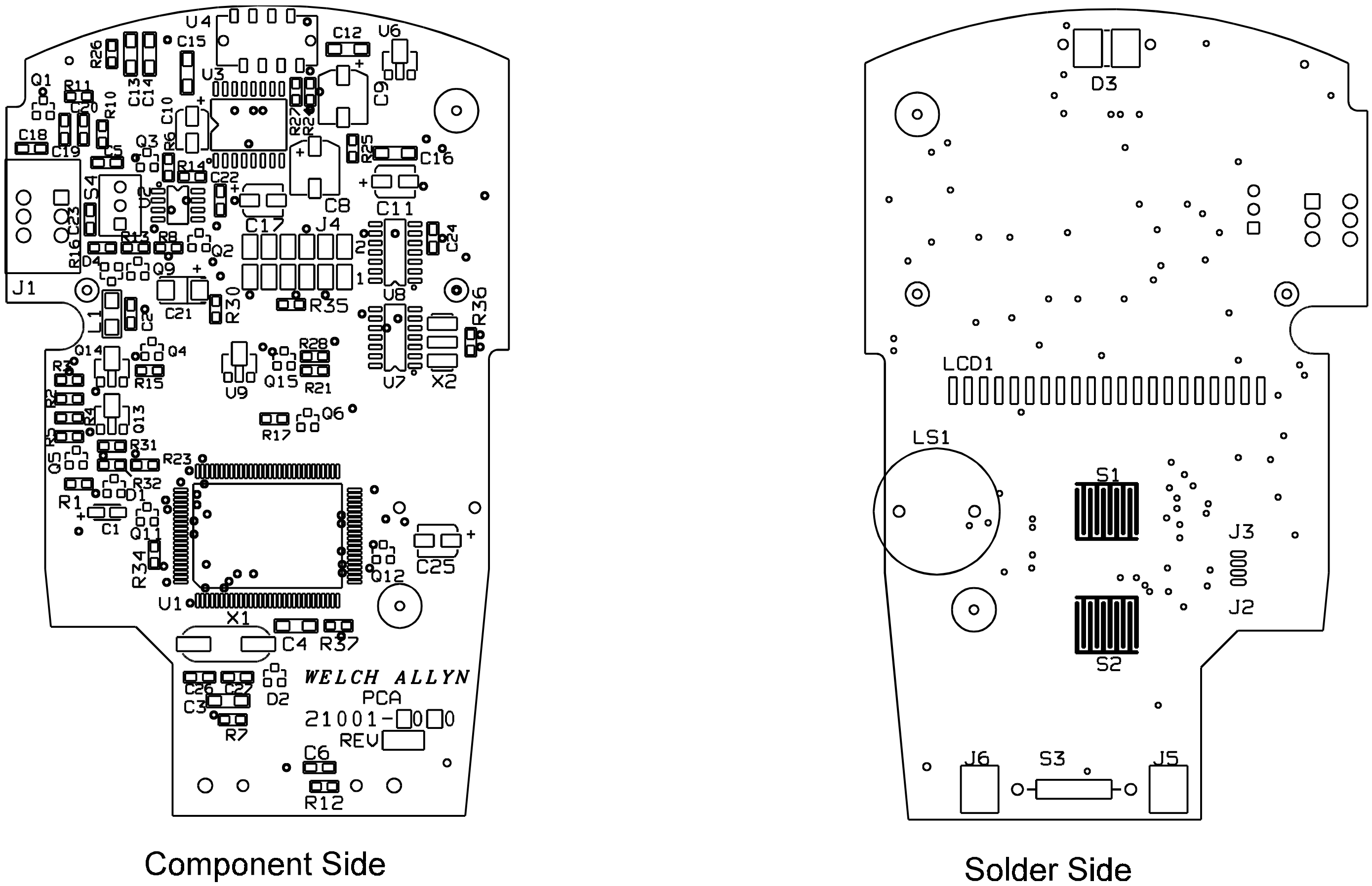
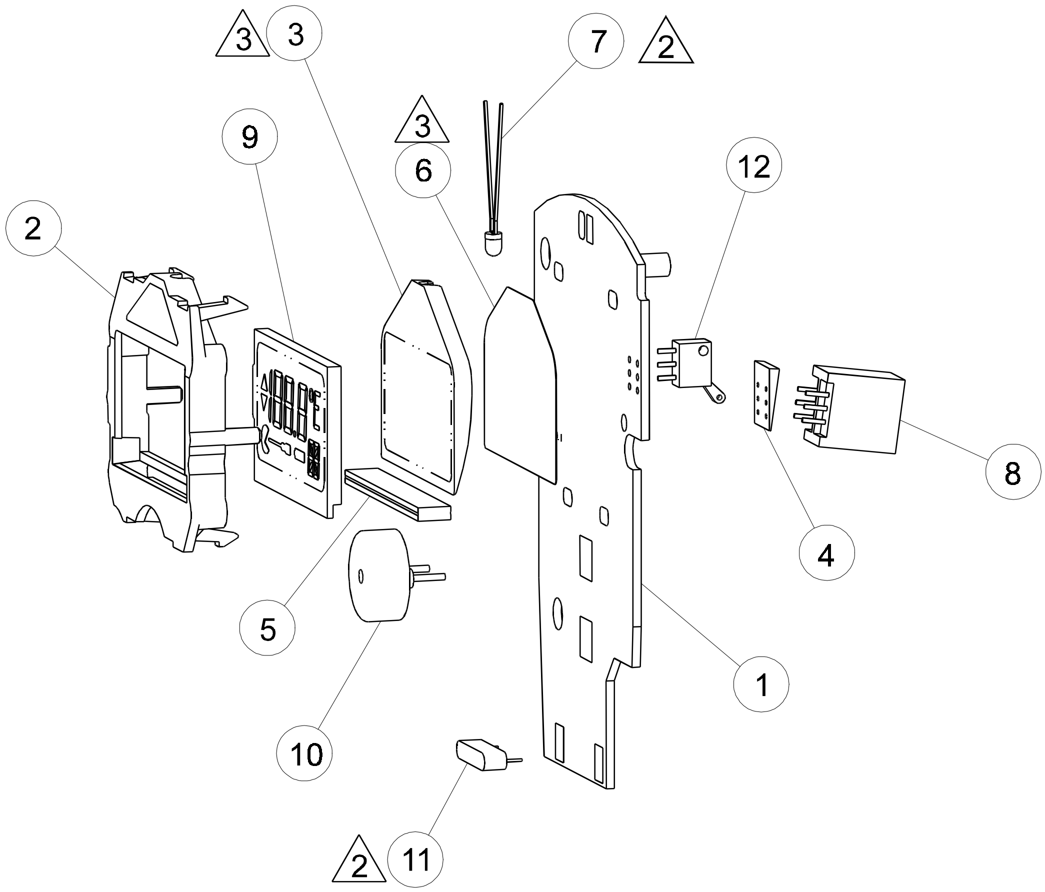


Figure 8 - Main PCA

Notes: Unless otherwise specified:

1. Maximum lead protrusion after trimming to be .060 inch.
2. Square pads indicate pin number 1 of components.
3. Silkscreened circles with no reference numbers are test points.
4. All post-mounting transportation and storage is to be within anti-static packing and under anti-electrostatic discharge handling packaging practices.



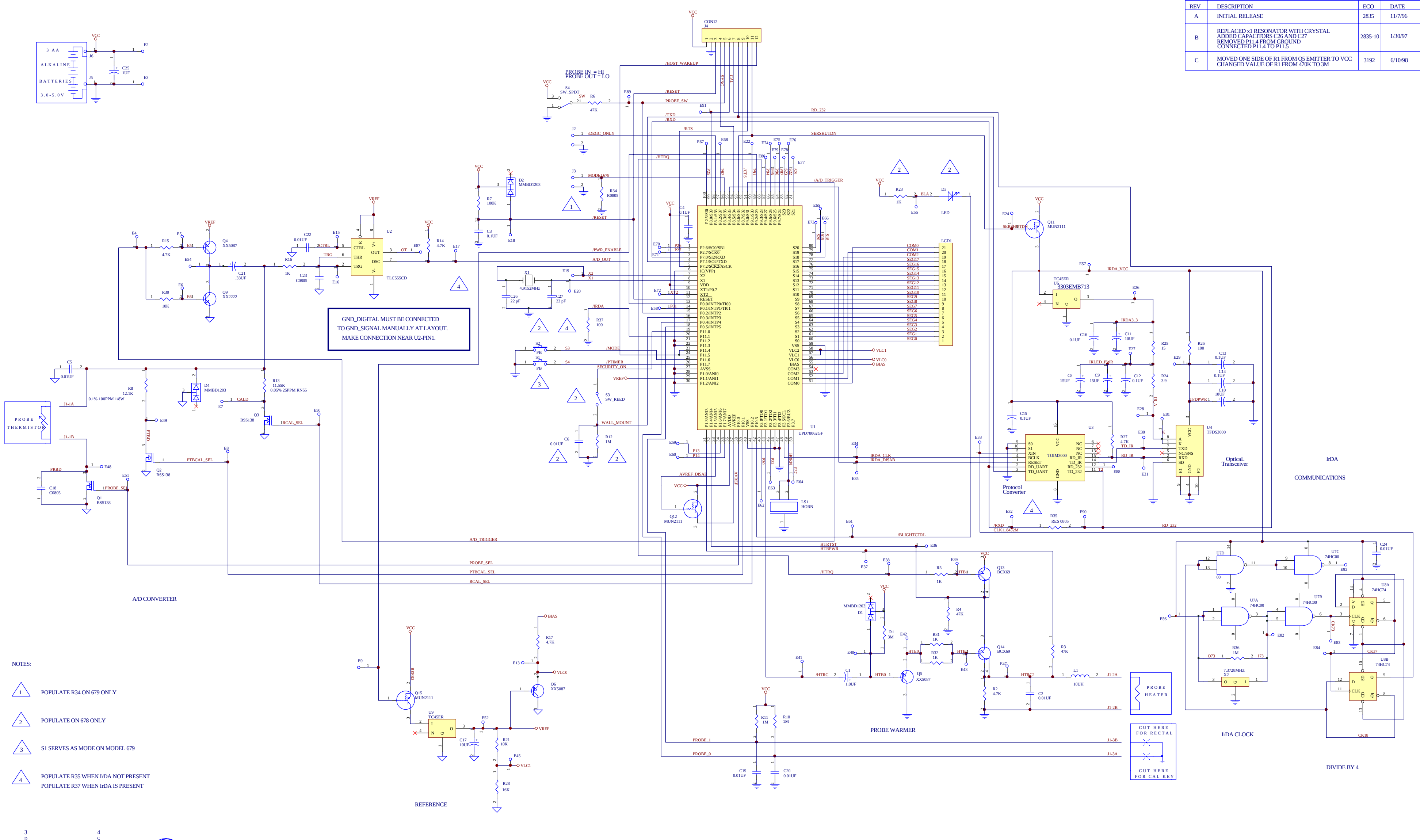
Notes: Unless otherwise specified:

1. Refer to manufacturing procedures 97033-0000, 97034-0000 and 97035-0000 for assembly instructions.

△2 Model 678 only.

1	PC Assembly	5	Zebra Connector	9	LCD
2	LCD Frame	6	Reflective Label	10	Speaker
3	Light Panel	7	Yellow LED	11	Reed Switch
4	EDAC Spacer	8	Probe Connector	12	Probe Switch

Figure 9 - Electronics Assembly



NOTES:

1. POPULATE R34 ON 679 ONLY
2. POPULATE ON 678 ONLY
3. S1 SERVES AS MODE ON MODEL 679
4. POPULATE R35 WHEN IrDA NOT PRESENT
   POPULATE R37 WHEN IrDA IS PRESENT

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REVISIONS

REV	DESCRIPTION	ECO	DATE
A	INITIAL RELEASE	2835	11/7/96
B	REPLACED x1 RESONATOR WITH CRYSTAL ADDED CAPACITORS C26 AND C27 REMOVED P11.4 FROM GROUND CONNECTED P11.4 TO P11.5	2835-10	1/30/97
C	MOVED ONE SIDE OF R1 FROM Q5 EMITTER TO VCC CHANGED VALUE OF R1 FROM 470K TO 3M	3192	6/10/98

FILE:

APPROVAL	DATE
CHECK	
PROJ. MGR.	
Q.A.	
MFG. ENG.	
REL.	

APPROVED DOCUMENT SIGNATURES ON FILE IN ENGINEERING SERVICES

WELCH ALLYN

Title: SCHEMATIC, 678/679 PCB

Size: Orcad D | Number: 55105-0000 | Revision: C

Date: 7-Apr-2000 | Sheet 1 OF 1

File: I:\Documentation\..\55105C.SCH | Drawn By: E Rivera