SureTemp® & SureTemp 4®

Model 670 & Model 675 Thermometer

Technical Manual

Welch Allyn

TABLE OF CONTENTS

TABLE OF FIGURES

WARRANTY

1-YEAR LIMITED WARRANTY ON NEW INSTRUMENTS: 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 one year 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.

The information in this manual has been carefully reviewed and is believed to be accurate; however, no responsibility is assumed for inaccuracies. Furthermore, this information does not convey to the purchaser of Welch Allyn or Diatek devices any license under the patent rights to the manufacturer.

SPECIFICATIONS

- Case Dimensions (nominal): 6.25 inches long x 3.7 inches wide x 2.4 inches deep.
- Case Material: ABS Plastic.
- Weight (nominal): 10.5 ounces with batteries.
- Input: Welch Allyn Thermistor Probe.
- 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 proposed ASTM clinical test criteria.
- Push buttons: Backlight/Recall and Pulse Timer.
- Selection Switches: Normal/Monitor and F/C (No F/C Switch for Euro/German version).
- Probes: Interchangeable Oral (also used for Axillary) and Rectal.
- Power Source: Three “AA” Batteries.
- Battery Operating Life: Up to 6,000 temperature measurements (At 72º F ambient temperature and 15% backlight use).
- 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.

OPERATIONAL CHARACTERISTICS

INTRODUCTION

Note: This manual describes both the Model 670 and the Model 675 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 670 and 675 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 600, with enhancements in speed and features. Model 670 provides a Normal mode oral temperature in about 10 seconds. Model 675 provides this temperature in about 4 seconds. These are significantly faster than the typical 30 to 40 second average time to temperature in earlier products. Several other features have been added, including a temperature recall feature, probe type display, displayed error codes for more information when operation is abnormal, and a biotech mode to allow further investigation of some internal parameters without the need for disassembly.

The basic end user operation of the Model 670 and Model 675 is covered in the User's Manual and this manual assumes an understanding of these operations. The following sections will help you determine if the Model 670/675 is functioning properly and, if it is not, refer you to the proper section to isolate the problem. There are many things that can be done to check operation before the unit is disassembled. This section will cover these normal operating characteristics.

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.

The Model 670 and Model 675 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 charging cycles than alkaline battery life.

The main instrument looks and operates very similarly to the Model 600 with enhancements described below. Basic operation has been kept very similar to that of the Model 600 to ease learning and use.

The wall mount is easily mounted to a wall (or rolling stand) and provides a locking mechanism with a removable key for securing the instrument. Through the use of available long probe cords, the thermometer can be used without removing it from the wall mount.

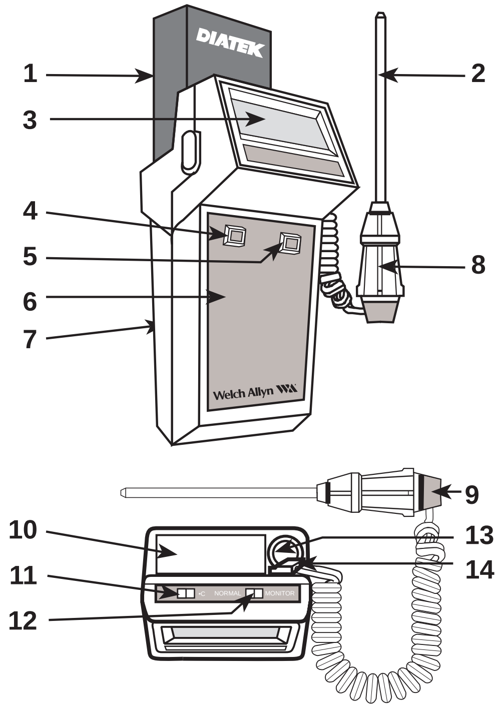
The probe is similar in appearance to the Model 600 probe, but is incompatible with Model 600. Model 600 probes are also incompatible with Model 670/Model 675 instruments. Enhancements to the probe are detailed in the Theory of Operation section.

Model 670 probes are incompatible with Model 675 probes, but Model 675 probes can be used in Model 670 thermometers.

The Model 675 instrument has a key in the connector receptacle to disallow any but Model 675 probes.

The probe covers are unchanged from previous models and are compatible across all of Welch Allyn and Diatek thermistor based thermometers. Welch Allyn's thermistor based probes can be identified by color combinations as follows:

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
Blue	Blue	White	Blue	M670	Oral
Red	Red	White	Red	M670	Rectal
White	Blue	White	White	M675	Oral
White	Red	White	White	M675	Rectal



1. Probe cover box
2. Probe
3. Display
4. Backlight/Recall switch
5. Timer switch
6. Display legends
7. Battery access door
8. Probe handle collar
9. Probe cover ejection button
10. Probe cover storage well
11. Fahrenheit/Celsius select switch
12. Normal/Monitor mode select switch
13. Probe storage channel
14. Probe connector receptacle

FIGURE 1 - THERMOMETER DIAGRAM

Operating Controls and Components

Setup

If a problem is reported with an instrument, it is sometimes wise to investigate operation before the unit is reset, but generally resetting the electronics is the recommended starting point in the process.

Instrument Reset/Self Tests

The batteries must be removed from the instrument to reset the internal microprocessor electronics. Follow the battery removal instructions in the **Maintenance** section on page 11.

Because the instrument uses very little power, the reset will not occur immediately upon battery removal until the capacitance of the circuit is discharged. To speed this discharge, after the batteries are out, press the backlight or timer button for about 10 seconds. The electronics will now properly reset upon battery installation.

Remove the probe from the probe storage channel and unplug the probe connector from the instrument by pulling on the connector body. Do not pull on the cord.

While watching the display, install the batteries per the instructions in the 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, an error code (EX.X) will be displayed. Refer to the **Error Codes** section on page 21 for an explanation.

The display test begins with each display segment individually lit in brief and rapid succession. At the same time, the timer segments are incrementally turned on until all 30 are illuminated. Immediately after this, all display segments 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 tests, at the 15 second mark of the timer and at the 30 second mark. If all is well from the power up self test, the display goes blank at this time (with no probe installed.)

Note: If a probe is installed during this power up time, different results will occur depending on whether the probe is functioning properly or not. See the **Probe Initialization/Self Tests** section below for these tests. At this point, there should be no probe connected to the instrument.

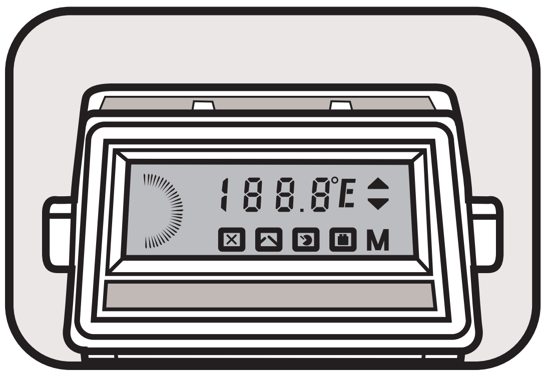


FIGURE 2 - THERMOMETER DISPLAY

If there is no display, any missing segments, or no beeper, refer to the **Troubleshooting** section on page 22.

Probe Initialization/Self Tests

With a properly functioning instrument, the probe can be put through self test. The instrument will, if functioning properly and a probe installed, initiate the probe self test during the instrument reset self test. Proper instrument functionality should be verified first as described in the **Instrument Reset/Self Tests** section before a probe is installed.

With an instrument that passed the **Instrument Reset/Self Tests** section, install the probe connector first (with the Diatek or Welch Allyn logo showing) and then fully insert the probe shaft into the storage channel. Observe the display of the probe type. For Model 670, this probe type display will be very brief (less than 1 second.) For Model 675 Oral probes, the probe type will be displayed for about 10 to 15 seconds or possibly even longer. Do not withdraw the probe. For Rectal probes, the display is brief. If the display does not show “OrL” with an Oral probe plugged in, or “rEC” with a Rectal probe plugged in, there is a problem with the probe, or the probe connector in the instrument. (For Model 670, if no display of probe type is shown, the probe might be the wrong type for this thermometer and the instrument will not function.)

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 an error code (such as E5.4), the probe is suspect.

Note: Probes are very sensitive to temperature variations and the self tests include thermal tests that can be disturbed by any temperature changes. Therefore it is extremely important to minimize thermal disturbance before and during these tests. Handle the probe only by the probe handle, not the metal shaft, and minimize the amount of time the instrument is held in the hand before and during these tests.

The instrument stores individual probe characteristics as a result of this test so it is important to reinitialize the probe after any repair has been done to the instrument or probe.

When removing a probe, always extract the probe from the storage channel first and then disconnect the connector by pulling on the connector body. Do not pull by the cord.

If there are any problems with probe initialization refer to the **Troubleshooting** section on page 22.

Normal Mode

After instrument and probe self tests, the system is ready for use. Normal mode operation is the rapid mode of temperature taking. This mode is selected by the switch on the top of the instrument before the probe is withdrawn from the probe channel.

Upon withdrawal of the probe from its storage channel, the beeper will sound and every segment on the display will be illuminated. Load a probe cover at this time and watch for the display to change from the all segments test to the probe type display; “OrL” or “rEC” followed by °C or °F, which ever is selected. This display might take several seconds to appear. At this point the instrument is ready for the probe to be inserted into the patient.

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, but is indicative of the need to “re-characterize” the probe. Refer to the **Probe Self Tests** section on page 5.

Note: The unit cannot be switched from Monitor mode to Normal mode with the probe out of the storage channel. A double beep will indicate this error and the probe must be returned to the channel to restart the thermometer.

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

1. If the prediction algorithm has not been activated for more than 30 seconds after taking the probe out of the storage channel.
2. If the instrument determines that room temperature is above 33.9°C (93.0°F).
3. If the thermometer is unable to predict a temperature after 15 seconds due to improper technique such as excessive probe movement at any patient site (i.e. mouth, rectum).

Note: The thermometer reads the probe temperature immediately upon removal from the storage channel. If the probe was just replaced from a previous temperature and immediately extracted, insufficient time has 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.

With correct use, the patient's temperature will be displayed in about 10 seconds for Model 670 and 4 seconds for Model 675. The instrument will beep to signal completion of the Normal mode temperature cycle.

If the probe is left out of the storage channel after completion of a Normal mode temperature, the unit will shut down after 5 minutes to conserve power. Simply replace the probe into the storage channel to prepare for the next temperature.

Monitor Mode

The instrument can be switched to Monitor mode at any time by using the slide switch on the top right of the unit. 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 provides the ability to provide long term monitoring of a patient's temperature. Unlike a glass thermometer which is only peak reading, 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 thus drawing it down. 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, 3 minutes is the recommended time to wait before recording a Monitor mode temperature.

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 water bath.

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

If Monitor mode does not display expected temperatures or exhibits other problems, refer to the **Troubleshooting** section on page 22.

Pulse Timer

The pulse timer provides a 30 second timer for general purpose use. This timer runs independently of other thermometer functions and can be started and stopped at any time by pressing the Timer push-button.

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

Backlight/Temperature Recall

The backlight and temperature recall features are combined into one push-button.

The backlight provides a dim display light for use in dark rooms. It is usually not visible in well lit areas. Shadowing the display with your hand is an effective way to see backlight operation. With the probe in the storage channel, a momentary press of the backlight/recall button turns on the backlight and the last temperature reading for 5 seconds. With the probe out of the storage channel, pressing the backlight/recall button turns on the backlight only for the duration of the button press and then at the end of a Normal mode temperature, the reading will display with the backlight for 5 seconds.

Note: When a temperature is recalled, the mode in which it was obtained (Normal or Monitor) will be shown independent of the present setting of the mode switch.

Note: When the instrument is in Monitor mode the last temperature memory is updated every second. During the time between removing the probe from the patient, (at say 99.0 degrees) to inserting the probe in the storage channel, it will have cooled. Therefore, the temperature stored in memory will be lower than the patient's temperature. This is not an issue in Normal mode as the memory is not updated after the temperature is displayed.

If the backlight does not work or is showing other problems or if you cannot recall the last temperature, refer to the **Backlight/Temperature Recall Problems** section in the **Troubleshooting** section on page 22.

F/C Switch

The temperature scale displayed can be changed at any time by use of the slide switch on the top of the unit.

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

If the F/C switch does not change the scale of the displayed temperature, refer to the **F/C Switch Problems** section in the **Troubleshooting** section.

Biotech Mode

Biotech mode provides the ability to query the following information:

1. Battery voltage (total of all three).
2. Internal instrument calibration signal.
3. Instrument's ability to detect probe type.
4. Software revision.
5. Display test.

Biotech mode is entered by the following steps:

1. Remove at least one battery.
2. Set the Normal/Monitor mode slide switch to Monitor.
3. While pressing and holding BOTH the Backlight/Recall and Timer switches, install the last battery.
4. Observe the display. The Monitor mode icon "M" will be flashing and the low battery icon will be on steady. The timer will be operating. The number showing on the display is the total battery voltage. The battery is considered acceptable if 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 about 3.2 volts, the low battery error E3.0 is triggered, the malfunction icon [X] is displayed, and temperature taking is disallowed. This provides a margin of safety in preventing any inaccuracy in the results.
5. Press the Backlight/Recall button once to advance the display to the internal calibration signal. This reading is generated by the instrument reading an internal precision fixed resistor as if it were a probe. If

all of the A/D conversion electronics are functioning properly, this resistor will produce a reading between 36.7°C and 37.0°C (98.1°F and 98.6°F) inclusive.

6. Press the Backlight/Recall button once to advance the display to the probe type identification test. At this point, probes can be installed or removed. Oral probes should produce the “OrL” display, while rectal probes should produce the “rEC” display. When no probe is installed, the display is blank (except for the flashing M). A calibration key, when plugged in at this time, looks like no probe is plugged-in.
7. Press the Backlight/Recall button once to advance the display to the software revision. The display should show “r X.X” where “X.X” is a number such as 1.8. This can be helpful when discussing operation with Welch Allyn customer support.
8. Press the Backlight/Recall button once to advance to the repeating display test. This is the same display test as initiated when batteries are first installed. Each segment of the timer is incrementally turned on while each segment of the remainder of the display is individually lit. Following this, all segments are lit briefly and then the test repeats.
9. To repeat the sequence of displays in Biotech mode, press the Backlight/Recall button during the display test when all segments are on.
10. To exit biotech mode at any time, switch to Normal mode. On exit, probe initialization will be started.

If you cannot enter the Biotech mode, refer to the **Biotech Mode Problems** section of the **Troubleshooting** section on page 22.

Battery Life

Under normal use, battery life is expected to give up to 6,000 temperatures. This number is based on a 22.2°C (72.0°F) ambient temperature and 15% backlight use. Colder ambient temperatures, excessive backlight usage, 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 the **Battery Life Problems** section in the **Troubleshooting** section on page 22.

PREVENTATIVE MAINTENANCE

The following preventative maintenance is recommended to maximize uninterrupted service on the Model 670 SureTemp and 675 SureTemp 4 Thermometer:

Units which are in service on a regular basis should have the following preventative 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 your 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 670 or Model 675 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 or MetriSpray™ cleanser. Care should be taken not to scratch the LCD faceplate. Make sure that the cloth is damp, but not too wet. <u>Do not allow cleaning solution to run inside the instrument.</u> <u>Never</u> immerse the thermometer into the cleaning solution. <u>Never</u> autoclave the thermometer or probe.

Sporicidin is a registered trademark of Sporicidin International (800) 424-3733.

MetriSpray is a trademark of Metrex Research Corporation (800) 841-1428.

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.

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 channel 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 following the **Battery Removal and Replacement** section, and verify a successful self test.
9. Install the probe connector and insert the probe into the storage channel which will 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 case.
2. Remove the **BATTERY ACCESS** screw from the thermometer back case using a Phillips screwdriver.
3. Remove the battery door from the thermometer by sliding it out.
4. Remove the batteries.
5. Press either the Backlight/Recall switch or the Timer switch for approximately ten seconds to discharge the electronics.
6. 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.**
7. Reinstall the battery door.
8. Reinstall and tighten the **BATTERY ACCESS** screw.

CALIBRATION TESTING

Calibration Key Procedure

Extract the probe and disconnect it from the thermometer. Set the Normal/Monitor switch to the Monitor position and set the F/C switch to the F position. Insert the Calibration Key into the probe connector receptacle on the thermometer. Insert a probe shaft into the probe storage channel 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. Remove the Calibration Key and reinstall the probe connector plug. Then install the probe into the probe storage channel. (This will initiate the probe self test.)

Note: This Cal Key test does not test the calibration of 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 the **Cal Key Problems** section of the **Troubleshooting** section on page 22.

Model 9600 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.

THEORY OF OPERATION

Technical Overview

The heart of the Model 670 and Model 675 is comprised of three custom integrated circuits which provide most of the microcontroller and analog circuit functions. All control and display functions are governed by the microcontroller (U2), all analog interfacing to the microcontroller, probe, horn and backlight is provided by U1, and operating parameter data is handled by the EEPROM U3.

Probe resistance measurements are made by ratioing pulse widths which are generated by sequentially switching in two calibration resistors 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.

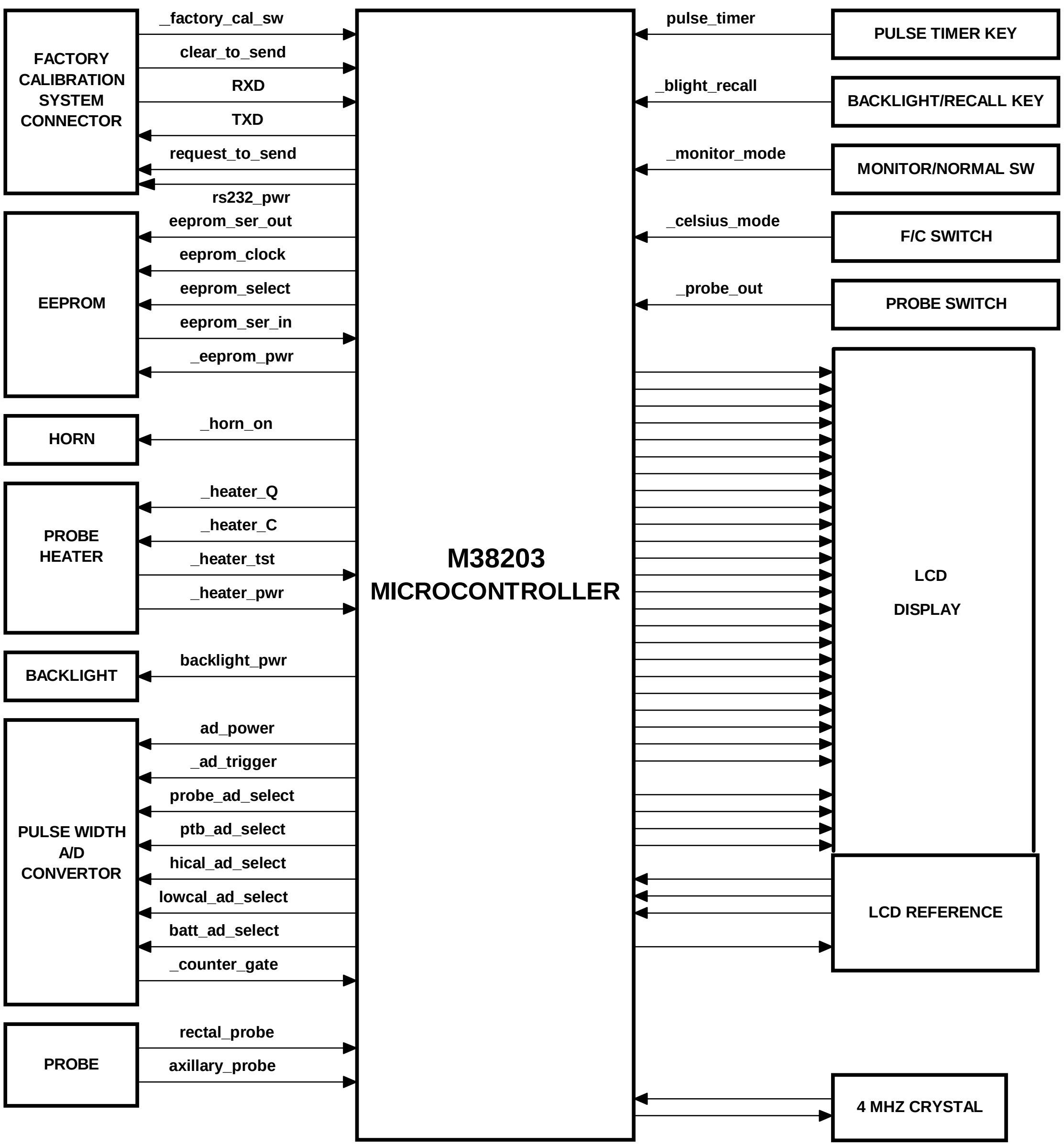


FIGURE 3 - SYSTEM BLOCK DIAGRAM

Probe Enhancements

The Model 670 and Model 675 series thermometers have the capability to detect probe type - oral vs. rectal. This allows the oral temperatures to be as fast as possible (10 seconds in the 670 and 4 seconds in the 675) by using different operating modes based on probe type. Rectal probes give a Normal mode temperature in about 15 seconds for both models. This 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 ground and two of the probe connector contacts.

In addition to the probe type enhancements, Model 670 and Model 675 probes have been improved for thermal time constant (speed of response).

Model 675 oral probes incorporate a warming resistor in the tip to pre-warm the probe before placement in the mouth, thus speeding response even further.

Probe Switch

The probe switch (S1) is activated by the probe shaft when the probe is installed or removed from its storage channel. Placing the probe into the channel, pulls processor pin 23 high via R24. When the probe is removed, this line is pulled low. This signal is also routed to test connector J3 pin 7 to allow automated testing of this function during factory test. R24 allows this line to be pulled high or low at J3 during factory test regardless of the actual switch position.

HINT/CAUTION: For the technician, J3 serves as a convenient set of “test points” to monitor proper operation of all user switch functions, BUT BE CAREFUL WITH STATIC DISCHARGE! J3 TIES DIRECTLY TO CMOS PROCESSOR INPUTS WHICH ARE EASILY DAMAGED BY STATIC DISCHARGE. FOLLOW PROPER HANDLING TECHNIQUES.

Monitor Mode

The Monitor mode is selected manually by the Normal/Monitor mode slide switch (S3) on the top of the instrument. This switch ties pin 10 on the processor (U2) either high or low for Normal or Monitor modes respectively. This signal is routed through R14 and is also taken to the test connector J3 pin 4 to allow automated testing of this function during factory test. R14 allows this line to be pulled high or low at the test connector regardless of the switch position.

The actual probe temperature, as determined by the A/D conversion electronics, appears directly on the liquid crystal display which is driven by the integral LCD driver in the microprocessor. See the **Temperature Measurement and Display** section on page 16 for a description of the A/D operation.

The displayed temperature range (for any mode) is limited to 28.9°C to 42.2°C (84.0°F to 108.0°F).

Normal Mode, Model 670

The shape of the rising temperature curve is monitored and a continuously computed correction factor is added to the actual probe temperature. The temperature cycle is terminated and the temperature is displayed when the predicted temperature remains stable.

If the thermometer does not detect a rise of two degrees above ambient within 30 seconds of removing the probe from its holder, it will automatically switch to Monitor mode.

Normal Mode, Model 675

The Oral probe is pre-warmed using a pulse width modulation (PWM) controller to 33.9°C (93°F) upon extraction from the storage channel. When the probe is first extracted and colder than 33.9°C, the 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) 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.

If the prediction criteria explained above are not met within 15 seconds of starting the prediction process, it will automatically switch to Monitor 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 and the operation is similar to that in the Model 670.

Power Supply

Power is drawn from the three “AA” alkaline cells directly to the circuit electronics. The voltage from the batteries is unregulated but filtered for noise by capacitor C9. The power supply voltage will range from about 4.8 volts with new batteries to 3.2 volts at shut down. The thermometer has two low battery voltage indicators. 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 3.4 volts. Accuracy is not effected during low battery warning indication. When the batteries fall to approximately 3.2 volts, the low battery error condition is defined to exist. Operation is halted and the E3.0 error message is displayed.

At this point, the batteries must be replaced and the thermometer electronics reset. See the Reset Self/Tests section on page 16 and in the Operational Characteristics section on page 2.

Microprocessor Usage

Inputs to the microprocessor include LCD voltage regulator lines (pins 6,7 and 8), user switch lines (pins 10, 11, 23, 39 and 40), A/D done output signal (pin 13), low battery signal (not used by software)(pin 14), probe warmer self check lines (pins 15 and 16), probe type identification lines (pins 17 and 18), serial port lines (pins 19 and 22), EEPROM U3 data line (pin 25), factory calibration mode select line (pin 26), reset line (pin 27), slow clock (not used) (pin 28), and the 4MHz microprocessor clock (pin 30).

Outputs from the microprocessor include LCD driver lines (pins 1 through 5, 57 through 72, and 74 through 80), horn control line (pin 12), serial port lines (pins 21, 24 and 53), slow clock (not used) (pin 29), the 4MHz microprocessor clock (pin 31), battery voltage measure line (pin 41), A/D control lines (pins 42 through 45, 51 and 56), EEPROM control lines (pins 46, 47,48 and 50), LCD voltage regulator control line (pin 49), backlight control line (pin 52), probe warmer control lines (pins 54 and 55).

Reset/Self Tests

Upon battery installation, (assuming that the electronics has 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 U2-27. During short duration power dropout capacitor C1 is discharged quickly through D6. When power is applied continuously, C1 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, EEPROM test, instruction set test, self calibration tests (PTB 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 processor is generated by X1. This is a single 3 pin ceramic resonator with internal capacitors running at 4 MHz. The processor U2 drives this component into oscillation by incorporating an internal inverter.

[The other clock circuitry (if shown on schematic) consisting of X2, R9, C4 and C6 is no longer used.]

Temperature Measurement and Display

The thermometer uses probes which incorporate negative temperature coefficient thermistors. When the temperature of the probe is increased, its electrical resistance decreases. Earlier products (Model 600, Model 650) use "10K" thermistors which means that, at room temperature (25°C), their value is approximately 10 Kohms. Model 670 and 675 use "20K" thermistors so they are approximately 20 Kohms at room temperature. At 37°C (patient temperatures) they are near 12 Kohms. The change in resistance is nonlinear with temperature and an equation describing this curve is programmed into the thermometer.

The thermometer contains three high precision calibration resistors (0.1% tolerance) R3, R5 and R8. Their values are programmed into the instrument so that A/D conversions from these can be done to "calibrate" the electronics. This allows results from the unknown probe resistance to be compared to the known resistance. These three resistors are referred to as "hi cal", "low cal" and "PTB" resistors. They are equivalent to temperatures in that if the probe were at a high temperature 41.6°C (106.8°F), its resistance would equal the hi cal resistor value. Similarly if the probe were at a low temperature 33.8°C (92.9°F), its resistance would equal the low cal resistor value. The PTB resistor is in the middle of the range and equivalent to 36.8°C (98.3°F). Use of these resistors in the A/D process allows the probe resistance readings to be "ratioed" against known resistance readings, and thus "absolute" readings, which can be affected by drift in the electronics due to aging and temperature, are eliminated.

The actual A/D conversion consists of converting resistance to a timed pulse width. The components involved are C2 (the timing capacitor), Q11 (the constant current transistor), any one of R3, R5, R8 or the actual probe resistance, and the associated FET transistors Q4, Q5, Q6 or Q10.

Due to U1 design, on power up R26 and R29 bootstrap U1 to begin the charge of C2. Once a small voltage is developed on C2, U1 takes over and maintains C2 at 2.4 volts via pin 7 of U1. When an A/D conversion is to start, prior to the trigger from the processor, it turns on one of the four FETs. This establishes a constant current through the associated resistor. The current flowing is supplied from U1 pin 7 while maintaining its voltage at 2.4 volts. Throughout the A/D process, U1 pin 4 is held at 1.2 volts. This means that while current is flowing through Q11, its emitter sits at 0.6 volts. Since this is a constant voltage, the current through the selected resistor and FET is also constant. The next event is to trigger the start of the pulse measurement which occurs via processor control into U1 pin 5. This makes U1 pin 7 go to high impedance ending its supply of current for the selected resistor. Therefore current must now be supplied by C2. Since it is still a constant current situation, C2 discharges linearly with time. Its voltage is monitored by an internal comparator in U1 and when it drops to 1.2 volts the A/D OUT line (U1 pin 2) goes active stopping the timer in the processor. The constant current value is inversely proportional to the resistance value selected so that small resistance values produce high currents and therefore fast discharges. Since small resistance's are related to high temperatures, short pulse widths are also related to high temperatures. L2 is in series with the discharge current but constitutes a very small constant DC resistance so it has no effect on results. Its only purpose is for RFI suppression. C3, C10, C11, C12 and C13 are also only for RFI, and ESD purposes.

In Monitor mode a calibration cycle, where each of the fixed resistors is measured by the A/D function, is performed once every second. In Normal mode a calibration cycle is performed once at the beginning of the temperature prediction process.

Battery Voltage Reading

Battery voltage reading capability has been added over previous products providing necessary information to the probe warming function and also providing the enhanced two stage low battery indicator.

When not in use, the BATT AD SELECT line (U2 pin 41) is held low. This keeps diode D9 reverse biased and thus R28 has no effect on the normal A/D function during temperature measurements.

When battery voltage is to be read, this line is brought high by the processor (to whatever the battery voltage happens to be). This voltage across R28 establishes a current flow. (The common point of R28 with the other resistors is at 0.6 volts - because Q11 base is at 1.2 volts). This current flowing through R28 increases the A/D pulse width since this much current is *not* needed from C2. R5 is always selected for battery voltage reading since it normally produces the shortest pulse. If battery voltage is low, the current supplied via R28 is low and therefore the pulse width is lengthened only slightly. If the battery voltage is high, the pulse width is lengthened more. Knowing the standard pulse width from R5 allows the instrument to relate this lengthening of pulse width to the supply voltage.

A/D Power Control

When A/D conversions are not needed, power is saved by shutting down U1 via the A/D PWR line on U2 pin 56. R27 serves as a current limiting resistor and establishes the low power draw for U1's internal current sources.

This A/D Power line is also routed to R11 and R13 for probe detection. This provides a power saving function so supply current is not drawn through these resistors when probe detection is complete.

Probe Detection

Upon power reset or when a new probe is first installed, the thermometer performs a probe initialization process. Probe type is first detected and then if it is a Model 675 and an oral probe, its warming characteristics are determined. Model 670 thermometers do not warm probes so warming characteristics are not tested on any type of Model 670 probe. No rectal probes are warmed, so warming characteristics are not tested in either instrument on these probes.

The instrument keeps track of whether a probe is installed or not. This is accomplished by the fact that to unplug a probe, the shaft must first be withdrawn from the storage channel. This wakes up the thermometer which then turns on A/D power. This activates the probe type lines U2 pins 17 and 18 via R11, R12, R13 and R25. When the probe connector is removed, these lines are pulled high and a "no probe" logic is detected. (The Cal Key is also "no probe" logic so the software upon seeing no probe actually reads the probe resistance and if it falls well outside the Cal Key value, determines that indeed there is no probe attached.) Upon determining that the probe has been removed, a software flag is set in RAM indicating the probe has been removed. (RAM contents are not lost when the processor "goes to sleep.") With no probe installed, the unit "goes to sleep" and turns off the clock and the A/D power line to save battery power.

Probe connector installation does not “wake” the instrument up. When the probe shaft is stowed, the probe switch places voltage on U2 pin 23 via R24. This “wakes up” the processor which then reads the RAM flag and sees that the probe logic lines are indicating a probe is connected. This situation triggers a probe characterization routine as described in the Probe Warming section.

The probe type is determined by the probe logic lines at J1-B and E. Oral probes pull both lines low. Rectal probes pull only J1-E low.

Probe Warming (675 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. To establish proper control parameters, the probe under control must be characterized.

The probe characterization process begins with a battery voltage reading. The battery voltage is needed in the calculations to determine how much power will be applied to the probe during the 200mS test pulse.

After the battery voltage is read, the probe temperature is read once every 200 mS until the temperature is found to be not changing.

Once a stable temperature is determined a 200 mS test pulse of power is applied to the probe via the warming circuitry. The probe temperature change resulting from this pulse is used to determine parameters needed for the PWM algorithm. This completes the probe characterization process.

The warming circuitry consists of Q7, Q8, Q9, R16, R18, R20, R21, R22, R23, C7, C8, D7, L1 and the resistance in the probe connected to J1-D and J1-F. Power is applied to the probe connection only when both Q7 and Q9 are turned on. When this occurs, both feedback lines to the processor (U2 pins 15 and 16) are pulled high indicating proper operation. A fail safe hardware shut off circuit is incorporated consisting of C8, D7, Q8 and R22. This circuit will shut off power to the probe if the software fails to refresh this circuit. This prevents overheating due to any software errors leaving the warmer circuit on continuously.

At the start of a warming pulse, the processor drives both heater control lines (pins 54 and 55) low. This turns on all three transistors Q7, Q8 and Q9. Q8 is turned on because the voltage across capacitor C8 cannot change instantly. Its positive side goes low when its negative side is pulled low by the processor. Since Q9 E and B are pulled near the positive rail and Q8 B and E are pulled near the negative rail, the base current from Q9 flows through R16 and mostly into Q8, but some current flows through R22 to satisfy the diode drop across Q8 E to B. This current and Q8 base current flow into C8 charging it. As it charges, the voltage rise eventually shuts off Q9.

This hardware shut off is only allowed to progress to completion during factory test and each time an oral probe is installed as part of the instrument self test process. The thermometer checks that the hardware shut off has occurred within one second of turn on.

Normal probe warming is controlled by the software and if the probe is well below the control temperature of 33.9°C (93°F), the pulse widths are at a maximum. Every 100 mS the hardware shutoff circuit is briefly refreshed by the processor driving its pin 54 high. This momentarily shuts off power to the probe while discharging C8 into the positive supply through D7.

Once the probe has been brought near 33.9°C (93°F), the pulse widths are reduced to maintain this temperature. This is when the display switches from the all segments display test to “OrL” indicating that the unit is ready for placement in the mouth.

Note: Do not confuse this with the displays during probe characterization, where “OrL” is indicating that characterization is in progress with the probe in the holder.

R20 and R21 in combination with R23 serve as pull down resistors ensuring that the processor feedback lines (U2 pins 15 and 16) go low immediately upon warmer component shut off. L1 and C7 serve as RFI suppression components.

Note: On Model 670, some of the components in the warmer circuit may be installed but they are not used. Q7 is NEVER installed at the factory and should never be installed on Model 670. Installation of Q7 will NOT activate the warmer on Model 670 and will cause a malfunction error code to result, inhibiting further use of the instrument.

EEPROM

U3 is an Electrically Erasable Programmable Read Only Memory (EEPROM) incorporating a serial data communication interface with the microprocessor. Data is clocked synchronous with the “serial clock” input on pin 2. Data into the EEPROM goes into pin 3. Data out of U3 comes out on pin 4. Pin 1 is the chip select line. Pin 5 is the ground pin but is tied to a processor port line. This allows power to be saved by driving all EEPROM pins to the positive supply which reduces power consumption to zero for this part. The EEPROM is therefore only turned on when needed, which is only during power up routines. Most of the time the EEPROM data is stored in RAM, which remains even when the processor enters sleep mode (as long as battery power is available). Therefore, unless a software error has occurred, the EEPROM is only read upon installation of new batteries. The EEPROM is downloaded initially at the factory with operating parameter data giving the thermometer most of its operating characteristics such as factory test system parameters, Normal mode prediction parameters, warmer control parameters, and numerous miscellaneous parameters setting operating temperature limits, times, warning levels, etc. The EEPROM cannot be changed in the field.

Liquid Crystal Display

The LCD has 4 backplane lines (U2 pins 2-5) and 24 segment lines (U2 1, 57 - 72, 74 - 80). The LCD fluid thresholds require a regulated set of voltages at 1.2, 2.4, and 3.6 volts. These are supplied to processor pins 6, 7 and 8 from the diode stack D1, D2, D3, D4, D5 and related components Q3, R4 and R17. Circuit operation is initiated by the processor pulling pin 49 low. This draws the emitter of Q3 low and thus the base of Q3 to .6 volts above ground. This voltage across R4 establishes a current through the diode stack. Any change in power supply voltage is absorbed to a great extent by R17 and the Q3 collector connection keeping the voltages across the diodes relatively constant.

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

Backlight/Temperature Recall

The backlight is an electroluminescent style flat panel lamp residing directly under the LCD.

An oscillator is required to convert battery DC voltage to an AC voltage of about 80 volts and 300 Hz.

The momentary backlight switch (S4) pulls processor pin 39 low. R19 acts as a pull up to return this line high when not in use. This line is also run to test connector J3 pin 6 to allow automated testing of this function during factory test.

The processor active high signal is sent out on U2 pin 52 to U1 pin 12 where it is inverted and buffered. This signal coming out of U1 pin 13 pulls through diode D8 and flex strip J2 pin 21 to the display board mounted oscillator. The oscillator consists of Q1, Q2, C5, R1, R2, T1 and the lamp itself.

If the thermometer is not in the process of taking a temperature, the Backlight/Recall switch will wake up the thermometer and display the last recorded temperature.

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 and 30 seconds, and for various error conditions.

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

The horn is a piezoelectric ceramic resonator driven by a processor square wave buffered through U1. The horn control signal comes from U2 pin 12 and enters U1 pin 3 where it is buffered and inverted and sent out on pin 1 directly to the horn LS1.

F/C Switching

The F/C switch (S2) sets the processor pin 11 via resistor R6 high or low for F or C respectively. This line is also run to the test connector J3 pin 3 to allow automated testing of this function during factory test. R6 allows this line to be pulled high or low at J3 during factory test regardless of the position of the switch.

Timer

The 30 second timer is started or stopped at any time by pressing the Timer switch (S5). This pulls processor pin 40 low momentarily. This line is also run to test connector J3 pin 5 to allow automated testing of this function during factory test. Resistor R10 returns this line high when not in use.

ERROR CODES

Error codes fall into three categories. Transitory, Recoverable and Non-Recoverable.

Transitory errors are generated by external events 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 transitory error can occur. All probe problems are considered by the thermometer to be external events and are therefore classified as transitory.

Recoverable errors are generated from internal test failures, which are non-catastrophic and require that temperature measuring be inhibited until the error is cleared. A recoverable error will be promoted to a non-recoverable error if it occurs four times sequentially. After displaying the error code and any appropriate icon, the instrument will reset itself and attempt to resume normal operation. After the fourth attempt to clear itself, the error becomes non-recoverable.

Non-recoverable errors are generated from internal test failures that are catastrophic (or from promoted recoverable errors). The error code and any appropriate icon will be displayed along with the "[X]" Instrument Malfunction icon.

The only way to continue at this point is to reset the electronics by removing the batteries.

NOTE: The error codes E2.1, E2.3, E3.0, E3.1, E3.2 and E4.1 can sometimes be caused by a faulty probe. It is advisable to remove probe completely from instrument and check functionality as described in the Setup section on page 4 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.

Error Code Table

NUMBER	ERROR TYPE	DESCRIPTION
		System Hardware Errors
E0.0	NON-RECOVER	Stack ram test error
E0.1	NON-RECOVER	Internal RAM test failed
E0.2	NON-RECOVER	Internal ROM check sum failed
E0.3	NON-RECOVER	Instrument error
E0.4	RECOVERABLE	EEPROM check sum error
E0.5	NON-RECOVER	RAM check sum error
E0.6	RECOVERABLE	EEPROM busy too long
E0.7	RECOVERABLE	EEPROM address write error
		Exception Errors
E1.0	NON-RECOVER	External interrupt 0. (INT0.)
E1.2	NON-RECOVER	Transmitter interrupt (TXD)
E1.3	NON-RECOVER	Timer Y interrupt (TYINT)
E1.4	NON-RECOVER	Timer 2 interrupt (T2INT)
E1.5	NON-RECOVER	External counter interrupt 0. (CNTR0.)
E1.6	NON-RECOVER	Timer 1 interrupt (T1INT)
E1.7	NON-RECOVER	Serial I/O
E1.8	NON-RECOVER	Software break
		A/D Converter Errors
E2.0	RECOVERABLE	Low cal. resistor pulse width error
E2.1	RECOVERABLE	Hi cal. resistor pulse width error
E2.2	RECOVERABLE	PTB resistor pulse width error
E2.3	RECOVERABLE	Probe pulse width error
E2.4	RECOVERABLE	Could not determine cause

Error Code Table (continued)

		System Functional Errors
E3.0	NON-RECOVER	Low battery error
E3.1	RECOVERABLE	PTB test error
E3.2	TRANSITORY	Outside operating temp range
		Math Errors
E4.0	RECOVERABLE	Floating point over flow
E4.1	RECOVERABLE	Log of zero is undefined
		Warmer and Probe Errors
E5.0	RECOVERABLE	Q warmer transistor failure
E5.1	RECOVERABLE	C warmer transistor
E5.2	RECOVERABLE	Warmer protection circuit failure
E5.3	TRANSITORY	Probe warmer not warming
E5.4	TRANSITORY	Probe missing or thermistor failure
E5.5	RECOVERABLE	Warmer circuit failure
E5.6	RECOVERABLE	Warmer overheated
E5.7	RECOVERABLE	Warmer watch dog time out
		Serial Communications Errors
E6.1	RECOVERABLE	Serial overrun error
E6.2	RECOVERABLE	Serial framing error
E6.3	RECOVERABLE	No data time out error
E6.4	TRANSITORY	Transmit buffer overflow (transmit only, no display)
		System Software Errors
E9.9	RECOVERABLE	Undefined software state

TROUBLESHOOTING

Many thermometer operational parameters can be tested for proper operation before the unit is taken apart and without needing any tools. Refer to the **Operational Characteristics** section on page 2 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 the **Calibration Testing** section on page 12.

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.

Equipment Required

Most operations can be performed with standard tools and meters. A #1 Phillips screwdriver suffices for all instrument screws.

A standard lab 3.5 digit digital multi-meter (DMM) will provide sufficient accuracy for a host of 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 electronics 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 light touch, tweezers, sharp soldering iron tip and low heat (#7 tip) is recommended.

Power and ground are available at the end terminals of slide switches S2 or S3.

Terminology

Many standard abbreviations are used in this section (and elsewhere):

PCB	printed circuit board (the board itself)	LCD PCB	PCB holding the display assembly
PCA	printed circuit assembly (the board with all its components)	DMM	Digital Multi-Meter
main PCB	large PCB holding the microprocessor	O-Scope	Oscilloscope
LCD	Liquid Crystal Display		

Component Reference Designators:

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

Troubleshooting Table

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
No operation	Dead batteries, no batteries, battery missing, battery incorrectly installed	Refer to Battery Replacement section on page 11. Check that all batteries are installed in proper direction. Reset electronics (see Instrument Reset/Self Tests section on page 4) Refer to Biotech Mode section on page 8 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.
	Circuit short preventing operation.	Remove batteries, press backlight switch for 1 second, 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 C9 charges.
	Failed component.	Check oscillator at U2-31 for 4 MHz sine wave. If not present, suspect X1 or U2.
Display problems	LCD frame loose.	Check that all 6 white plastic rivets (heat staked pins) for the LCD frame are tight and not broken on either side of PCB. The frame should not be lifting off of PCB.
	Dirty LCD elastomeric conductor strips.	Have a new LCD frame handy. Remove old one by breaking plastic pin rivets. 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)	Broken/shorted flex strip cable.	Check continuity of all 30 lines. Assure continuity with flexing of strip. Check for shorts between adjacent lines at both ends.
	Failed component in LCD voltage regulator circuit.	Check voltages on U2-6, 7 and 8 for about 3.6, 2.4 and 1.2 volts respectively with LCD active.
	Cracked LCD.	Inspect LCD for hairline cracks especially in corners.
	Short circuit or open LCD lines.	Check continuity from U2 through to LCD board. Check for shorts between adjacent processor LCD pins.
	Microprocessor failure.	Check for improper soldering of pins, crystal operation on O-scope, proper reset.
No beeper sound	Broken horn wire	Inspect horn wires for proper solder
	Defective horn	Replace horn
	Broken connection	Check continuity from U2-12 to U1 3. From U1-1 to red horn wire. From U1-14 to black horn wire.
	Defective U1	Factory only repair.
	Defective U2	Replace U2
No Timer function	Defective Timer switch.	Check J3-5 for proper switch function.
	Broken trace.	Check U2-40 for proper switch function.

Troubleshooting Table (continued)

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
Timer segment missing.	LCD problem.	See Display problems section.
No Backlight/Recall	Defective backlight/Recall switch	Check J3-6 for proper switch function.
	Broken trace.	Check U2-39 for proper switch function also J2-21. With backlight off, all of oscillator parts (Q1, Q2, R1, R2, C5 and T1(primary) should be at Vcc.
	Defective Component	Check U1-12 and 13, check D8, Q1, Q2.
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 and before insertion in the storage channel.
	Probe withdrawn or batteries replaced.	Last stored temperature is erased by starting next temperature cycle when probe is extracted from storage channel. Battery replacement erases last stored temperature.
F/C switch problems	Defective switch	Check J3-3 for proper switch function.
	Broken trace	Check U2-11 for proper switch function.
Probe: Wrong type displayed.	Missing A/D power to R11 and/or R13	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.
Probe: Plugged in but no display	Probe not characterized	A new probe must be installed and left in the storage channel until the display goes blank. If probe is extracted during characterization, display goes blank and operation is halted.
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 30 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 switch	Check J3-4 for proper switch function.
		Check U2-10 for proper switch function.
Cannot enter Biotech Mode	Improper switch setting.	Normal/Monitor switch must be in Monitor position.
	Improper switch setting.	Must hold BOTH push-button switched closed while installing battery.
	Failed component, broken trace.	Check proper switch operation. Refer to F/C and Backlight/Recall switch troubleshooting.

Troubleshooting Table (continued)

SYMPTOM	POSSIBLE CAUSE	PROCEDURE
Battery Life Problems	Excessive backlight use	Backlight draws significant current. Normal battery life calculations assume only 15% backlight usage.
	Dead cell	If cell voltage is down significantly in only one cell, this battery is defective. All batteries are drained at the same rate by the instrument.
	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 used.	M670/M675 thermometers (unlike M600) need probe switch activated before they will start. Use a probe shaft in storage channel temporarily to start Cal Key process.
Cal Key shows OrL, rEC, or ALy	Defective Cal Key	Replace Cal Key
Cal Key shows only "°F".	Normal/Monitor switch in wrong position.	Normal/Monitor slide switch must be in Monitor position to see a Cal Key temperature. (Or wait 30 seconds for auto switch to Monitor mode.)
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 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. Recalibration requires a computer-based system and is normally performed at the factory.

All probes designed to work with the thermometer are fully interchangeable.

All components in the Model 670 and Model 675 **except U1 and U3** can be replaced without effecting instrument operation or calibration. Some minor changes to the exact calibration point will be caused by changing R3, R5 and R8, but as long as the proper type and tolerance resistors are used (0.1%, as supplied by Welch Allyn), the unit will remain within specifications.

Replacement of the LCD frame is somewhat difficult due to the need to “heat stake” the assembly while under pressure to assure proper compression of the elastomeric connector. The LCD frame once removed cannot be re-used.

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

FACTORY SERVICEABLE ONLY REPAIRS

Because of programming requirements and characterization requirements, if problems are traced to U1 or U3, the unit must be returned to the factory or properly equipped service center for repair. Very specialized custom test equipment is required to perform recalibration and characterization after replacing U1 or U3.

FIELD SERVICEABLE PARTS

All parts are serviceable by qualified technicians except for the EEPROM (U3) and the Monochip (U1).

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 channel.
2. Unplug the probe connector from the thermometer.
3. Peel the **°F**-**°C** / **NORMAL**-**MONITOR** label from the top of the thermometer.
4. Lay the thermometer on its front case.
5. Remove the **BATTERY ACCESS** screw from the thermometer back case.
6. Remove the battery door from the thermometer.
7. Remove the batteries.
8. Remove the other three screws from the thermometer back case.
9. Carefully remove the thermometer back case, keeping the thermometer electronics assembly and mid-frame in the front case.
10. Remove the neck strap or neck strap pins.
11. Remove the two internal screws securing the display board to the thermometer front case.
12. Remove the electronics assembly by gently lifting the mid-frame and display board from the front case. The electronics assembly can be removed from the mid-frame by carefully desoldering the battery wires and horn wires from the main PCA, gently pulling outward on the two plastic tabs securing the PCA at the top of the mid-frame, and carefully sliding the main PCA towards the top of the mid-frame until the lower edge of the PCA clears the two retaining tabs on the mid frame.

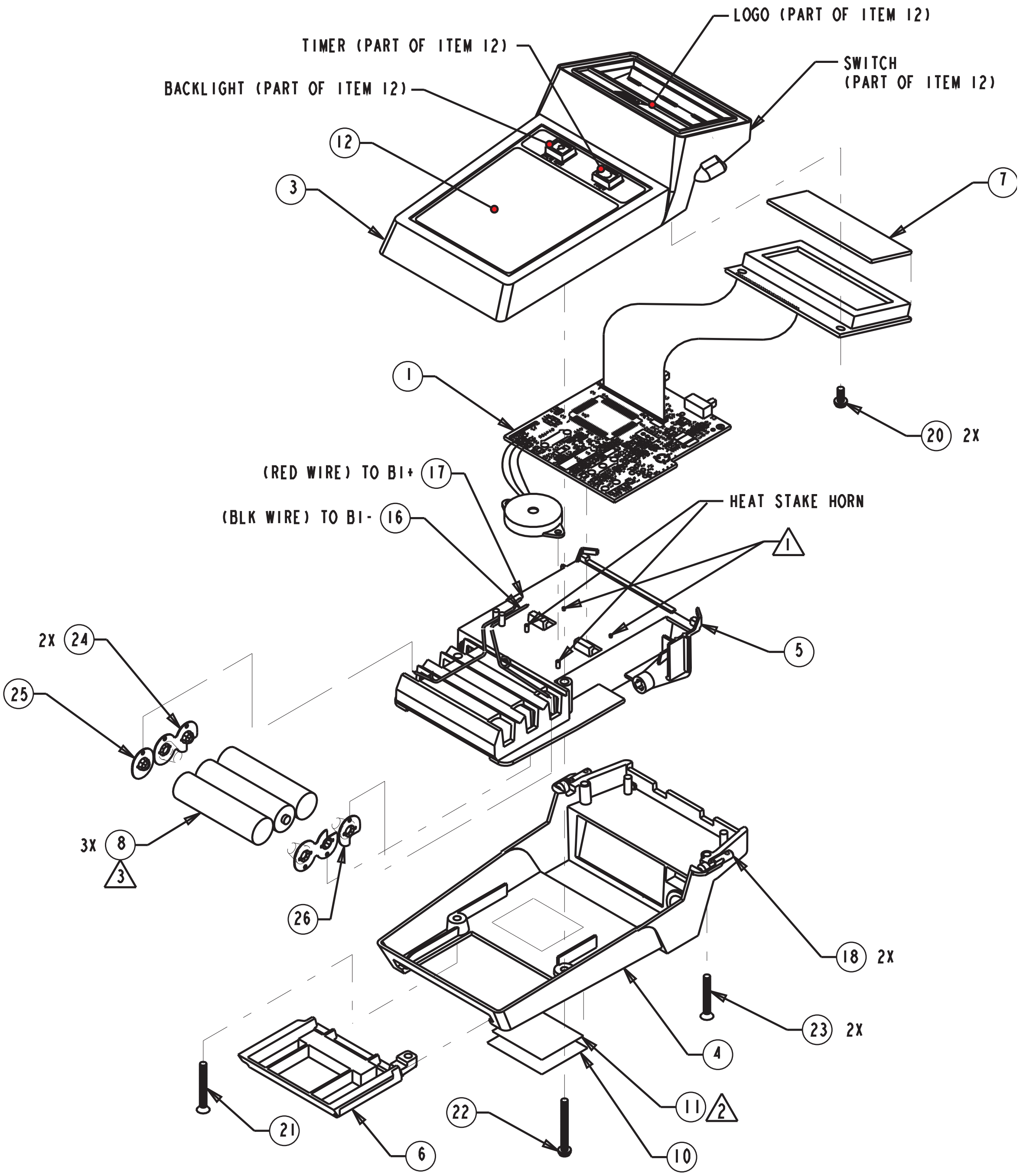


FIGURE 4 - THERMOMETER ASSEMBLY DRAWING

Item	Model 670	Model 675 (if different from Model 670)	Description	Qty
1	20952-000	20952-100	Electronics Assembly	1
3	25088-001		Case Front	1
4	25089-001		Case Back	1
5	25090-100		Mid-Frame	1
6	25091-001		Battery Door	1
7	25103-000		Window, Display	1
8	53009-000		Battery. Alkaline “AA”	3
10	70082-001		Blank Overlay	1
11	70082-000		Label, Serial Number	1
12	70158-200	70158-300	Label Set	1
14	70437-000		Label, Serial Number	2
16	80013-001		Wire, 26 AWG, Stranded - Black	0.3 Ft
17	80013-0002		Wire, 26 AWG, Stranded - Red	0.3 Ft
18	30056-0000		Pin, Strap	2
20	83021-0000		Screw, Thd-Roll #4 X 1/4 Philips	2.
21	83035-000		Screw, Thd-Roll #4 X 7/8 Plastilok	1.
22	83036-0000		Screw, Mach 4-40 X 1/16 Philips	11
23	83037-000		Screw, Thd-Roll #4 X 3/4 Plastilok	2.
24	58411-000		Battery Contact, Common	2
25	58412-000		Battery Contact, Positive	1
26	58413-000		Battery Contact, Negative	1

FIGURE 4 - THERMOMETER ASSEMBLY DRAWING (Continued)

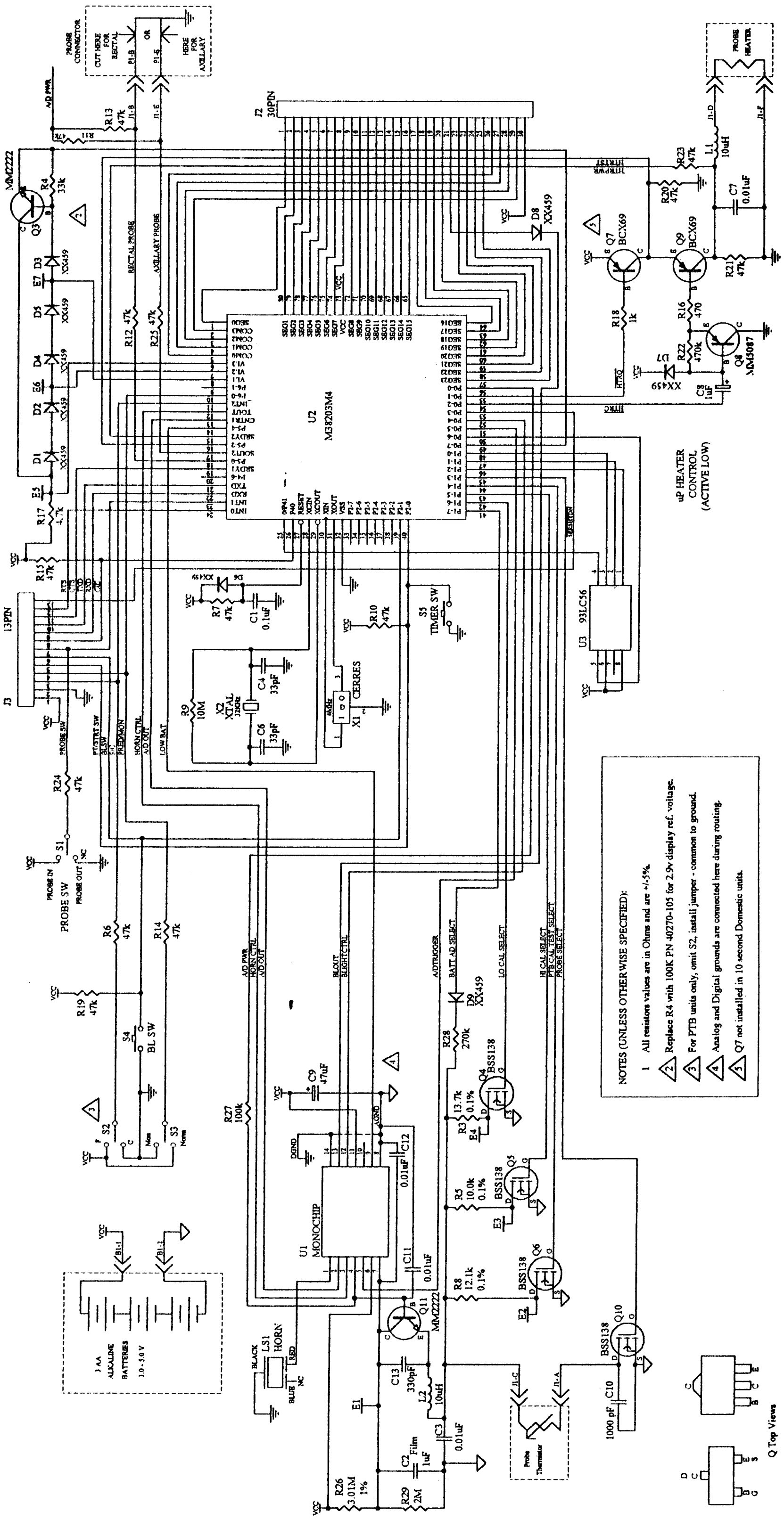
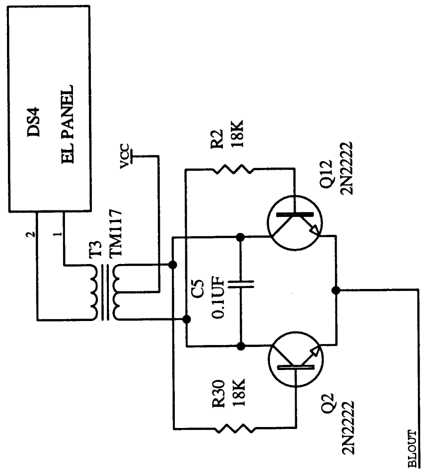


FIGURE 5 - SYSTEM SCHEMATIC



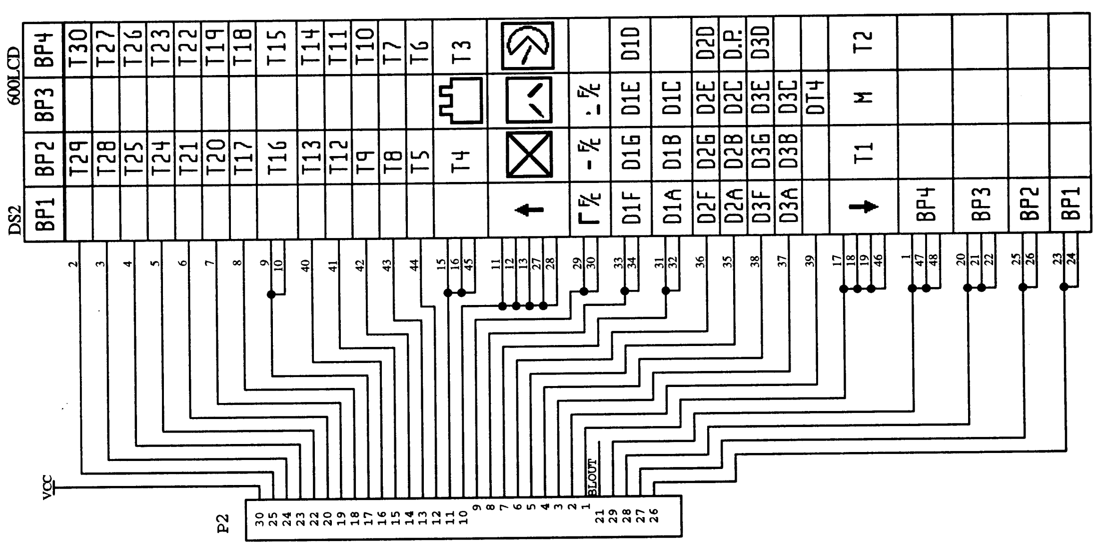
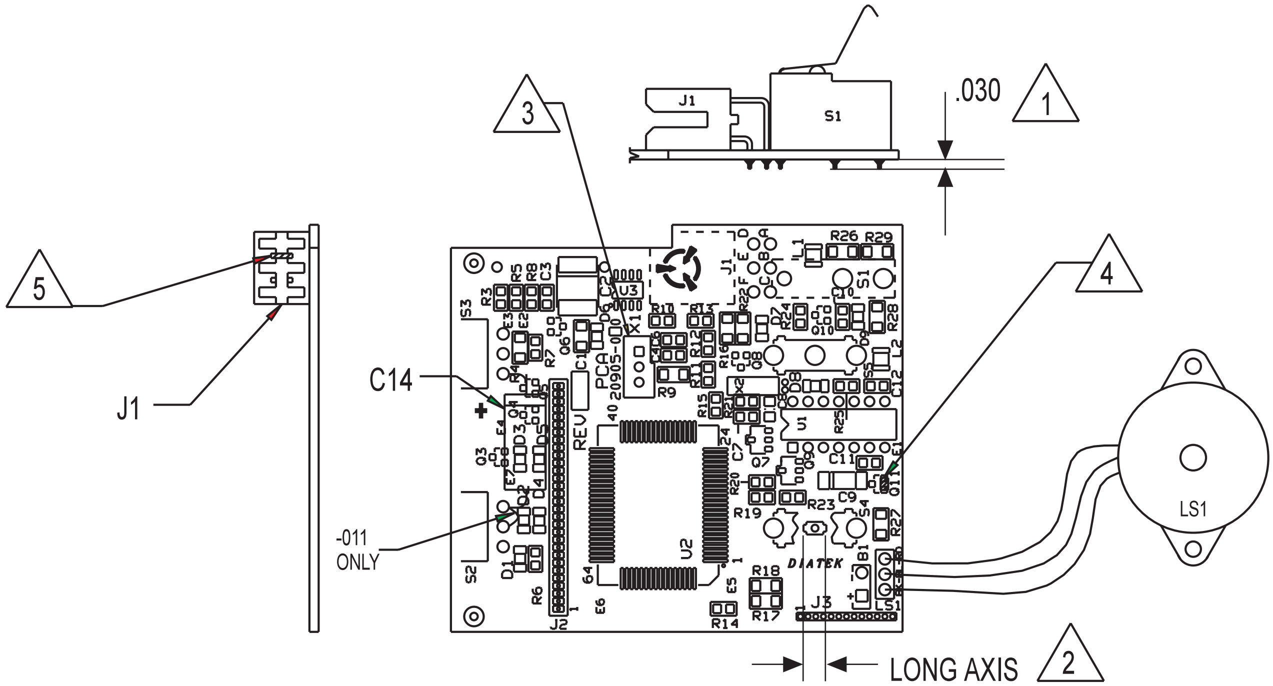


FIGURE 5 - SYSTEM SCHEMATIC (CONTINUED)



NOTES: UNLESS OTHERWISE SPECIFIED

1. MAXIMUM LEAD PROTRUSION OF COMPONENT CONTACTS TO BE .030 INCH, AS SHOWN.
2. INSTALL SWITCH CONTACTS (PART OF S4 & S5) WITH LONG AXIS, AS SHOWN.
3. INSTALL CERAMIC RESONATOR (X1) WITH LETTERING FACING S4 & S5 END OF BOARD.
4. SOLDER CAPACITOR (C13) ACROSS TWO LEADS OF Q11, AS SHOWN.
5. INSERT POLARIZING KEY (DIATEK P/N 58514-0000) INTO CONNECTOR (J1) IN POSITION SHOWN AND SECURE WITH LOCTITE ADHESIVE 495.

FIGURE 6 - MAIN PCA

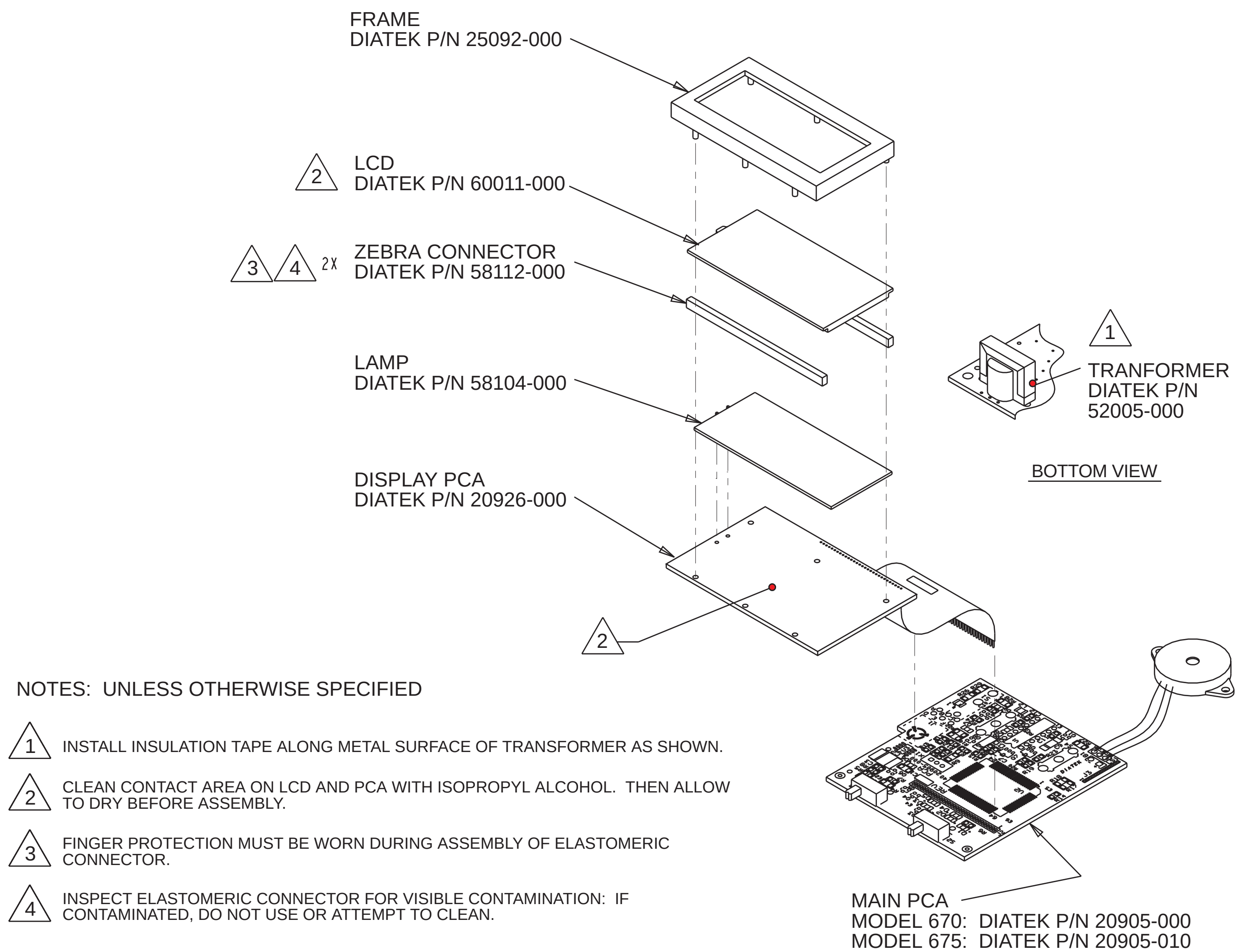


FIGURE 7 - ELECTRONICS ASSEMBLY

THERMOMETER REASSEMBLY

Note: Most of the screws in the unit are plastic thread rolling screws and do not require excessive tightening which will strip out the case plastic threads.

1. If the electronics assembly has been removed from the mid-frame, solder the battery wires and the horn wires to the main PCA, then slide the main PCA into the two retaining tabs near the center of the mid frame and insert the top of the main PCA under the two plastic tabs towards the top of the mid-fame.
2. Lay the front case face-down on a flat surface.
3. Ensure that the display window has been cleaned and installed in the front case, with its slightly rough, scratch resistant surface facing outward.
4. Carefully slide the display board assembly under the retaining tabs at the top of the front case.
5. Gently press the bottom of the display board until it contacts the screw wells in the front case and install the two shortest display board retaining screws.
6. Install 3 “AA” batteries according to the battery polarities marked inside the battery compartment. Verify that the thermometer completes self-test, and the display goes blank.

CAUTION: Incorrect battery polarity may result in damage to the thermometer.

7. Install the back case.
8. Install the battery door.
9. Insert all four screws into the back case, but leave loose. Note that there are two shorter screws for the display area, and one machine screw for the Battery Door.
10. Insert one of the neck strap pins into its receptacle and tighten the screw adjacent to the receptacle.
11. Insert the other neck strap pin into its receptacle and tighten the screw adjacent to it.
12. Tighten the two remaining screws.
13. Install the **°F**-**°C** / **NORMAL**-**MONITOR** label (at the top of the thermometer).
14. Plug the probe into the thermometer.
15. Insert the probe into the probe storage channel. Verify that the thermometer displays “OrL” (briefly for Model 670 and for several seconds for Model 675) then goes blank.

SUGGESTED SPARE PARTS LIST

Welch Allyn Part No.	Description	Qty Per 100 Units
25088-001	Case Front	5
25089-001	Case Back	2
25090-100	Mid-Frame-drilled	10
25091-001	Battery Door	2
25092-000	Frame, Zebra	15
25103-000	Window, Display	4
30056-0000	Pin, Strap	2
40301-0020	Resistor, 10.0K Surface Mount 0.1% 0805 Size	1
40301-2120	Resistor, 12.1K Surface Mount 0.1% 0805 Size	1
40301-3720	Resistor, 13.7K Surface Mount 0.1% 0805 Size	1
44043-0000	Diode, XX459, Low Leakage, Surface Mount, Mini Melf	2
44046-0000	Diode, XXX4448/XX459 Surface Mount, Mini Melf	2
46128-4760	Capacitor, 47µF Tant. Chip, 10V ± 20% D Case	2
46129-1050	Capacitor, 1µF Tant. Chip, 16V ± 20% D Case	2
47017-000	Resonator, Ceramic 4.00MHz, with Caps	2
50004-0000	Transistor, PN2222	4
50029-0000	Transistor, XX2222A NPN, SOT-23	1
50030-0000	Transistor, XX5087, PNP, SOT-23	1
50031-0000	Transistor, BCX69 PNP, SOT-89	1
50032-0000	Transistor, BSS138, FET, SOT-23	2
52005-000	Transformer, Subminiature, PC Leads .1W	2
53009-000	Battery. Alkaline, “AA”	30
54249-000	IC, Microprocessor	2
58096-000	Spring, Contact -Gold Stripe AMP 62314-2	4
58097-000	Contact, Bottom -Gold Stripe AMP 62313-4	4
58100-000	Switch, Slide MA012-4-CE-P-RA	4
58101-000	Switch, Probe	4
58102-000	Horn, Piezo	4
58103-000	Cable, Flexible, Ansley FSN-12A-30	4
58104-000	Lamp, Electroluminescent	10
58112-000	Connector, Zebra	10
58411-000	Battery Contact, Common	4
58412-000	Battery Contact, Positive	2
58413-000	Battery Contact, Negative	2
58465-000	Connector, 6 Conductor	6
58514-0000	Polarizing Key, Between Contact	6
60011-000	LCD Display	10
70082-000	Label, Serial Number	2
70082-001	Blank Overlay, Serial Number Label	2
80013-0002	Wire, 26 AWG Stranded - Red	2 feet
80013-001	Wire, 26 AWG Stranded - Black	2 feet
83021-0000	Screw, Thread roll #4 x 1/4 Philips	4
83035-000	Screw, Thread roll #4 x 7/8 Plastilok	2
83036-0000	Screw, Machine 4-40 x 1 1/16 Philips	2
83037-000	Screw, Thread roll #4 x 3/4 Plastilok	4

OPTIONS AND ACCESSORIES

- Wall mount bracket with locking mechanism for securing thermometer to wall or cabinet.
- Calibration Key for verifying calibration - inserts in place of probe plug and provides correct reading of 97.3°F.
- Rectal Probe
- Second Probe Holder
- Thermometer Stand
- Calibration Tester (Model 9600)

Welch Allyn™

7420 Carroll Road, San Diego, California 92121 • (800) 854-2904 • (619) 621-6600 • FAX (619) 621-6610

70840-0000A