

# Technical Service Manual

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## **MPA160 and MPA161**

# **DigiMelt Student Melting Point System**



Revision 0.7 (February 2010)

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## Precautions

THIS TECHNICAL SERVICE MANUAL IS INTENDED SOLELY FOR USE BY QUALIFIED REPAIR TECHNICIANS. DANGEROUS POWER LINE VOLTAGES ARE PRESENT IN THIS PRODUCT. ONLY PERSONNEL FAMILIAR WITH POWER LINE VOLTAGE SAFETY PROCEDURES SHOULD ATTEMPT TO REPAIR DIGIMELT

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## Power-on error messages

DigiMelt normally displays the firmware version number for 2 seconds at power-on. The following error messages indicate failed self-checks in the power-on sequence:

### *Err 7*

The User Offset Calibration has been cleared. Re-enter your desired User Offset Calibration. See “User Temperature Calibration” (Page 5) for details.

### *Err 8*

Burn-in mode is enabled. DigiMelt will cycle between room temperature and 250 C every 30 minutes. Remove Test Jumper JP1 before returning the unit to service. **Never allow the user to operate DigiMelt in this condition!**

### *Err 9*

The Factory installed calibration data is corrupted so the unit is no longer calibrated. Return the unit to SRS for recalibration.

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## Major Error Indications

The following error displays indicate a broken unit. If either display appears, disconnect the unit from the power line and remove it from service:

### *799.0*

A temperature reading of 799 C is used to indicate that the RTD is either open or shorted. The actual oven temperature is unknown, but the CPU will not apply power to the oven in this condition. Repair the RTD wiring, if possible. Otherwise, the unit must be returned to SRS for a new sample oven and calibration.

### ***Flashing display and alarm sound***

**Unplug the line cord immediately!** The sample oven temperature is above 280 C. This can only be caused by a short in the heater control circuit. See “Runaway Heat” in the troubleshooting section.

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## Circuit Description

Please see “SRS MPA160 7-01780-701E Schematic” for the Printed Circuit Board.

Please see “SRS Assembly 316 Schematic” for the all electrical components that are not on the PCB.

### ***Line Voltage***

DigiMelt uses a standard power entry module with both line and neutral legs switched and fused at 1 Amp (115 VAC units) or ½ Amp (230 VAC units). Step-down transformer T1 supplies up to 3 Watts to the control and display electronics. The line power is switched by TRIAC Q10 to modulate power to the two 40 Watt cartridge heaters in the sample oven. The heaters are wired in parallel for 115 VAC units and in series for 230 VAC operation. DigiMelt is protected from transient line over-voltage damage by a MOV varistor (R69). This product cannot be operated from a DC supply.

### ***Heat regulation***

The voltage zero crossings of the power line appear at the output of opto-isolator U14 and are detected by comparator U16. A logic “high” at ZERO\_CROSS (U16, pin 7) indicates the line voltage is near zero. At the start of each line cycle, the CPU (U11) uses a PID algorithm to decide whether or not to fire Q10 to apply more power to the sample oven.

### ***Vcc***

The CPU, display, and other logic functions are powered by a buck topology switch-mode power supply (U15) which is fed by a full-wave rectified secondary voltage from T1. Transformer T1 is protected from short circuit damage by a self-resetting polyfuse (R50).

### ***Temperature measurement***

The Platinum Resistance Temperature Detector (RTD) has a nominal resistance of 1000 ohms at 0C and a temperature coefficient of 3.85 Ohms / C degree. A bias current of roughly 0.28 milli Amps generates a voltage on both the RTD and the reference resistor (R26). The ADC (U10) produces a digital code proportional to the ratio of the two voltages approximately every 128 milliseconds. The CPU applies a calibration formula that is specific to each unit to determine the actual sample oven temperature. Full range temperature calibration can only be performed at SRS. Please see the “User Temperature Calibration” section (Page 5) to apply a single offset to all temperature measurements.

### ***Keypad and LED scanning***

Shift registers U5 and U6 form a 16 bit serial-to-parallel converter. Every 2 milliseconds, the CPU asserts -CS\_STROBE and clocks new data into U5 and U6. Only one column select line, -S0 though -S3 is active (low) at a time. The low state of -Sx forces STROBEx high, energizing the anodes of one of the 7 segment digits (U1 through U4) and up to 4 discrete LEDs (D1 through D14). Low states on any output pins of U5 light the appropriate segments in the digit display. High state on L0 through L3 force one or more -LAMPx low to light the discrete LEDs. STROBE0 and STROBE1 also

apply voltage to the membrane keypad columns. Any pressed keys are sensed by the CPU as high states on KEY0..3.

### ***Tube Tapper***

The sample compactor (Tube Tapper) consists of a cell phone vibrator motor on a freely suspended section of printed circuit board. The CPU enables the motor driver (U19) by driving VM\_ON high. The CPU generates a PWM signal on V\_SPEED that controls the voltage on the motor. U19 effectively inverts the PWM average voltage, so that a low PWM duty cycle generates a high motor voltage. The motor voltage determines compaction intensity.

### ***CPU Failsafe***

TRIAC Q10 ceases conduction when the heater current falls to zero at the end of a line half cycle. The opto-isolated trigger TRIAC (Q9) is fired by the combination of two one-shot circuits: Both the cathode of Q9 must be low and the anode must be driven high to trigger a heater line cycle. The cathode is held low by periodic CPU activity on -CS\_STROBE (U7, pin 4) to update the LED display. If the CPU fails to update the display for more than 7 milliseconds, then the one-shot (U7) disables both the display and the TRIAC. The anode of Q9 is driven by a 1.9 millisecond pulse from U7. Each half cycle of the line power requires a new rising edge from the CPU to re-trigger U7 at pin 12. These two one-shot circuits ensure that heater power will be interrupted in the event of a CPU malfunction or failure.

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## **Firmware Safety Features**

### ***RTD Failsafe***

The CPU will only apply power to the oven if the measured RTD resistance is within the range of expected temperatures (approximately 1000 to 2000 ohms). DigiMelt will display 799.0 C and no power will be applied to the sample oven if the RTD resistance is outside this range. This feature leaves DigiMelt in a safe state in the event of either of the most likely failure modes of the RTD (short or open circuit).

### ***Over-Temperature Alert***

If the CPU measures an oven temperature in excess of 280C, the unit will continuously flash the measured temperature and sound an alarm. This state indicates that the heater is shorted to the line voltage. The unit should be unplugged immediately. See the troubleshooting section on “Runaway Heat”.

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## Calibration and Test

DigiMelt will exit the following test and calibration menus and revert to normal operation after 30 seconds of button inactivity.

### ***User Temperature calibration***

A temperature offset can be applied to all readings. Press and hold Sample 2 and 3 buttons for at least 4 seconds to enter the User Temperature Calibration display. Release the 2 and 3 buttons. Then, use the 2 and 3 buttons (Up and Down) to edit the calibration offset value. The offset is added to the reading before display, so a negative offset will lower the displayed temperature. The calibration offset takes effect immediately and is applied to all subsequent readings. Set this value to 0.0 to disable this function. Press the Start/Stop button to exit this menu. Continue to power the unit for at least 12 more seconds so that the new calibration value can be stored.

### ***Tube Tapper adjustment***

The Tube Tapper intensity can be adjusted. Press and hold the Sample 1 and 2 buttons for at least 4 seconds. Release the 1 and 2 buttons. Then, use the 2 and 3 buttons (Up and Down) to edit the Tube Tapper intensity. Each press will start a new Tube Tapper burst at the new intensity. Press the Start/Stop button to exit this menu. Continue to power the unit for at least 12 more seconds so that the new Tube Tapper adjustment can be stored.

### ***LED and Keypad test***

The LED and keypad function can be tested by pressing and holding the Sample 1 and Start/Stop buttons for at least 4 seconds. All LEDs and digit segments will light. Release the Sample 1 and Start/Stop buttons. Then, press each of the 8 buttons once (or any odd number of presses). When all 8 buttons have been pressed an odd number of times, the firmware version will be displayed for 2 seconds before returning to normal operation.

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## Burn-in mode

After repair, the unit can be set to automatically cycle between room temperature and 250 C every 30 minutes. This is called “burn-in mode”. It simulates repeated operation of the unit and can be used to discover any marginal components that might fail prematurely. Burn-in mode is enabled by shorting JP1 on the PCB. DigiMelt will display “Err 9” on power-up to warn that the burn-in function is active. **Never allow an end-user to operate a unit with its burn-in jumper installed!**

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## Repair

### **Disassembly**

Remove the 4 black screws holding the base plate to the body casting. If access to the top side of the printed circuit board is required, then:

1. Disconnect the orange line power connector from J4 and the flex cable from J2.
2. Read and understand the heater wiring diagram on the PCB **before** using a small flat-bladed screwdriver to disconnect the heater leads from J5.
3. remove the 4 screws holding the PCB to the casting and gently guide the PCB part way out of the casting. Be careful not to damage the RTD wires. If necessary, de-solder the RTD wires to entirely remove the PCB from the casting.

The heater cartridges can usually be removed without disassembling the entire oven:

1. Loosen the thumb screw and remove the sample oven cover.
2. Push the heater wires from below and slide the cartridge up out of the oven.

Temporary removal of the safety cowl may ease cartridge removal and reinsertion. Always restore the safety cowl before use. A stuck heater can often be freed by warming the oven with a heat gun.

### **Reassembly**

Reverse the disassembly instruction above. Be certain to wire the heaters as shown on the PCB and ensure that all of the heater lead strands are completely enclosed by J5. Each heater cartridge has one taped (or otherwise marked) lead. J5 pin-out is Neutral, Open, Hot (pins 1, 2, and 3).

- 115 VAC configuration:
  - Both marked leads to J5-1 (Neutral);
  - Both un-marked leads to J5-3 (Hot).
- 230 VAC configuration:
  - One marked lead to J5-1 (Neutral);
  - Both un-marked leads to J5-2 (Open).
  - One marked lead to J5-3 (Hot);

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## Troubleshooting

### No Tube Tapper

Cell phone vibrator motors being the cheap things that they are, this is the least reliable component in DigiMelt. Before replacing the motor, see that the shaft and eccentric weight are free to rotate and re-secure the motor with a cable tie if necessary.

### No Display

- LED D34 indicates that line power is present on the printed circuit board. If D34 is dark, then suspect the line cord, fuses, power entry module, and the connections from the power entry module to J4. The fuses should only blow if there is a short circuit in the wiring. In the event that a new fuse blows, the unit must be returned to SRS for repair.
- If D34 is lit, but the unit seems otherwise dead, then suspect a short in the secondary (C10, C22, C23, C15, C17). A secondary short condition is confirmed by a large (10 volts or more) voltage across R50. When the short is located and eliminated, R50 will return to normal operation (low resistance).
- If the voltage across R50 is less than a volt and Vcc is less than 4.5 volts then either Vcc is shorted or the SMPS (U15, C12, L8, D33, C13, C14, and C16) has failed and the unit must be returned to SRS for repair.

### No Heat

If the unit seems fine except that it doesn't heat the sample oven, suspect the heaters, the TRIAC and the zero-crossing circuits.

- Unplug the unit from the wall, remove the bottom plate and measure the resistance of the heaters by probing between pins 1 and 3 of J5. A 115 VAC MPA160 should read approximately 180 ohms. A 230 VAC MAP161 should read about 720 ohms. Replace any heater cartridges that are more than 30% above or below nominal resistance.
- Check the Tube Tapper function:
  - If Tube Tapper works, then the zero-crossing circuit is functioning.
  - If Tube Tapper does not work, then observe D34.
    - If D34 is not lit, then D22, R36, R46, R47, R48, R49, D34, or U14 must be open.
    - If D34 is lit, then trace the zero crossing pulses (twice local line frequency) from U14 through U16 to find the problem.
- If neither of the above areas are at fault, then either Q10 or Q9 is open and must be replaced. Carefully probe the gate of Q10 when DigiMelt is preheating: Presence of full line voltage indicates that Q10 is open.

## **Too Much Heat**

If the sample oven temperature ever reaches 280 C, then either Q10 or Q9 is shorted. The short must be removed or the component replaced. Carefully probe the gate of Q10 when DigiMelt is idle (cooling LED lit): Presence of full line voltage indicates that Q9 is shorted.

## **Temperature Calibration**

The calibration data for a particular oven RTD is stored in NVRAM within the CPU of the unit. For this reason, the sample oven should not be swapped or replaced in the field. If the sample oven does require replacement, the unit must be returned to SRS for recalibration.

An uncalibrated unit will still operate safely, but accurate melting point determination will require a manual adjustment to the readings. This can be done either of 2 ways:

1. If the unit will only be used over a small range of temperatures, say 50 C, then the User Temperature Calibration menu can apply a fixed offset to all readings based on a single CRS compound. This will almost certainly be less accurate than a factory calibrated unit, but may suffice in a teaching lab. See “User Temperature Calibration” (Page 5) to store the offset in DigiMelt.
2. Two or more CRS compounds can be used to find a calibration formula that will calculate an offset as a function of temperature. The offset can be applied manually (e.g. paper and pencil) to the experimental results.

In either case, the accuracy of the field calibration depends on the quality and preparation of one or more certified standard compounds. Please see any SRS Melting Point Operation Manual for detailed instructions on sample preparation. Contact SRS sales to purchase Certified Reference Standards (SRS P/N O100MPS ).



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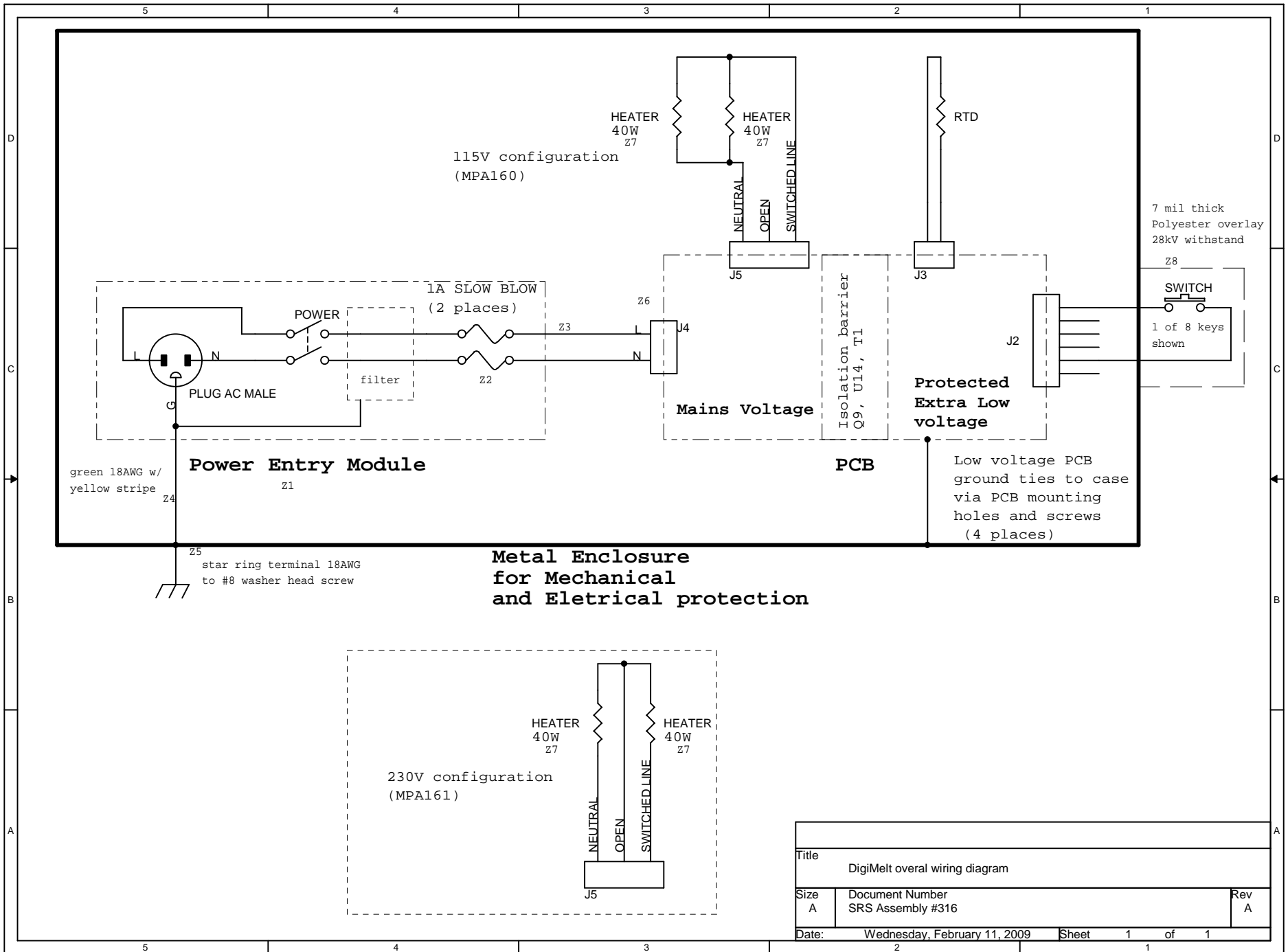
## Abbreviated Parts List

### *Chassis Components*

<b>Description</b>	<b>SRS P/N</b>
Screw: PCB and oven stand, 4-40 x ¼ panhead, phillips, zinc	0-00187-021
Screw: Foot, 4-40 x 3/8 panhead, phillips, zinc	0-00209-021
Rubber foot	0-00221-000
Screw: oven, 2-56 x 3/16 allen head, stainless steel	0-00764-025
Screw: Bottom plate, 4-40 x 3/8 panhead, phillips, black	0-01270-021
Screw: Safety cowl, 4-40 x ¼ panhead, phillips, black	0-01276-021
Screw: grounding, 8-32 x ¼ slotted hex washer head, stainless steel	0-01282-072
Fuse (MPA161) Littlefuse 313.500P, ½ Amp, 3AG	6-00003-611
Fuse (MPA160) Littlefuse 313.001P, 1 Amp, 3AG	6-00004-611
Lens – Pyrex, 25mm diameter, plano-convex, 50mm focal length	6-00801-670
Cartridge heater	6-00813-600
Keypad	7-01816-740
Safety cowl (with “Caution...” label)	7-02018-720
Illumination window (prism)	7-02019-720
Lens support (eyepiece slide)	7-02020-721
Lens cap (lens retaining ring)	7-02032-721
Heater cover (eyepiece slide retainer with captive thumbscrew)	7-02054-720

## Printed Circuit Board Components

Ref	Description	Manf.	Model	SRS P/N
J5	Heater terminal block	Tyco	282847-3	0-01281-032
J4	Line power header	Tyco	640445-2	1-00250-116
J2	Keypad header	Samtec	LCW-106-08-G-S-300	1-00516-130
U14	Opto-isolator	Fairchild	MOC213-M	3-01414-360
D37 or D38	White LED	LiteOn	LTW-2S3D7	3-01896-304
Q9	Opto-TRIAC	Fairchild	FODM3083	3-01897-360
Q10	TRIAC	Fairchild	FKPF3N80	3-01898-340
D22	Bridge rectifier	Fairchild	DF08S	3-01934-360
R69	MOV over-voltage protector	LittleFuse	V300LA40AP	4-02484-435
C10	2200 uF, 35V, Al, radial	Sprague	515D228M035EN6AE3	5-00201-526
C12, C17, C22, or C23	0.01 uF 1206 SMT	Kemet	C1206C103K1RACTM	5-00298-568
W1 through W19, or C21	0.1 uF 1206 SMT	Kemet	C1206C104K5RACTM	5-00299-568
C8, C11, C18, or C19	10 uF, 16V, tantalum, C case	Kemet	T491C106K016AT	5-00471-569
C1	330 uF, 35V, high ripple current, Al, radial	Panasonic	EEU-FC1V331	5-00516-526
C2	0.33 uF, 35V, tantalum, Y case	Panasonic	ECS-T1VY334R	5-00519-596
C15	4.7 uF, 35V, tantalum, C case	Panasonic	ECS-T1VC475R	5-00520-596
C13, C14, or C16	47 uF, 10V, tantalum, D case	Nichicon	F931C476MNC	5-00522-569
LS1	Speaker	CUI	CMT-1603	6-00793-600
X1	Cell phone vibrator motor			6-00800-650
T1	Transformer	Tamura	3FD-420	6-00803-610
R50	Polyfuse over-current protector	LittleFuse	60R040XU	6-00812-611

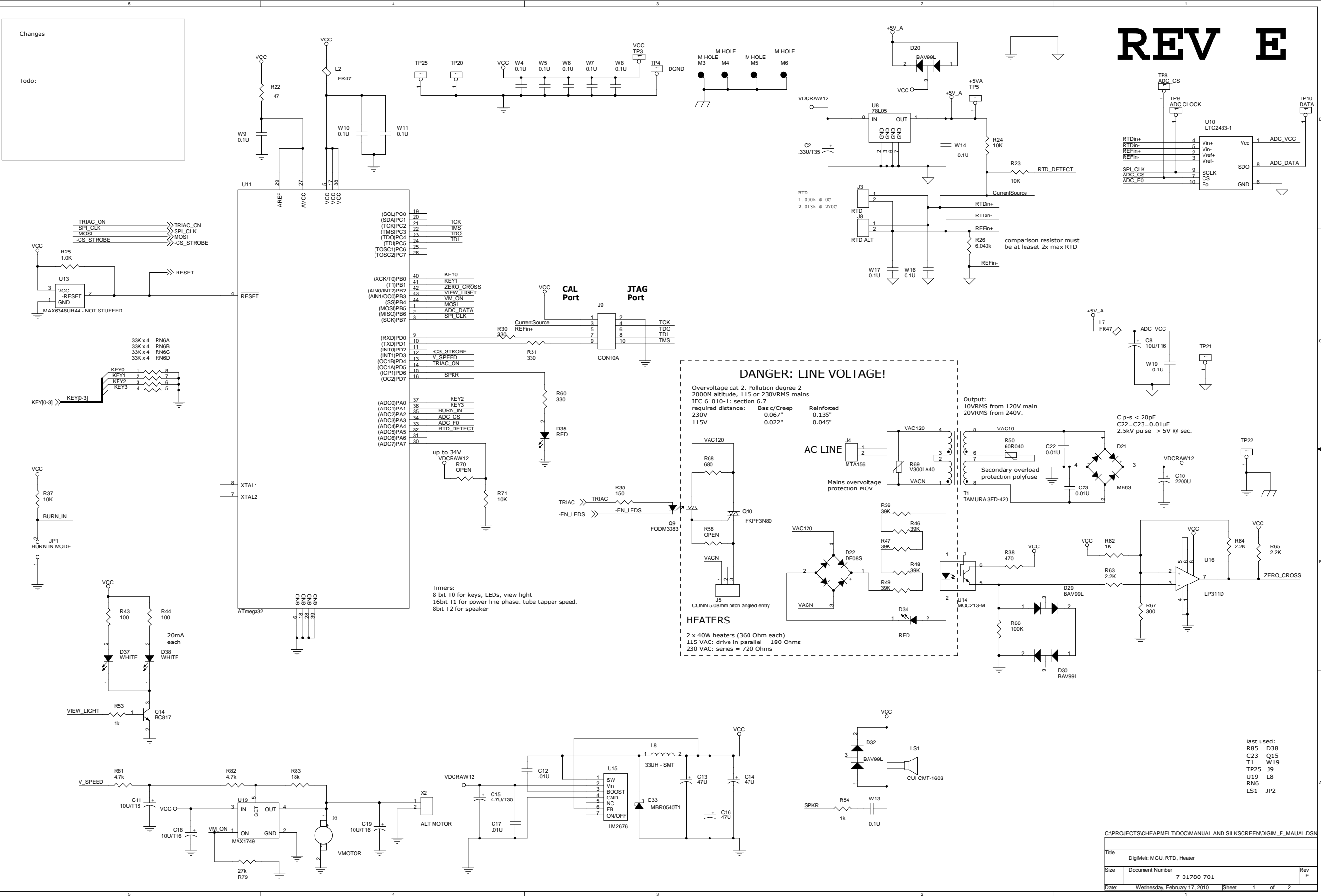


Title		
DigiMelt overall wiring diagram		
Size	Document Number	Rev
A	SRS Assembly #316	A
Date:	Wednesday, February 11, 2009	Sheet 1 of 1

# REV E

Changes

Todo:



**DANGER: LINE VOLTAGE!**

Overtoltage cat 2, Pollution degree 2  
 2000M altitude, 115 or 230VRMS mains  
 IEC 61010-1: section 6.7  
 required distance: Basic/Creep 0.067"  
 Reinforced 0.135"  
 115V 0.022" 0.045"

Output:  
 10VRMS from 120V main  
 20VRMS from 240V.

AC LINE

Mains overvoltage protection MOV

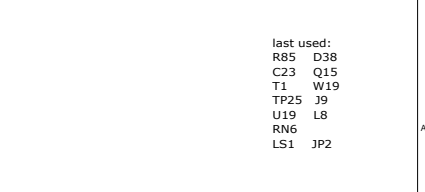
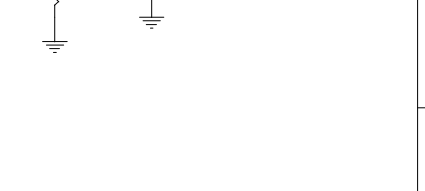
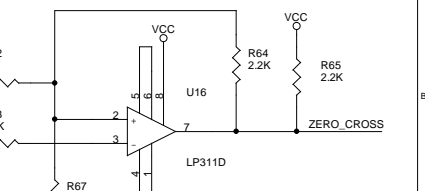
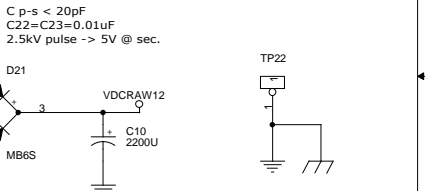
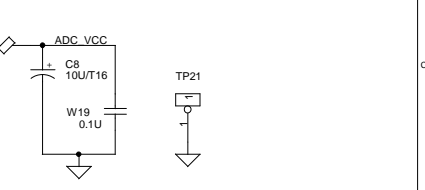
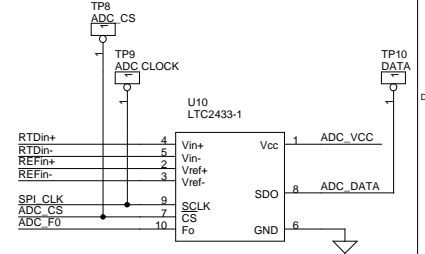
Secondary overload protection polyfuse

T1 TAMURA 3FD-420

CONN 5.08mm pitch angled entry

**HEATERS**

2 x 40W heaters (360 Ohm each)  
 115 VAC: drive in parallel = 180 Ohms  
 230 VAC: series = 720 Ohms



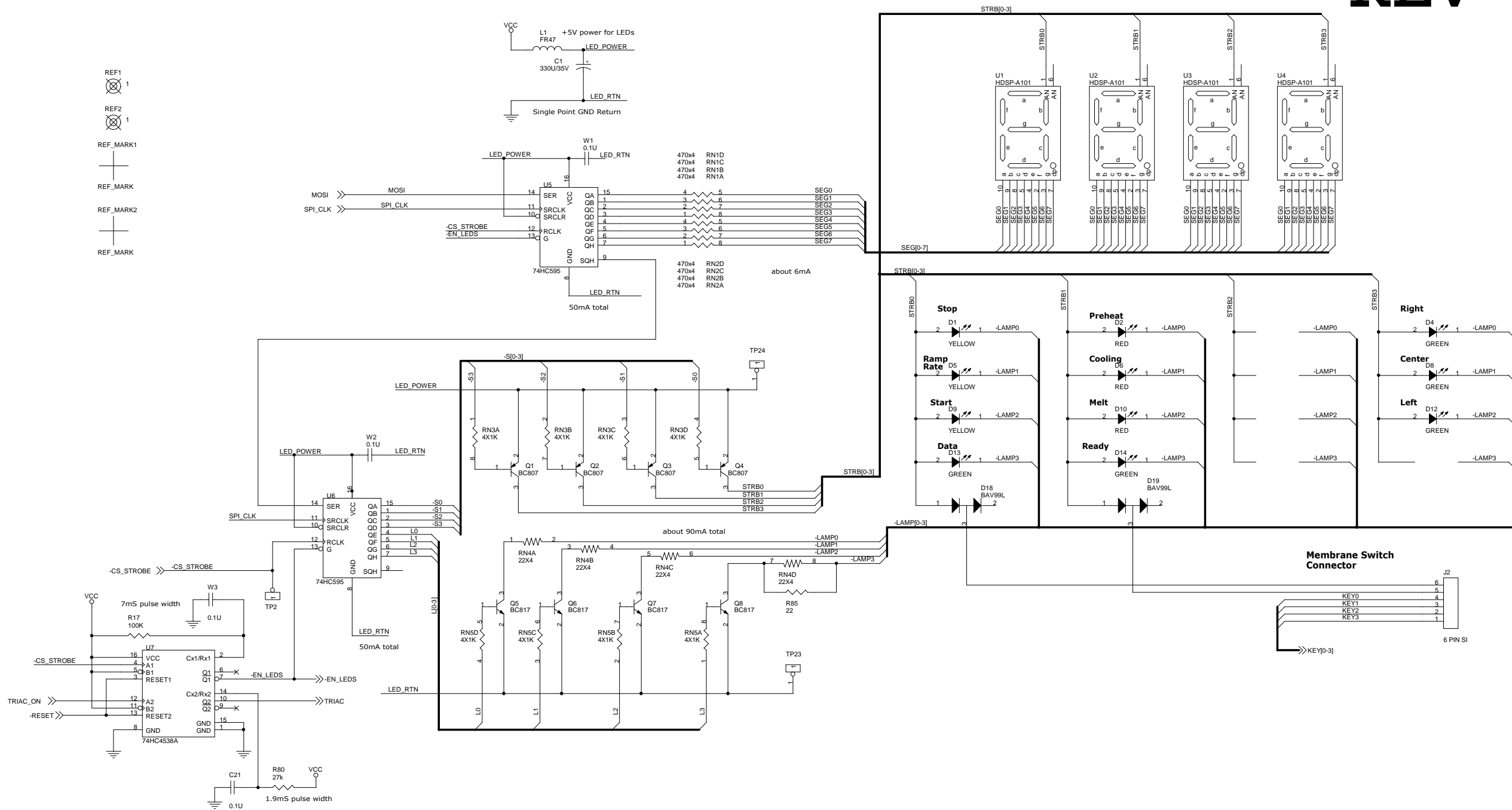
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Title	DigMelt: MCU, RTD, Heater	
Size	Document Number	7-01780-701
Date	Wednesday, February 17, 2010	Sheet 1 of 2

last used:  
 R85 D38  
 C23 Q15  
 T1 W19  
 TP25 J9  
 U19 L8  
 R86  
 LS1 JP2

# REV E

- REF1
- REF2
- REF\_MARK1
- REF\_MARK
- REF\_MARK2
- REF\_MARK



DISABLE LEDES AND TRIAC IF CPU STOPS FOR MORE THAN 7mS

**-CS\_STROBE**

**-EN\_LEDS**

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Title	DigMelt : Front Panel Lamps & Keys	
Size	Document Number	7-01780-701
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