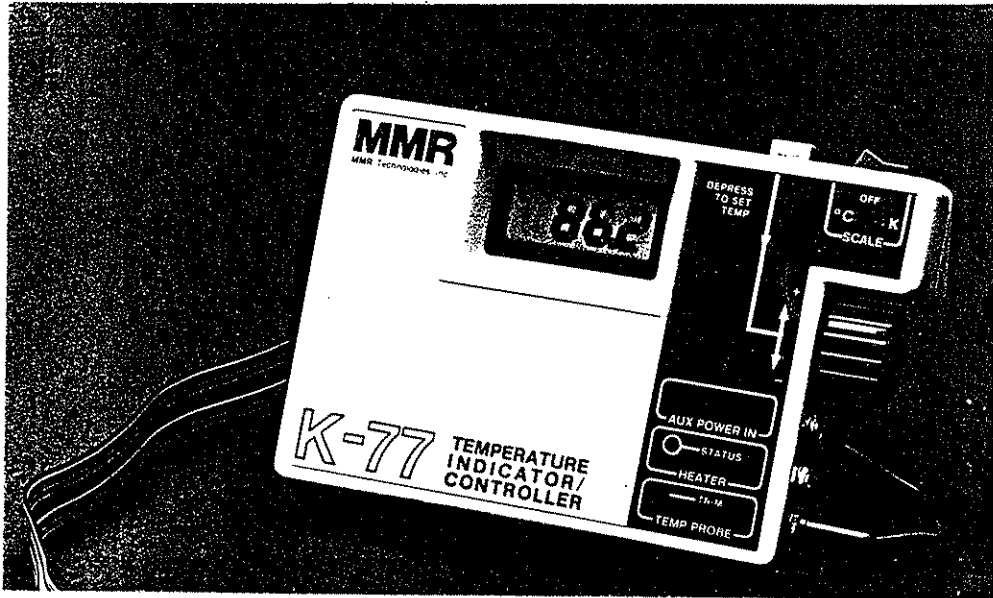


TATE

WAKEN

Temperature Indicator/Controller

MODEL K-77



USER'S MANUAL

MMR Technologies, Inc.
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(415)962-9620

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Section 1. General Information

1.1. General Description

The K-77 Temperature Indicator/Controller interfaces with MMR's patented Microminiature Refrigerators to provide a convenient, low temperature characterization system for heating or cooling small samples and electronic devices from $50\text{ }^{\circ}\text{C}^1$ to $-197\text{ }^{\circ}\text{C}$ (76K)². Operating as a temperature indicator, the K-77 can display the refrigerator's temperature in either degrees C or K. As a temperature controller, the K-77 rapidly changes the refrigerator's temperature to a point set by the user, and then automatically stabilizes it there.

The heart of this system is a ceramic package, on the one end of the refrigerator, in which are encapsulated a silicon diode and a resistor heater. The silicon diode serves as a thermometer and the resistor heater serves as the heat source to raise the refrigerator's temperature above its minimum operating temperature of $-197\text{ }^{\circ}\text{C}$. Together, these components complete a feedback control circuit in the K-77 controller.

1.2. K-77 Features

1.2.1 Temperature Indication

A liquid crystal display indicates the refrigerator's temperature in either degrees C or K.

The temperature readout circuit is powered by a 9 volt battery included with the kit. Hence, no external power supply is required for the K-77 when it is operated solely as a temperature indicator.

The temperature accuracy is $\pm 2^{\circ}$ from $-197\text{ }^{\circ}\text{C}$ to approximately $50\text{ }^{\circ}\text{C}$. Above this point, the accuracy decreases to about $+6\%/-0^{\circ}$ at $100\text{ }^{\circ}\text{C}$. This accuracy is limited by the nonlinearity of the silicon diode's electrical properties over the temperature range.

1.2.2 Temperature Control

The user can conveniently set any temperature from $100\text{ }^{\circ}\text{C}$ to $-197\text{ }^{\circ}\text{C}$ (76K). The controller will supply the appropriate amount of power to the heater in the refrigerator's coldstage to

¹ The system can be operated up to $100\text{ }^{\circ}\text{C}$, however the temperature accuracy above $50\text{ }^{\circ}\text{C}$ may be outside of the $\pm 2^{\circ}$ specification.

² Temperatures below 80K require vacuum assist. The temperature accuracy below 76K may be outside of the $\pm 2^{\circ}$ specification.

bring its temperature rapidly to within $\pm 2^\circ$ of the set point. The user then fine tunes to the exact temperature desired. Stabilization will be within $\pm 0.1^\circ\text{C}$.

The rate of change of the refrigerator's temperature in response to a change in the set temperature normally exceeds $1^\circ/\text{second}$.

The heater circuit in the K-77 requires an external power supply, provided as a separate component in each kit.

A fail-safe feature has been built into the K-77 to limit the maximum refrigerator temperature to slightly above 100°C and break the heater circuit if the temperature indicator circuit is shorted for some reason.

1.1.3 Other Features

The user can obtain an accurate indication of the power dissipated by the sample being cooled during its operation at any given temperature by monitoring the voltage across the resistor heater (Pin 8 & 14 on the 20 lead ribbon cable).

Section 2. Kit Assembly

2.1. Battery Installation

1. Place the K-77 unit face down on a flat surface.
2. Loosen the mounting screw (by turning it counter-clockwise) until it moves up and down freely.
3. Remove the rear cover of the unit.
4. Place 9 volt battery in the battery holder, observing polarity. Be sure the battery terminals and holder terminals have been fully pressed into each other.
5. Replace the rear cover, being careful to line up the edges, and tighten the mounting screw (by turning it clockwise) until snug.

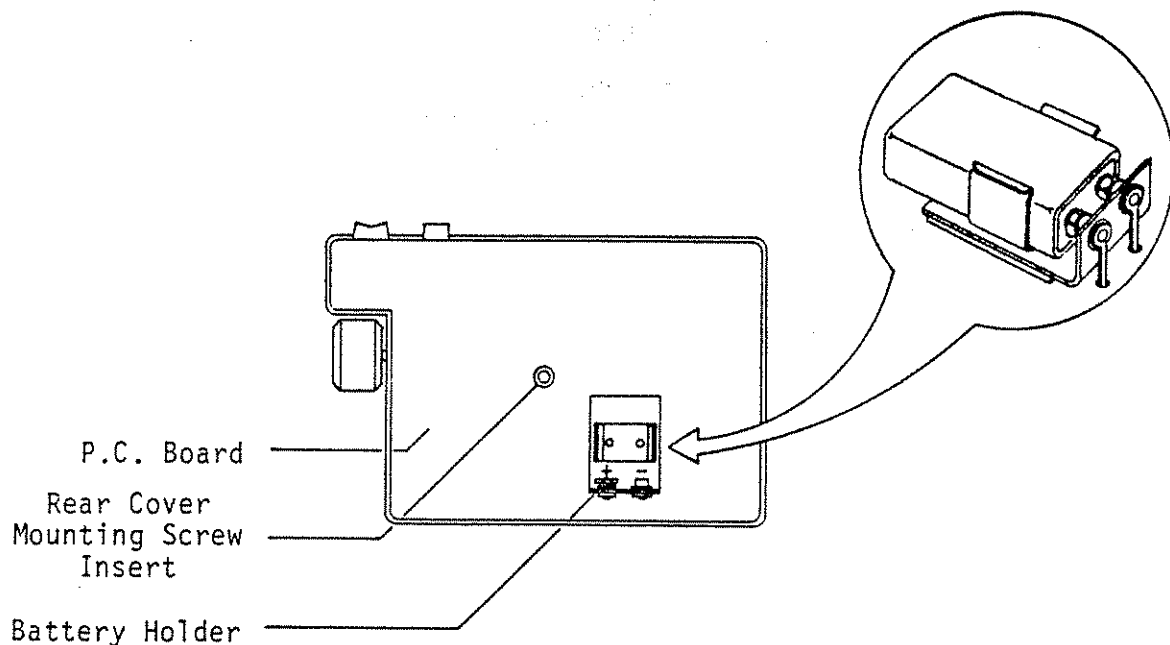


Figure 1. Battery Installation

2.2. Harness Connection

Connections are as shown below.

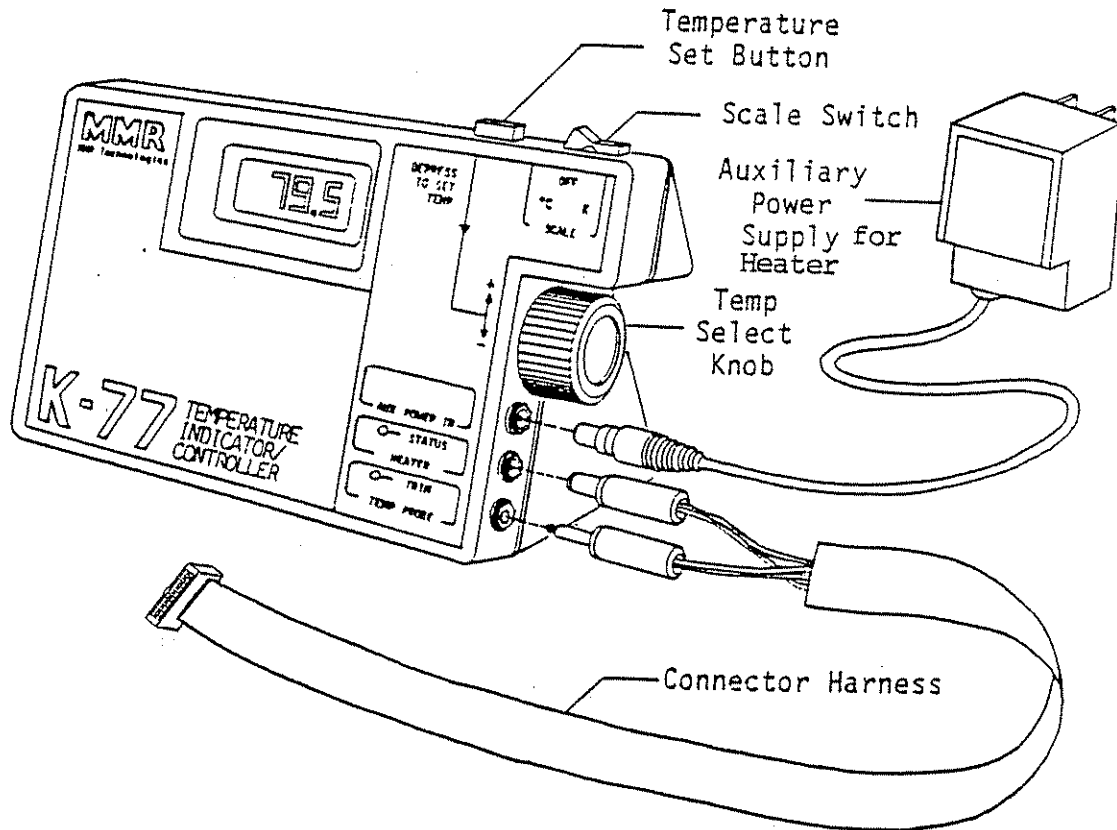


Figure 2. K-77 Set-Up

Refrigerator harness conductor destinations are as follows:

- Wires 8 and 14 go to the resistor heater
- Wire 10 goes to the anode of the diode (Temperature Sensor)
- Wire 12 goes to the cathode of the diode (Temperature Sensor)

2.3. Auxiliary Power Supply Connection

The auxiliary power supply plugs into any standard wall outlet (90-120 VAC, 50-60 Hz), or 220-240 VAC. The input jack then plugs into the AUX POWER IN jack on the K-77 unit. Output is 12 VDC @ 350 mA.

Section 3. Temperature Calibration

The K-77 is initially calibrated at the factory, and the user need only fine-tune it for use with each refrigerator. The reason for this is that each refrigerator coldstage contains a temperature sensing diode, and these diodes vary slightly in forward voltage.

NEVER PLACE THE REFRIGERATORS IN LIQUID NITROGEN. The thermal shock from placing a refrigerator in liquid nitrogen will crack the refrigerator.

Calibration is done with the K-77 and refrigeration system completely assembled, except that the vacuum chamber lid or jacket is left off to provide access to the refrigerator, and the auxiliary power supply is left disconnected.

1. Set the scale switch to °C.
2. Determine the refrigerator coldstage temperature by placing a Celsius contact thermometer on the refrigerator coldstage.
3. Adjust the trim pot on the front panel so that the temperature displayed by the thermometer and the temperature displayed on the K-77 are the same. Turning the trim pot clockwise raises the displayed temperature, counterclockwise lowers it.

Section 4. K-77/Refrigeration System Operation

1. With the entire system assembled (the K-77 should be calibrated and set to the OFF position) begin refrigerator cool-down as outlined below.
2. Select coldstage set-temperature on the K-77:
 - a) Set the scale switch to °C or K.
 - b) Depress the set-temperature button - the K-77 will display the set-temperature.
 - c) Turn the temperature select knob to increase or decrease the set-temperature which will be displayed as long as the set-temp. button is depressed.
 - d) After selecting a set-temperature, release the set-temperature button - the K-77 will display the coldstage temperature.

Once the system is fully cooled, the temperature displayed may be slightly different than the set-temperature (this represents the $\pm 2^\circ$ specification). Simply fine-tune to the desired temperature by turning the temp. select knob (this changes the set-temp.). The new set-temperature may be seen by pressing the set-temperature button.

3. Turn power on to the device mounted on the coldstage, let the temperature stabilize, and conduct experiment.
4. After the experiment is finished, turn off the controller, the nitrogen gas, and the vacuum. If the refrigerator has been operating at a high or very low temperature, minimize thermal shock by bringing the refrigerator close to ambient temperature before venting the vacuum chamber. **TO AVOID FROSTBITE OR BURNS BE AWARE OF THE TEMPERATURE OF THE REFRIGERATOR AND MOUNTED DEVICE BEFORE TOUCHING THEM.**

4.1. Indicating Temperature

The K-77 will continuously display the coldstage temperature, in degrees C or K, as the refrigerator cools. When the coldstage temperature reaches the set-temperature, the K-77 will provide enough power to the heater in the coldstage to keep the coldstage at the set-temperature.

4.2. Controlling Temperature

The user may change the coldstage set-temperature at any time by repeating step 2, above. If the coldstage temperature is at 90K or below and the user wishes to raise its temperature only

a few degrees, the K-77 must be set to about 5 degrees above the new desired temperature. This will allow the K-77 to deliver enough power to the coldstage to increase its temperature. Once the coldstage reaches the desired temperature, the set-temperature may be lowered back down to the desired setting.

4.3. Calculating Power Dissipated by a Device Operating at a Given Set-Temperature

1. With the coldstage at a given set-temperature, remove the HEATER input jack from the K-77 and measure the resistance (R) of the resistor heater. This is done by connecting a resistance meter to the appropriate wires on the 20 conductor ribbon cable:

All Systems - wires 8 and 14

2. Reconnect the HEATER input jack. With the coldstage stabilized at the set-temperature and the device not powered, measure the voltage (V1) across the resistor heater.
3. With the coldstage stabilized at the set-temperature, and the device powered, again measure the voltage (V2) across the resistor heater.
4. Calculate the power (P) dissipated by the device:

$$P = \frac{(V1)^2 - (V2)^2}{R}$$

4.4. Using Vacuum Assist

The minimum operating temperature of MMR's refrigerators is determined by the pressure of the nitrogen gas as it exists through the outflow channels. This pressure is typically around two atmospheres, providing a minimum temperature of about 80K. Temperatures down to 76K can be achieved by attaching a vacuum pump to the refrigerator outflow port.

Small, direct drive, mechanical pumps with 20 liters/minute flow capacities are adequate for this purpose.

Section 5. Troubleshooting Guide

Problem	Reasons	Solutions
No display	<ul style="list-style-type: none"> - K-77 unit set to OFF - Battery not installed - Dead battery 	<ul style="list-style-type: none"> - Set unit to °C or K - Install battery - Replace battery
Display shows "1"	<ul style="list-style-type: none"> - Overrange (unit is set to K range and diode temperature is above 199.9K) - Diode shorted 	<ul style="list-style-type: none"> - Set unit to °C range - Check diode circuit continuity
Display shows "-1"	<ul style="list-style-type: none"> - Underrange (unit is set to °C range and diode temperature is below -199.9 °C) - Overrange (diode disconnected) 	<ul style="list-style-type: none"> - Set unit to K range - Check TEMP PROBE input jack connection diode circuit continuity
K-77 unit does not control temperature (displayed temp. is below set-temp.)	<ul style="list-style-type: none"> - Auxiliary power supply not connected - Resistor elements disconnected 	<ul style="list-style-type: none"> - Check AUX POWER IN input jack connection and wall plug connection - Check HEATER input jack connection and resistor heater circuit continuity
Refrigeration system will not cool down properly	<ul style="list-style-type: none"> - Set-temperature is incorrect - See refrigeration system manual, troubleshooting section 	<ul style="list-style-type: none"> - Check set-temperature

Section 6. Reference Material

6.1. Specifications

Temperature Range:	50 °C ¹ to -197 °C (76K) ²
Read Out Resolution:	0.1°
Temperature Accuracy:	± 2° from 50 °C to -197 °C (76K) Above 50 °C, accuracy decreases to about +6 °/-0 ° at 100 °C
Read Out:	3 1/2 digit, LCD display reading in °C and K
Temperature Control Pad:	Encapsulated temperature sensor and control element mounted under 10 mm x 13 mm alumina sample mounting stage
Sensor:	Silicon Diode
Control Element:	100 ohm resistor element

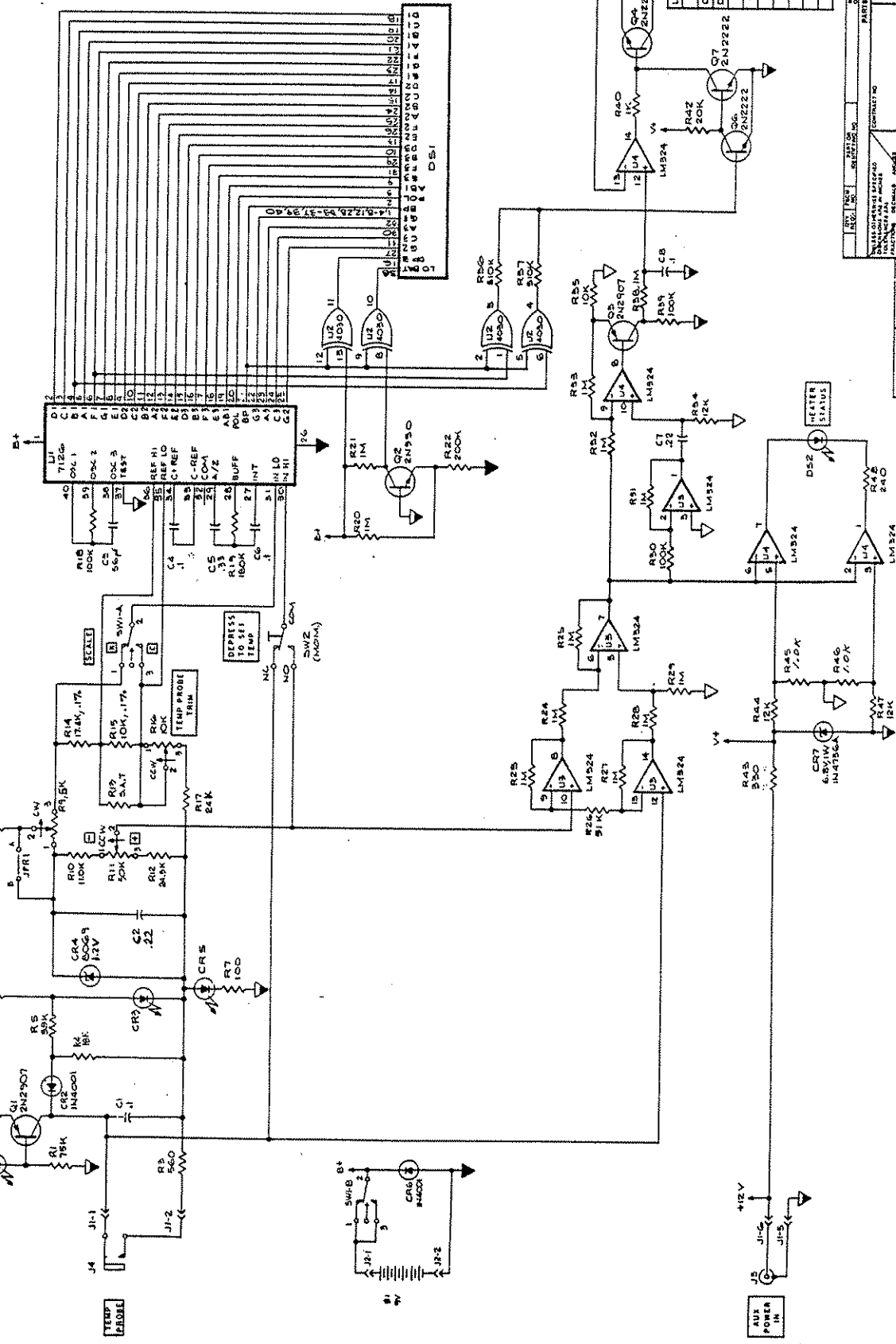
6.2. Reorder Parts List

Description	Part Number
K-77 Controller (Complete)	D000017-000
K77 Board Assembly Only	D000021-000
K-77 Enclosure Only	D000018-000
Connector Harness	B000040-020
Auxiliary Power Supply	A931019-000
Calibration Screwdriver	A930009-000
K-77 User's Manual	A920004-000

¹ The system can be operated up to 100 °C, however the temperature accuracy above 50 °C may be outside of the ± 2° specification.

² Temperatures below 80K require vacuum assist. The temperature accuracy below 76K may be outside of the ± 2° specification.

REV	DATE	DESCRIPTION	BY	CHKD
D	1/18/82	REVISED & REDRAWN		



LAST USED	PNR	QTY	REVISION
CR1	2N14981		
CR2	2N14981		
J2	2N12222		
Q7	2N12222		
R45			
U1	74180		
U2	7401		
U3	7401		
U4	7401		

MMR MMR Technologies, Inc.
MOUNTAIN VIEW, CA 94031 (415) 941-8800

SCHEMATIC,
CONTROLLER, K77

000021-01 K7700

DO NOT SCALE DRAWING

APPROVED: [Signature]

DATE: 1/18/82

DESIGNED BY: [Signature]

DATE: 1/18/82

APPICATION: [Blank]

REV: 1/1

1

- ALL LEADS ARE HP 1082-4650
- ALL CAPACITOR VALUES ARE IN MICROFARADS, 10³ = 30V
- ALL RESISTOR VALUES ARE IN OHMS, 10³ = 1.0K
- NOTES: (UNLESS OTHERWISE SPECIFIED)

8 7 6 5 4 3 2 1

1 2 3 4 5 6 7 8