T100MD-1616+ (Rev D-1) PLC Installation Guide
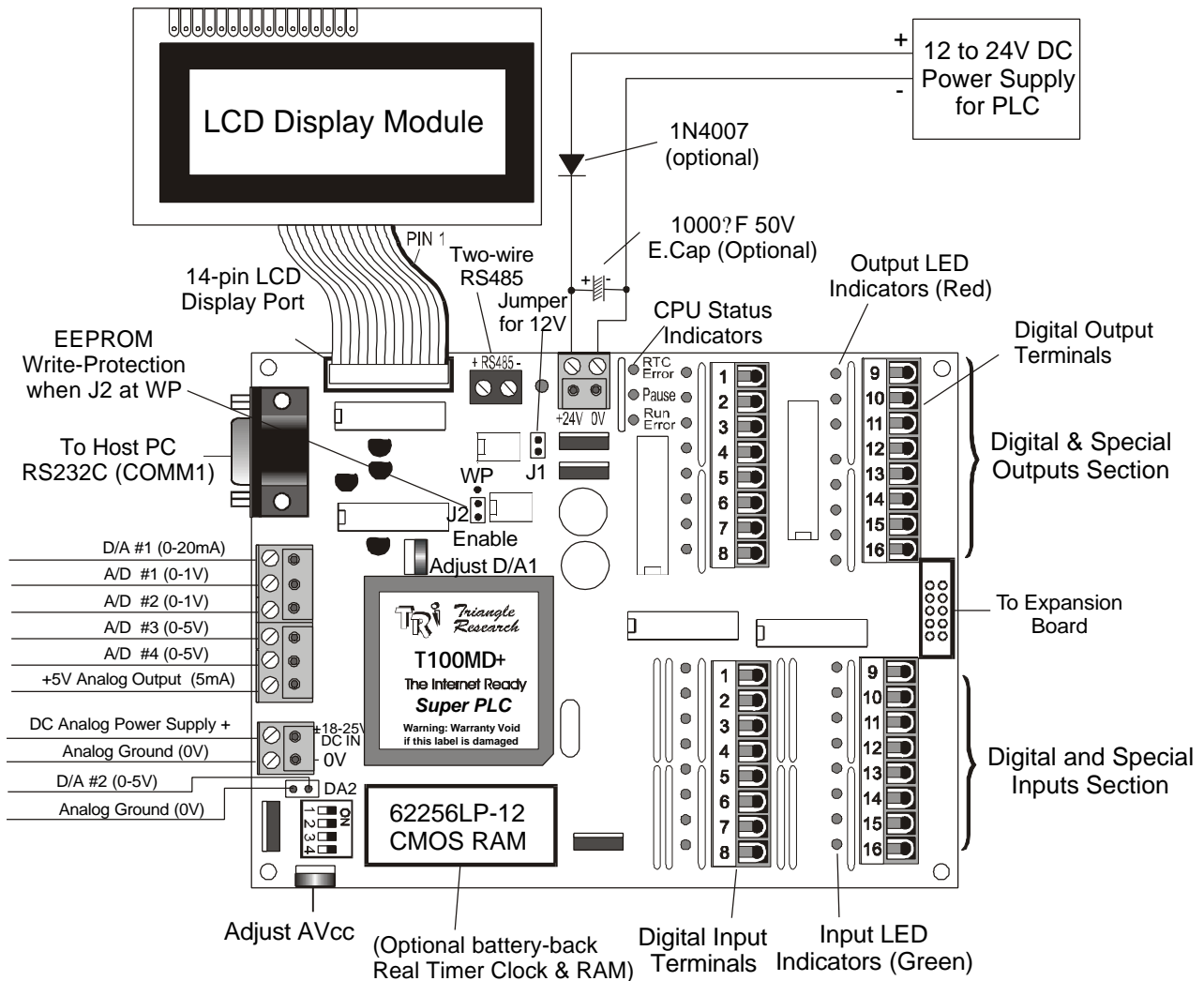
Figure 1 - T100MD-1616+ and 4x20 LCD Module

1. Introduction

The T100MD1616+ is an extremely powerful programmable controller equipped with an arsenal of sophisticated built-in hardware and firmware that allows you to tackle complex control tasks at minimum cost and at great ease.

For Rev. D-1 models there is an addition of an EEPROM write protection jumper J2. For normal programming the jumper block for J2 should be placed at the "Enable" position. If J2 is placed at the "WP" position the PLC's EEPROM is write-protected. In this case the SAVE_EEP statement will not work and if you transfer a new program to the PLC, the new program will reside temporarily in RAM will not be saved in the EEPROM. It will also be lost when the PLC powers down.

2. Physical Mounting & Wiring

The compactly designed T100MD1616+ PLC can be easily installed in many kinds of plastic or metal enclosures. You need to use 4 PCB standoffs (or some screws and nuts) to support the controller and fasten it to a console box.

Analog I/O Ports: The analog I/Os and the analog power supply connection are located along the left edge of the PCB via a 6-way detachable screw-terminals and a 2-way screw terminal below it as shown in Figure 1.

Digital I/O Ports: Detachable screw terminals are provided for quick connection to all digital inputs, outputs and power supply wires. Each block of screw terminals can easily be detached from the controller body, enabling easy replacement of the controller board when necessary. Since the terminal block for digital I/O is inserted vertically to the board surface, you need to remove the terminal block before you can start wiring. Use a small flat-head screw-driver and insert underneath the terminal block, apply even pressure to raise the terminal block until it becomes loosened from the connecting-pin strip, as shown below:
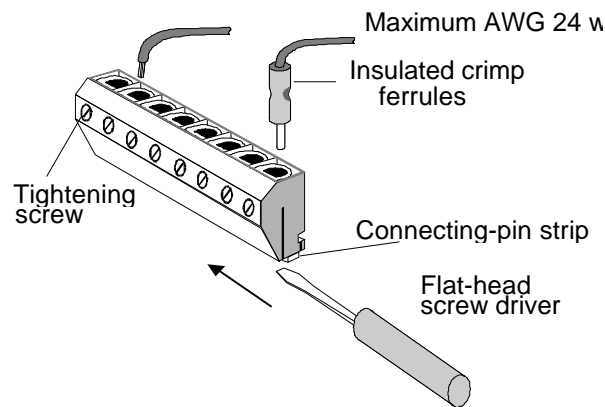

Figure 2 - Removing Screw Terminal block

Although wires of up to 24 AWG may be connected directly to the screw terminal, insulated crimp ferrules should be used to provide a good end termination to multi-stranded wires. Use of ferrules reduces the possibility of stray wire-strands short-circuiting adjacent terminals and their use is therefore highly recommended.

3. Power Supply

A T100MD1616+ requires a single regulated 12 to 24V (+/- 5% ripple) DC power for both the CPU and the I/Os. It is recommended that whenever possible, use a higher power supply voltage since the voltage difference between ON and OFF state is wider for operation at higher voltage. To use the T100MD1616+ at 12VDC you should place a jumper block on the two-pin header marked "J1-12V" near the power supply terminals. You must remember to remove the jumper when operating the PLC above 18V otherwise the voltage regulator can overheat.

Please use only industrial grade linear or switching regulated power supply from established manufacturers for best results. Using a poorly made switching power supply can give rise to a lot of problems if the noisy high frequency switching signals are not filtered properly. **Note**: If your application demands very stable analog I/Os you should choose a linear power supply instead of a switching power source for the CPU.

Always place the power supply as near to the PLC as possible and use a separate pair of wire to connect the power to the PLC. Keep the power supply wire as short as possible and avoid running it along side high current cable in the same cable conduit. The T100MD-1616+ PLC will be reset when the power supply voltage dips below 9V. It is a good idea to connect a 470?F to 1000?F, 50V electrolytic capacitor near the power supply connector to suppress any undesirable voltage glitches from conducting into the PLC. If other high current devices such as a frequency inverter were to affect the operation of the PLC, then you should also

connect a diode before the capacitor to prevent reverse current which might flow back to the power supply, as shown in the following diagram:
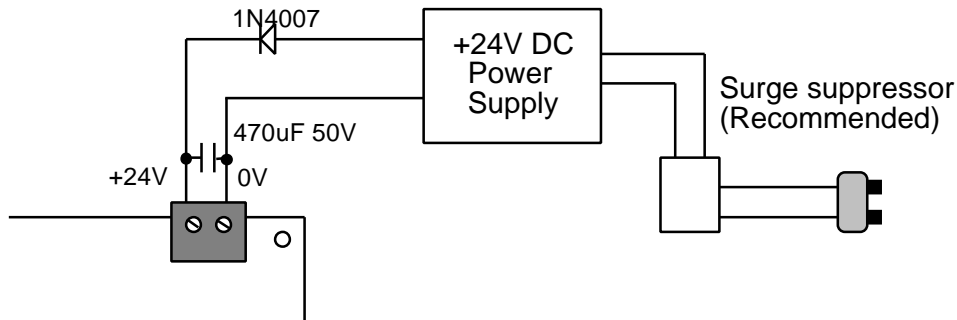

Figure 3

If the AC main is affected by nearby machines drawing large currents (such as large three-phase motors), you should use a surge-suppressor to prevent any unwanted noise voltage from being coupled into the T100MD power supply. The required current rating for the power supply depends mainly on the total output current, taking into consideration the peak current demand and the duty cycle of the operation. Normally, a 2A, 24V DC switching power supply should be enough.

4. LCD Display Module

The built-in 14-pin **LCD DISPLAY MODULE PORT** (hence the suffix "MD") is compatible to the Hitachi HD44780 display controller which is a *de facto* industry standard.   This allows low cost, easily available LCD modules from third-party manufacturers to be connected directly to the PLC to implement very economical man-machine interface. You simply connect the LCD module to the T100MD's LCD port using a 14-way IDC ribbon cable and header. Make sure that the pin number on the PLC matches that of the LCD module. Wrong cable connection can destroy the LCD port or LCD module.

The +5V logic power required by the LCD module is supplied by the 14-pin header. However, **NEVER** connects the LCD backlight terminals to the +5V pin of the 14-pin header or the +5V output of the analog power supply as this will overheat the PLC's voltage regulators. For modules with LED backlight you can simply connect the backlight terminals in series with a 150? to 220? 5W resistor to the 24V power supply.

You may use any of the Industry standard 14-pin LCD modules. There are many different display sizes or character formats to choose from, e.g., 1x8, 1x16, 1x20, 2x16, 2x20, 1x40, 2x40 and 4x20. We strongly recommend those with Super-Twisted Nematics (STN) type which gives high contrast and wide viewing angle. The contrast of the LCD can be adjusted using the preset potentiometer R7 marked with the word "contrast" below the LCD connector.

Programming the LCD Display

The **SETLCD** *y, x, string* TBASIC command allows you to easily display any string of up to 20 characters on the yth line starting from the xth column. E.g., to display the message "T100MD-1616" on the 3rd line starting from the 5th character position from the left end of the screen, you use the command:

```
SETLCD 3, 5, "T100MD-1616"
```

Normally, y = 1,2,3, 4; x = 1, 2, …. 20. Integers must be converted to strings using the STR$( ) or HEX$( ) before they can be displayed using SETLCD. You can use the concatenation operator "+" to combine a few components together in the command. E.g.

```
SETLCD 1,1,"Rm Temp = "+ STR$(ADC(1)/100,3)+CHR$(223)+"C"
```

The function STR$(ADC(1)/100,3) reads the content of ADC channel #1, divides it by 100 and converts the result into a 3-digit string, the CHR$(223) append a special character which corresponds to the ' ° ' symbol. E.g. if ADC(1) returns the value 1234, the final string being displayed will be : Rm Temp = 012 °C.
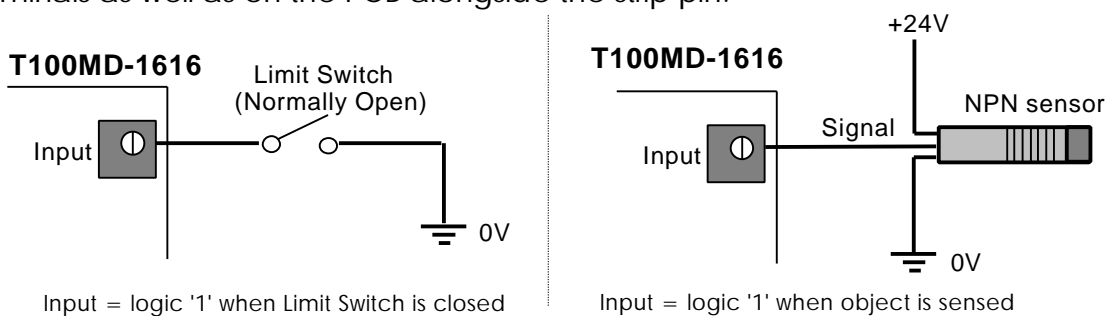
Special Commands For LCD Display

If you use the SETLCD command with line #0, then the strings will be treated as special "instructions" to be sent to the LCD module to program it for various modes of operation. This includes blinking cursor, underline cursor or no cursor as well as display shift mode. You have to refer to the LCD manufacturer's data sheet for the detailed commands. Some of the most useful commands are listed below:

Action	Command
1. Clear screen	SETLCD 0,1, CHR$(1)
2. No cursor	SETLCD 0,1, CHR$(12)
3. Underline Cursor	SETLCD 0,1, CHR$(14)
4. Blinking Cursor	SETLCD 0,1, CHR$(13)
5. Underline + Blinking Cursor	SETLCD 0,1, CHR$(15)

5. Digital Input Circuits

All inputs have green color LED indicators. Every 8 inputs are grouped together into a single strip of detachable screw terminal. All inputs are NPN types, meaning that to turn ON an input is to connect it to low voltage rail (0V terminal) of the power supply as shown in the following diagram. The input numbers are marked on their screw terminals as well as on the PCB alongside the strip pin.

Input = logic '1' when Limit Switch is closed   Input = logic '1' when object is sensed

Input Voltage for Logic 0:   Open Circuit or +10V to +24VDC
Input Voltage for Logic 1:   0V to +2.5V DC

6. Digital Output Circuits

All outputs have red color LED indicators. T100MD1616+ PLC employs "sink" (NPN) type power transistor outputs that turn ON by sinking current from the load to the 0V terminal. Every 8 outputs are grouped together into a single strip of detachable screw terminal. Figure 3 shows the wiring diagram of the digital outputs.
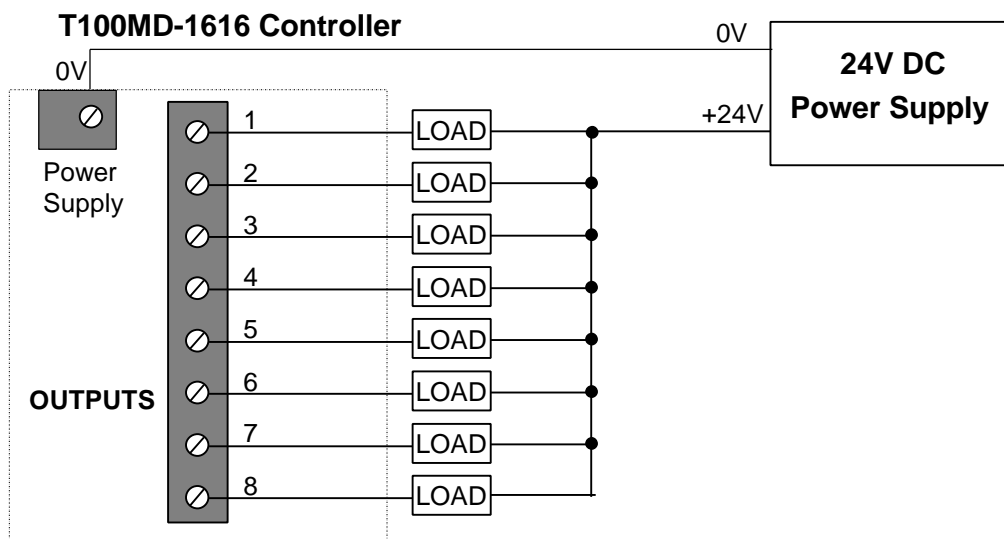
T100MD-1616 Controller

Figure 4 - Transistor Output Interfacing to Load

Outputs Electrical specifications:

	Output #5 to #8	All Other Outputs (1- 4, 8-16, ..)
Output Driver type	NPN Darlington Power Transistors	N-Channel power MOSFET with low $r_{DS} = 1$?
Maximum Output Current:	1.0A	1.0A
Continuous Output Current (with all other outputs ON)	250mA	350mA
Output Voltage when OFF	Resistor pulled up to 24V power rail	
Output Voltage when ON: @ $I_{out} = 700$ mA	1.2V	0.7V
Inductive Back EMF Bypass	Yes	Yes
Short Circuit Protection	No (External fuse)	Yes (Built-in current limited)

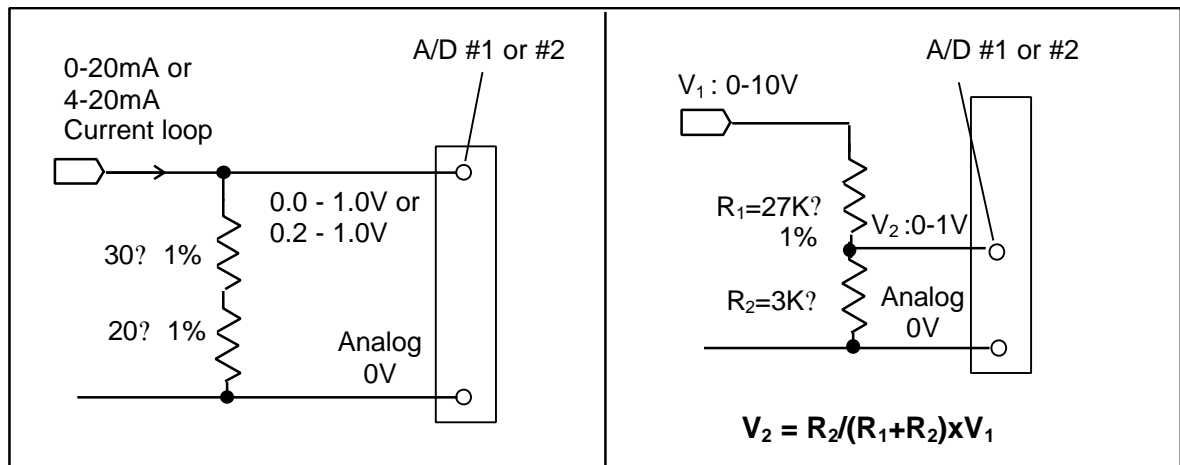# 7. Analog I/Os and Power Supply

7.1 Analog Power Supply

The analog section of the PLC requires an +12 to +24V DC low-ripple power supply. It will generate a stable 5V (?1% accuracy) regulated DC voltage which will be used internally as voltage reference and is available externally for use by other analog input devices. The reference voltage output is available on the analog I/O connector and may be used as the source voltage for connecting to potentiometers. It is current-limited by a 10 Ohm resistor RA5. If you need more current you can replace RA5 with a lower resistance value.

The analog reference voltage can be calibrated by adjusting the preset potentiometer on the circuit board marked "**Cal AVcc**" until the reference voltage of 5.00V is reached. Before calibration please make sure that the +5V output terminal is not connected to any load so that accurate reference voltage can be set.

Use a <u>linear power supply</u> if possible as it tends to be less noisy than a switching power supply. If possible avoid sharing with the 24V switching power supply of the CPU and digital I/Os because the digital power supply is usually very noisy due to the presence of fast switching transients. T100MD-1616+ itself consumes very little current from the analog power supply. Usually, a low cost 0.2A linear power supply which can be constructed or purchased easily should suffice.

7.2 <u>Analog Input #1 to #4</u>

Each T100MD-1616+ is equipped with 4 channels of built-in 10-bit A/D converters. A/D #1 and #2 are buffered by operational amplifiers with a x5 gain and they accept analog signals with 0-1V full scale. A/D #3 and #4 are unbuffered and they accept 0-5V full-scale analog signal. It is very easy to interface to other analog voltage or current input range by using external resistors as voltage-dividers or current-to-voltage converters as shown in the following diagram:
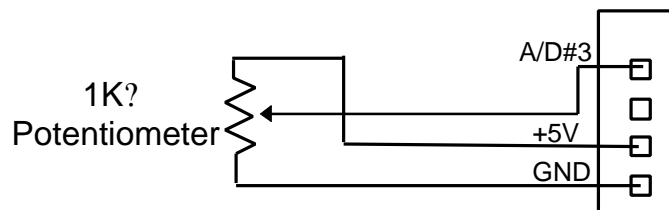

Converting 20mA current-loop to 0-1V   *Converting 0-10V signal to 0-1V*

Note that If the sensor has its own power supply then you must connect the sensor "ground" to analog "AGND" terminal to provide a common ground. All the analog inputs to the T100MD CPU are protected by Zener diodes to guard against transient over-voltage damage. However, <u>care should be taken to prevent applying excessive over-voltage</u> to the analog inputs for prolonged periods of time which will blow the Zener diode and cause a short circuit. This is especially so in the case of A/D #3 and #4 because they are not buffered by Op-Amp. If the Zener diode is short-circuited it will have to be replaced.

Using Potentiometer to Set Parameters

A potentiometer can provide a very low cost means for users to input parameters to the PLC such as setting of temperatures, timers or counter values, etc. The following diagram show how easy it is to implement such a device using the 5V output and the A/D #3 or #4:

Very accurate parameters can be set if the LCD display is used as visual feedback of the settings.

Reading Analog Input Data

The 4 analog input signal is read by the TBASIC command ADC(1) to ADC(4). For 10-bit resolution the theoretical possible range is 0-1023. However, as explained in the programming manual, ADC(n) commands convert the result to a 12-bit number. This is done by multiplying the value by 4. Hence the data returned by ADC(n) command will be 0,4,8,… 4092.
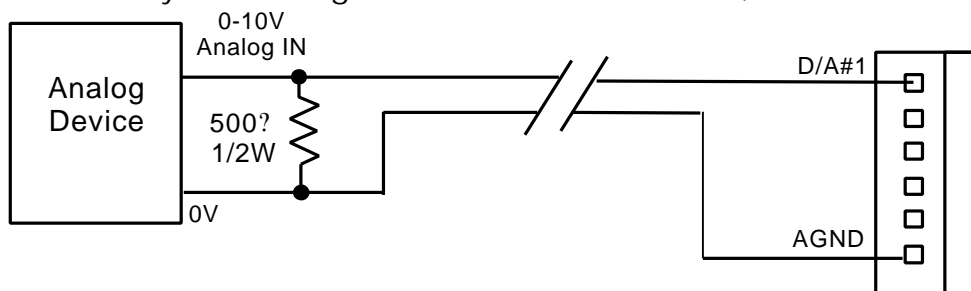
7.3 <u>Analog Output #1</u>

T100MD features 1 channel of 8-bit Digital-to-Analog converter. D/A #1 output is a 0-20mA current loop signal. Current loop output has the advantage over voltage output especially for long distance applications because the signal would not be diminished by the resistance of the wire. The 0-20mA current loop output works by controlling the output voltage until it achieves the desired current. When the loop is opened (not connected to the load) the output will be driving at its maximum voltage (known as the output compliance) The compliance is about =(analog power supply voltage - 2V). i.e. if the analog power supply is 20V, the output compliance is about 18V.

<u>Calibration of Analog Output #1</u>: A preset potentiometer marked "Cal DA1" is available for calibrating the 0-20mA output. Write a short program to execute the following statement: SETDAC 1,2048. Then use a multimeter to measure the loop current between D/A #1 and 0V terminal. Adjust the potentiometer until you obtain a current reading of 10.0 mA.

The Rev D board T100MD1616+ actually also features D/A #2 to a PCB pads located just above DIP Switch #1. This is a 0-5V high impedance output which is unbuffered and unprotected and is connected directly to the CPU. This is made available for OEMs who need 2 analog outputs and are able to build their own D/A interface. However, use it with extreme care as damage to D/A #2 is not covered by warranty.

Conversion of 0-20mA to Voltage Outputs e.g. 0-10V

To convert a current loop output to a voltage output, connect a resistor R across the output terminals such that V = I x R. Hence to achieve 0-5V, connect a 250? resistor, and to achieve 0-10V, connect a 500? resistor. For loads located at a longer distance from the controller, you can take advantage of the current loop interface by connecting the resistor at the load end, as follow:

This method will only work if the target analog load is of sufficiently high input impedance (most are) which means the current drawn by the input is negligible.
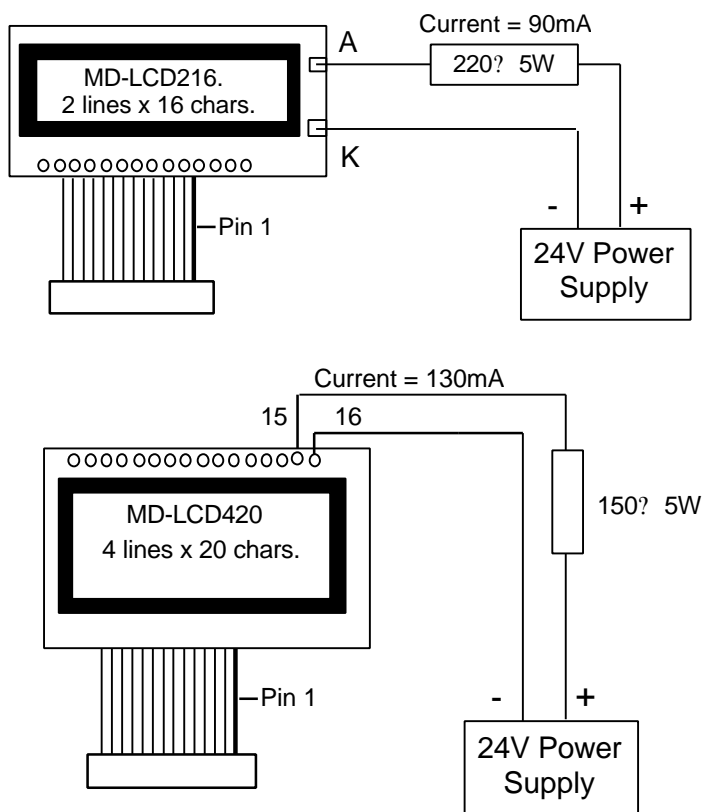
If there is a need to parallel the output to more than one device, then only one resistor is used.

Programming Analog Output

You can use the TBASIC command SETDAC 1,x to set the analog output to a 12-bit value x. (x = 0 to 4096). The actual analog outputs can only assume the value 0,16,32,48...4080 because of its 8-bit resolution, which was normalized to 12-bit by multiplying by 16. So if you execute SETDAC 1.20 the actual output will only be assigned a value =16.

Appendix: LCD Display For T100MD-1616+: Wiring Instruction

TRi currently supplies two models of back-lit LCD display modules for use with the T100MD-1616+ PLC. Each model is supplied with a 0.5m long 14 pin ribbon cable for connection to the T100MD-1616+'s LCD port. Simply plug the 14-pin plug onto the LCD port header, making sure that the pin 1 (the colored wire) of the ribbon cable aligns with the pin 1 of the port header. (Pin 1 is the pin with a square solder pad and the pin number is also printed on the PCB.). However, wiring of the back-lights differs slightly for the two models as shown below. It is assumed that the unit will be connected to the 24V power supply of the T100MD-1616+ PLC. If you are using other voltages then compute the values of the current limiting resistors to obtain the same back-light current.

IMPORTANT!

Please ensure that the current limiting resistor is in place and functioning properly before turning on the power supply. Connecting the LED backlight to the 24V power supply without the current limiting resistor will definitely destroy the backlight unit. Also ensure that the polarity is connected correctly as reverse connection is likely to damage the backlight unit as well.

For MD-LCD420 the backlight is brought to a screw terminal via a small PCB. Use a multi-meter to check which terminal is connected to pin 15 (Anode+) and 16 (Cathode-) if the legend is not clearly visible.