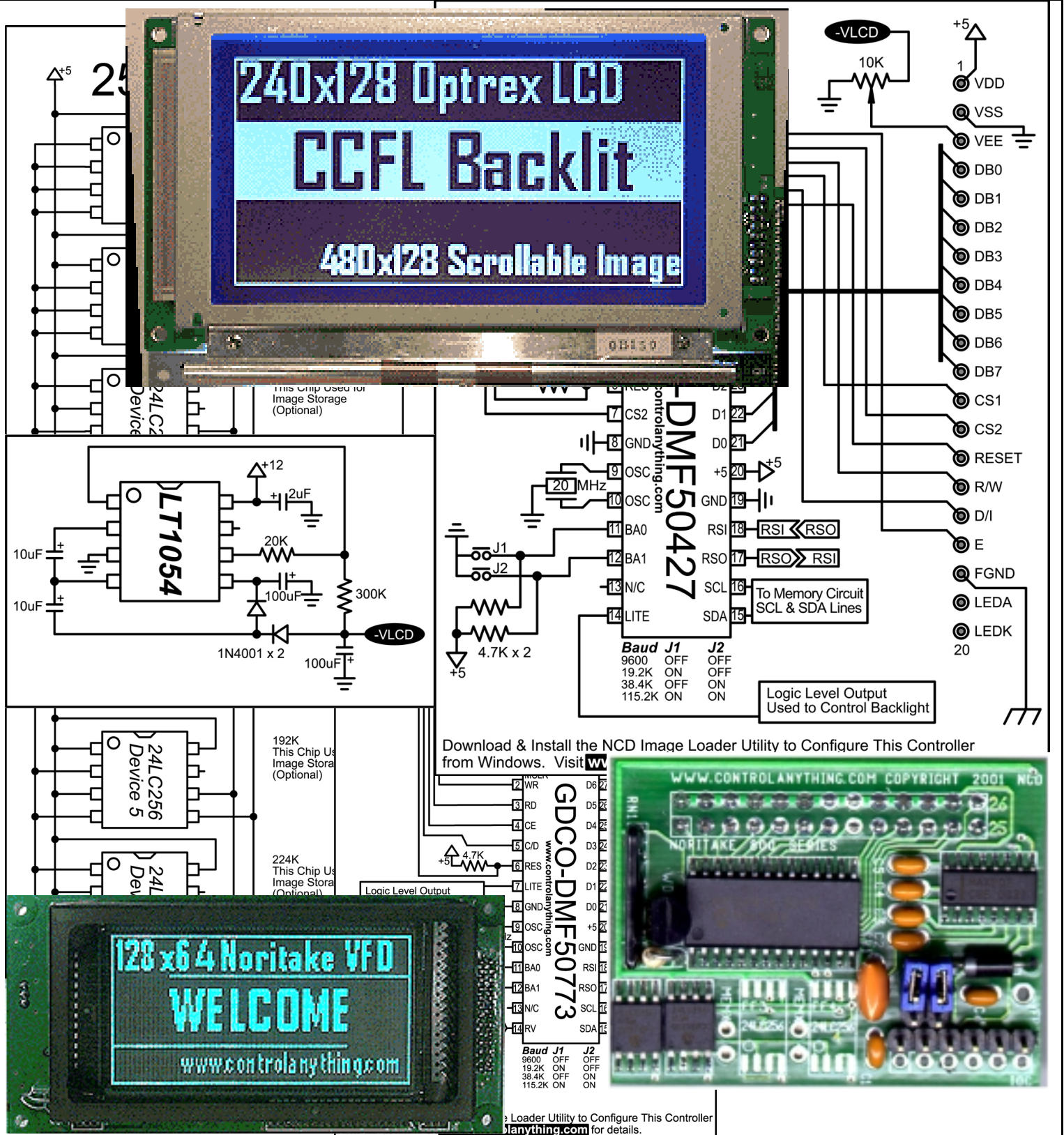


Embedding NCD Graphic Display Controllers



Introduction

In January, 2001, we released our fourth generation of graphic display controllers. Unlike previous releases, we were able to modularize our designs in an effort to make them compatible with future generations of display technologies.

This document guides you through the design process of building your own graphic display controller using NCD firmware. This document explains the electronic theories used in our designs, it does NOT discuss commands or usage of our display controllers. Here, we will focus on the usage of our firmware by modularizing the individual support circuits required to make proper use of our firmware in conjunction with various types of graphic display technologies.

Additional information concerning the command set, programming, and the required NCD Image Loader (a utility used to store pictures into display controller memory) can be found on our web site at www.controlanything.com.

The contents of this document should be used to assist in the engineering or embedding of NCD graphic display firmware into a custom application. The schematics provided in this document do not necessarily reflect the actual board designs released by National Control Devices. Therefore, this document SHOULD NOT be used for troubleshooting of these designs.

Choosing a Display Technology

While it is our intention to eventually support just about every sub-VGA graphic display ever produced, it only makes sense that we begin our designs using the most commonly available display technologies. We currently support firmware for vacuum florescent displays as well as many popular sizes of LCD displays. If you are unsure of which display technology to choose in your new design, our explanation of these technologies will give you a good understanding of what to expect from the most popular display technologies.

Vacuum Florescent Displays

Vacuum florescent displays yield the best picture quality of all monochromatic display technologies. They offer the furthest viewing distance, the highest contrast, and the widest viewing area at the expense of being somewhat high-cost and power-hungry. VF displays typically have large pixels and light up bright blue-green using a technology similar to that of a television set. VF displays are typically not an ideal choice for use in direct sunlight. However, a small amount of shade will make them viewable again because of their high-brightness. Physically, VF displays are a little heavy, relatively thick, and somewhat fragile. It is much easier to design a controller for VF displays because of their single +5 volt requirement. Unlike LCDs, they do NOT require a negative voltage inverter to bring the display into viewable bias, further simplifying the design of a VF display controller. The release of the Noritake 800 series displays (supported by NCD firmware), makes significant strides in lowering the cost of this fantastic technology.

Liquid Crystal Displays

Liquid Crystal Displays are the most common type of sub-VGA display technology available. They are relatively low-cost, offer good contrast and viewing distance while maintaining low-power requirements. Many monochrome LCDs are sunlight readable. LCDs are chosen in designs where the user interface is near the user and the viewing area does not have to be shared by neighboring users.

LCDs can require up to 3 separate power supplies, making the electronics somewhat more complicated to produce. Note that we have provided solutions for all power requirements in this guide. As a rule, LCD are chosen because of their high durability and low cost. Newer LCD technologies have made some LCD display models comparatively bright to vacuum florescent displays.

Supported Vacuum Florescent Display Models

We currently support the following Noritake Vacuum Florescent Display Models.

Noritake Display Model Number	Part Number issued by Noritake, www.noritake.com .
NCD Firmware Part Number	Firmware used to control Noriake Display Model Number
Current Firmware Version	Current Firmware Release Version Number
Pixel Array Size	Display Area in Pixels
NCD Board Release Part Number	Printed Circuit Board Product using Indicated Firmware

Noritake Display Model Number	NCD Firmware Part Number	Current Firm-ware Version	Pixel Array Size (width x height)	NCD Board Release Part Number	Schematic
GU128x32-800	GDCN-GU128x32	V1.0	128x32	VFD800	Page 8
GU128x64-800	GDCN-GU128x64	V1.0	128x64	VFD800	Page 8
GU160x16-800	GDCN-GU160x16	V1.0	160x16	VFD800	Page 8
GU160x32-800	GDCN-GU160x32	V1.0	160x32	VFD800	Page 8
GU192x16-800	GDCN-GU192x16	V1.0	192x16	VFD800	Page 8
GU256x32-800	GDCN-GU256x32	V1.0	256x32	VFD800	Page 8
GU256x64-372	Not Released	Not Released	256x64	VFC256x64	Firmware was NOT released, only a board-level product for this display model.

Supported Liquid Crystal Display Models

We currently support the following Optrex Liquid Crystal Display Models.

Optrex Display Model Number	Part Number issued by Optrex
NCD Firmware Part Number	Firmware used to control Optrex Display Model Number
Current Firmware Version	Current Firmware Release Version Number
Pixel Array Size	Display Area in Pixels

Optrex Display Model Number	Backlight	NCD Firmware Part Number	Current Firm-ware Version	Pixel Array Size (width x height)	Schematic
DMF50426	LED	GDCO-DMF50426	V1.0	128x32	Page 9
DMF50427	LED	GDCO-DMF50426	V1.0	128x64	Page 10
DMF5005/10	LED or CCFL	GDCO-DMF5005/10	V1.0	240x64	Page 11
DMF5001	CCFL	GDCO-DMF5001	V1.0	160x128	Page 12
DMF5003	LED	GDCO-DMF5001	V1.0	160x128	Page 13
DMF50773	LED or CCFL	GDCO-DMF5773	V1.0	240x128	Page 14

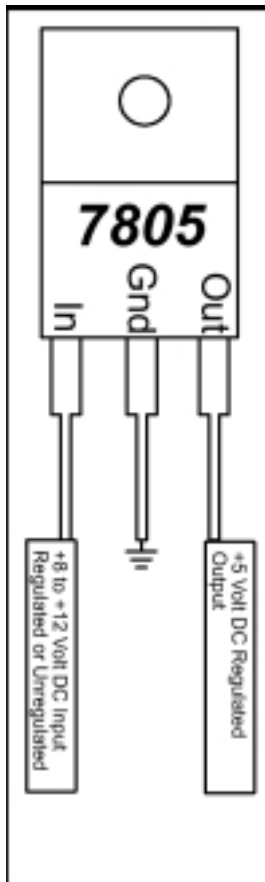
Building a Power Supply

Perhaps the most difficult part of designing a graphic LCD display controller is setting up the power supply requirements. While this is no trick for Vacuum Florescent screens (since they only need a single +5 volt supply), planning the power system for a graphic LCD will prove to be more complicated.

A typical LCD display requires 3 voltage levels. A single +5 volt DC supply powers the logic on the LCD display. LCD also require a negative voltage (used for adjusting display contrast), typically between -5 and -12 volts DC. The only way to produce this negative voltage is to use a negative voltage inverter such as the LT1054. But the LT1054 requires +9 to +12 volts to generate negative voltages.

We highly recommend the use of a single +12 volt power supply when controlling an LCD display. A single +12 volt power source is commonly available, and is easily converted to +5 volts and -12 volts DC.

+12 Volts to +5 Volts



The illustration at left uses the popular 7805 voltage regulator to drop +12 volts down to a regulated +5 volt supply suitable for powering the logic on the display and the RS-232 display controller. The 7805 is available from www.digikey.com or from your local Radio Shack.

You should use .1uF capacitors between ground and input to help filter incoming noise.

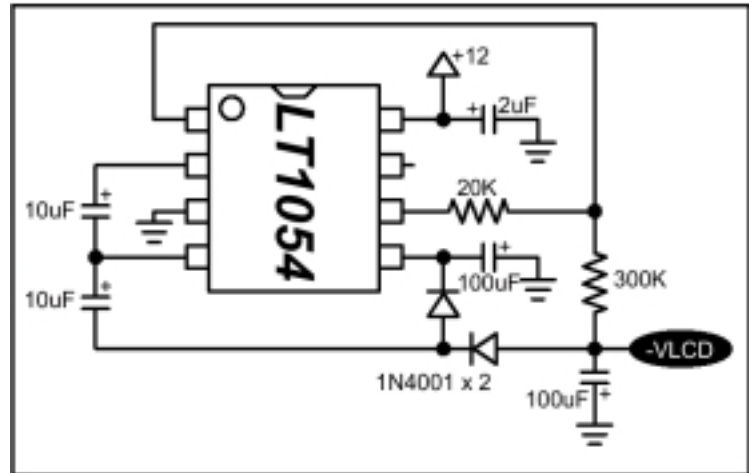
A .1uF cap between the ground and output is also recommended to reduce noise generated by various high-speed clock signals on the logic side.

If you choose to omit these capacitors, you may see noise on the display in the form of a wavy or uneven image. Noise suppression is recommended regardless of the display type you choose.

+12 Volts to -12 Volts

The following circuit was published in the Linear Technology Linear Applications Handbook, Volume 1, 1990. Application note AN30-37, Figure 67.

I have chosen this circuit because it makes use of the popular LT1054 configured as a negative voltage doubler with regulator. The LT1054 is commonly available from www.digikey.com, is low cost, and requires only basic support components (many of them require chokes, which can be difficult to find). This circuit only requires a small handful of parts and is very effective in generating negative voltages suitable for driving all monochrome LCDs up to 256x128.



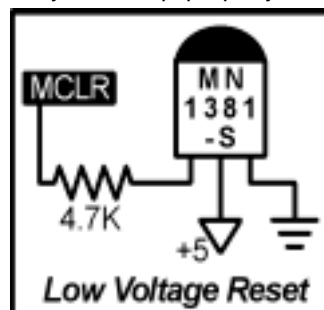
The black -VLCD output is your negative output and must be connected to the -VLCD indicated in the schematics later in this manual. **The LT1054 may NOT be necessary in some LCD Display Controller Designs. See Hint on Page 5.**

PCB Board Design & Power Supplies

When designing your own circuit board, use thicker traces for all power supply lines. Be sure to star your supply traces from the incoming power connector. This will help eliminate noise. Also, use plenty of .1uf capacitors between the power supply lines and ground. This will also help reduce noise, which in turn will improve image quality. Remember, a noise design will result in a noisy display image.

Low Voltage Reset

The Low-Voltage Reset circuit is a very important part of this design. While it is possible to use our microprocessors without this low-voltage detector, you may find the display may not always boot up properly. This circuit makes sure the operating



voltage is well within specification. The MCLR line in the diagram connects to the MCLR line on the CPU. The 4.7K resistor ensures compatibility with our programmer should your design need to be sent to us for an in-circuit firmware update.

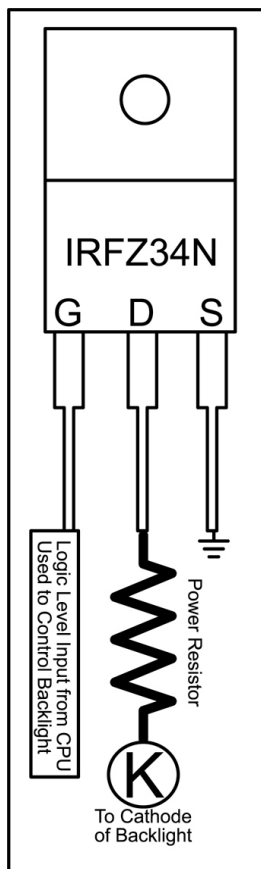
The MN1381-S is available from www.digikey.com.

Software Controlled Backlight

If you are using an LED or CCFL backlit LCD, then you may want to take advantage of the software controlled backlight designed into our firmware. The following circuit demonstrates the connection of a Hexfet manufactured by International Rectifier for software control of both LED or CCFL backlights.

You do NOT have to use a Hexfet, you can use many types of switching devices. We chose a Hexfet that we regularly stock, and admittedly, it is complete overkill for the load being placed on it.

The LITE line of our CPU is turned on when power is first applied to our graphic display controller CPU. As the bootup process executes, the firmware reads user settings to determine whether the backlight should remain on or be turned off as the power-up default. The LITE line can also be software-controlled by the user.



The LITE line from the display controller CPU connects to the Gate of the Hexfet. The Drain line connects to the ground of the CCFL inverter or the Cathode (K) of the LED Backlight. The Source of the Hexfet connects to ground. When the LITE line goes high, the Gate between Source and Drain are connected, essentially "feeding" the LED or CCFL inverter a ground signal. When the LITE line is turned off, the ground connection to the LED or CCFL inverter is severed. At all times, the LED or CCFL inverter will have a positive voltage going into the Anode side.

If you decide to use a Hexfet in your design, consult www.digikey.com for commonly available, low-cost Hexfets. Most of the 4-Pin DIP and TO-220 package Hexfets will work, but make sure you choose an N-Channel device.

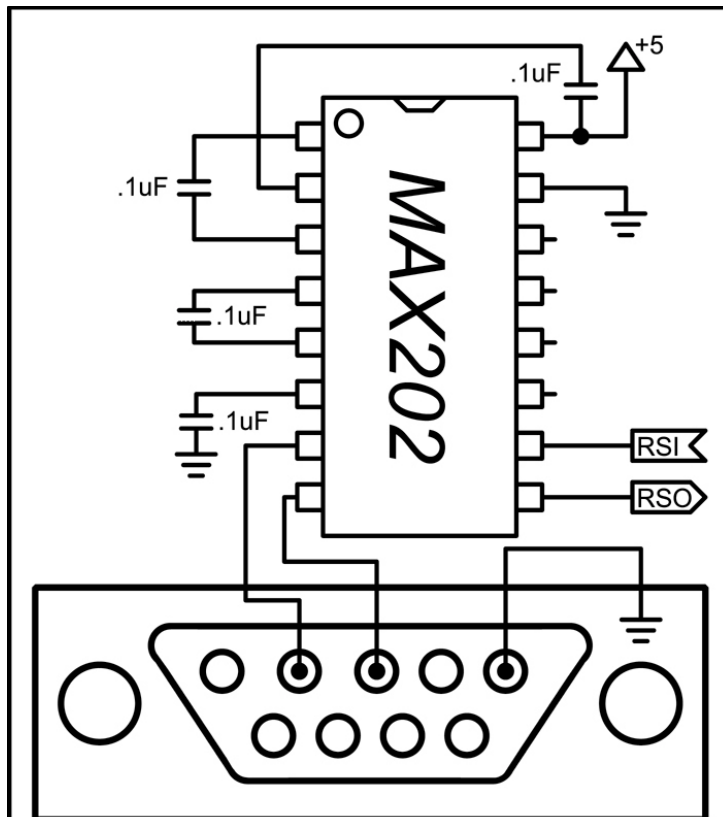
Note that a Power Resistor should be used to limit the current into LED backlit displays. Use two 4.3 Ohm 10 Watt resistors when dropping the voltage down from +12 Volts to +4.1 Volts as required by most LED backlights. If you are an experienced user capable of running your display at 5 volts, use a 2 Ohm 3 Watt resistor to drop +5 volts down to +4.1 Volts.

RS-232 Interface

Building an RS-232 interface for our display controller chips is relatively easy using the MAX202 chip from Maxim (available from www.digikey.com or www.maxim-ic.com). This is a standard circuit as published in the Maxim data sheets.

Hint:

If you are controlling an LCD screen that is 240x64 or smaller, it is possible to eliminate the LT1054 negative voltage inverter completely. Simply use Pin 6 of the MAX202 for the -V_{LCD} voltage. The LCD only draws a small amount of current from the MAX202, keeping RS-232 communications well within specifications.



DB9 Female: Solder Side Connect to any Available RS-232 Serial Port.

**RSO Connects to RSI on Controller Chip
RSI Connects to RSO on Controller Chip**

If you experience communication problems between your computer and the display controller chip, make sure the MAX202 is properly wired. Take particular care to ensure the RS-232 Data Output of the MAX202 chip connects to the Data Input of the display controller chip. Make sure the RS-232 Data Output on the display controller chip connects to the RS-232 Data Input on the MAX202 chip. A very common, yet harmless mistake is to reverse the RSI and RSO lines when connecting them to the display controller chip. Use the NCD Image Loader Utility to Verify Communication. A "No Response" Error may indicate improper wiring.

Non-Volatile Memory

Our line of graphic display controllers **REQUIRES** at least one EEPROM memory chip (wired as Device 0) as shown in the schematic. The Microchip 24LC256 was chosen because of its high-capacity and low cost. The 24LC256 is available from www.digikey.com.

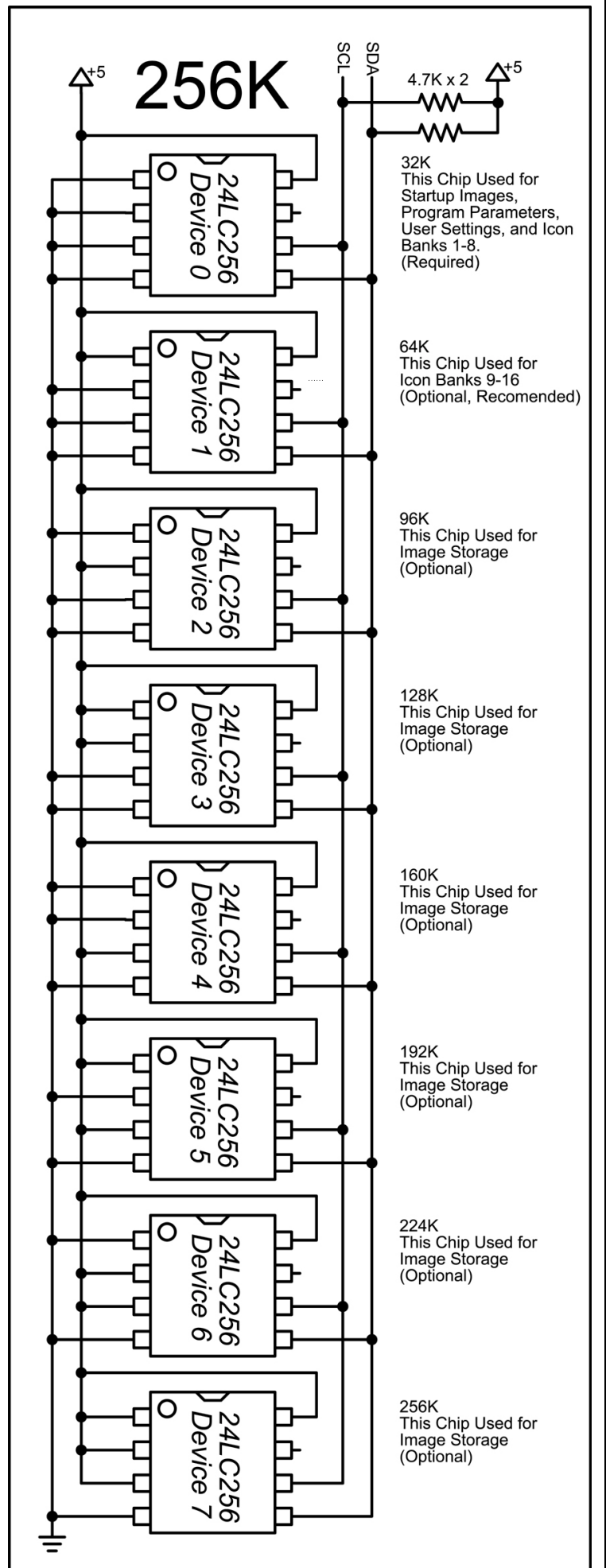
The Device 0 EEPROM is used to store user-settings, a startup-image, ICON banks (or fonts) 1-8, and various other firmware parameters important for proper operation.

The second EEPROM memory chip, Device 1, is highly recommended. It is used **EXCLUSIVELY** for storage of ICON banks 9-16. This chip may be eliminated for the purposes of building a more cost-effective controller. The NCD Image Loader Utility **EXPECTS** this chip to be installed. Trying to store ICONs in banks 9-16 (without this chip installed) will result in unpredictable results, though no permanent damage will result (but it may be necessary to exit the Image Loader Utility **AND** reset the display controller).

EEPROM devices 2-7 are used to store image data and are completely optional. Of course, adding more image memory will allow you to permanently store images in the display controller.

Note:

As of firmware revision 1.0 for the Noritake Vacuum Florescent Display Controller chips, Devices 4-7 are **NOT** supported by the firmware. Later revisions are planned to support memory devices 4-7.



Important Precautions

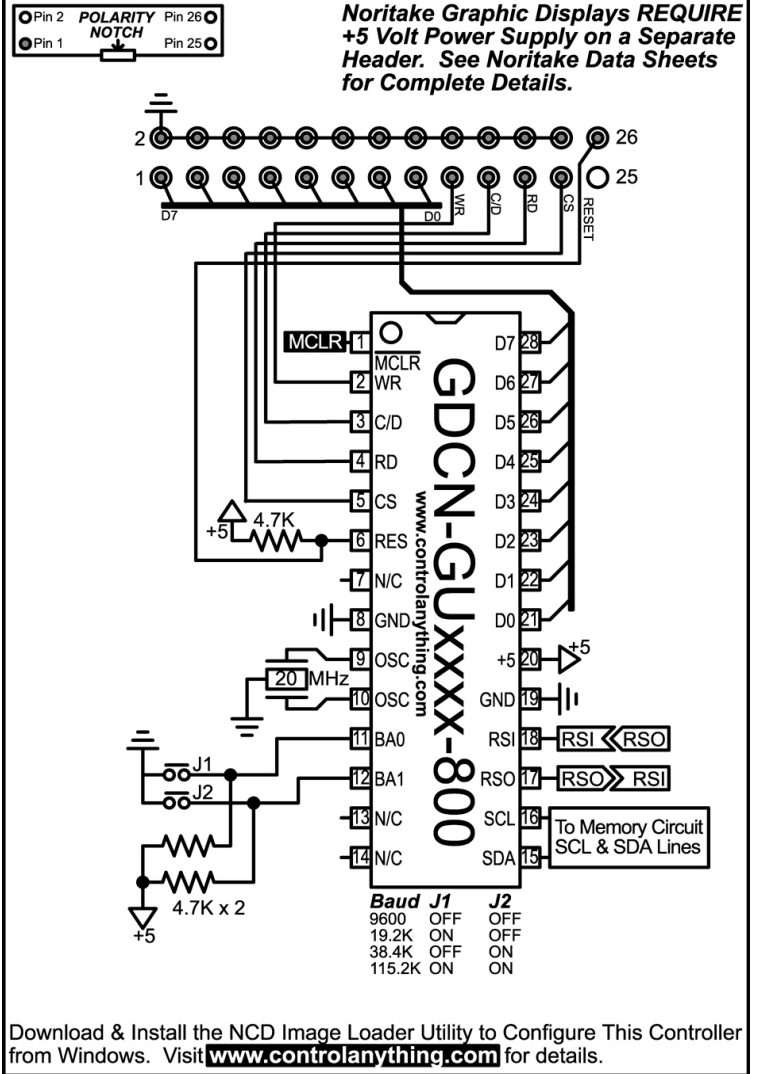
The 20 MHz Ceramic Resonator, Included with the display controller chip, is NOT polarity sensitive. The center lead of this device connects to ground. See sample schematic.

Never use an Oscilloscope to monitor the OSC lines on the display controller chip. Doing so has been known to permanently damage the CPU. Only monitor these lines with an Oscilloscope if you are failure with troubleshooting these devices.

Never use a breadboard when prototyping this device. A breadboard will disrupt the OSC lines of this chips, potentially causing permanent damage. For best results, solder a 28-pin socket onto a blank perforated board and insert the chip only after the electronics have been completed.

Follow the voltage requirements and polarity indicators strictly. Use only a well regulated power supply, suitable for computers or other digital electronics when powering these devices. Never "Ramp" the voltage up to the voltage requirements, doing so may result in CPU lockup.

Static is always a concern when working with electronic devices. Always discharge static from your body prior to working with these devices. A static strap is highly recommended.



Building a VF Display Controller

Noritake did us a tremendous favor when they decided to use a single layout for a standardized 26-pin connector for ALL of their displays. This greatly reduced development time for the GDCN line of display controller chips. The GDCN (Graphic Display Controller Noritake) firmware were the first modular graphic display controller chips we developed. We began our designs with the GDCN line because the Noritake screens required only a single +5 volt supply (like our controller).

As of this writing, Noritake has completed the release of the following graphic displays compatible with this schematic:

Noritake Display	Display Size	NCD Controller Chip
GU128x32-800	128 x 32	GDCN-GU128x32-800
GU128x64-800	128 x 64	GDCN-GU128x64-800
GU160x16-800	160 x 16	GDCN-GU160x16-800
GU160x32-800	160 x 32	GDCN-GU160x32-800
GU192x16-800	192 x 16	GDCN-GU192x16-800
GU256x32-800	256 x 32	GDCN-GU256x32-800

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	Memory Device 1-3, Page 6
RS-232 Interface, Page 5	
Memory Device 0, Page 6	

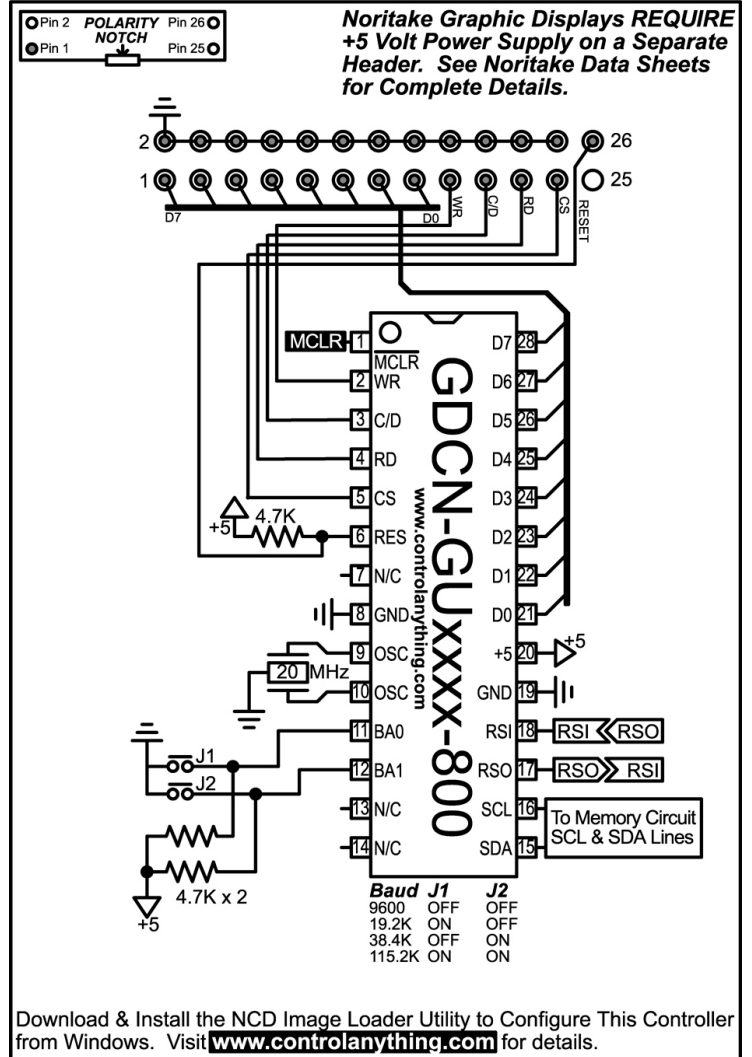
IMPORTANT VOLTAGE REQUIREMENT:

Every Noritake screen has a small 3-pin header used to supply power to the display screen. One of these pins is used to supply +5 volts to the display screen (see Noritake Data Sheets for details, www.noritake.com). If the controller responds properly, but nothing appears on the screen, check the 3-pin power connector to make sure it is properly wired to a +5 volt power supply.

Noritake VF displays have a long thin filament that runs horizontally across the display. In a dark room, these filaments will dimly glow (a faint orange color) when power is properly connected to the display.



Noritake GU128x64-800 Vacuum Fluorescent Display controlled with our GDCN-GU128x64-800 controller chip.



Download & Install the NCD Image Loader Utility to Configure This Controller from Windows. Visit www.controlanything.com for details.



Noritake GU256x32-800 Vacuum Fluorescent Display controlled with our GDCN-GU256x32-800 controller chip.



The NCD VF800 Universal Display controller may be factory programmed with GDCN-GUxxxx-800 firmware for control of ANY Noritake -800 series display. This device adds serial communications and a simple command set, making the Noritake Line of Vacuum Fluorescent Displays easy to control from any computer or embedded system.



Noritake GU160x16-800 controlled by our GDCN-GU160x16-800 controller chip.



Noritake GU160x32-800 controlled by our GDCN-GU160x32-800 controller chip.

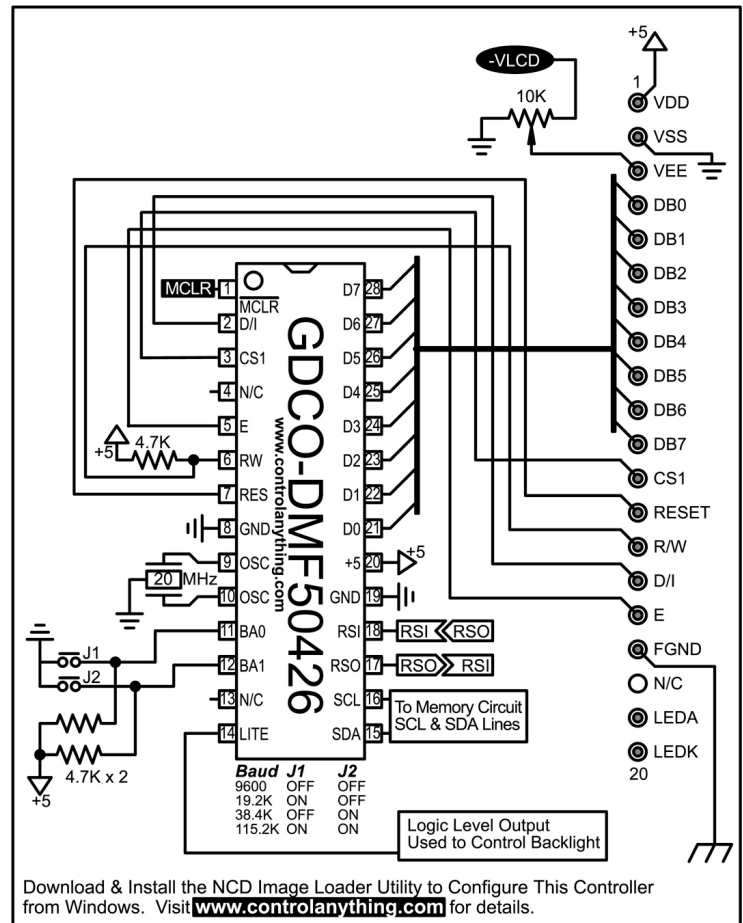
Building the DMF50426 128x32 LCD Display Controller

The GDCO-DMF50426 RS-232 display controller chip should be used with the Optrex DMF50426 series LED and Reflective LCD displays. The DMF50426 is a very small high-resolution 128x32 display. The controller is very easy to build as seen in the schematic.

The LEDA and LEDK lines on the 20-Pin connector supply the LED backlight with power. Follow the directions on Page 5 if you would like to make the backlight software controllable.

The DMF50426 requires a negative voltage (-VLCD), which can be supplied by Pin 6 of the MAX202 RS-232 interface circuit shown on page 5.

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	LT1054 & 7805, Page 4
RS-232 Interface, Page 5	Soft-Backlight, Page 5
Memory Device 0, Page 6	Memory Device 1-7, Page 6



The Optrex DMF50426 LCD Display with LED Backlight controlled by the GDCO-DMF50426 RS-232 LCD Display Controller Chip.

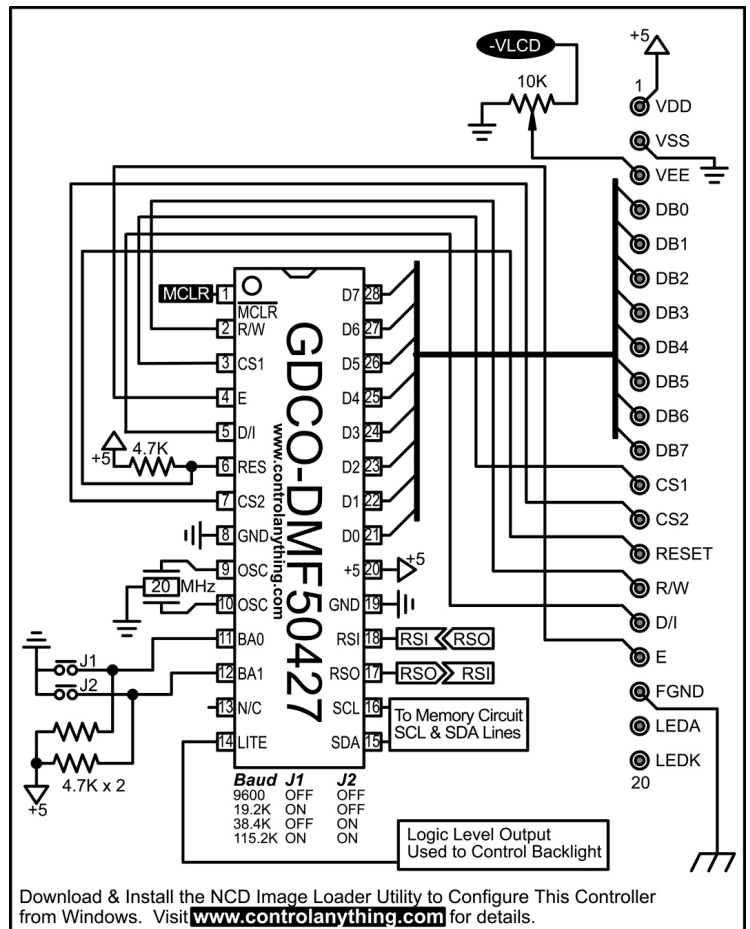
Building the DMF50427 128x64 LCD Display Controller

The GDCO-DMF50427 RS-232 display controller chip should be used with the Optrex DMF50427 series LED and Reflective LCD displays. The DMF50427 is a very small high-resolution 128x64 display. The controller is very easy to build as seen in the schematic.

The LEDA and LEDK lines on the 20-Pin connector supply the LED backlight with power. Follow the directions on Page 5 if you would like to make the backlight software controllable.

The DMF50427 requires a negative voltage (-VLCD), which can be supplied by Pin 6 of the MAX202 RS-232 interface circuit shown on page 5.

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	LT1054 & 7805, Page 4
RS-232 Interface, Page 5	Soft-Backlight, Page 5
Memory Device 0, Page 6	Memory Device 1-7, Page 6



The Optrex DMF50427 LCD Display with LED Backlight controlled by the GDCO-DMF50427 RS-232 LCD Display Controller Chip.

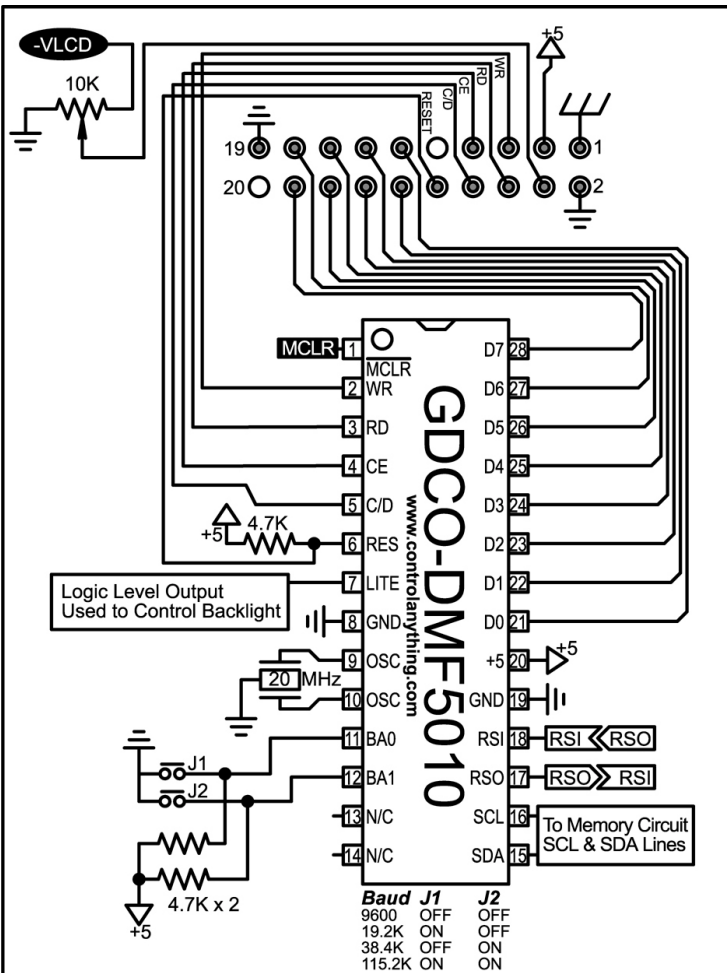
Building the DMF5005 & DMF5010 240x64 LCD Display Controller

The GDCO-DMF5005/10 RS-232 display controller chips were designed to accommodate the Optrex line of 240x64 LCD displays. The Optrex line offers a large display area with a built-in character generator and large 480x128 scrollable image area (240x64 viewable). The controller is very easy to build as seen in the schematic.

The LEDA and LEDK lines on the side of the display supply the LED backlight with power. Follow the directions on Page 5 if you would like to make the backlight software controllable. Detailed information on CCFL inverters should be obtained from Optrex USA directly.

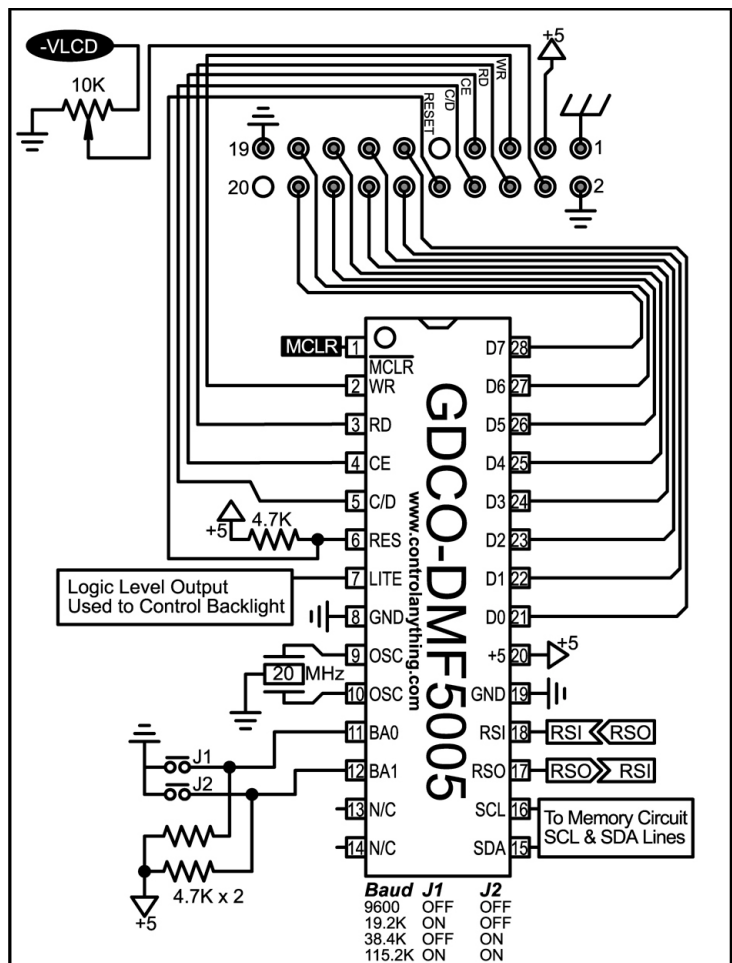
The DMF5005/10 requires a negative voltage (-VLCD), which can be supplied by Pin 6 of the MAX202 RS-232 interface circuit shown on page 5.

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	LT1054 & 7805, Page 4
RS-232 Interface, Page 5	Soft-Backlight, Page 5
Memory Device 0, Page 6	Memory Device 1-7, Page 6

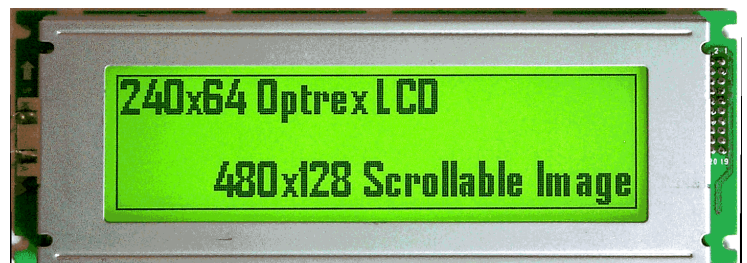


DMF5010 has a 20x1 Single In-Line Connector, Pinout Same as DMF5005.

Download & Install the NCD Image Loader Utility to Configure This Controller from Windows. Visit www.controlanything.com for details.



Download & Install the NCD Image Loader Utility to Configure This Controller from Windows. Visit www.controlanything.com for details.



The Optrex DMF5005 LCD Display with LED Backlight controlled by the GDCO-DMF5005 RS-232 LCD Display Controller Chip.



The Optrex DMF5010 LCD Display with CCFL Backlight controlled by the GDCO-DMF5010 RS-232 LCD Display Controller Chip. This display is very similar to the DMF5005, with the exception that it uses a 20x1 single in-line header rather than a 2x10 dual-row header. Detailed information on the backlight inverter is available from Optrex USA.

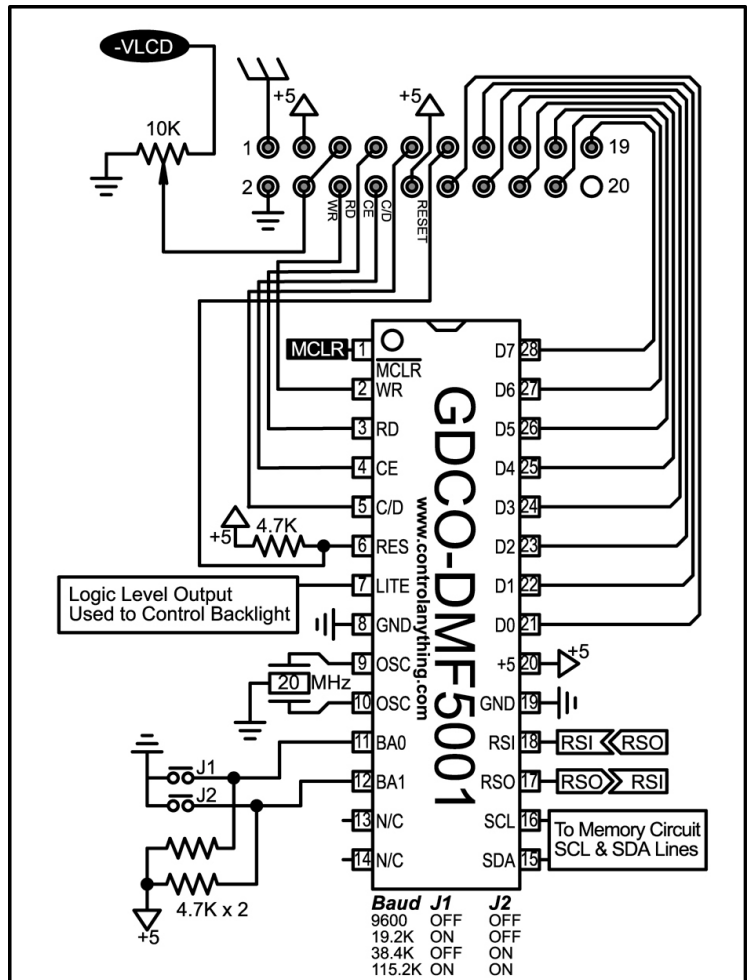
Building the DMF5001 160x128 LCD Display Controller

The GDCO-DMF5001 RS-232 display controller chip should be used with the Optrex DMF5001 series LED Backlit LCD displays. The DMF5001 offers a large display area with a built-in character generator and large 480x128 scrollable image area (160x128 viewable). The controller is very easy to build as seen in the schematic.

The DMF5001 requires a negative voltage (-VLCD), which can be supplied by the LT1054 on Page 4.

The LEDA and LEDK lines on the side of the display supply the LED backlight with power. Follow the directions on Page 5 if you would like to make the backlight software controllable.

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	Soft-Backlight, Page 5
LT1054 & 7805, Page 4	Memory Device 1-7, Page 6
RS-232 Interface, Page 5	
Memory Device 0, Page 6	



Download & Install the NCD Image Loader Utility to Configure This Controller from Windows. Visit www.controlanything.com for details.



The Optrex DMF5001 LCD Display with LED Backlight controlled by the GDCO-DMF5001 RS-232 LCD Display Controller Chip.

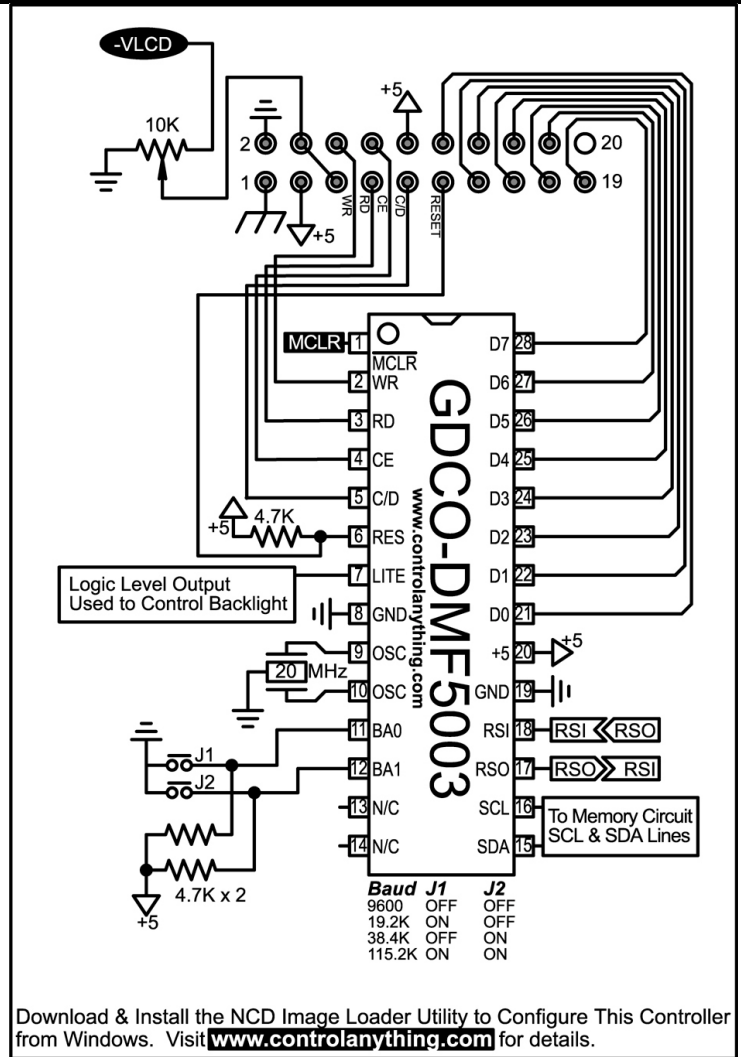
Building the DMF5003 160x128 LCD Display Controller

The GDCO-DMF5003 RS-232 display controller chip should be used with the Optrex DMF5003 series CCFL Backlit LCD displays. The DMF5003 offers a large display area with a built-in character generator and large 480x128 scrollable image area (160x128 viewable). The controller is very easy to build as seen in the schematic.

The DMF5003 requires a negative voltage (-VLCD), which can be supplied by the LT1054 on Page 4.

Detailed information on CCFL inverters should be obtained from Optrex USA directly.

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	Soft-Backlight, Page 5
LT1054 & 7805, Page 4	Memory Device 1-7, Page 6
RS-232 Interface, Page 5	
Memory Device 0, Page 6	



The Optrex DMF5003 LCD Display with CCFL Backlight controlled by the GDCO-DMF5003 RS-232 LCD Display Controller Chip.

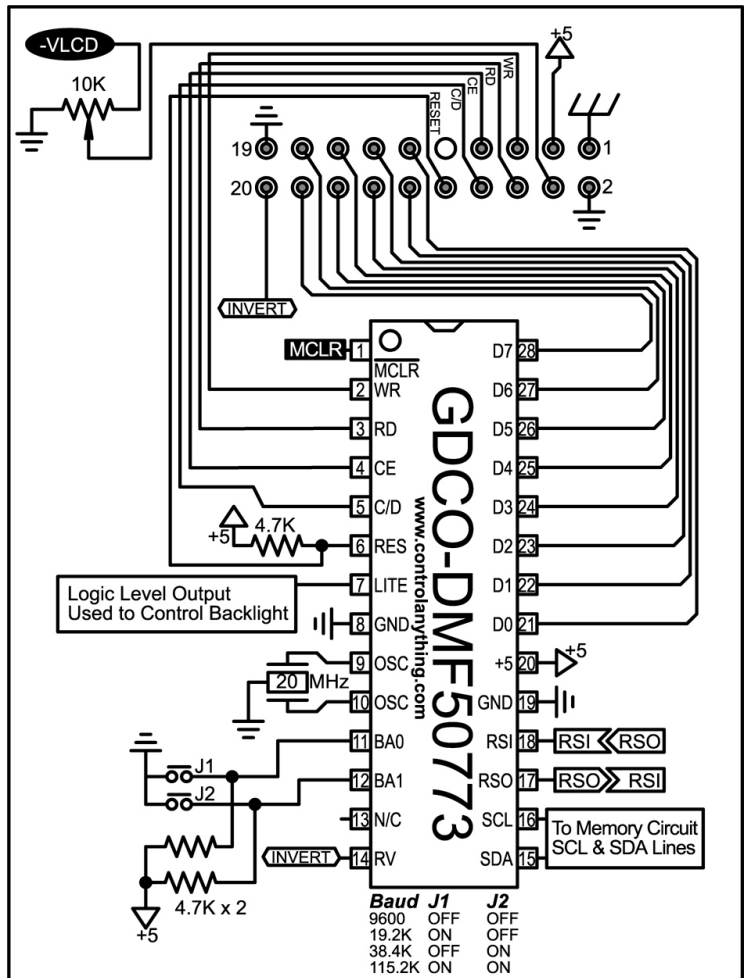
Building the DMF50773 240x128 LCD Display Controller

The GDCO-DMF50773 RS-232 display controller chip should be used with the Optrex DMF50773 series Reflective, LED, or CCFL Backlit LCD displays. The DMF50773 offers a large display area with a built-in character generator and large 480x128 scrollable image area (240x128 viewable). The controller is very easy to build as seen in the schematic.

The DMF50773 requires a negative voltage (-VLCD), which can be supplied by the LT1054 on Page 4.

Detailed information on CCFL inverters should be obtained from Optrex USA directly.

Required Support Electronics	Optional Support Electronics
Low Voltage Reset, Page 4	Soft-Backlight, Page 5
LT1054 & 7805, Page 4	Memory Device 1-7, Page 6
RS-232 Interface, Page 5	
Memory Device 0, Page 6	



Download & Install the NCD Image Loader Utility to Configure This Controller from Windows. Visit www.controlanything.com for details.



The Optrex DMF50773 LCD Display with CCFL Backlight controlled by the GDCO-DMF50773 RS-232 LCD Display Controller Chip.

Additional Resources

This guide was developed to demonstrate connection of NCD graphic display controller chips to various types of graphic display modules. This guide does NOT discuss the command set for the individual chips. The command set can be found at www.controlanything.com. Download the product manuals for the various display types to see examples of how to send commands to our line of graphic display controllers.

You will also need to download and install the NCD Image Loader Utility to initially configure the display controller with icons, images, fonts, and various user settings. The latest version of our ILU can always be found at www.controlanything.com, along with a comprehensive manual that discusses the use of this utility in depth.

We have also posted Basic Stamp II SX example code for controlling the various displays at www.controlanything.com.

Also on our web site is basic dimensional data for the displays that we offer.

Warranty

The devices discussed in this manual are provided to the user at the microprocessor level. Since it is impossible for us to guarantee proper handling of these devices, we cannot offer a warranty of any kind for microprocessor products if the seal to the packaging has been broken. Unopened microprocessors may be returned for a full refund or exchanged for a similar device.

Firmware upgrades are free. User pays all shipping charges.

The NCD line of graphic display controllers have been thoroughly tested prior to release. In its current state, no bugs have been found. As with any firmware, the potential for bugs does exist. This is why we offer a free firmware upgrade program. We WILL NOT accept a request for refund based on a bug report in our firmware. The user agrees, by opening of the sealed packaging, to accept the device in its current state of technology at the time of purchase. In the unlikely event a bug is discovered, it will be scheduled for immediate repair.

We reserve the right to improve upon our product without notice to the user. All changes to the firmware will be clearly posted on our web site. Changes may NOT be posted if they improve the internal workings of the firmware without affecting the user interface or instruction set.

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