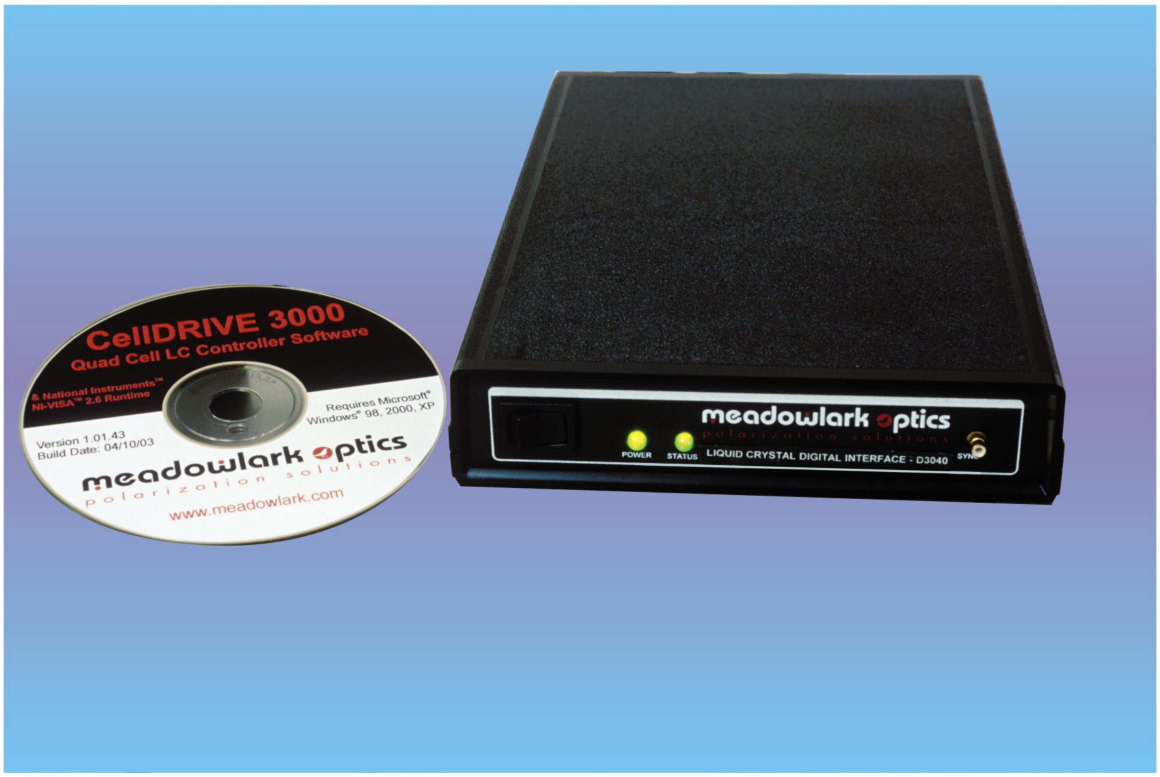


D3040 Quad Cell Nematic Liquid Crystal Digital Interface User's Manual

Revision 2.01

meadowlark optics
polarization solutions

D3040 Quad Cell Nematic Liquid Crystal Digital Interface
Quick Setup Guide

1. Install the CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced software on a PC running Microsoft® Windows® (98SE or later). Place the included CD in the CD-ROM drive, open the "Installer" folder, and double-click "setup.exe".

2. Plug either the USB or serial cable into the appropriate connector on the D3040 control module. Plug the other end into an appropriate USB or RS232 connector on the PC.

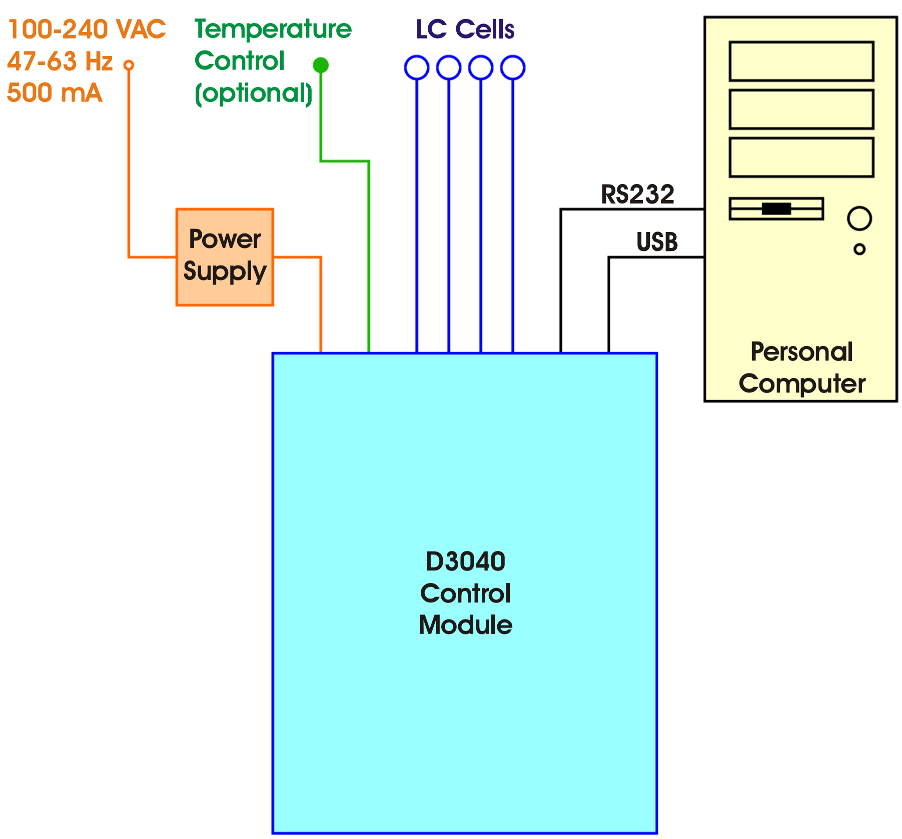
3. Connect up to four voltage-controlled liquid crystal devices to SMA connectors on the D3040 control module. If the temperature control option was included, connect a temperature sense-and-control cable to the five-pin LEMO™ connector on the D3040 control module.

4. Plug the power supply into the appropriate connector on the D3040 control module. Connect the power to a properly grounded outlet.

5. Power on the D3040 control module. Both LED's should illuminate. After a few seconds, the STATUS light will go off. The POWER light remains illuminated until the power is turned off.

6. If using a USB interface, Windows® will detect new hardware and prompt for a driver. The driver files are on the CellDRIVE 3000 CD. For Windows® 2000 and Windows® XP, drivers are in the USB DRIVERS\WIN2K_XP directory. The drivers for Windows® 98SE and Windows® ME are in the USB DRIVERS\WIN98_ME directory.

7. Start the CellDRIVE 3000 software by clicking Start|Programs|Meadowlark Optics|CellDRIVE 3000.



D3040 Quad Cell Nematic Liquid Crystal Digital Interface
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D3040 Quad Cell Nematic Liquid Crystal Digital Interface

The D3040 from Meadowlark Optics provides precise and convenient control of up to four liquid crystal cells. The D3040 control module generates 2-kHz null-offset squarewave signals on four industry-standard SMA connectors. Squarewave amplitudes are configured on a PC and communicated to the controller by serial or USB interface. The D3040 includes a CD with executable software developed in LabVIEW™, configuration for command line control by Microsoft® HyperTerminal, and development resources for customers wishing to design custom LabVIEW™ controls.

1. Nematic Liquid Crystal Variable Retarders: The Basics

1.1 Nematic LCVR physical architecture

Typical nematic Liquid Crystal Variable Retarders (LCVRs) such as the LVR- and LRC- series by Meadowlark Optics are constructed using optically flat fused silica windows coated with transparent conductive indium tin oxide (ITO). A thin dielectric layer is applied over the ITO and gently rubbed, creating parallel micro-grooves for liquid crystal molecular alignment. Two windows are then carefully aligned and spaced a few microns apart. The cavity is filled with birefringent nematic liquid crystal material. Electrical contacts are attached and the device is environmentally sealed

Anisotropic nematic liquid crystal molecules form uniaxial birefringent layers in the liquid crystal cell. An essential feature of nematic material is that, on average, molecules are aligned with their long axes parallel, but with their centers randomly distributed, as shown in Figure 1. With no voltage applied, the liquid crystal molecules lie parallel to the glass substrates and maximum retardation is achieved.

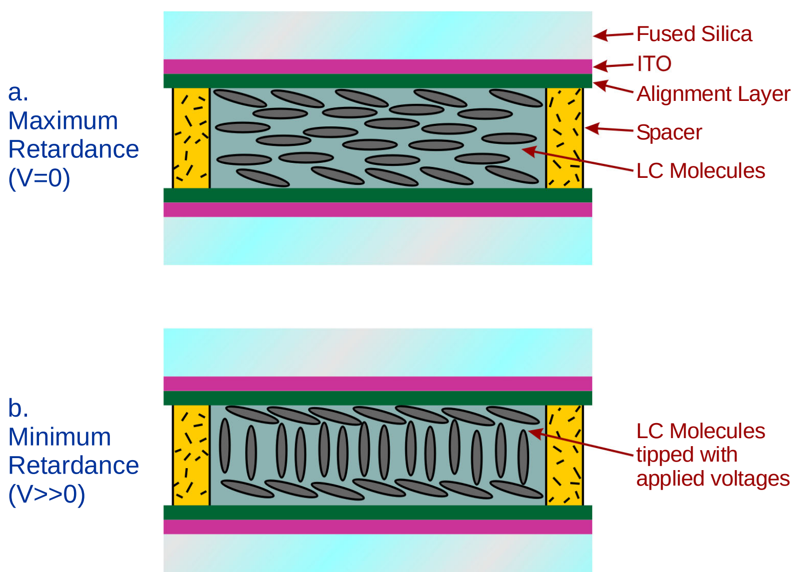

Figure 1 Liquid Crystal Variable Retarder construction showing molecular alignment (a) without and (b) with applied voltage (drawing not to scale)

When voltage is applied, liquid crystal molecules begin to tip perpendicular to the fused silica windows. As voltage increases, molecules tip further causing a reduction in the effective birefringence and hence, retardance. Molecules at the surface, however, are unable to rotate freely because they are pinned at the alignment layer. This surface pinning causes a residual retardance of ~30 nm even at high voltage (20 volts).
We achieve zero (or any custom) retardance with a subtractive fixed polymer retarder, called a compensator, attached to the liquid crystal cell. Negative retardance values are sometimes preferred for example, when converting between right- and left-circularly polarized states. Figure 2 illustrates retardance as a function of

voltage for a typical LCVR with and without an attached compensator. Placing a compensated LCVR between two high extinction polarizers creates an excellent optical attenuator, with convenient electronic control.

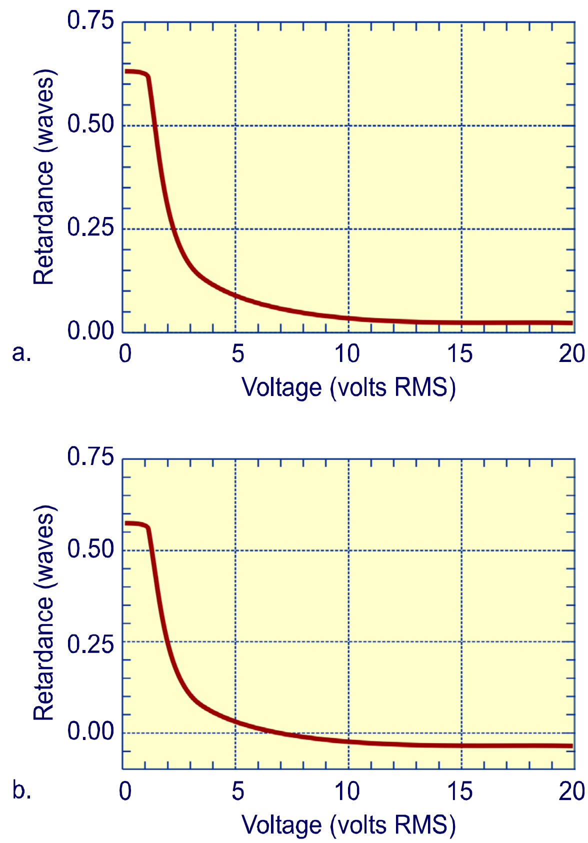

Figure 2 Liquid Crystal Variable Retarder performance at 632.8 nm, 21°C (a) without compensator, and (b) with compensator

As with any birefringent material, retardance is dependent upon thickness and birefringence. Liquid crystal material birefringence depends on operating wavelength, drive voltage, and temperature. The overall retardance of a liquid crystal cell decreases with increasing temperature (approximately -0.4% per °C).

1.2 Nematic LCVR response time

Liquid Crystal Variable Retarder response time depends on several parameters, including layer thickness, viscosity, temperature, variations in drive voltage, and surface treatment. Liquid crystal response time is proportional to the square of the layer thickness and therefore, the square of the maximum cell retardance.

Response time also depends upon direction of the retardance change. Nematic molecules can be forced into a tilted orientation faster than the intermolecular forces (from the alignment layers) can realign the molecular directions back to the zero-voltage state. Typical response time for a standard visible LCVR is shown in Figure 3. It takes about 5 ms to switch from one-half to zero waves (low to high voltage) and about 20 ms to switch from zero to one-half wave (high to low voltage). Response times improve by using custom materials with high birefringence and a thinner liquid crystal layer. At higher temperature, material viscosity decreases, also contributing to a faster response.

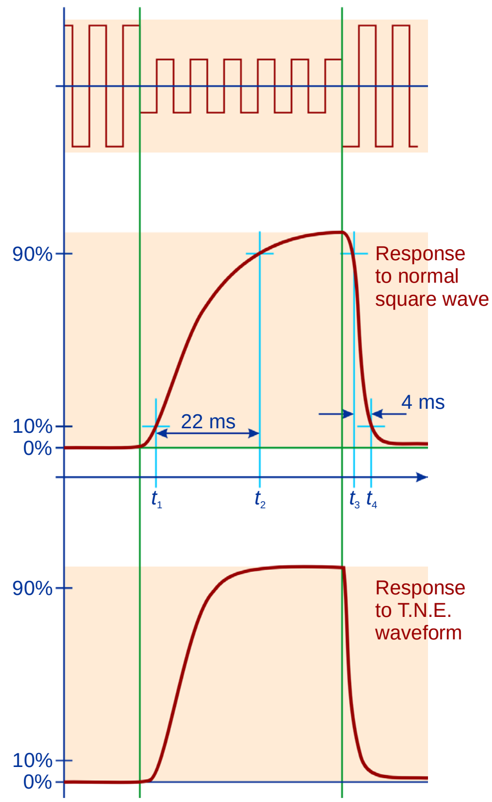

Figure 3 Transient response of LC variable retarder

Another technique involves the Transient Nematic Effect (TNE) to improve response times. With this drive method, a high voltage spike is applied to accelerate the molecular alignment parallel to the applied field. Voltage is then reduced to achieve the desired retardance. When switching from low to high retardance, all voltage is momentarily removed allowing the liquid crystal molecules to undergo natural relaxation. Response time achieved with the transient nematic effect is also shown in Figure 3.

Liquid crystal devices should be electrically driven with an AC waveform with no DC components to prevent ionic buildup which can damage the liquid crystal layer. LCVR's from Meadowlark Optics for instance require a 2 kHz square wave with a zero-average voltage. Retardance is controlled by varying the peak-to-peak voltage from zero to ±10V.

2. Hardware Setup and Configuration

2.1 Laboratory and system requirements for the D3040

- 1, 2, 3, or 4 voltage-controlled liquid crystal cells and SMA-to-SMB cables to connect the LC cells. BNC cables may be used with SMA-to-BNC adaptors. Please note that LC cells and cables are not included with the D3040.
- 100-240 VAC, 47-63 Hz 500 mA utility power.
- A PC with an available USB or serial port.
- Minimum PC requirements to run the included CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced software are a Pentium® processor, 32 MB RAM, 20 MB hard drive space, 800x600 pixel, 16-bit color or better graphics display, a CD-ROM, and Microsoft® Windows® 98/2000/XP. A Microsoft® HyperTerminal configuration is also included; HyperTerminal is component of Microsoft® Windows®.

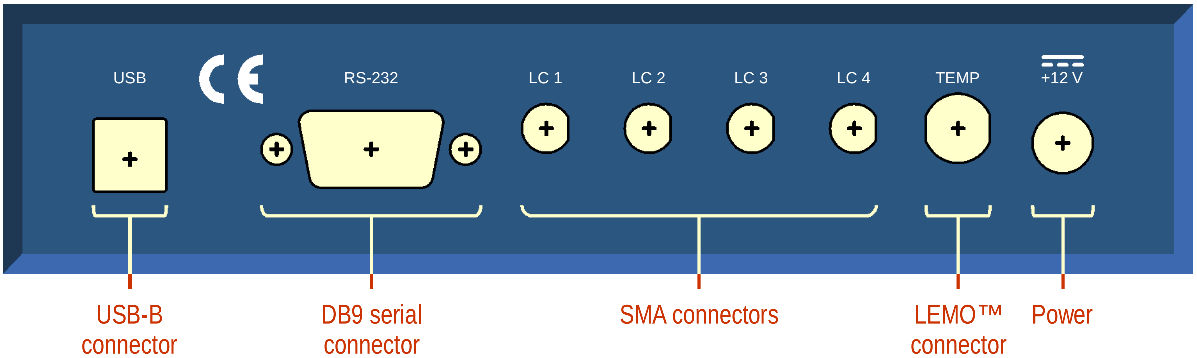

Figure 4 D3040 connector panel

2.2 Procedure for using the D3040

1. Unpack controller and cables from shipping container. Please verify that your shipment included:
   - D3040 controller unit (1 unit)
   - +12V power supply and power cable (1 unit with +12V cable attached and 1 AC power cable)
   - USB cable or Serial cable (1)
   - Temperature sensing/control cable (1, if your order included the temperature control option)
   - CellDRIVE 3000 software CD (1, Basic or Advanced version depending on your order)
   - User's manual (1 printed copy)

2. Install the CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced software.
   - Place the CellDRIVE 3000 CD in the CD-ROM.
   - Double-click the setup.exe icon in the Installer folder and follow the on-screen instructions to install CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced.

3. Hardware configuration of the D3040 control module:
   - Connect the +12VDC supply to the D3040 control module. Plug the power supply into a properly grounded AC outlet.
   - If using the USB interface, attach the USB cable to the USB connector on the rear of the D3040 control module, and connect the other end to an available USB port on a PC. If using the serial interface, attach the serial cable to the DB9 connector on the D3040 control module, and connect the other end to an available serial port on the PC.
   - Connect SMA to SMB cables to attach up to four liquid crystal cells to the controller. (If necessary, SMA to BNC adapters can be used to allow the use of BNC cables).
   - If the temperature control option was included, connect the temperature sensing/control cable to the five-pin NEMO® connector on the temperature-enabled D3040 control module.

4. Turn on the front panel switch and observe the LEDs. The green power LED remains illuminated as long as the unit is powered on. The yellow status LED illuminates for approximately 5 seconds as the D3040 control module performs a power-on self-test.

5. If using USB, Windows® will detect new hardware after the D3040 completes its self-test. For installation to a PC running Windows® 2000 or Windows® XP, direct Windows® to look in the USB Drivers\Win2K_XP directory on the CD. For installation to a PC running Windows® 98SE or Windows® ME, specify the USB Drivers\Win98_ME directory.

3. Computer Control of the D3040

The D3040 includes several computer-based approaches by which to control the amplitude of the 2-kHz square wave output signals. In this context, we refer to signals and waveforms that define an amplitude envelope about a 2-kHz square wave. For instance, a driver signal described as “invariant” actually refers to a square wave with a steady amplitude; the envelope is unchanging in time but the signal itself (if measured with an oscilloscope for instance) oscillates about the zero-voltage axis. It is important to note that the square wave is always symmetric about the zero-voltage axis, thus when we say “time-invariant”, we do not actually apply a DC voltage to a liquid crystal cell. As previously mentioned, zero-offset is critical for nematic liquid crystal cells.

☞ **Voltage levels here refer to the amplitude envelope about a 2 kHz square wave with zero DC offset. Never apply a voltage with a non-zero DC component to a liquid crystal cell.**

The three most accessible platforms by which to interface the D3040 are

1. Using either the standard CellDRIVE 3000-Basic or optional CellDRIVE 3000-Advanced nematic liquid crystal driver software package from Meadowlark Optics.
2. Typing command-line ASCII control codes through a terminal interface (Microsoft® HyperTerminal, for example).
3. Developing a custom LabVIEW™ application using sub-VI’s included on the CellDRIVE-3000 Basic or CellDRIVE 3000-Advanced CD.

Installation procedures for CellDRIVE 3000-Basic and CellDRIVE-Advanced are identical. Insert the CD, double-click My Computer, and double-click the icon representing the CD-ROM. Open the “Installer” folder and double-click the “Setup.exe” application and follow the on-screen instructions. The installer will install the CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced software. The D3040 should be powered on prior to starting the software. To start either version of the program after installation, click Start|Programs|Meadowlark|CellDRIVE 3000.

Both versions of CellDRIVE 3000 include an interface to the optional temperature control feature. A temperature control-enabled D3040 maintains a setpoint temperature by a feedback-controlled closed-loop PWM circuit that drives a heater element within an LC unit. Nematic LC setpoint temperatures are typically 10-30°C above ambient levels; the temperature control circuit of the D3040 therefore employs active heating and passive cooling to maintain the setpoint.

3.1 CellDRIVE 3000-Basic

CellDRIVE 3000-Basic provides time-invariant control of the D3040. Again note that in this context, “time-invariant” refers to an unchanging amplitude of the 2-kHz square wave. The CellDRIVE 3000-Basic user interface is shown in Figure 5.

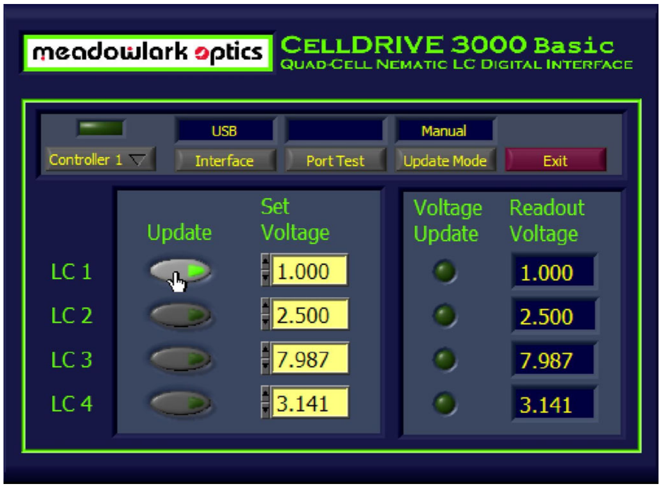

Figure 5 CellDRIVE 3000-Basic screenshot

The CellDRIVE 3000-Basic user interface consists of three sections: a top-row control panel, a voltage input section (left), and a voltage readout section (right). In addition to the controls listed below, clicking the Meadowlark Optics logo displays the software and firmware version numbers. The CellDRIVE 3000-Basic controls and their functions are:

3.1.1 Control Panel

- **Controller *n* (USB interface selected):** Selects between multiple D3040's when several are connected to multiple USB ports. This control does not appear when a serial interface is used.
- **I/O COM *n* (Serial interface selected):** Selects the COM port to which the D3040 is connected. Note that while "LPT *n*" options appear on this pulldown menu, the D3040 is not configured for connection to a parallel port.
- **Interface:** Selects between USB and Serial interface.
- **Port Test:** Initiates a read/write test of the controller. The status light illuminates yellow during the test, then green or red following the test. A green light indicates proper communication between the D3040 control module and the computer. A red light indicates unsuccessful communication. The following suggestions may be useful in the event of a red light: check the cable connections, with waveform generation in the "paused" mode cycle the D3040 power off and back on, wait a few seconds for the status LED to go out, then repeat the COM Test.
- **Update Mode:** Under "Manual" mode voltages are only uploaded to the controller when an "update" button is clicked. Under "Automatic" mode voltages are uploaded to the controller immediately.
- **Exit:** Quits CellDRIVE 3000-Basic. The last set voltages will remain in the controller after exiting the program until the D3040 is powered off.

3.1.2 Input Section

- **Update:** Click to set the specified channel voltage in Manual update mode. In Automatic update mode, these buttons are disabled.
- **Set Voltage:** Enter the voltage value to be applied to the LC channel. The range is 0-10 volts and the precision is 1 mV.

3.1.3 Readout Section

- **Update:** Illuminates when the LC voltage is changed. Thus in Manual update mode an Update LED illuminates when the corresponding Update button is clicked. In Automatic update mode the Update LED's are on steady.
- **Readout Voltage:** Displays the LC voltages read from the controller. Consistency between the set voltage and readout values indicates that communication between the PC and the D3040 is properly established. If the readout voltages do not match the set voltages, the link is not functioning properly.

Stop and exit the CellDRIVE 3000 application, cycle the D3040 power off and back on, wait a few seconds for the status light to go out, then restart CellDRIVE 3000.

3.2 CellDRIVE 3000-Advanced

CellDRIVE 3000-Advanced is a significantly enhanced nematic liquid crystal controller program, designed to meet the requirements of most LCVR applications. In addition to all of the options offered in the Basic version, CellDRIVE 3000-Advanced provides waveform generation (amplitude modulation of the 2-kHz squarewave) and temperature sensing and control options. The temperature control feature (part of the Advanced option) is implemented by a closed-loop proportional feedback control circuit in the D3040. A setpoint is entered and measured temperature is monitored through the CellDRIVE 3000-Advanced user interface. Temperature control is implemented by active heating and passive cooling of a liquid crystal cell. Once the program has been installed, it is started by clicking Start|Programs|Meadowlark|CellDRIVE 3000. The user interface shown in Figure 6 consists of a control section (lefthand side of the user interface) and a waveform display section (righthand side of the user interface). In addition to the controls listed below, clicking the Meadowlark Optics logo displays the software and firmware version numbers.

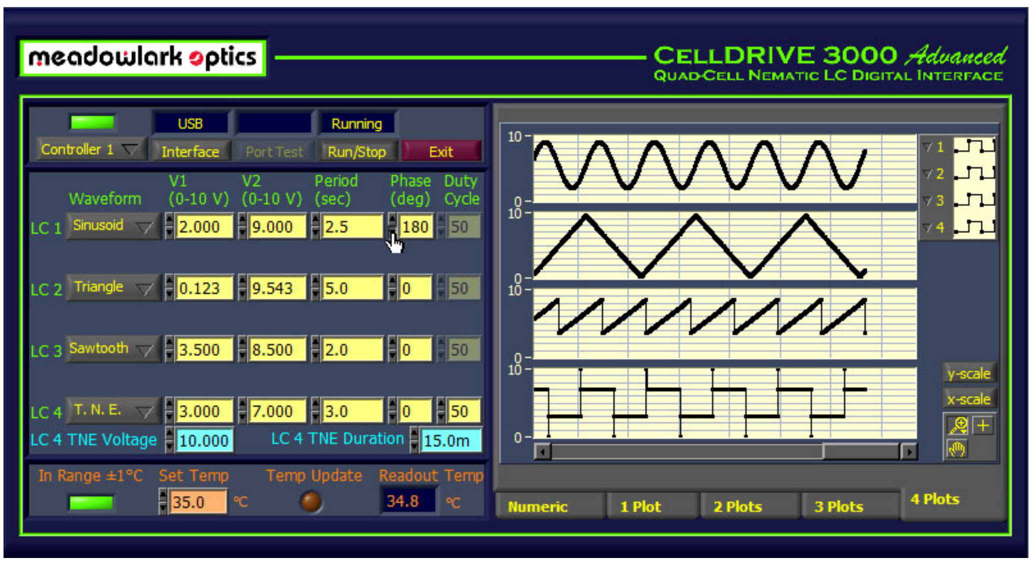

Figure 6 CellDRIVE 3000-Advanced user interface

3.2.1 Control Panel

Along the top of the control section are buttons and indicators that perform as follows:

- **Controller *n* (USB interface selected):** Selects between multiple D3040's when several are connected to multiple USB ports. This control does not appear when a serial interface is used.
- **I/O COM *n* (Serial interface selected, active when waveforms are "off"):** Selects the COM port to which the D3040 is connected. Note that although "LPT *n*" options appear on this pulldown menu, the D3040 is not configured for connection to a parallel port.
- **Status Light:** Illuminates as follows (these items will be discussed presently):
  - **Green** (waveforms "on") Port status OK when last checked
  - **Green** (waveforms "off") Positive result following a user-initiated serial port test
  - **Yellow** (waveforms "off") User-initiated port test underway
  - **Red** (waveforms "off") Negative result following a user-initiated port test
- **Interface:** Selects between USB and Serial interface.
- **Port Test (active when waveforms are "off"):** Initiates a read/write test of the controller. The status light illuminates yellow during the test, then green or red following the test. A green light indicates proper communication between the D3040 control module and the computer. A red light indicates unsuccessful communication. The following suggestions may be useful in the event of a red light:

check the cable connections, with waveform generation in the "paused" mode cycle the D3040 power off and back on, wait a few seconds for the status LED to go out, then repeat the COM Test.

- **Run/Stop:** Toggles waveform generation on (Run) and off (Stop). In "Stop" mode the Port Test may be executed.
- **Exit:** Quits CellDRIVE 3000-Basic. The last set voltages (or the last $V(t)$ values generated at the moment Exit was pressed) will remain in the controller after exiting the program until the D3040 is powered off. The temperature setpoint will also be maintained in the D3040 until it is powered off.

3.2.2 Temperature Control

Along the bottom of the control section is the temperature control interface. Temperature-related controls and indicators are disabled if the temperature sense-and-control cable is not connected. The temperature controls include the following:

- **In Range ±1°C:** Indicator lights green if readout temperature is less than one degree above or below the set temperature, lights red if the readout temperature is outside the acceptable range.
- **Set Temperature:** Enter the temperature (°C) at which a temperature-controlled LC is to be maintained.
- **Temp Update:** Flashes every 5-10 seconds as the temperature measurement displayed on the screen is updated.
- **Readout Temperature:** The measured temperature value returned by the controller.

3.2.3 Waveform Control

In addition to the time-invariant setting of the Basic version, CellDRIVE 3000-Advanced provides the capability to select from and configure a variety of waveforms for each output channel individually. Table 1 lists configuration parameters available with each waveform.

Table 1 CellDRIVE 3000-Advanced waveform options

Waveform	*Available Parameters and Allowable Ranges*		*Description*
Off	(*None*)		Output for the selected channel is 0.0 V
Invariant	V_1	0 – 10 V	Output for the selected channel is a time-invariant 2-kHz square wave with a user-specified amplitude. The Invariant mode is functionally identical to CellDRIVE 3000-Basic.
Sinusoid	V_1 V_2 T φ	0 – 10 V 0 – 10 V 0.5 – ∞ sec -360° – 360°	Output for the selected channel is a 2-kHz square wave within an envelope that varies sinusiodally between V_1 and V_2 over a user-specified period. The phase relative to that of the other output channels can also be varied.
Triangle	V_1 V_2 T φ	0 – 10 V 0 – 10 V 0.5 – ∞ sec -360° – 360°	Output for the selected channel is a 2-kHz square wave within an envelope that varies linearly from V_1 to V_2 and linearly back to V_1 over a user-specified period. The phase relative to that of the other output channels can also be varied.
Square	V_1 V_2 T φ % Duty Cycle	0 – 10 V 0 – 10 V 0.5 – ∞ sec -360° – 360° 0 – 100 %	Output for the selected channel is a 2-kHz square wave within an envelope that varies instantly between V_1 and V_2 over a user-specified period. The phase relative to that of the other output channels and the duty cycle (the ratio of the positive-voltage duration to the total period, expressed as a percent) can also be varied.
Sawtooth	V_1 V_2 T φ	0 – 10 V 0 – 10 V 0.5 – ∞ sec -360° – 360°	Output for the selected channel is a 2-kHz square wave within an envelope that rises linearly to V_1 or V_2 (whichever is greater) over a user-specified period, then drops instantly to the lower voltage. The phase relative to that of the other output channels can also be varied.
T.N.E.	V_1 V_2 T φ % Duty Cycle V_{TNE} T_{TNE}	0 – 10 V 0 – 10 V 0.5 – ∞ sec -360° – 360° 0 – 100 % 0 – 10 V 0 – 255 ms	*Transient Nematic Effect.* This mode is similar in behavior to a square wave with the following exception. A voltage spike occurs for a brief interval immediately following a positive transition, and similarly the voltage drops to zero for a brief interval immediately following a negative transition.

3.2.4 More on T.N.E.

The CellDRIVE 3000-Advanced user interface with T.N.E. mode configured on channel 4 is shown in Figure 7. An example T.N.E. output envelope is shown in Figure 8; the 2-kHz square wave is within the envelope in Figure 8 (the shaded region).

By considering the positive-voltage (top half) of the signal shown in Figure 8, one can distinguish a square wave varying between +3 and +7 volts. For a brief interval following the positive-going transition, a 10-volt spike can be observed. Similarly, immediately following the negative-going transition, a zero-volt spike can be observed. The purpose of these spikes is to drive the state change in the liquid crystal faster than what would otherwise occur. In other words, with a simple change in voltage from +7 to +3 volts, the relaxation response of the molecules in the LC cell to the step-change in voltage approximates a first-order system. Adding a spike immediately following a voltage step reduces the time constant of this first-order response. When the T.N.E. waveform is selected, CellDRIVE 3000-Advanced allows the user to specify the duration of the T.N.E. spikes as well as the magnitude of the positive-transition spike (the negative-transition spike is always zero).

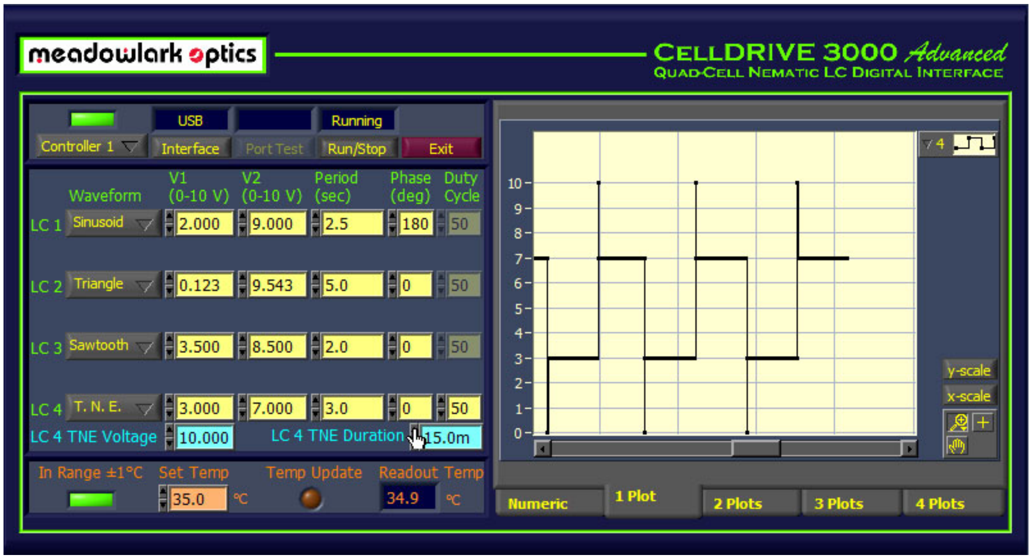

Figure 7 T.N.E. Waveform on LC channel 4

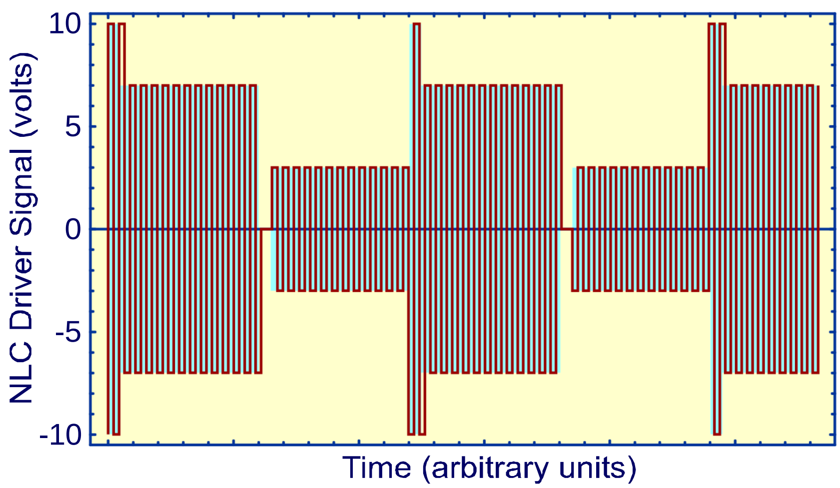

Figure 8 T.N.E. envelope

3.2.5 Waveform display

The righthand side of the user interface consists of waveform display options. The row of tabs along the bottom of the display section provides choices for numeric or graphic display modes. User-controlled display options are

- **Numeric** Shows the instantaneous voltage for each channel, and status lights that indicate updated voltages on each channel.
- ***n* Plot(s)** Specifies the number of channels to plot on the waveform to display. For instance, if only three channels are being used, one might select "3 Plots". Or if two channels are driven by time-invariant values while a third is driven in T.N.E. mode, one might choose to plot only the T.N.E. channel. The choice of display has no effect on output to the LC channel, *e.g.*, choosing to display channel 2 does not affect the signal output of channel 3.
- **Legend** The waveform plotted on a particular graph is selected by clicking left of the number on the plot legend. Clicking right of the number on the plot legend gives a menu of options for displaying a plot.
- **Y** This button auto-scales the vertical axis or axes to a range of 0-10 V.

- **X** This button auto-scales the horizontal axis to show the most recent 5000 voltage values, or to all of the voltage values if less than 5000 have been acquired.
- **Zoom/Pan** Includes a variety of zoom and pan features.
- **Horizontal Scroll bar** Enables scrolling back to review 5000 most recent voltage values.
- **Vertical Axis Values** These may be double-clicked and "edited" to change the vertical axis range..

3.3 HyperTerminal command line control:
The HyperTerminal interface is available only through a COM port (RS-232) connection. After initiating a HyperTerminal session (see Appendix A for details), textual commands are issued directly to the controller unit and responses are printed to the HyperTerminal screen. A complete list of ASCII firmware commands is tabulated below. Note that commands are all lowercase.

Table 2 ASCII terminal commands for the D3040

Firmware Command		***Description***	***Notes***
Ver. 1.xx	***Ver. 2.xx***		
`tty:`*n*	(N/A)	Terminal mode.	See Appendix A. This command is discontinued in firmware versions 2.xx.
`ldac:`*n*`,`*i*	`ld:`*n*`,`*i*	Sets the modulation voltage on the specified LC channel. Converts an integer *i* to a square-wave amplitude voltage.	*n* = LC channel (1,2,3,4) *i* = 16-bit integer (0-65535) that translates to voltage as $V = i/6553.6$.
`ldac:`*n*`,?`	`ld:`*n*`,?`	Query voltage setting on channel *n*.	*n* = LC channel (1,2,3,4) Controller returns a 16-bit value *i*, corresponding to a voltage by $V = i/6553.6$
(N/A)	`ldd:`i_1, i_2, i_3, i_4	Simultaneously sets the modulation voltages on all four LC channels. Converts an integer *i* to a square-wave amplitude voltage.	This command is enabled in firmware versions 2.xx only.
(N/A)	`ldd:?`	Query the voltage settings on all four channels.	Controller returns a 16-bit value *i*, corresponding to a voltage by $V = i/6553.6$. This command is enabled in firmware versions 2.xx only.
(N/A)	`tne:` *n*`,`*t*`,`*i*	Activate *TNE* switching on channel *n*. *t* = duration of TNE pulse (1-255 ms), *i* is a 16-bit integer corresponding to the amplitude of the TNE pulse by $V = i/6553.6$	Specifying *t*=0 turns off the *TNE* feature. This command is enabled in firmware versions 2.xx only.
(N/A)	`tne:` *n*`,?`	Query the *TNE* duration and voltage settings on channel *n*.	This command is enabled in firmware versions 2.xx only.
`ver:?`	`ver:?`	Query firmware version.	Versions 1.xx and 2.xx use different command sets as indicated in this table.

Two families of commands exist depending on the firmware version. The firmware version is identified by activating the CellDRIVE 3000 software and clicking the Meadowlark Optics logo in the upper-left corner, or by typing the `ver:?` ASCII command in an appropriately configured HyperTerminal session. Firmware upgrades require returning the unit to the factory; please contact Meadowlark Optics, Inc. if you feel a firmware upgrade is necessary.

For controllers with firmware versions 1.xx (typically, those delivered prior to February 2004), the first command that should be typed is `tty:1` followed by two "returns" (i.e., press the ENTER key twice) to enable screen display of firmware responses. For controllers with firmware versions 2.xx, the "TTY" mode is automatic. Please see Appendix A for HyperTerminal configuration details.

3.4 User development with LabVIEW VI's provided by Meadowlark Optics, Inc.

Several VI's are included in a library file on the CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced CD. They can be found in <drive letter>:\LabVIEW\ directory. LabVIEW VI's that interface with the D3040 by the serial port are:

- Meadowlark Serial IO Example.VI
- Meadowlark Serial.LLB
    - Meadowlark Serial Com.VI
    - Meadowlark Serial Read Voltage.VI
    - Meadowlark Serial Set Voltage.VI

LabVIEW VI's that interface with the D3040 by the USB port are:

- Meadowlark USB IO Example.VI
- Meadowlark USB.LLB
    - Meadowlark USB Com.VI
    - Meadowlark USB Easy Close.VI
    - Meadowlark USB Easy Open.VI
    - Meadowlark USB Read Voltage.VI
    - Meadowlark USB Set Voltage.VI

The serial and USB files are similar in that each includes a LabVIEW library file containing fundamental VI's and an example that implements them in a basic program that sets and reads D3040 voltages. The LabVIEW back panels of the *IO Example* VI's have been made accessible to our customers to facilitate independent development. Programmers are encouraged to open and examine the *IO Example* diagram screens. Please note that the LabVIEW development suite (version 6.1 or greater) from National Instruments is required to use the included VI's, and Meadowlark Optics does not provide this development package with any version of CellDRIVE 3000. It is assumed that the customer has experience programming in LabVIEW and understands good programming practices. Meadowlark Optics cannot offer customer support for LabVIEW application development. If a developed or modified LabVIEW application is to be distributed in any way, please contact Meadowlark Optics for licensing and copyright details.

4. Frequently Asked Questions

Q: The controller is not working.

A: Check that the power supply is plugged in, front panel switch is on and the green power light is steady. If using a USB interface, check the status of the D3040 under Windows® Device Manager. If using a serial interface, double check RS232 connection and attempt a HyperTerminal session. Occasionally it helps to reboot the controller: turn off the controller, wait a few seconds, then turn it back on.

Q: I started the CellDRIVE 3000 software and then turned on the D3040, and now the software is behaving erratically. What is happening?

A: The D3040 control module must be turned on and have completed its power-on self-test *before* starting the CellDRIVE 3000 software.

Q: HyperTerminal commands do not seem to have any effect.

A: Confirm that HyperTerminal is properly configured as outlined in Appendix A.
A2: HyperTerminal commands are only available through a COM (RS-232) port. A D3040 connected to a USB port will not respond to a HyperTerminal session.

Q: Liquid crystal cells are not changing state.
A: Check SMA connections and measure LC cell end of the cable with an AC (true-RMS) voltmeter or oscilloscope. Default values after power up (before running either of the CellDRIVE 3000 applications) are 555 mV. An oscilloscope will show a 2-kHz square wave with a 1.12 V peak-to-peak amplitude.
A2: Double check optical alignment of cell. Some cell orientations won't affect polarization if they happen to align with an eigenaxis (fast or slow axis of the liquid crystal retarder).

Q: I can't use the SMA connectors on the back of the device, I need BNC.
A: BNC jack to SMA plug adapters exist from Cambridge Products (CP-AD508) and Amphenol (901-166). Meadowlark can also provide (SMA to SMB) custom cable adapters to attach Meadowlark LC cells.

Q: I need a particular waveform generated.
A: Use HyperTerminal and a text file editor to generate a piecewise approximation using `ld:` or `ldd:` commands (`ldac:` commands for controllers with legacy firmware). Transfer text file through HyperTerminal to the D3040 controller. Or, develop code using LabVIEW™ development suite and VI's included on the software CD. Meadowlark's engineers can custom-program any waveform into CellDRIVE 3000-Advanced; please contact Meadowlark Optics for details.

Q: How do I uninstall the CellDRIVE 3000 software?
A: Use the Add/Remove Programs option in the Windows® control panel.

Q: Can I use multiple D3040's to control more than four LC cells?
A: Yes. The CellDRIVE 3000-Basic and CellDRIVE 3000-Advanced programs are both designed to handle up to four D3040's connected to USB ports, giving a total of 16 channels of control. Waveform generation is limited to four channels (one controller) at a time.

Q: In TNE mode, the graphical display shows that TNE spikes are sometimes missing from the waveform.
A: extremely short TNE spikes are occasionally misrepresented on the CellDRIVE 3000-Advanced interface, but viewing the output with an oscilloscope will verify that they are consistently produced and delivered to the LC cell.

Q: Are there Apple, Linux, OS/2, or UNIX versions of CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced? Can I use CellDRIVE 3000-Basic or CellDRIVE 3000-Advanced on a PC running MS-DOS®, Windows® 3.1, Windows® 95, Windows® 98, or Windows® NT?
A: No. CellDRIVE 3000-Basic and CellDRIVE 3000-Advanced run under the 98SE, ME, 2000, and XP versions of Microsoft® Windows® only.

Q: What is the purpose of the SYNC connector on the front panel?
A: The D3040 does not presently use the SYNC connector.

Q: What are the power-on default voltage and temperature values?
A: After powering on the D3040, each LC channel will have a 2-kHz, 555-mV (zero-to-peak amplitude) squarewave, and the temperature setpoint (on units equipped with temperature sensing and control) initializes to the LC temperature detected when the controller was powered on.

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Appendix A: Configuring HyperTerminal for D3040 terminal sessions

The interface between the host computer and the D3040 controller consists of ASCII commands issued from the PC, and ASCII responses issued by the controller. When the RS-232 interface is used, ASCII commands and responses can be respectively issued by and read from a terminal application. HyperTerminal is a terminal application that is included with the Microsoft® Windows® operating system and can be installed from any Windows® CD. Note that HyperTerminal supports only communication over the COM ports; USB communication is not supported through HyperTerminal.

A HyperTerminal configuration file that configures the terminal interface for use with the D3040 is included on the CellDRIVE 3000 CD. In this appendix, the configuration parameters for ASCII terminal communications are detailed so that users may configure alternative terminal programs. If HyperTerminal has already been configured for use with a D3040 on a given computer, or if the HyperTerminal configuration file from the CD is used, these steps do not need to be followed.

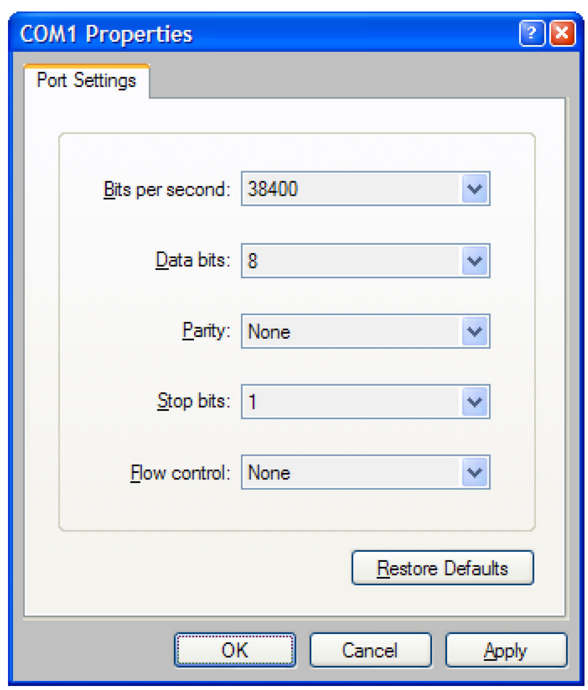
1. Confirm that a D3040 is connected to one of the COM ports of the PC, that the D3040 is powered on, and that the PC is booted into with Windows® 98SE or later. Launch the HyperTerminal program from: Start|Programs|Accessories|Communications|HyperTerminal.

2. The HyperTerminal title screen will appear briefly, and then the "Connection Description" dialog box will appear. The dialog will prompt you for a name and an icon for the new connection to be created. Type an appropriately descriptive name such as `D3040` in the "Name:" field. Click on one of the icons displayed to choose a connection icon. Click on the OK button to continue.

3. The "Connection Description" dialog box will close, and the "Connect To" dialog box will open. There are four fields in this dialog box, three of which refer to dial-up modem connections and are therefore not relevant. Click on the bottom-most field labeled "Connect using:" and select the COM port to which the D3040 is connected. Click the OK button to proceed.

4. The "Connect To" dialog box will close and a dialog box labeled "COM*n* Properties" (where *n* is the COM port number selected in the previous step) will appear. The COM port connection parameters (illustrated below) are:

- Bits per second: 38400
- Data bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: None



When the port settings are complete, click the OK button to proceed.

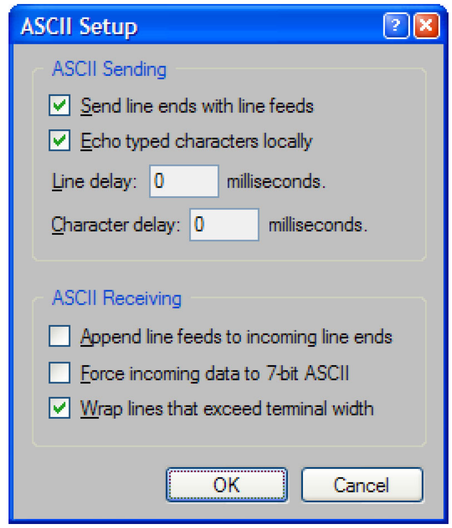
A HyperTerminal screen will now open. At this point, the terminal connection has been established and properly-typed commands issued from the PC will be detected and appropriately followed by the D3040. The steps that follow are necessary to properly display the ASCII commands and responses in the HyperTerminal window.

5. Click File|Properties and a dialog "Properties" box will open. The dialog box will have two tabs at the top: "Connect To" and "Settings". Click the "Settings" tab. Click the button called "ASCII Setup…".

6. In the "ASCII Setup…" page, the two following settings must be enabled:

- ✓ Send line ends with line feeds
- ✓ Echo typed characters locally

These settings are activated by placing a "check" in the appropriate boxes as shown in the adjacent figure. Click OK to close the "ASCII Setup…" screen, and click OK again to exit the "Properties" dialog box.



7. To save this configuration for future terminal sessions, click File|Save As… Select a location and filename that will be convenient to remember.

8. Test the connection by typing `ver:?` And pressing the RETURN key. The controller should generate a response that includes the version number and copyright information.

Once the configuration is complete, commands listed in Table 2 can be used to initiate D3040 controller functions.

Using HyperTerminal with legacy firmware

For legacy firmware versions (1.xx), the following applies: there is a `TTY:`*n* command (where *n* = 0 or 1) that alters the behavior of the HyperTerminal responses. The HyperTerminal configuration procedure is the same as that used with newer firmware, with the following exceptions.

The default controller setting is `TTY:0`. In this mode, the "Append line feeds to incoming line ends" option in the "ASCII Setup…" screen should be enabled with a check mark.

Typing `TTY:1` alters the behavior of the controller such that the "Echo typed characters locally" option in the "ASCII Setup…" screen should be disabled. The "Append line feeds to incoming line ends" option in the "ASCII Setup…" screen should be enabled with a check mark, as in `TTY:0` mode.

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The parties shall endeavor to resolve any dispute by mediation in Boulder, CO under the CPR Mediation Procedure. If the parties have not resolved this matter within 45 days from the selection of a mediator, the parties shall settle any controversy arising out of this Agreement) by arbitration to be held in Boulder, Colorado, in accordance with the rules of the American Arbitration Association. A single arbitrator shall be agree upon by the parties, or, if the parties cannot agree upon an arbitrator within thirty (30) days, then the parties agree that a single arbitrator shall be appointed by the American Arbitration Association. The arbitrator will apply the substantive law of the State of Colorado. The arbitrator may award attorney's fees and costs as part of the award. The award of the arbitrator shall be binding and may be entered as a judgment in any court of competent jurisdiction.

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Any notice under this Agreement will be in writing and delivered by personal delivery, overnight courier, confirmed facsimile, confirmed e-mail, or certified or registered mail, return receipt requested, and will be deemed given upon personal delivery, 1 day after deposit with an overnight courier, 5 days after deposit in the mail, or upon confirmation of receipt of facsimile or email. Notices will be sent to a party at its address set forth at the end of this Agreement, or such other address as a party may specify in writing pursuant to this Section.

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