INTRODUCTION ........................................................................................................ 3
   1.1 Mission Statement .......................................................................................... 3
   1.2 Warranty ....................................................................................................... 3
   1.3 Copyrights .................................................................................................... 3
   1.4 Product Overview ........................................................................................ 3

GETTING STARTED ............................................................................................... 4
   2.1 Verify Shipping Contents ............................................................................ 4
   2.2 Hardware Connections ............................................................................... 4
   2.3 Baud Rate .................................................................................................... 4
   2.4 Attaching a Detector ................................................................................... 5
   2.5 Product Specifications ............................................................................... 5

SOFTWARE .......................................................................................................... 6
   3.1 CM110/112 Demo Software-Windows™ .................................................. 6
      3.1.1 Hardware Connections ........................................................................ 6
      3.1.2 Getting Started .................................................................................... 6
      3.1.3 CM110/112 Visual Basic™ ................................................................. 7
   3.2 CM-Series Visual Basic Library ................................................................. 8

OPERATION .......................................................................................................... 9
   4.1 Writing Your Own Control Program ........................................................ 9
   4.2 Hand Held Controller DK1200 ................................................................. 14
      4.2.1 Operation .............................................................................................. 14
      4.2.2 Error Screens ...................................................................................... 17
      4.2.3 Query Commands ............................................................................... 18
      4.2.4 Option Commands ............................................................................. 19
      4.2.5 Manual Commands ............................................................................ 19

APPENDICES ...................................................................................................... ERROR! BOOKMARK NOT DEFINED.
   A. Wavelength Ranges .................................................................................... 20
   B. Wavelength Scan/Slew Speeds ................................................................... 21
   C. Encoding/Decoding Data Bytes ................................................................. 22
   D. Status Bytes ............................................................................................... 24
   E. Novram Program/Calibration Procedures .............................................. 25
   F. Accessories ............................................................................................... 28
   G. Product Conversions ................................................................................ 29
      Changing Slits ............................................................................................ 29
      Converting to a Spectrograph .................................................................. 29
      Changing the Optical Path ....................................................................... 29
      Changing Gratings .................................................................................... 29
   H. Reference Drawings ................................................................................. 30
      Connections – Power / RS232 ................................................................... 30
      Changing the Optical Path ....................................................................... 30
      Optical Bench Mounting .......................................................................... 31
      Optical Path Design ................................................................................ 32
   I. Reference CM110/CM112 Interface Pin Layout ....................................... 33
   J. Reference Serial Relay Command ............................................................ 34
Introduction

1.1 Mission Statement

Our mission is to provide our customers with reliable products, on time, and at a fair price. We are continually striving to maintain the highest standards, by assuring defect-free products and by providing prompt and courteous customer service.

The staff at Spectral Products will be happy to answer any questions about our products and our services. For immediate assistance, please contact the Spectral Products Group directly at (505) 296-9541, by fax (505) 298-9908, or by e-mail at instruments@cvilaser.com

1.2 Warranty

This product is warranted to be free of defects in materials and workmanship for one year from date of purchase.

This manual and the software it describes are provided free of charge as a service to the customer. The software is intended to be used as a tool for development and as an example of one possible method of code implementation. It is not intended to be a “user application.”

Any software associated with this product is provided “as is” with no warranty, expressed or implied. While it is Spectral Products’s intent to provide error-free development tools, no guarantee is made regarding either the accuracy or usefulness of this material.

Failures or damages resulting from lack of operator attention to proper procedures, failure to follow operating instructions, unauthorized modifications, and natural disasters are not covered under this warranty.

The Digikröm CM110/112 does not contain any user serviceable parts. Removing its cover, without explicit written permission from Spectral Products, will void any written or implicit warranty.

Spectral Products reserves the right, without prior or further notice, to make changes to any of its products described or referred to herein to improve reliability, function, or design.

Spectral Products accepts no liability for incidental or consequential damages arising from the use of this software.

Spectral Products does not recommend the use of its components or software products in life support applications wherein a malfunction or failure of the product may directly threaten life or result in injury.

Spectral Products does not recommend that this product be used on the same power line as other equipment with high current draw requirements.

1.3 Copyrights

Spectral Products maintains the copyright on this material, but grants the customer rights to use or to modify the software described herein without obtaining Spectral Products permission and without the requirement to reference Spectral Products as the source of the material.

LabVIEW® is a registered trademark of National Instruments.

Windows™, Microsoft® Visual Basic™ and Microsoft® Quick Basic™ are registered trademarks of Microsoft Corporation.

1.4 Product Overview

The Digikröm CM110/112 is a one-eighth meter, Czerny-Turner type monochromator/spectrograph. Unlike other small devices that provide only one optical orientation, the Digikröm CM110/112 can accommodate both a straight through and a right-angle orientation from the source. Optical path conversion is outlined in Appendix G: Product Conversions.
2.1 Verify Shipping Contents
The following items are shipped with your order of a CM110/112 1/8m monochromator:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CM110/112</td>
</tr>
<tr>
<td>1</td>
<td>DKFS100 Slit Set (2 each, -.125mm, .15mm, .3mm, .6mm, 1.2mm and 2.4mm slits)</td>
</tr>
<tr>
<td>1</td>
<td>15/5V power supply</td>
</tr>
<tr>
<td>1</td>
<td>Power cord</td>
</tr>
<tr>
<td>1</td>
<td>Dual power cable</td>
</tr>
<tr>
<td>1</td>
<td>User’s manual</td>
</tr>
<tr>
<td>1</td>
<td>Demonstration software. If not included, this can be downloaded from our website at <a href="http://www.cvilaser.com">www.cvilaser.com</a></td>
</tr>
</tbody>
</table>

2.2 Hardware Connections
Power is supplied to the CM110/112 by the power supply, which has an output patch cord with two connectors. The connector with the threaded sleeve connects to the CM110/112, page 30, while the un-sleeved connector is for the optional DK1200 hand-held controller.

   a. Attach the power cord to the three-prong outlet on the back of the power pack.
   b. Attach the connector from the power supply to the single output end of the dual output patch cord.
   c. Attach the locking power plug located at the other end of the dual power cable, labeled CM110/112, to the power jack on the back of the Digikröm CM110/112, labeled POWER. Lock it in place.
   d. Plug the power cord into your wall or power strip outlet. The CM110/112 will reset and find home position.

The RS232 connection requires a cable with a DB9-M subminiature connector at the monochromator, and a computer communications port connector as appropriate for the user. Spectral Products offers a DK12AT, DK12PS and DK12MA cable for connecting to AT, PS2 and MAC style computers, respectively.

<table>
<thead>
<tr>
<th>Pin</th>
<th>NAME</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DC</td>
<td>Not used with the CM110/112</td>
</tr>
<tr>
<td>2</td>
<td>RxD</td>
<td>Data out (from CM110/112 to computer)</td>
</tr>
<tr>
<td>3</td>
<td>TxD</td>
<td>Data in (from computer to CM110/112)</td>
</tr>
<tr>
<td>4</td>
<td>DTR</td>
<td>Not used with the CM110/112</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Signal ground</td>
</tr>
<tr>
<td>6</td>
<td>DSR</td>
<td>Not used in CM110/112</td>
</tr>
<tr>
<td>7</td>
<td>RTS</td>
<td>Request to send (from computer)</td>
</tr>
<tr>
<td>8</td>
<td>CTS</td>
<td>Clear to send (from CM110/112)</td>
</tr>
<tr>
<td>9</td>
<td>RNG</td>
<td>Not used in CM110/112</td>
</tr>
</tbody>
</table>

The pin assignments above are mapped one-to-one between the cable connection of a Digikröm CM110/112 and an IBM-AT style serial communications port.

2.3 Baud Rate
The computer must be set to the Digikröm CM110/112 data type and baud rate

   Character length: 8 bits
   Baud rate: 9600 bits/sec
   Stop bits: 1
   Parity: None

The Digikröm CM110/112 is factory configured and the character length, number of stop bits and parity cannot be changed. Its signal levels and format are the same as those that are specified for the RS-232. The CM110/112 emulates data communications equipment (DCE).
2.3 Attaching a Detector

Attach a detector to the monochromator using the bayonet mounting flange. In order to maintain a tight optical seal between the monochromator and the detector, it may be useful to allow the detector’s mounting flange to protrude slightly into the hole in the slit plate. A rubber or foam gasket between flat surfaces is also frequently used.

2.4 Product Specifications

- **Wavelength Drive:** Anti-backlash worm and wheel with microprocessor control. Bi-directional. Usable in positive or negative grating orders.
- **Beam Path:** Either right angle or straight through (standard configuration) from source
- **Design:** Czerny-Turner, dual-grating turret
- **Focal Length:** 110 mm
- **F/#:** 3.3
- **Gratings:** 30 x 30 mm. See the Standard Grating Table in Appendix B.
- **Wavelength Precision:** >0.2 nm with 1200 g/mm grating
- **Wavelength Accuracy:** ± 0.2 nm with 1200 g/mm grating
- **Slewng Speed:** >100 nm/second with 1200 g/mm grating
- **Maximum Resolution:** 0.2 nm with 1200 g/mm grating
- **Bandpass:** 1 nm with .150 mm slit and 1200 g/mm grating
- **Standard Slits (mm):** 0.125, 0.15, 0.3, 0.6, 1.2, and 2.4. For other values, consult Spectral Products.
- **Software:** Demo control program with source is included. A LabVIEW® Driver is available upon request.
- **Power:** UL listed 110/220 V power pack, meets or exceeds UL1950, CSA 1402C, and IEC 950.
- **Interface:** RS-232 standard
- **Warranty:** One year from delivery date
- **CE Marked**
- **Options:** Hand-held control module for local control, IEEE-488 interface, Interface cables, GPIB to RS232 converter, Gold optics for IR range.
Software

3.1 CM110/112 Demo Software—Windows™

3.1.1 Hardware Connections
Refer to section 2.2, page 5 for the proper power and communication line connections, as well as any other pertinent installation information. The serial port and baud rate setting for the CM110/112 is saved in the "CM11X.INI" file in the Windows™ directory.

3.1.2 Getting Started

Software Installation
The software is written in Visual Basic™ for Windows™. To install the CM110/112 demo software, run the program SETUP.EXE found on disk number one. It must be run from within Microsoft® Windows™. Once the demo software has been installed, you are ready to get started. The demo software does not allow the user to plot. We offer software packages with plotting capability and also AD110, AD130, AD140, and Kestrel Spec data acquisition software for CCD cameras.

Configure Serial Port
The first time you run the CM110/112 demo software, you may need to configure the software for the correct serial port. When you run the program, it will search for the "CM11X.INI" file in the Windows™ directory. If this file exists, the CM110/112 demo software will initialize the serial port with the information that is saved in the "CM11X.INI" file. If the computer is unable to locate the "CM11X.INI" file, the "Initializing Communication Port" form will appear on the screen. If you want to re-initialize the serial port, do it now. You can skip the initialization procedure by clicking "Cancel" in the "Initializing Communication Port" form. However, if you choose not to reinitialize, some commands may not perform. If the computer is able to communicate with the monochromator, the computer will prompt you with the "saving configuration dialog box". Clicking "Yes" will save the configuration to "CM11X.INI" in the Windows directory.

Menus and Commands
This section contains descriptions about both menus and the commands. For each menu, a brief description of commands are given. For more information on these commands, please refer to either Section 3.2.2, page 9 or the online help menu.

Commands Menu
- Control: Use the "Control" sub-menu to display control commands. The commands are: Goto, Scan, Speed, Step, Size, Select, Inc and Dec, Query, and Echo.
- Setup: Use the sub-menu to drop-down setup commands that are used to specify the operation of the monochromator. They are: Calibrate, Zero, Order, Units, Type (CM112 only).
- Exit: Use the "Exit" command on the file menu to quit the CM110/112 Demo Software.

Novram Menu
- Novram Read: Use this command to read a byte from the monochromator's non-volatile memory.
- Novram Write: Use this command to write a byte to the monochromator's non-volatile memory.

WARNING!!! Improper use of this command may corrupt the configuration and the calibration information of the monochromator. Consult Spectral Products before using!
- Novram Utility: Use this command to read, or write 128 (0-127) bytes from or to either the monochromator's non-volatile memory or the file. The print feature is also included in this command.
Chapter 3 - Software

COM Port Menu

Baud Finding Use this command to determine the current baud rate of the CM110/112.

Loopback COM Test Use this command to test the serial cable and the communication port. To run this command make an adapter to plug into your serial port which will loopback the PC’s serial data output into its serial data input. Placing a jumper between pins 2 and 3, and leaving all other pins unconnected does this.

RTS, CTS Status Use this command to display the status of the request to send and the clear to send lines. The RTS line is true if the PC enables the line, and the CTS line is true if this line is high.

Initialize COM Port Use the command to initialize a serial port and the baud rate of your host computer.

Option Menu

Save Configuration Use "Save Configuration" to save the current values of the serial port, and the baud rate. These values will be saved to the file "CM11X.INI" in the Windows directory.

Help Menu

Contents Use the "Contents" command to access the table of contents page of the CM110/112 Help file.

Using Help Use the “Using Help” command to display the contents page about How to Use Help.

About CM110/112 Use this command to display the program version information.

3.1.3 CM110/112 Visual Basic™

Spectral Products offers software that was designed in Microsoft® Visual Basic™ 16 bit, Ver. 4.0 for Windows™ and will run on Windows 3.11, 95 and NT 4.0. If you are interested in writing software that supports the CM110/112, we will be pleased to send this software to you upon request. If you have any questions about the operation of your monochromator or if you have suggestions, please contact us. We appreciate your comments and suggestions.

Hardware Connections / Software Installation / Configuring Serial Port

See section 3.1.1 and 3.1.2 on page 7. If installed correctly, this screen will appear:

The current wavelength. Push this button to pop up the “Goto” form.

The current unit

Click the buttons will step up/down the grating motor in a single unit step.

Click the buttons will step up/down the grating motor in 20 unit steps.

The current wavelength.

The current grating ruling

The current grating blaze wavelength.

Groove: 1200 g/mm
Blaze: 500 nm
Serial: 20250

3674 Angstroms
3.2 CM-Series Visual Basic Library

The Spectral Products Instrument Group is providing a software library which was designed in Microsoft Visual Basic for Windows 16-bit version 4.0. If you are interested in writing your own software for the DK-Series, we will be pleased to send this software library, 8-2006.BAS, to you upon request. In addition, if you have any unanswered questions about the operation of the CM-Series or if you have any suggestions on how to improve it, please feel free to contact us. We appreciate all of your comments and suggestions.
Chapter 4 - Operation

Operation

4.1 Writing Your Own Control Program

The subscript \(_D\) indicates the decimal value of the byte is listed.

CALIBRATE

This command allows recalibration of the monochromator positioning scale factor and should ALWAYS be used immediately after using the ZERO command (see page 13). The monochromator should be set to the peak of a known spectral line, then the position of that line is input using the CALIBRATE command.

CAUTION: Use of this command will erase factory settings.

To CM110/112: \(<18_D\ <\text{High Byte}>\ <\text{Low Byte}>\)

CM110/112 Action: If \((256 \times <\text{High Byte}>) + <\text{Low Byte}>\) is a valid position, then the scale factor used in determining position will be recalibrated to make the current position agree with the input position. The gratings return to zero after completion.

From CM110/112: \(<\text{Status Byte}>\)

DEC

This command decrements the zero offset value and changes the grating angle by 0.0075 degrees in the clockwise direction. This is generally always followed by the ZERO command. The CM110/112 does not track the change in wavelength incurred by this command. The new offset is not in effect unless the ZERO command is issued.

To CM110/112: \(<1_D\>

From CM110/112: \(<\text{Status Byte}>\)

CM110/112 Action: Moves one motor step clockwise

From CM110/112: \(<24_D\>

DEC Machine #2 (CM112 only)

This command decrements the zero offset value for machine #2 and changes the grating angle by 0.0075 degrees in the clockwise direction. This is generally always followed by the ZERO command. The CM110/112 does not track the change in wavelength incurred by this command. The new offset is not in effect unless the ZERO command is issued.

To CM110/112: \(<2_D\>

From CM110/112: \(<\text{Status Byte}>\)

CM110/112 Action: Moves one motor step clockwise

From CM110/112: \(<24_D\>

ECHO

The ECHO command is used to verify communications with the CM110/112.

To CM110/112: \(<27_D\>

From CM110/112: \(<27_D\>

CM110/112 Action: No action.

GOTO

This command moves the monochromator to a selected position. Valid values of position are grating dependent and are described in Appendix C.

To CM110/112: \(<16_D\ <\text{High Byte}>\ <\text{Low Byte}>\)

From CM110/112: \(<\text{Status Byte}>\)

CM110/112 Action: If valid, move to position \((256 \times <\text{High Byte}>) + <\text{Low Byte}>\) [units].

From CM110/112: \(<24_D\>

For example, the command to instruct the monochromator to GOTO the wavelength 250 nm could be sent as the three bytes \(<16_D\ <0_D\ <250_D\>\) (if the current units are in nm). Here, \(<16_D\>\ specifies the GOTO command while \(<0_D\ <250_D\>\ specifies the destination of 250 nm.
INC
This command increments the zero offset value and changes the grating angle by 0.0075 degrees in the counter-clockwise direction. This is generally always followed by the ZERO command. The CM110/112 does not track the change in wavelength incurred by this command. The new offset is not in effect unless the ZERO command is issued.

To CM110/112:  \(\langle 7\rangle_D\)
From CM110/112:  \(\langle\text{Status Byte}\rangle\)
CM110/112 Action:  Moves one motor step counter-clockwise
From CM110/112:  \(\langle 24\rangle_D\)

INC Machine #2 (CM112 only)
This command increments the zero offset value for Machine #2 and changes the grating angle by 0.0075 degrees in the counter-clockwise direction. This is generally always followed by the ZERO command. The CM110/112 does not track the change in wavelength incurred by this command. The new offset is not in effect unless the ZERO command is issued.

To CM110/112:  \(\langle 8\rangle_D\)
From CM110/112:  \(\langle\text{Status Byte}\rangle\)
CM110/112 Action:  Moves one motor step counter-clockwise
From CM110/112:  \(\langle 24\rangle_D\)

ORDER
This command determines if the grating rotates clockwise or counter-clockwise.

To CM110/112:  \(\langle 51\rangle_D\ \langle\text{Order Byte}\rangle\)
From CM110/112:  \(\langle\text{Status Byte}\rangle\)
CM110/112 Action:  If valid, moves to the zero order position of the selected grating. Rotation of the grating thereafter will be clockwise if the order byte was 01, and counter-clockwise if the order byte was 254.
From CM110/112:  \(\langle 24\rangle_D\)

QUERY
This command displays the monochromator’s status.

To CM110/112:  \(\langle 56\rangle_D\ \langle\text{Query Byte}\rangle\)
From CM110/112:  \(\langle\text{Status Message}\rangle\)

\(<\text{Query Byte}>\quad\text{Status Message}\)
\(<00>_D\quad\text{<Position High Byte><Low Byte>}\)
\(<01>_D\quad\text{<Type Byte>}
0 = \text{Single}\n1 = \text{Additive dbl(CM112 only)}\n254 = \text{Subtractive dbl(CM112 only)}\)
\(<02>_D\quad\text{<Grooves/mm High Byte><Low Byte>}\)
\(<03>_D\quad\text{<Blaze High Byte><Low Byte>}\)
\(<04>_D\quad\text{<Current Grating No.>}\)
\(<05>_D\quad\text{<Speed High Byte><Low Byte>}\)
\(<06>_D\quad\text{<Size Byte>}\)
\(<13>_D\quad\text{<Number of gratings>}\)
\(<14>_D\quad\text{<Current Units>}\)
\(<19>_D\quad\text{<Serial Number High Byte><Serial Number Low Byte>}\)

CM110/112 Action:  No action.
From CM110/112:  \(\langle\text{Status Byte}\rangle\)
From CM110/112:  \(\langle 24\rangle_D\)
**Chapter 4 - Operation**

**RESET**
This command returns the grating to home position.

To CM110/112: \(<255>\_D <255><255>\)
CM110/112 Action: Grating will return to home position

**SCAN**
This command scans the monochromator between a START position and an END position at a rate determined by the SPEED command. The START may be greater or smaller than the END. Valid values of position are grating and units dependent and are described in Appendix B, page 21.

To CM110/112: \(<12>\_D
<\text{Start High Byte}> <\text{Start Low Byte}>\)
<\text{End High Byte}> <\text{End Low Byte}>\)
From CM110/112: <Status Byte>
CM110/112 Action: Sets CTS low, and moves below (above) the starting value. Sets CTS high and accelerates to scanning speed. Sets CTS low when the Start is reached. Sets CTS high again as END is passed.
From CM110/112: <24>\_D

**SELECT**
Selects the grating that will be used.

To CM110/112: \(<26>\_D <\text{Grating Byte}>\)
From CM110/112: <Status Byte>
CM110/112 Action: If valid, moves to the zero order position of the selected grating. Valid grating bytes are 1 and 2.
From CM110/112: <24>\_D

**SIZE**
This command determines the change in magnitude and the direction of the monochromator’s position after a STEP command.

To CM110/112: \(<55>\_D <\text{Size Byte}>\)
From CM110/112: <Status Byte>
CM110/112 Action: No immediate action. If the Size Byte is less than or equal to 127 (i.e., the most significant bit = 0), a subsequent STEP command will increase the position by that number of units. If the Size Byte is greater than 127 (most significant bit = 1), then a subsequent STEP command will decrease the position by that number of units.
From CM110/112: <24>\_D

**SPEED**
Selects the speed at which the monochromator may scan. Valid values of speed are grating dependent and are given in Appendix B, page 20.

To CM110/112: \(<13>\_D <\text{High Byte}> <\text{Low Byte}>\)
From CM110/112: <Status byte>
CM110/112 Action: No immediate action. If a valid value is selected, the SCAN command will thereafter cause the monochromator to move at approximately a speed value of \((256 * <\text{High Byte}> + <\text{Low Byte}>)\) [Å/sec].
From CM110/112: <24>\_D
Chapter 4 - Operation

STEP
Moves the monochromator by a preset amount defined by the SIZE command.

To CM110/112: \(<54>_D\)
From CM110/112: \(<\text{Status byte}>\)
CM110/112 Action: If valid, moves the monochromator so that the position is changed by the value determined by SIZE.
From CM110/112: \(<24>_D\)

TYPE*
Induces the CM112 only, to change between additive and subtractive mode. Consult \textit{Spectral Products} before using this command!!

To CM112: \(<57>_D\)
From CM112: \(<\text{Status byte}>\)
CM112 Action: If \(<\text{Type}>1\) , then the monochromator will subsequently operate in the additive mode. If \(<\text{Type}>2\) , then the monochromator will subsequently operate in the subtractive mode. The monochromator will return to the zero order position in both cases.
From CM112: \(<24>_D\)

UNITS
This command allows the selection of units used in the GOTO, SCAN, SIZE, and CALIBRATE commands.

To CM110/112: \(<50>_D <\text{Units Byte}>\)
From CM110/112: \(<\text{Status byte}>\)
CM110/112 Action: If units byte is valid, the CM110/112 will move to the zero order position. The specified units will be used in subsequent commands. Note: Each grating may have a different type of unit specified. Ex: Grating 1 = Å, grating 2 = nm. The valid units bytes are listed below.

\begin{tabular}{ll}
\text{<Units Byte>} & \text{<Spectral Units>} \\
00 & Microns \\
01 & Nanometers \\
02 & Angstroms \\
\end{tabular}

From CM110/112: \(<24>_D\)

ZERO
This command allows the recalibration of the position of the zero order transmission of the monochromator. \textit{Note:} on a CM112, this will Zero both gratings at the same time. The monochromator should be set to the peak of the zero order transmission for each grating while wavelength = 0 using INC, then the zero command is entered.

\textit{CAUTION: Use of this command will erase factory settings.}

To CM110/112: \(<52>_D <1>_D\)
CM110/112 Action: The current zero offset values of the gratings are saved as the zero order position.
From CM110/112: \(<\text{Status Byte}>\)
From CM110/112: \(<24>_D\)

*Note: The CM112 has separate digital drives in each cascaded monochromator and can be used in additive or subtractive mode. Additive dispersion provides better resolution. Subtractive dispersion provides better imaging and low temporal dispersion.

In additive dispersion, the two gratings rotate in the same direction. The grating of the first monochromator spreads the spectrum over an angular range. The grating of the second monochromator doubles this dispersion.
In subtractive dispersion, the two gratings rotate in opposite directions. The first monochromator is used to select a bandpass. The second monochromator removes temporal and angular aberrations introduced by the first monochromator.
4.2 Hand Held Controller DK1200

The DK1200 Handheld Controller instructs the CM110/112 to control a selected spectral region or the CM110/112 can be remotely controlled via a computer.

4.2.1 Operation

The DK1200 receives power from the CM110/112 power pack. Attach the free end of the dual power cable to the DK1200 extension cable. Attach other end of cable to power jack on back of controller. Once the DK1200 receives power, the control display will read:

\[
\text{SPECTRAL PRODUCTS} \\
\text{<> DIGIKROM CM110/112 <>}
\]

Connect the controller RS232 cable to the rear of the CM110/112. Connect the other end of the dual power cable to the power jack on the CM110/112. The CM110/112 will find home position and the control unit display will read:

\[
\text{READY } \lambda = xxxxx \ y \\
\text{UNIT: } zzzzz \ ORDER: \ w
\]

The keyboard consists of 21 keys, 11 control keys, and 10 number keys, including a decimal point. The STOP option, SLIT ADJ and FILTER/SOURCE keys are disabled with the DK1200.

<table>
<thead>
<tr>
<th>KEY NAME</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOTO</td>
<td>The user can change the ( \lambda ) wavelength by entering a value for a new wavelength and then pressing enter. This command changes the grating angle, which in turn changes the wavelength at the exit slit.</td>
</tr>
<tr>
<td>SCAN</td>
<td>The user can scan the intensity of light leaving the exit slit over a wavelength range defined as ( \lambda_2 - \lambda_1 ).</td>
</tr>
<tr>
<td>( \lambda_2 - \lambda_1 )</td>
<td>The user can scan different ranges of wavelength by entering the values of ( \lambda_1 ) and ( \lambda_2 ) with this command, then pressing enter. The value of ( \lambda_2 - \lambda_1 ) may be either positive or negative. Valid values of wavelength are both grating and unit dependent. See Appendix A, page 20.</td>
</tr>
<tr>
<td>FILTER SOURCE</td>
<td>Not applicable</td>
</tr>
<tr>
<td>ENTER STOP</td>
<td>Press the ENTER/STOP key after every command to carry out that action.</td>
</tr>
<tr>
<td>OPTIONS</td>
<td>This command offers 7 menu commands to adjust grating angle number, current units, current order, current type, baud rate, calibration, and to go to next. See section 4.2.4, page 19.</td>
</tr>
<tr>
<td>SCAN SPEED</td>
<td>This command selects the speed at which the CM110/112 will scan the intensity of light at the exit slit for a given wavelength range. The user should refer to Appendix B, page 21 for a list of scan speeds that are appropriate for various gratings.</td>
</tr>
<tr>
<td>SLIT ADJ</td>
<td>Not applicable</td>
</tr>
<tr>
<td>MANUAL •</td>
<td>This command allows the user to change the rotation of the grating by one motor step. It also allows the user to set a new zero position for either ( \lambda ) equal to zero or a nonzero value.</td>
</tr>
</tbody>
</table>
Chapter 4 - Operation

Spectral Products

RESET

Resets the grating turret to the home position when pressed simultaneously with the arrow key ᐊ.

Use the GOTO command to instruct the CM110/112 to find a discrete wavelength. The values of wavelength are grating dependent. Once the key is pressed, the display reads:

```
GOTO λ
ENTER λ = _
```

In response to this prompt, the user may enter the desired wavelength value and press ENTER. During this part of the operation, the display reads:

```
GOTO λ = xxxxx
RUNNING………..
```

Once the CM110/112 finds the specified wavelength, the GOTO operation stops and the READY screen appears.

The SCAN key allows the user to scan between a start and an end position specified by the user. The START position(\(λ_1\)) may be greater or smaller than the END position(\(λ_2\)). Valid values of position are grating and units dependent. The scanning speed for the SCAN command is a constant and is determined by the user. Once the SCAN key is pressed, the display reads:

```
SCAN λ_1 - λ_2
ENTER λ_1 =
```

Enter the starting wavelength and press ENTER. The display will then read:

```
SCAN xxxxx - λ_2
ENTER λ_2 =
```

Now, enter the ending wavelength and press ENTER. Note: once the scan is started it cannot be stopped unless power is disconnected. After the ending wavelength value is entered, the CM110/112 will go to the START position at maximum speed. The CM110/112 will begin scanning, while the display reads:

```
SCAN xxxxx - xxxxxx
SCANNING………..
```

When the scan is complete, the DK1200 will display the READY screen.

The SCAN SPEED key allows the user to control the rate at which the wavelength changes. Values of speed are grating and units dependent and are given in Appendix B, page 21. Once the key is pressed, the display reads:

```
SCAN SPD = xxxxx yy/s
NEW SPD?= zzzzz yy/s
```

```
xxxxx= indicates the present scan speed.
yy = indicates the present unit.
zzzzz = indicates the new scan speed
s = second
```

Pressing the SCAN SPEED key allows the user to cycle to the next value. Pressing ENTER will select the new scan speed. If the user does not wish to change the scan speed, pressing the ← key will return to the READY screen.
Chapter 4 - Operation

Spectral Products

The **QUERY** command offers 19 categories to inquire about. These categories are described in section 4.2.3, page 18.

| ENTER=...........cccccccc | QUERY=Next ←=Cancel |

Note: ccccccccc = the query subject. Pressing **QUERY** again will cycle through the query options. Pressing **ENTER** will select the ccccccccc query. Pressing the ← key will return to the **READY** screen.

The **OPTIONS** command offers seven functions described in section 4.2.4, page 19. Cycle through these options by pressing the **OPTIONS** key. Each option is selected by pressing **ENTER**. Once selected, each option has submenus that will prompt the user for information. Press **ENTER** to accept the changes. Pressing the ← will exit the **OPTIONS** mode and return to the **READY** screen.

| OPTION.................xxxxxx | yyyyyyyyyy |

The **MANUAL** key can be used as a decimal point or **MANUAL** mode key. Section 4.2.5, page 19 describes the functions available under **MANUAL**. Note: once the **MANUAL** key is pressed, and you want to exit the program without entering a change, you must use reset and ← or power off the controller. The power off method will not move the mono and retain previous settings. The reset method will cause the mono to physically move.

Pressing the **MANUAL** key will display the following screen:

| MANUAL = . . . . .Cancel | 4 = Inc & Dec 6 = Step |

CHANGING STEP SIZE
To change the step size, press “6” and **ENTER**. The DK1200 will display the following message:

| MANUAL: | 5 = Size |
| 3 = Step - | 6 = Step + |

Press “5” to specify the step size. The DK1200 will display the following message:

| CUR. SIZE = ppppppppp | NEW SIZE = (see right) |

Value of 1 – 127 increments from size 1 to 127
Value of 127 – 256 decrements from 1 to 127

After entering the step size and pressing **ENTER**, the following message is displayed:

| 5 = Size  λ | 3 = Step - 9 = Step + |

Current λ is displayed.
Pressing “3” decreases λ by one established step size.
Pressing “9” increases λ by one established step size.
Pressing the **MANUAL** key will exit the **MANUAL** mode and return the program to the **READY** screen.
Chapter 4 - Operation

CHANGING THE OFFSET

Note: this command will erase the values previously programmed into your NOVRAM’s memory.

To change the offset value, press MANUAL, enter “4”. The DK1200 will display the following message:

<table>
<thead>
<tr>
<th>CM110</th>
<th>CM112</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANUAL = . . . . CANCEL</td>
<td>MANUAL = . . . . CANCEL</td>
</tr>
<tr>
<td>1 = Dec.</td>
<td>4 = Inc &amp; Dec</td>
</tr>
<tr>
<td>7 = Inc.</td>
<td>6 = Step</td>
</tr>
</tbody>
</table>

7 moves the grating one step below zero (ccw)
1 moves the grating one step above zero (cw)

Pressing MANUAL displays:

<table>
<thead>
<tr>
<th>CM110</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZERO:</td>
</tr>
<tr>
<td>ENTER = YES</td>
</tr>
</tbody>
</table>

Pressing Enter establishes a new zero, ← keeps old zero

OLD OFFSET = ffffff
NEW OFFSET = sssss

Any change in zero offset will be reflected here. Pressing any key will return the program to the READY screen.

4.2.2 Error Screens

VALUE INVALID
Whenever a value is entered that is out of range of the machine or the grating or the units are incorrect, the following screen appears:

VALUE INVALID
HIT ANY KEY TO CONT

Pressing any key will return the program to the READY screen.

COMPLETION ERROR
When there is a failure to complete a task, a value of 24 occurs, the following message appears:

<24> WAS NOT RECEIVED
TURN OFF & ON

The CM110/112 must be turned off and then back on to recover from this error.
### 4.2.3 Query Commands

<table>
<thead>
<tr>
<th>QUERY COMMAND</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTER = . . . . Wavelength</td>
<td>This command describes the current wavelength.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
<tr>
<td>ENTER = . . . . Type</td>
<td>This command is used with the CM112 only. It describes if the monochromator is in subtractive or additive mode.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
<tr>
<td>ENTER = . . . . Cur. Grve</td>
<td>This command describes the groove of the current grating.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
<tr>
<td>ENTER = . . . . Cur. Blaze</td>
<td>This command describes the blaze of the current grating.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
<tr>
<td>ENTER = . . . . Num. Grts.</td>
<td>This command describes which grating is currently in the optical path.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
<tr>
<td>ENTER = . . . . Scan Spd</td>
<td>This command describes the current scan speed.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
<tr>
<td>ENTER = . . . . Size</td>
<td>This command describes the size of each motor step.</td>
</tr>
<tr>
<td>QUERY = Next ← Cancel</td>
<td></td>
</tr>
</tbody>
</table>
| ENTER = . . . . Offs. m1g1     | This command describes the number of motor steps, using motor 1, required for grating 1 to move from the “home” position to the zero order position.
| QUERY = Next ← Cancel         | (CM112 only)                                                           |
| ENTER = . . . . Offs. m1g2     | This command describes the number of motor steps, using motor 2, required for grating 2 to move from the “home” position to the zero order position. |
| QUERY = Next ← Cancel         | (CM112 only)                                                           |
| ENTER = . . . . Offs. m2g1     | This command describes the number of motor steps, using motor 2, required for grating 1 to move from the “home” position to the zero order position (CM112 only) |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Offs. m2g2     | This command describes the number of motor steps, using motor 2, required for grating 2 to move from the “home” position to the zero order position (CM112 only) |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Cal. m1g1      | This command describes the number of motor steps required to move the grating #1 from zero order to a specified “calibration” wavelength. |
| QUERY = Next ← Cancel         | (CM112 only)                                                           |
| ENTER = . . . . Cal. m1g2      | This command describes the number of motor steps required to move the grating #2 from zero order to a specified “calibration” wavelength. |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Grtngs m1      | This command describes the number of gratings configured in NOVRAM.     |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Cur. Unit      | This command describes the current unit setting: microns, nanometers, or angstroms. |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Grve m1g1      | This command describes the groove spacing of grating 1 that is configured in NOVRAM. |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Blze m1g1      | This command describes the blaze of grating 1 that is configured in NOVRAM. |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Grve m1g2      | This command describes the groove spacing of grating 2 that is configured in NOVRAM. |
| QUERY = Next ← Cancel         |                                                                         |
| ENTER = . . . . Blze m1g2      | This command describes the blaze of grating 2 that is configured in NOVRAM. |
| QUERY = Next ← Cancel         |                                                                         |
### 4.2.4 Option Commands

<table>
<thead>
<tr>
<th>OPTION COMMAND</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTION: . . . . Select Grt Number of Grtings = 2</td>
<td>The CM 110 has two gratings. This command alternates the use of gratings 1 and 2.</td>
</tr>
<tr>
<td>OPTION: . . . . . . . . . Unit CUR. UNIT = angs</td>
<td>This command changes the current units to microns, nanometers, angstroms, and inverse centimeters of electron volts.</td>
</tr>
<tr>
<td>OPTION: . . . . . . . . . Order CUR. ORDER = +</td>
<td>This command changes the grating order by changing the direction that the grating rotates (clockwise, +, or counter clockwise, -).</td>
</tr>
<tr>
<td>OPTION: . . . . . . . . . Type CUR. TYPE = . . Single</td>
<td>Not applicable. This option is installed for the CM112 only.</td>
</tr>
<tr>
<td>OPTION: . . . . . . . . . Baudrate BAUDRATE = 9600</td>
<td>Not applicable. This option is not installed for changes.</td>
</tr>
<tr>
<td>OPTION: . . . . . . . . . Calibration Ready ( \lambda = 00000 )</td>
<td>This command calibrates the instrument at a wavelength specified by the user.</td>
</tr>
<tr>
<td>OPTION: . . . . . . . . . Remote OPTIONS = Nxt ( \leftarrow ) Cancel</td>
<td>This command sets the control module so that the monochromator can be operated remotely through an RS-232 serial port.</td>
</tr>
</tbody>
</table>

### 4.2.5 Manual Commands

<table>
<thead>
<tr>
<th>MANUAL COMMAND</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANUAL = . . . . Cancel 4 = Inc &amp; Dec 6 = Step</td>
<td>This command allows the user to recalibrate to a zero wavelength or a nonzero wavelength.</td>
</tr>
<tr>
<td>MANUAL = . . . . Cancel 1 = Dec 7 = Inc</td>
<td>This command moves the motor one step CCW, when pressing INC, and one step CW when pressing DEC.</td>
</tr>
<tr>
<td>MANUAL: . . . . 5 = Size 3 = Step - 9 = Step +</td>
<td>This command allows the user to calibrate to a nonzero wavelength. This command moves the motor one step CCW, when pressing STEP+, and one step CW when pressing STEP-.</td>
</tr>
</tbody>
</table>

Press MANUAL  " " " " " " " " " To exit MANUAL mode.
Appendix A  Wavelength Range

A. Wavelength Ranges

The CM110/112 is restricted to angles between 0 and 70 degrees. The upper restriction is imposed because the grating is almost edge-on to the incident beam beyond this angle.

From these restrictions, one may use the grating equations to calculate the valid ranges and step sizes for any particular grating. The table below lists the maximum wavelength for each grating set in the CM110/112’s software.

### UPPER WAVELENGTH SCAN LIMIT AND MAXIMUM WAVELENGTH INCREMENTS PER ANGULAR STEP FOR DIFFERENT GRATINGS

(Lower wavelength scan limit is zero)

<table>
<thead>
<tr>
<th>Grating (Grv/mm)</th>
<th>Upper limit (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3600</td>
<td>500</td>
</tr>
<tr>
<td>2400</td>
<td>750</td>
</tr>
<tr>
<td>1800</td>
<td>1000</td>
</tr>
<tr>
<td>1200</td>
<td>1500</td>
</tr>
<tr>
<td>600</td>
<td>3000</td>
</tr>
<tr>
<td>300</td>
<td>6000</td>
</tr>
<tr>
<td>150</td>
<td>12000</td>
</tr>
<tr>
<td>75</td>
<td>24000</td>
</tr>
</tbody>
</table>

Diffraction Limit to Resolution

The grating used in a CM110/112 is a reflective surface with a series of vertical parallel grooves. Collimated light is directed toward the grating, which in turn diffracts the light into component wavelengths. A slight rotation of the grating causes a change in wavelength transmission. For a fully illuminated grating, the resolution of a grating, or ability to distinguish between two wavelengths, is given by the following equation:

\[ \Delta \lambda = \frac{\lambda}{N} \text{ or } \Delta \lambda = \frac{\lambda}{Wd} \]

Example: with 1200 gr/mm, 30mm wide @ 600nm

\[ \Delta \lambda = \frac{600}{1200 \times 30} = 0.017 \text{ nm if grating is full} \]

- \( m \) = order
- \( N \) = total number of grooves illuminated
- \( \lambda \) = wavelength at slit
- \( d \) = groove density in gr/mm
- \( W \) = grating width (mm)

Grating Equation

\[ \lambda = \frac{\left(2 \cos \frac{\phi}{2}\right) \sin \theta}{mG} \]

Where

- \( G \) = groove density in gr/mm
- \( \phi \) = the full Ebert angle. This is a fixed angle determined by the position of the grating, the collimating mirror, and the focusing mirror. It is approximately 25.4° for the CM110/112.
- \( \theta \) = is the angle that the grating rotates measured from the point at which white light is specularly reflected through the instrument. 70° is the maximum grating angle for the CM110/112. The CM110/112 grating drive provides a minimum \( \Delta \theta \) of 0.0075°
- \( m \) = is the order of diffraction. For light incident normal to the grating, some of the light will be reflected, diffracted to the right (+1 order), and diffracted to the left (-1 order). Diffraction at greater angles also occurs, but it is not significant (orders \( \pm 2, \pm 3, \ldots \)).
Appendix B  Scan Speeds

B. Wavelength Scan/Slew Speeds

Valid scan speeds required by the SPEED command are listed below:

### TABLE E-1
Allowed Scan Speed Specifiers [Å/sec]

<table>
<thead>
<tr>
<th>Grating [grv/mm]</th>
<th>n = 0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>3600</td>
<td>333</td>
<td>166</td>
<td>83</td>
<td>41</td>
<td>20</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2400</td>
<td>500</td>
<td>250</td>
<td>125</td>
<td>62</td>
<td>31</td>
<td>15</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1800</td>
<td>666</td>
<td>332</td>
<td>166</td>
<td>82</td>
<td>40</td>
<td>20</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1200</td>
<td>1000</td>
<td>500</td>
<td>250</td>
<td>125</td>
<td>62</td>
<td>31</td>
<td>15</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>600</td>
<td>2000</td>
<td>1000</td>
<td>500</td>
<td>250</td>
<td>124</td>
<td>62</td>
<td>30</td>
<td>14</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>300</td>
<td>4000</td>
<td>2000</td>
<td>1000</td>
<td>500</td>
<td>248</td>
<td>124</td>
<td>60</td>
<td>28</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>150</td>
<td>8000</td>
<td>4000</td>
<td>2000</td>
<td>1000</td>
<td>496</td>
<td>248</td>
<td>120</td>
<td>56</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>75</td>
<td>16000</td>
<td>8000</td>
<td>4000</td>
<td>2000</td>
<td>992</td>
<td>496</td>
<td>240</td>
<td>112</td>
<td>48</td>
<td>16</td>
</tr>
</tbody>
</table>

The actual scan speed of the monochromator is determined by the formula:

\[
\text{Actual Speed} = \frac{\text{Maximum Speed}}{2^n}
\]

**Examples:**

- User defines scan speed as 1000 Å/sec w/1220 g/mm grating
  \[
  \text{Actual speed} = \frac{1000}{2^0} = 1000 \, \text{Å/sec}
  \]

- User defines scan speed as 62 Å/sec w/600 g/mm grating
  \[
  \text{Actual speed} = \frac{2000}{2^5} = 62.5 \, \text{Å/sec}
  \]
Many computer-based commands (RS-232) both send and receive information in the form of multi-byte specifiers. For a number given in decimal form, such as base 10, to be sent to the monochromator, the number must first be broken down into hexadecimal bytes (8 bits). Then, each byte is converted into a decimal value. This decimal value is transmitted as a ASCII character to the communication device. Then, the monochromator translates the characters into the form necessary to perform the operation. Conversely, the monochromator sends the data back in decimal characters. Each is a byte long, and the computer application must convert these separate bytes back to a useful decimal value.

**ENCODING DATA BYTES**

The desired command is **GOTO** 100 nm.

The **GOTO** command in RS-232 is specified as:

\[<16><HIBYTE><LOWBYTE>\]

where the units for the two byte specifier are determined by the current **UNITS** selected. For this example, the units are in Angstroms.

**Step 1:** Convert the desired specifier to proper units.

100 nm = 1000 Angstroms

**NOTE:** The following steps will be shown two ways: (A) with conversions performed by an unspecified algorithm, for example, using a calculator with decimal-hex conversion capability, and (B) using a numeric algorithm that is more suitable for computers.

**Method A:**

**Step 2:** Convert to Hexadecimal

1000(base 10) = 3E8(base 16)

**Step 3:** Break the hex value into two bytes

3E8(base 16) => 03 | E8  

Hi   Lo

**Step 4:** Convert each byte to its decimal equivalent

- Hibiye: 03(base 16) => 03(base 10)
- Lowbyte: E8(base 16) => 232(base 10)

**Step 5:** Send the command. The specifiers are 3 and 232.

**Method B:**

**Note:** All the following numbers are given in decimals.

**Step 2:** Divide by 256 and round down to the nearest whole number.

EX: 1000 / 256 = 3.90625 rounds to 3 = Hibiye

**Step 3:** Adjust the remainder. The remainder is the Lowbyte.

EX: 1000 - (256 x Hibiye) = 1000 - (256 x 3) = 232

Remainder = 232 = Lowbyte

**Step 4:** Send the command. The specifiers are 3 and 232.
The desired command is **QUERY POSITION**.

The **QUERY POSITION** command returns two bytes indicating the current wavelength, in the form

\[
<\text{HIBYTE}><\text{LOWBYTE}>
\]

To be useful to the user, the two bytes must be converted back to a single decimal number. As before, we can do this by either method A or method B, by essentially reversing the above procedures.

For this example, the **QUERY POSITION** command returns the ordered pair (5, 106), Híbyte, Lowbyte respectively, as the current wavelength. For this example, the units are in Angstroms.

**Method A:**

**Step 1:** Convert each byte to its hex equivalent

Híbyte: \(05\) (base 10) = \(5\) (base 16)

Lowbyte: \(106\) (base 10) = \(6A\) (base 16)

**Step 2:** Concatenate the 2 bytes to form one hex number

\(05 \mid 6A = 056A\) (base 16)

**Step 3:** Convert the hex number to a decimal

\(056A\) (base 16) = \(1386\) (base 10) Å = \(138.6\) nm.

**Method B:**

*Note:* All of the following numbers are in decimals.

**Step 1:** Use the formula:

\[
\text{Wavelength } (\lambda) = (\text{Híbyte} \times 256) + \text{Lowbyte}
\]

\((05 \times 256) + 106 = 1386\) Angstroms
Appendix D  Status Bytes

D. Status Bytes

Whenever the CM110/112 is given a command, it will respond with a status byte that indicates whether or not the command was accepted. Each bit in the status byte has a meaning, which is given below. When a command is not accepted, some of the bits of the status byte will indicate the reason. In general, if $<\text{Status Byte}>_D$ is smaller than 128, then the command was accepted.

Bit 7: 0 if the command is accepted.
       1 if the command is not accepted.

Bit 6: 0 if the command requires action
       1 if the command requires no action (specifier value equals present value)

Bit 5: 0 if the specifier was too large
       1 if the specifier was too small (Irrelevant if Bit 7 is 0.)

Bit 4: 0 if scan is positive going
       1 if scan is negative going (Irrelevant if Bit 7 is 0.)

Bit 3: 0 if positive orders
       1 if negative orders

Bit 2,1,0: Binary value is:
         000 if units are microns
         001 if units are nanometers
         010 if units are angstroms

For the SCAN command, which uses two specifiers, bits 6 and 5 take slightly different meanings.

Bit 6: 1 if Lambda 1 is not acceptable
       0 if Lambda 1 is acceptable

Bit 5: 1 if Lambda 2 is not acceptable
       0 if Lambda 2 is acceptable
These commands are **Read from Novram** and **Write to Novram**. There are 128 memory locations in the Novram, and their addresses are from 0 to 127. Table on page 27 gives the address and the meaning in the Novram memory.

### READ FROM NOVRAM

These commands read a byte from the monochromator's non-volatile memory.

- **To CM110/112:** `<156>`<Address Byte>
- **From CM110/112:** `<Data Byte>`
- **From CM110/112:** `<Status byte>`
- **CM110/112 Action:** No action.
- **From CM110/112:** `<24>`<D>

*Data Byte* contains a returned value, and *Address Byte* is 0 through 127.

### WRITE TO NOVRAM

These commands write a byte to the monochromator's non-volatile memory.

> **WARNING !!!**
> Improper use of this command may corrupt the configuration and calibration information of the monochromator. Consult **Spectral Products** if you need to restore factory settings.

- **To CM110/112:** `<159>`<Address Byte><Data Byte><Checksum Byte>
- **From CM110/112:** `<Status byte>`
- **CM110/112 Action:** If valid, *Data Byte* is saved into non-volatile memory at *Address Byte*.
- **From CM110/112:** `<24>`<D>

Valid choices for *Address Byte* are integer values between 0 and 127, and valid values for *Data Byte* are integer values between 0 and 255. The *Checksum Byte* = *Address Byte* + *Data Byte*. The checksum will be truncated to 1 byte long if its value is bigger than 255.

### CALIBRATION

Proper calibration should always be a two step procedure where ZERO is set first, followed by calibrating at a specific wavelength as follows:

#### CALIBRATING ZERO WITH A HANDHELD CONTROLLER

*Calibrating CM110 zero will erase the value previously programmed into your NOVRAM’s memory. Consult **Spectral Products** before proceeding with CM112. CM112 Zero is factory set.*

1. Using a white light source, illuminate the entrance slit. Make sure the light source is aligned perpendicular to the entrance slit.
2. Install your smallest slits, preferably .125 mm, at both the entrance and exit.
3. Look through the exit slit. You should see the illuminated white light source.
4. If necessary, you may have to reset the Zero location using the MANUAL command.
5. Using GOTO, Set $\lambda=0$
6. Press Enter.
8. To move the motor one step **counterclockwise** press “1”, one step **clockwise** press “7”. Press either “1” or “7” until you see the white light source at its brightest intensity.
9. You will be asked if you want to accept the new value for zero. You can accept or reject the changes.
CALIBRATING AT A WAVELENGTH WITH A HANDHELD CONTROLLER

Recalibration will erase the values previously programmed in your NOVRAM’s memory.

1. Using a discrete light source, such as a HeNe laser or a Hg pen lamp, illuminate the entrance slit. Make sure the light source is aligned perpendicular to the entrance slit.
2. Install your smallest slits, preferably .125 mm, at both the entrance and exit.
3. Use an appropriate detector for determining maximum intensity.
4. Using GOTO, set \( \lambda \) = (to the new wavelength). Press Enter.
5. If the new wavelength is not correct, enter into MANUAL mode, press 6 (step).
6. At this point, you have three options: 3=STEP-, 5=SIZE, and 9=STEP+. “3” and “9” move the motor one unit wavelength in each direction. Toggle between 3 and 9, until the light source is at its maximum intensity.
7. Press MANUAL to exit.
8. Press OPTIONS until CALIBRATION appears. Press ENTER.
9. Enter the spectral wavelength, in the appropriate units, press ENTER to calibrate the machine.
## NOVRAM ADDRESS

<table>
<thead>
<tr>
<th>Address</th>
<th>The meaning of the content</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The baudrate index: 0 is 9600 b/s</td>
</tr>
<tr>
<td>1</td>
<td>Current selected grating: 1 or 2.</td>
</tr>
<tr>
<td>2</td>
<td>Zero offset high byte of machine 1, grating 1.</td>
</tr>
<tr>
<td>3</td>
<td>Low byte of the above number.</td>
</tr>
<tr>
<td>4</td>
<td>Zero offset high byte of machine 1, grating 2.</td>
</tr>
<tr>
<td>5</td>
<td>Low byte of the above number.</td>
</tr>
<tr>
<td>6</td>
<td>Calibration high byte of machine 1, grating 1</td>
</tr>
<tr>
<td>7</td>
<td>Low byte of the above number</td>
</tr>
<tr>
<td>8</td>
<td>Calibration high byte of machine 1, grating 2</td>
</tr>
<tr>
<td>9</td>
<td>Low byte of the above number</td>
</tr>
<tr>
<td>10</td>
<td>Groove index of grating 1; 0: = 3600 g/mm; 1: = 2400; 2: = 1800; 3: = 1200; 4: = 600; 5: = 300; 6: = 150; 7: = 75.</td>
</tr>
<tr>
<td>11</td>
<td>Groove index of grating 2. The meaning is the same as grating 1.</td>
</tr>
<tr>
<td>12</td>
<td>Blazed high byte of grating 1 in nm.</td>
</tr>
<tr>
<td>13</td>
<td>Low byte of the above number.</td>
</tr>
<tr>
<td>14</td>
<td>Blazed high byte of grating 2 in nm.</td>
</tr>
<tr>
<td>15</td>
<td>Low byte of the above number.</td>
</tr>
<tr>
<td>16</td>
<td>Total gratings of machine 1.</td>
</tr>
<tr>
<td>17</td>
<td>Total gratings of machine 2. (CM112 only)</td>
</tr>
<tr>
<td>18</td>
<td>Zero offset high byte of machine 2, grating 1. (CM112 only)</td>
</tr>
<tr>
<td>19</td>
<td>Low byte of the above number. (CM112 only)</td>
</tr>
<tr>
<td>20</td>
<td>Zero offset high byte of machine 2, grating 2. (CM112 only)</td>
</tr>
<tr>
<td>21</td>
<td>Low byte of the above number. (CM112 only)</td>
</tr>
<tr>
<td>22</td>
<td>Order and Type. Bit 0 (for m1g1): 1 is - order, 0 is + order; Bit 1 (for m1g2): 1 is - order, 0 is + order; Bit 4 (for grating 1): 1 is subtractive dispersion, 0 is additive dispersion; Bit 5 (for grating 2): 1 is subtractive dispersion, 0 is additive dispersion. (Bits 4,5 CM112 only)</td>
</tr>
<tr>
<td>23</td>
<td>Not used</td>
</tr>
<tr>
<td>24</td>
<td>Current machine 1 unit – 0=centimicrons, 1=nm, 2=angstroms</td>
</tr>
<tr>
<td>25</td>
<td>Current machine 2 unit – 0=centimicrons, 1=nm, 2=angstroms (CM112 only)</td>
</tr>
<tr>
<td>26</td>
<td>Serial number high byte</td>
</tr>
<tr>
<td>27</td>
<td>Serial number low byte</td>
</tr>
<tr>
<td>28</td>
<td>Not used</td>
</tr>
<tr>
<td>29</td>
<td>Not used</td>
</tr>
<tr>
<td>30</td>
<td>Not used</td>
</tr>
<tr>
<td>31</td>
<td>Not used</td>
</tr>
<tr>
<td>32</td>
<td>AA in hex if programmed</td>
</tr>
<tr>
<td>33</td>
<td>AA in hex if programmed</td>
</tr>
<tr>
<td>34 - 127</td>
<td>Not used</td>
</tr>
</tbody>
</table>
Appendix F  Accessories

Complete listing of additional accessories and pricing is available from Spectral Products.

### Light Sources and Calibration Lamps available through Spectral Products

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS201-S</td>
<td>Xenon fiber optic &quot;extended&quot; light source, with type S liquid lightguide, 175 W in a combination power supply/lamp housing assembly. Range: 200-1100 nm.</td>
</tr>
<tr>
<td>AS220</td>
<td>Visible source assembly. A 30 W tungsten-halogen lamp in housing with focusing optics. A separate constant current power supply is provided for filament temperature control. Fiber coupling is available. Range: 300-2500 nm.</td>
</tr>
<tr>
<td>AS240</td>
<td>UV-Deuterium source assembly. A 30 W deuterium lamp in its own housing for coupling with Digikröm monochromators. Fiber coupling is available. Range 180-400 nm.</td>
</tr>
<tr>
<td>AS260</td>
<td>Spectral calibration assembly, lamp housing and power supply for the following spectral calibration lamps.</td>
</tr>
<tr>
<td>AS361</td>
<td>Hg spectral calibration lamp. Range: 180-1020 nm</td>
</tr>
<tr>
<td>AS362</td>
<td>Ne spectral calibration lamp. Range: 800-3500 nm</td>
</tr>
<tr>
<td>AS363</td>
<td>Xe spectral calibration lamp. Range: 800-3500 nm</td>
</tr>
<tr>
<td>AS364</td>
<td>Ar spectral calibration lamp. Range: 700-1000 nm</td>
</tr>
<tr>
<td>AS365</td>
<td>Kr spectral calibration lamp. Range: 400-2200 nm</td>
</tr>
</tbody>
</table>

**AD110 Photobyte-P Photomultiplier Amplifier System**

The AD110 is a computer controlled photomultiplier amplifier, which allows current measurements while interfaced with a side-on PMT. Signals from the detector are sent to an A/D converter data acquisition card, which communicates with LabVIEW®, QuickBASIC®, and Visual Basic® software packages. Interface cabling is provided and connections are explained in the AD110 user’s manual.

**AD130 Photodetector Module**

The AD130 is a Photobyte S detector module. It was designed to operate with any of Spectral Products’ monochromators. The AD130 module does not have the sensitivity of a photomultiplier tube, and is not appropriate for some applications. Spectral Products offers an uncooled germanium photodiode to extend the useful range of the AD130 module. However, due to high dark currents, this option is considerably less sensitive than alternative detection systems. Interface cabling is provided and connections are explained in the AD130 user’s manual.

**AD140 CCD Detection System**

The AD140 system consists of either a Digikröm CM110/112 monochromator, an EDC-1000 digital controlled camera and a plug-in interface card and connecting cables. The software is written in Visual Basic™ for Windows™ and runs on Windows™ 3.1. Interface cabling is provided and connections are explained in the AD140 user’s manual.

**AF Series –** A full line of fiber optic couplers, adapters, and cable assemblies that allow even greater portability of the CM110/112.
G. Product Conversions

Changing Slits
To change the entrance slit, pull the slit out from the slit mount. The slit mount flange has a spring ball plunger that is factory set for holding the slits firmly in place. When sliding the slit in and out, you should feel the force of the ball plunger.

Converting to a Spectrograph
The CM110/112 can be used in spectrograph mode when using the AD140 CCD camera with the exit folding mirror in place. Simply remove the exit slit and the bayonet flange. Then, attach the AD140 using its own mount.

If you are considering coupling the CM110/112 in spectrograph mode with other CCD array detection devices, use the CMSP110 instead. This unit has significant design differences, such as a different focusing mirror and exit port adapter (see below). Call Spectral Products for a quote on converting your CM110/112 to a CMSP110/112 or vice versa.

Optical Configuration of the CM110/112

Changing the Optical Path
Optical configuration may be changed to allow for either a right angle or a straight-through optical path. The Digikröm CM110/112 is factory assembled with a removable folding mirror in place, unless otherwise requested by the customer. Therefore, the instrument is usually configured for a straight-through optical path.

**NOTE:** only one of the two folding mirrors in the CM110/112 is removable. **Before** you attempt to remove the mirror, refer to page 28, and follow directions below:

The conversion of the monochromator from the straight-through optical configuration to the right angle optical configuration is a six-step process.
1. The folding mirror assembly is held in place by two 4-40 screws (items #1) located at the exit flange side. Remove the two screws, and gently pull the folding mirror mount assembly out of the CM110/112 housing.
2. To remove the folding mirror from its mount, remove the center 4-40 screw (item #2) that holds the mirror in place. Gently pull the mirror off of the mount. **Be careful** not to touch the mirror’s surface because it can be easily scratched or damaged.
3. Reinsert the middle screw into the mirror mount assembly and attach with a 4-40 nut. This is necessary in order to keep stray light to a minimum.
4. Move the exit flange from the side position to the position where you removed the folding mirror.
5. Install the mirror mount (which you disassembled in step 2) into the opening where you removed the exit flange.
6. The monochromator should be re-zeroed. **NOTE:** do not proceed with this step until you understand Calibrating Zero with a Handheld Controller and Calibrating at a Wavelength on pages 24 and 25.

Changing Gratings
To change gratings, please contact the Spectral Products Group at Spectral Products at (505) 296-9541.
Appendix H  Reference Drawings

H. Reference Drawings

Connections – Power / RS232

![Digikröm CM110- End View](image)

Changing the Optical Path

![Optical Path Diagram](image)
Appendix H  Reference Drawings

Optical Bench Mounting

Description

1. M6 threads (3) used for attaching the instrument to a optical bench.
2. ¼ - 20 threads (3) used for attaching the instrument to a optical bench.

Threaded holes are occupied with set screws to prevent light leaks. If set screws are removed for mounting, retain for future use.
Optical Path Design

Figure 1
Schematic of the “Straight-through” Optical Configuration for the Digikröm CM110

Figure 2
Schematic of the “Right Angle” Optical Configuration for the Digikröm CM110
I. Reference CM110/CM112 Interface Pin Layout

Fig. I-1 CM110 to AT 9 Pin Serial Port

Fig. I-2 CM110 To PC 25-Pin Serial Port
J. Reference Serial Relay Command

SERIAL RELAY OPERATION

All Spectral Products Instruments with an RS232 interfaces now support a serial relay mode. The serial mode allows multiple instruments to be controlled from one serial port.

In the serial relay mode, a daisy-chain cable allows serial messages to be relayed from instrument to instrument. Only one selected instrument will respond to the message.

A computer sends a serial message over its RxD line to instrument #1. If instrument #1 is in the SELECT state, that message is interpreted as a command. If the instrument is in the DELSELECT state, the message received on the RxD line is retransmitted on the TxD line. The handshaking signals (CTS, RTS) are similarly relayed. The deselected instrument acts as a repeater.

**DESELECT COMMAND**

The `DESELECT` command places the instrument in a serial relay mode. In the mode the instrument will echo all inputs. The monochromator will only recognize the `SELECT` command while in this mode:

To Instrument  `<255>` `<254>`
From Instrument `<255>` `<254>`

Instrument action: Relays all commands (Only recognizes select command).

**SELECT COMMAND**

The `SELECT` command places the instrument in normal operation. Because the `SELECT` command is serial number specific, a `SELECT` command will enable only a single instrument.

To Instrument  `<255>` `<253>` `<HighByte>` `<LowByte>`
From Instrument `<255>` `<253>` `<HighByte>` `<LowByte>`
From Instrument `<24>`

Instrument action: Recognizes all commands (Normal operation).

* Where `256 * <HighByte> + <LowByte> = Serial Number of Instrument`

**Caution:**

Only a single instrument should be selected at one time. Therefore, a `DESELECT` command should precede each `SELECT` command.

**Data Rate:**

All instruments must be set for the same baud rate, number of stop bits, and number of parity bits.