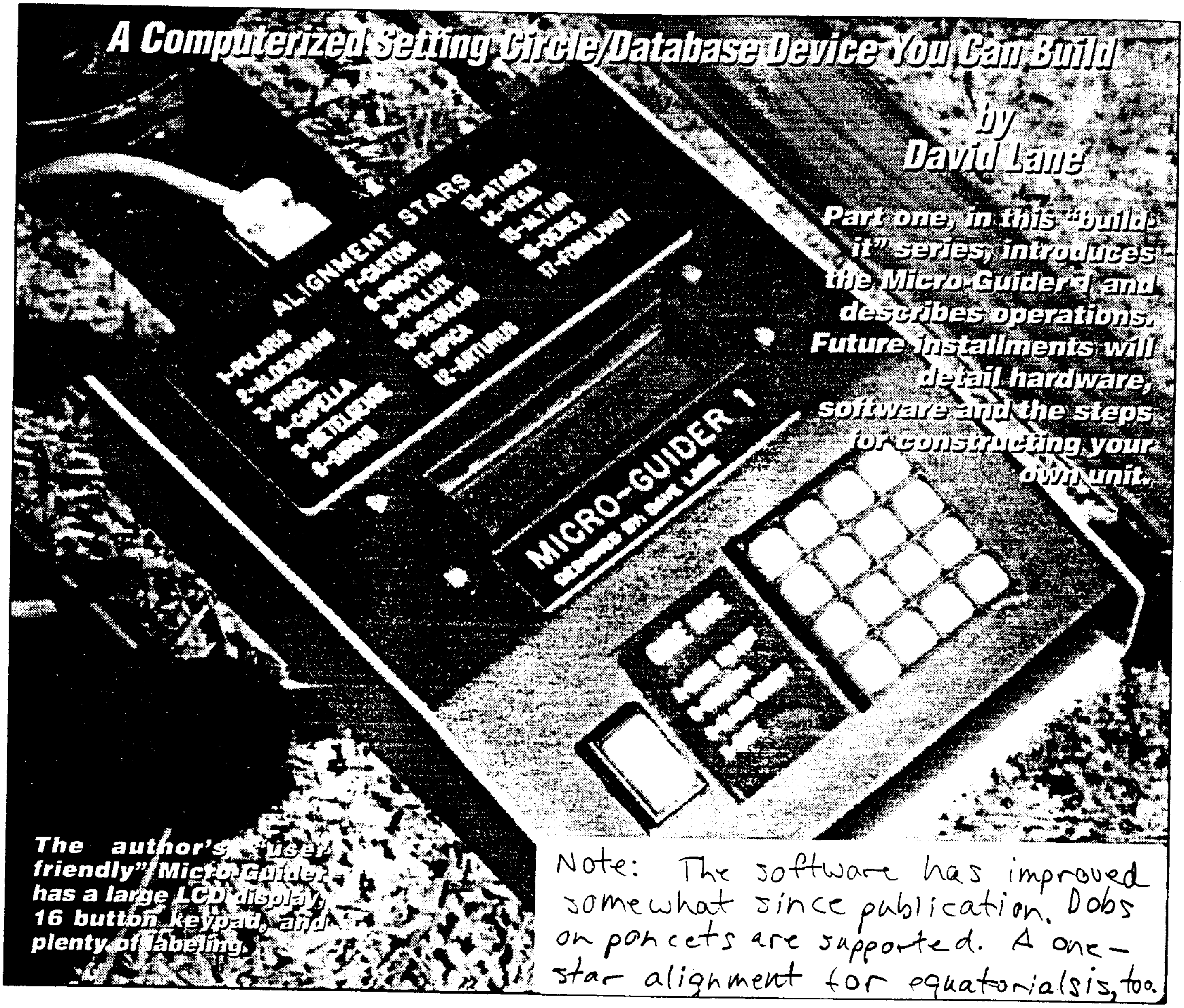
How to Build Your Own Digital Setting Circles!

The Micro-Guider 1

A Computerized Setting Circle/Database Device You Can Build

by David Lane

Part one, in this "build-it" series, introduces the Micro-Guider 1 and describes operations. Future installments will detail hardware, software and the steps for constructing your own unit.



The author's "user friendly" Micro-Guider has a large LCD display, 16 button keypad, and plenty of labeling.

Note: The software has improved somewhat since publication. Dobs on poncets are supported. A one-star alignment for equatorials, too.

The Micro-Guider is a device which I have designed and built to provide a telescope with digital setting circles, complete with a database of 7,875 celestial objects. Its design provides many of the features of commercially available units, but can be built for a fraction of their cost.

It also contains an RS232 port which is compatible with the commercial DOS and Windows-based *TheSky* Astronomy Software; more details about that later. This article will describe the Micro-Guider's operation, hardware, software, and construction. It is my intent to provide enough information here to allow the electronics-inclined telescope maker to build the device themselves. In fact, several Micro-Guiders have already been built and are in service.

To assist in building the Micro-Guider, I have available a supply of blank printed circuit boards, and will provide the programmed EPROM chips needed to complete the device.

DESCRIPTION

The Micro-Guider is a self-contained device which connects to a telescope by using two optical encoders, one attached to each axis. The optical encoders translate the rotational movements of the telescope into electrical signals which are interpreted by the Micro-Guider's on-board microprocessor.

The Micro-Guider is very user-friendly by incorporating a large two line by 20 column liquid crystal display (LCD), and a 16-key keypad for user interaction. In addition, the on-board software is entirely menu-driven.

As is normal practice with modern digital setting circles, the Micro-Guider uses two initial known coordinates to align itself. This allows it to work equally well with equatorial or altazimuth mounted telescopes, since it does not require polar alignment or mount leveling. Once aligned, it uses the elapsed time and the azimuth and altitude to calculate the current right ascension and declination.

In addition to the right ascension and declination display, the Micro-Guider also has a built-in database of celestial objects. The database contains 17 bright alignment stars, the 110 Messier objects, the entire 7740 object NGC database, and the eight planets. Five "user" objects also allow for the entering of comets, minor planets, etc.

The Micro-Guider also has a real-time clock which is used to calculate the planet positions and could be used for occultation timings, etc. Another time related feature is a countdown timer with a "beeper," which can be used to time astrophoto exposures.

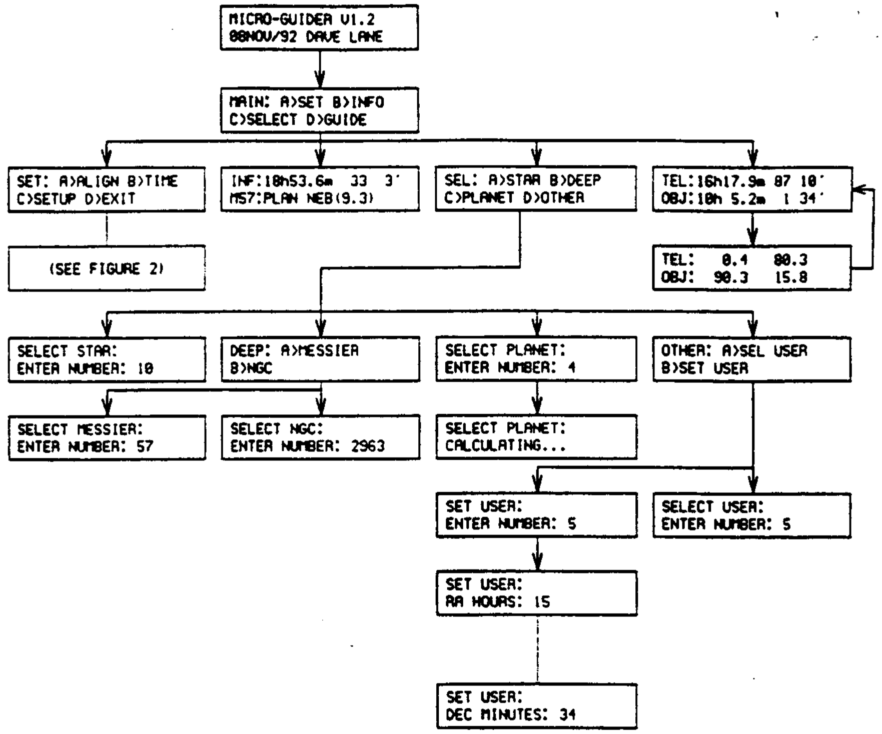


Figure 1
Micro-Guider Menu Structure

OPERATION

The operation of the Micro-Guider is quite intuitive, however some basic explanation is provided here. Figures 1 and 2 show the menu structure used. When the power is applied, a brief opening message is displayed, followed by the appearance of the "MAIN" menu (see Figure 1).

The keypad contains the ten numbers, the letters A through D and the keys '*' and '#'. The menus are accessed by pressing the letter immediately in front of the desired function. The 'D' key is usually used to select the previous menu. Numbers are entered directly from the keypad. The '*' key is used as a back-space and the '#' key is the enter key. To enter a negative number, the 'D' is used as the minus sign.

The first operation which must be performed is the "ALIGN" function. This is accessed by pressing 'A' to access the "SET" menu (see Figure 2) and then pressing 'A' again to access the "ALIGN" function. The user is asked to set the telescope to +90 degrees in altitude, which would correspond to +90 degrees in declination for an equatorially mounted telescope. This is gives the Micro-Guider a reference point for the altitude axis. A reference point for the azimuth axis is not needed.

The user then selects the first alignment star (or any other object in the database). The object is selected by using the "SELECT" menu, described a few paragraphs below. After the object is selected and is placed in the center of the

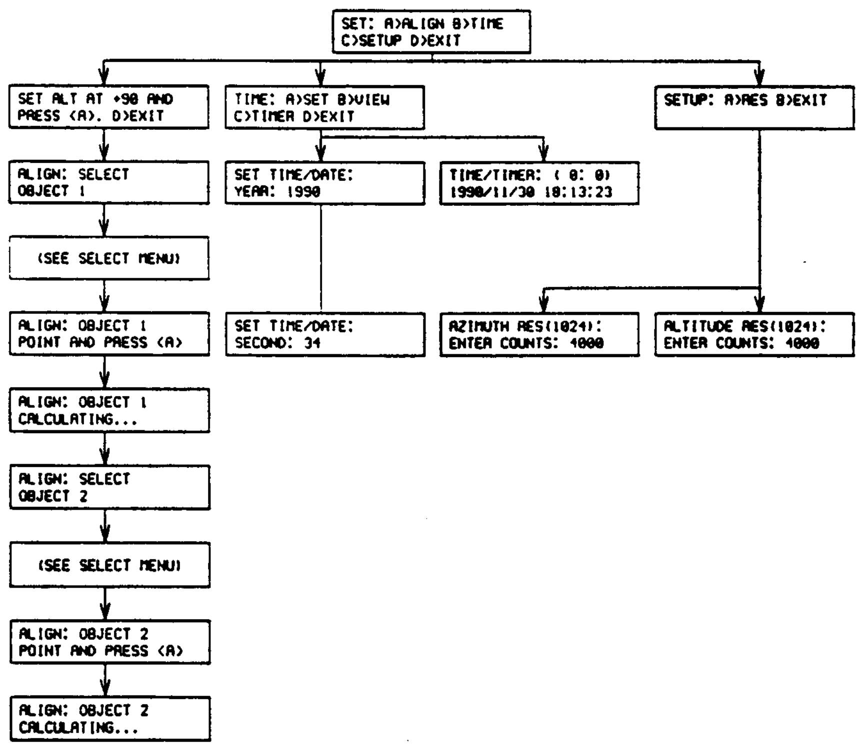
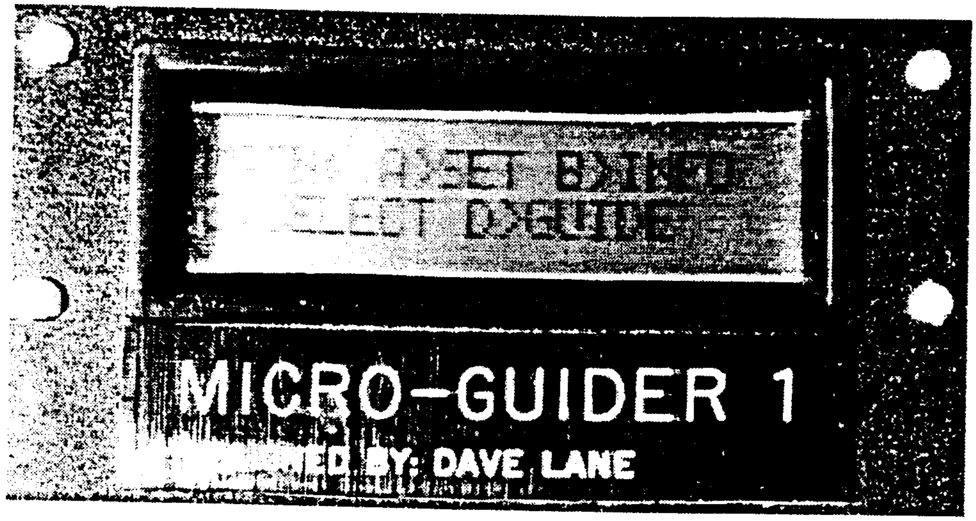


Figure 2
Micro-Guider Set Menu Structure



This view of the Micro-Guider shows the LCD display with the main menu; A) SET B) INFO C) SELECT and D) GUIDE.

telescope's field of view, the 'A' key is pressed.

The same procedure is performed for the second alignment star, following which, the Micro-Guider is ready for use. For maximum accuracy, the alignment objects should be selected such that there is a significant amount (more than 30 degrees) of movement of both encoders between the two objects. Accuracy will also be better if the objects being searched for are in the same general area of the sky as the alignment objects.

Some other important selections are also contained in the "SET" menu. The time and date are set and viewed by the "TIME" menu. The countdown timer is

The Micro-Guider is very user-friendly...

also set from this menu. The countdown timer, once set, operates while the Micro-Guider is in any menu. The time remaining is displayed in the "VIEW" selection. Once the time is expired, the beeper will "beep," and pressing any key will disable the beeper.

The "SETUP" menu is used to set the resolution (counts per revolution) of the encoders. The time and date as well as the parameters set in the "SETUP" menu are nonvolatile, thus are retained even when the power is removed.

Meanwhile, back at the "MAIN" menu, the "SELECT" menu, is used to select an object to search for, and is used by the "ALIGN" function, described above, to select alignment objects. The first selection in the "SELECT" menu is for stars. This database contains 17 bright stars visible from the northern hemisphere, numbered 1 to 17 (Polaris, Aldebaran, Rigel, Capella, Betelgeuse, Sirius, Castor, Procyon, Pollux, Regulus, Spica, Arcturus, Antares, Vega, Altair, Deneb, and Fomalhaut respectively).

The second selection is for deep sky objects. This selection provides a second menu for selection of Messier or NGC objects. The Messier database contains all the modern 110 objects and the NGC database contains all 7740 objects.

The eight planets are selected by a number corresponding to their order from the sun. If a '3' is entered (meaning the Earth), the coordinates calculated are not very accurate, simply instructing the user to "look down!"

The "OTHER" selection refers to what I call "user objects." Selecting "OTHER" provides a second menu which allows the user objects to be set to a specified right ascension and declination, and selected. The Micro-Guider supports up to five "user objects." This menu is not exited until the user selects one of the five user objects. The user objects are nonvolatile and thus, are even retained when the power is lost. The user objects are especially useful for objects such as comets or asteroids, since the expected locations of these objects can be programmed indoors before going out to observe.

The next "MAIN" menu item is the "INFO" selection, which provides information about the currently selected object. This includes the object's identity (M35, NGC4545, MERCURY, etc.), object type (STAR, OPEN CLUSTER, NEBULA, etc.), magnitude, and coordinates. Pressing any key returns to the "MAIN" menu.

The last selection in the "MAIN" menu is the "GUIDE" mode. Entering this mode displays one of two screens.

The first screen displays the telescope's coordinates on the top line and the selected object's (if an object is selected) coordinates on the bottom line. The telescope's coordinates are recalculated if the telescope is moved or at periodic intervals (depending on the encoder resolution). Pressing the 'A' key causes the display to change such that it displays the telescope azimuth and altitude continuously on the first line and the selected object's azimuth and altitude on the second line. The object's azimuth and altitude are recalculated at periodic intervals (depending on the encoder resolution). Pressing the 'A' key again will return to the first display. I use this second screen for locating objects, by following the steps below:

1) Select an object with the "SELECT" menu
2) Use the "INFO" selection to ensure selection of the correct object and to check the magnitude
3) Enter the "GUIDE" mode
4) Press 'A' to select screen 2
5) Turn the telescope axis until the two azimuth and altitude displays match
6) Center the object in the telescope with a low power eyepiece
7) Enjoy the view!

All of these steps take only a few seconds, except step 7. We must remember that for most of you (and me), this device will allow more objects to be found in a given amount of time, but we should use this time to more carefully observe the objects that we do find!

The final two active keys in "GUIDE" mode are the 'C' and 'D'. The 'C' key will cause the current object to be unselected and the 'D' key will cause the Micro-Guider to return to the "MAIN" menu.

If the "GUIDE" mode is entered without having previously done an alignment, the *TheSky* compatibility mode is entered. In this mode the current telescope altitude and azimuth is transmitted using the serial RS232 port whenever requested from a connected computer. Pressing any key will return to the "MAIN" menu. *Look forward to hardware details in the next OTM.*

The Micro-Guider 1

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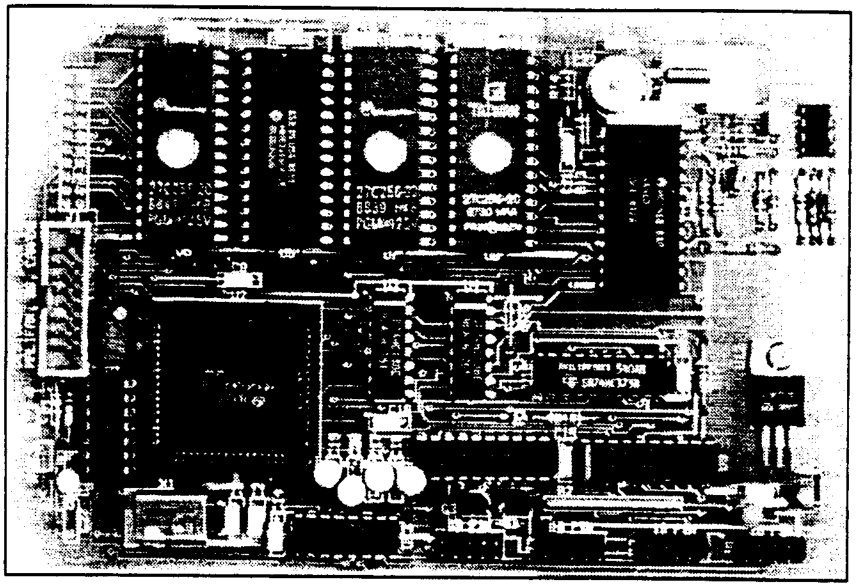

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Part two, the final "build-it" series, describes hardware, software and the steps for constructing your own unit.

The Micro-Guider provides a telescope with digital setting circles, complete with a database of 7,875 celestial objects. Its design provides many of the features of commercially available units, but can be built for a fraction of their cost. Left: the completed printed circuit board forms the "heart" of the Micro-Guider. If all of the components are "on hand," it can be assembled in a couple of hours.

HARDWARE

The Micro-Guider's internal hardware consists primarily of one printed circuit board. The schematic diagrams of the circuit board are depicted in Figures 3-5. The chassis wiring, interconnecting the circuit board and the other components, is shown in Figure 6. This section provides a brief description of how the Micro-Guider works, however, it is not required to understand how the hardware works to build the device.

The architecture of the Micro-Guider is based on Hitachi's HD64180 microprocessor. This microprocessor is a highly integrated version of the older Z80 microprocessor. Figure 3 shows most of the interconnections which make the microprocessor into a microcomputer. Components C2, C3, and X1 comprise the main oscillator which is used to time all functions of the computer. U6 is the main EPROM chip (32k bytes) used to store the Micro-Guider's software described in the next section. U5 provides 32K bytes of RAM for use by the software. Not all of this RAM is used; in fact, an 8K byte device is sufficient. Components U7 and U8 comprise 64K bytes of EPROM space which is used to store the object databases.

The components mentioned in the previous paragraph form a complete fully operational computer, but a computer by itself, with no input/output, is all but useless. Figures 4 and 5 comprise the input/output circuits. The keypad is interfaced by components U9 and U10. The keypad used is a matrix. This means that when a key is pressed, a short is made between the intersecting row and column of the key. U9 is used to generate the column signals and U10 is used to read the row signals. U9 is also used to control power to the beeper.

U11 is used to read the outputs from the encoders. U9, U10, and U11 also provide several spare input/output signals which could be used in the future for some yet undefined purpose.

The interface to the liquid crystal display is fairly simple, and for the most part, connects directly to the microprocessor. Resistor R4 is used to control the viewing angle and contrast of the LCD.

The power regulator, U12, is used to regulate positive five volts for the rest of the circuitry. The minimum operating voltage is nine volts, but it will operate properly up to at least 15 volts. The current consumption of the complete Micro-Guider is about 85ma (half of which is used by the encoders). This will provide operation from 6 'AA' alkaline cells for about 12 hours. I use a 12 volt gel-cell battery which also powers my telescope drive.

Components U13, and C17-C20 are used to provide the RS232 interface. U15 and related circuitry comprises a real time clock with RAM. It is powered by the ni-cad batteries connected to J6-4 when the main power is off, and is charged through R11 when the power is on. The clock will keep its time and internal RAM valid for about 6 months of non-use. U14 and related circuitry are used to detect the loss of main power following which it disables the clock to protect its contents from becoming corrupted.

SOFTWARE

As mentioned above, the Micro-Guider is basically a dedicated computer. The software has formed a major part of the effort in designing this device and reflects greatly in its functionality. The programs were written in a combination of the 'C' programming language and assembly language.

When writing the software for this project, I did not have many of the luxuries available to most programmers using a conventional computer. I had to start from absolute scratch, writing all of the software which scans the keypad, outputs to the LCD display, and various other miscellaneous functions.

The keypad scanning program operates 128 times per second. As was mentioned above in the hardware section, the keyboard is a matrix, thus, to read it, each column must be individually energized to check for an active row. The intersection between the active row and energized column defines the key which was pressed. The LCD display functions control such operations as "clear the display," "erase a line," "position the cursor," and "write data to the display."

The first major part of the software is the encoder and coordinate conversion routines. The optical encoders are read by the software at a rate of 2048 times per second. Each optical encoder produces two signals which are used to determine the direction of motion of each shaft. These two signals, when combined, form a "grey code." A grey code is a binary sequence, whereby, only one bit (or signal) can change from one state to the next. The software interprets these grey codes to determine the new azimuth and altitude of the telescope given the old and new grey codes.

Given the azimuth and altitude of the telescope, the Micro-Guider then uses the algorithm described by Toshimi Taki of Japan in *Sky and Telescope's Astronomical Computing* column (February, 1989). This algorithm, given two initial coordinates at known times, can be used to convert a telescope's azimuth and altitude into right ascension and declination. More information on the algorithm can be obtained by consulting the article.

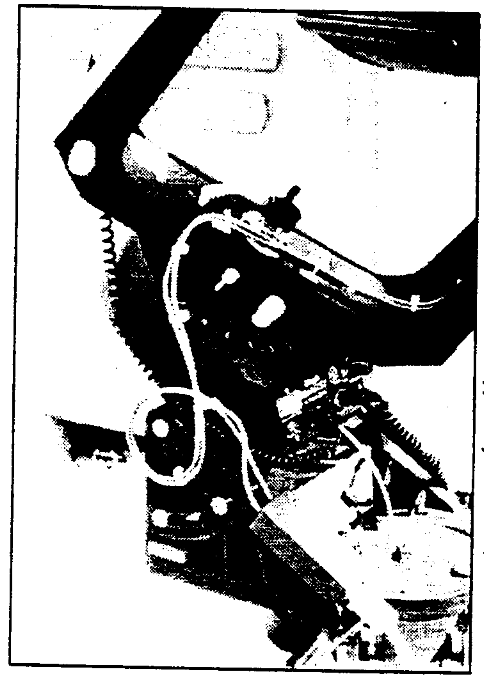
Another major part of the program is the object database and planet calculation functions. As mentioned earlier, there is a permanent database of alignment stars (17), Messier objects (110), and NGC objects (7740). The database contains the Epoch J2000.0 coordinates to a precision of 1/20 of a degree, the object type, and the magnitude of the object (if known) to the nearest tenth. Each entry is compressed into a size of 6 bytes per object in order to allow all of the objects to fit into the 64K of available object memory. There is space available for about 3000 more objects, which in the future, I may use for the brightest Index Catalogue objects, or double/variable stars.

The planet positions are calculated using the algorithm described in the book: *Practical Astronomy With Your Calculator* (equation 54) by Peter Duffett-Smith. The algorithm is not "super" accurate, but is a trade off between speed, program size, and accuracy. The user objects are entered by the user and stored in the real time clock's RAM.

CONSTRUCTION

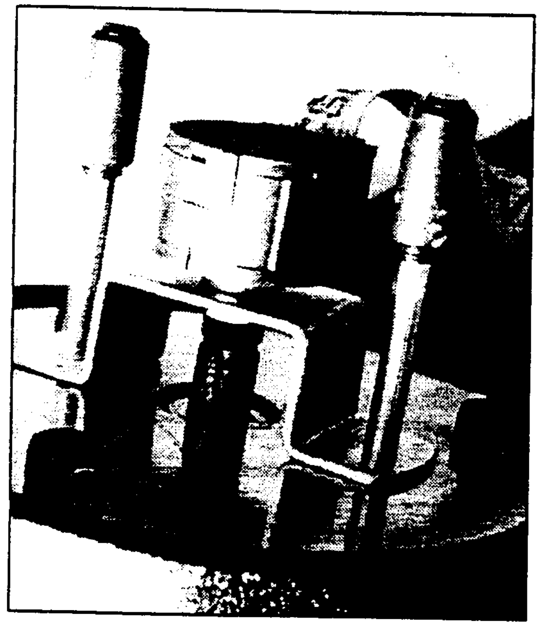
The construction of the Micro-Guider is quite straight forward. The most difficult tasks are the sourcing of the components and the design/construction of the encoder mounts.

The parts list will assist the prospective

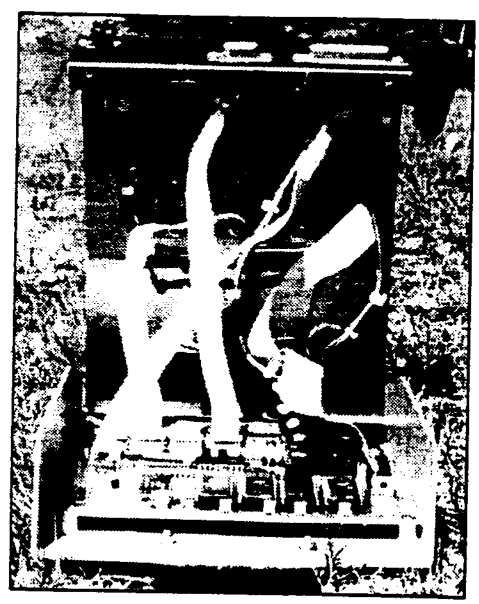


All of the encoder cabling is affixed to the telescope with Velcro® fasteners.

All Photos and schematics supplied by David Lane



The shaft encoders are attached to the telescope with quick release thumb-screws which make installation quick and easy.



The components which comprise the internals of the Micro-Guider are the PCB, LCD, keypad, backup batteries and beeper.

Schematics

Fig. 3

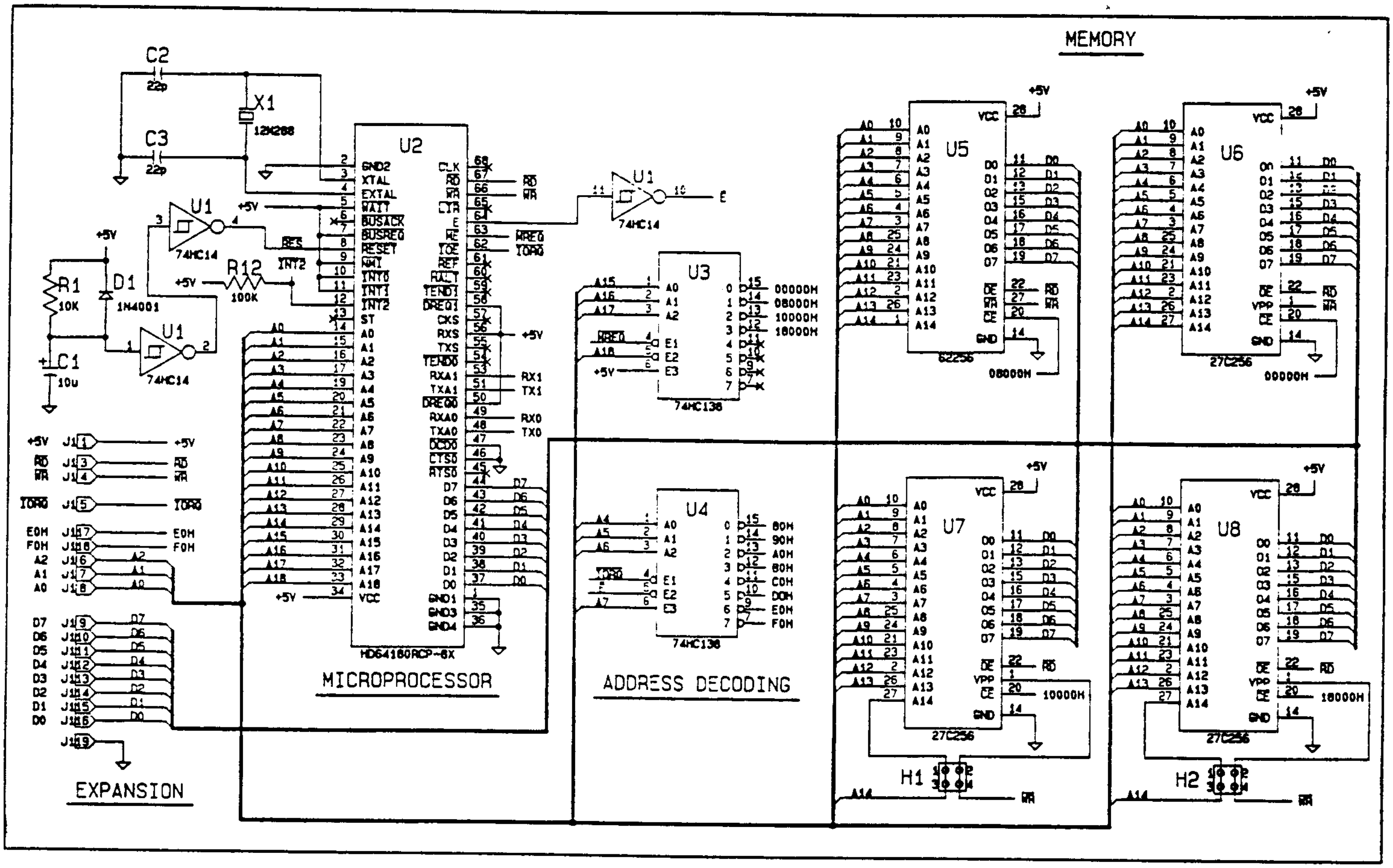
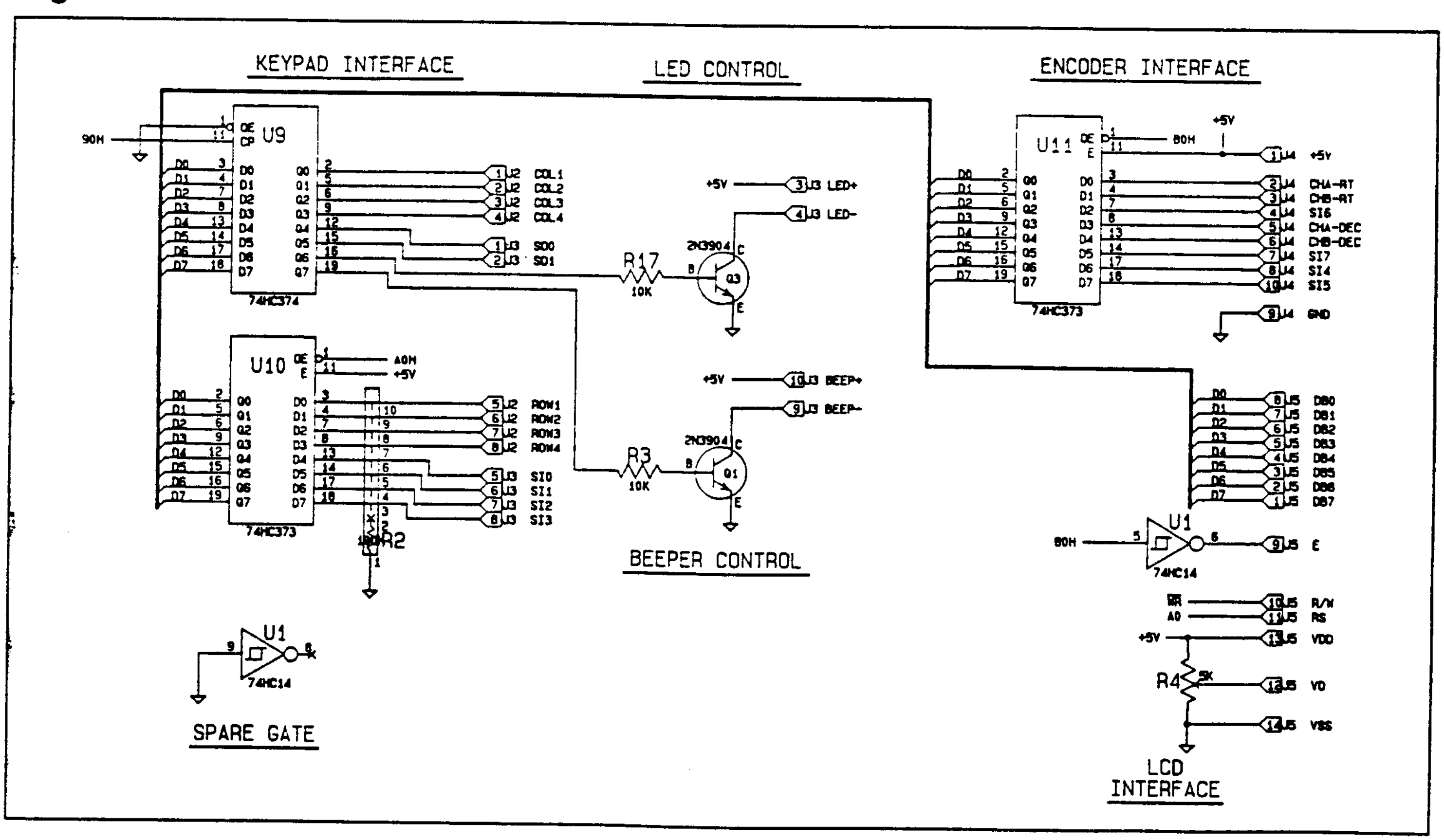


Fig. 4



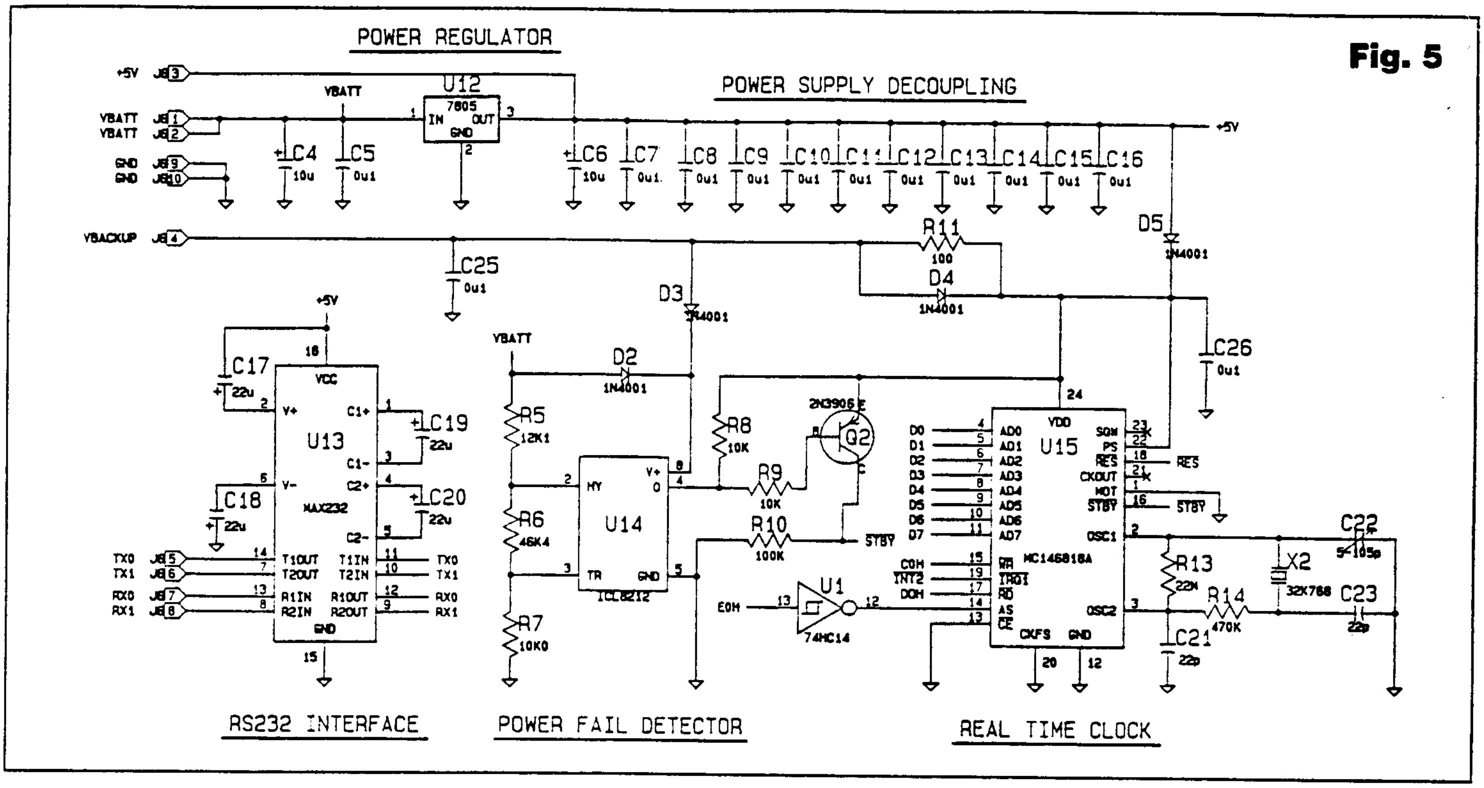


Fig. 5
POWER REGULATOR
POWER SUPPLY DECOUPLING
RS232 INTERFACE
POWER FAIL DETECTOR
REAL TIME CLOCK
U12
7805
U13
MAX232
U14
ICL8212
U15
MC146818A
U1
74HC14
Q2
2N3906
VBATT
VBACKUP
+5V
GND

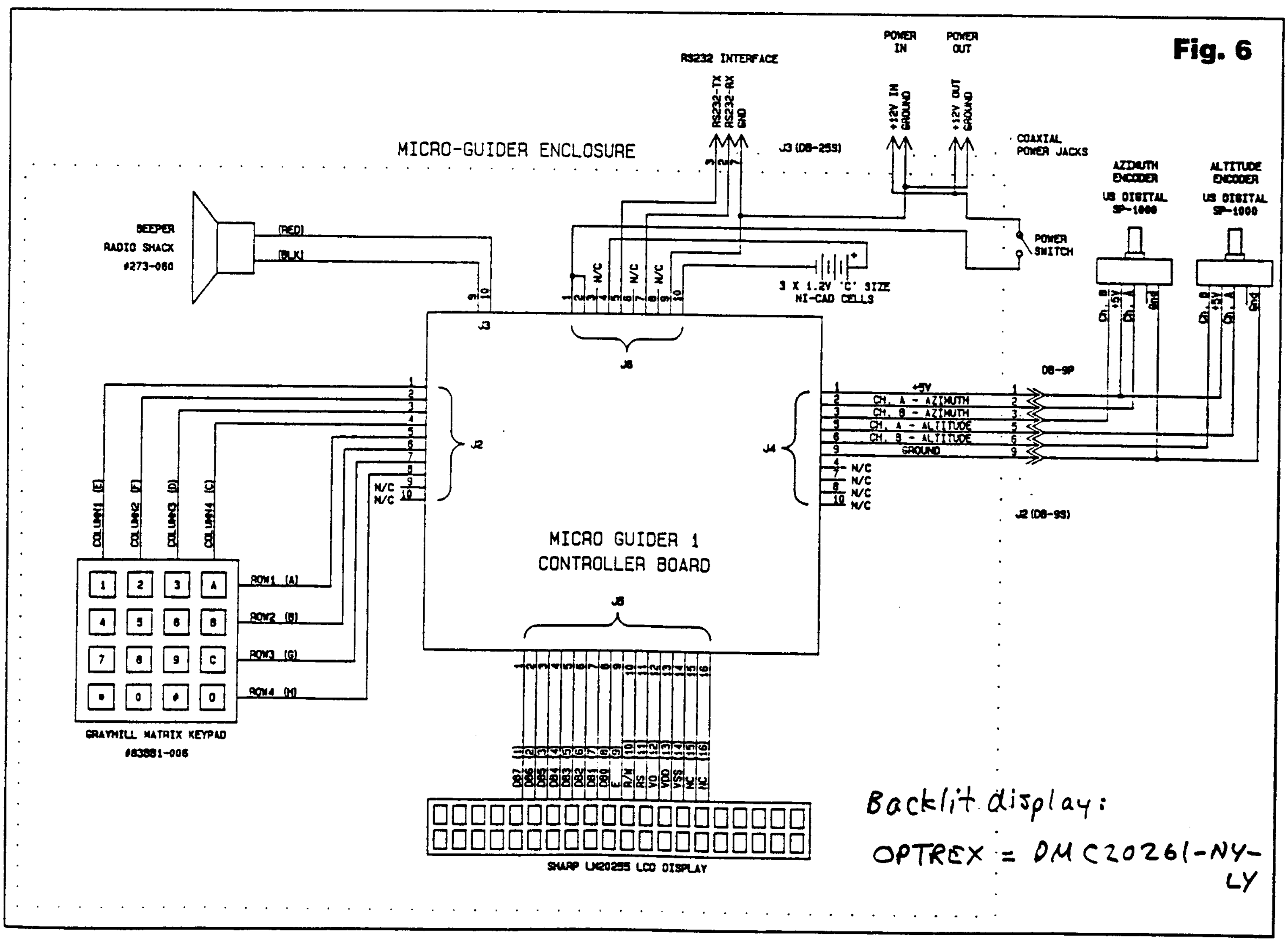


Fig. 6
MICRO-GUIDER ENCLOSURE
RS232 INTERFACE
POWER IN
POWER OUT
COAXIAL POWER JACKS
AZIMUTH ENCODER US DIGITAL SP-1000
ALTITUDE ENCODER US DIGITAL SP-1000
BEEPER RADIO SHACK #273-060
POWER SWITCH
3 X 1.2V 'C' SIZE NI-CAD CELLS
MICRO GUIDER 1 CONTROLLER BOARD
GRAYHILL MATRIX KEYPAD #83BB1-006
SHARP LM20255 LCD DISPLAY
Backlit display:
OPTREX = DMC20261-NY-LY

builder to locate the parts, many of which are available from mail order outlets that cater to the hobbyist, such as Jameco or Digi-Key (consult the advertisements in a recent electronics hobbyist magazine). If materials sourcing proves difficult, I am willing to assist the prospective builder. Many of the components in the parts list are suggestions, and many substitutes are possible. The total cost for all parts is under $300, assuming that you have to purchase everything. If you are an electronics hobbyist, you will probably find many parts already in your "junk" box!

The hardware for mounting the encoders to the telescope axis will not be discussed here, since every telescope will require different mounting hardware. It should be noted, however, that once the encoders are selected, one has to decide whether to mount the encoders directly to the shafts or to use a gear or belt system. A gear or belt system will allow for the use of more economical (lower resolution) optical encoders, but will have to be designed such that there is absolutely no backlash in the system, otherwise errors will be introduced. However the encoders are mounted, it is imperative that they read correctly. This can be checked by using the "GUIDE" mode's azimuth and altitude display. The altitude should increase as the altitude of the telescope is increased and the azimuth should increase as the telescope is rotated counter-clockwise. A diagram of these movements is shown in Mr. Taki's article. If either axis reads incorrectly, it can be reversed by switching the two signal wires from the encoder in error.

The circuit board should be populated according to markings on the printed circuit silkscreen. Be careful to note the polarity of the diodes and capacitors and the orientation of the integrated circuits. There are a few errors in the printed circuit board which affect the operation of the LCD. The notes listed below describe the changes required to make the circuit board identical to the schematics.

- ( ) do not install components R15, D6, R16, D7, and C27
- ( ) jumper out R15 and D7
- ( ) cut trace to U1, pin 11
- ( ) cut trace from U4, pin 5
- ( ) connect a jumper wire from U4, pin 5 to U1, pin 10
- ( ) connect a jumper wire from U1, pin 11 to U2, pin 64

Some of the components shown in the schematic are not absolutely required for installation. These components are the RS232 interface and LED control circuits (not currently used), which comprise the following components: H1, H2, R17, Q3, C17, C18, C19, C20, and U13. Components U2, U5-U8, and U15 should be socketed for their protection. The remaining ICs can be socketed if desired.

The chassis wiring can be performed using ribbon cable, as I have used, following the wiring diagram. Note that the right angle male header is to be soldered to the top of the LCD.

If, after you have built the Micro-Guider, you are having trouble getting it to operate, give me a call or write me a note. I'm sure I'll be able to help you diagnose the problem.

CONCLUSION

I have had a lot of fun designing and building the Micro-Guider, and it has been gratifying to hear nice comments from those who have built and are using it. Most have reported no difficulty with the construction and those who did run into problems, I was able to help them over the phone.

By the time you read this, I will have an enhanced version of it installed on the 16" Cassegrain telescope at the Burke-Gaffney Observatory of Saint Mary's University where I work as the Astronomy Technician. Because it will be used on an on-going basis at this observatory, I will make many improvements as time goes on, with the initial goal to obtain a system accuracy of 1 to 2 arc-minutes, so that an object can be directly placed in the field of the recently acquired SBIG ST6 CCD camera.

Another addition to the Micro-Guider, which I intend to work on, is to make it control a large altazimuth telescope. It will control two stepping motors, which, when driven at the correct speeds, will simulate the sidereal motion of the sky. If the tracking accuracy proves to be accurate enough for photography, I will add a third motor at the focus to correct for field rotation. I can't wait! ★

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Parts List

RESISTORS

R1,R3,R17,R8,R9	10K, 0.25W, 5%
R12,R10	100K, 0.25W, 5%
R11	100, 0.25W, 5%
R14	470K, 0.25W, 5%
R13	22M, 0.25W, 10%
R5	12.1K, 0.4W, 1%
R6	46.4K, 0.4W, 1%
R7	10.0K, 0.4W, 1%
R2	100K, SIP resistor (Bourns No. 10X-1-104)
R4	5K, 10 turn trimmer pot (Bourns No. 3296W-1-502)

CAPACITORS

C1,C4,C6	10uF, 25V tantalum (0.2" lead spacing)
C5,C7,C8,C9,C10,C11,C12,C13,C14,C16,C25,C26	0.1uF, 50V, ceramic (0.2" lead spacing)
C2,C3,C21,C23	22pF, 50V, ceramic (0.2" lead spacing)
C17,C18,C19,C20	22uF, 16V, tantalum (0.2" lead spacing)
C22	5-105pF trimmer or may be replaced with 22pF ceramic (see above) if a very accurate clock is not required.

CRYSTALS

X1	12.288MHz (HC-18/U case style)
X2	32.768KHz watch crystal

SEMI-CONDUCTORS

Q1,Q3	2N3904
Q2	2N3906
D1,D2,D3,D4,D5	1N4001

INTEGRATED CIRCUITS

U1	74HC14 hex inverter
U2	HitachiHD64180RCP-8X microprocessor *
U3,U4	74HC138 decoder
U5	Hitachi HM62256LP-15 32K static RAM
U6,U7,U8	27C256 EPROM, Programmed set available from the author for $35
U9	74HC374 octal latch
U10,U11	74HC373 octal buffer/latch
U12	7805 regulator (TO-220 case)
U13	Maxim MAX232CPE RS232 interface
U14	Intersil ICL8212CPE voltage level detector
U15	Motorola MC146818AP real time clock

MISCELLANEOUS

Quantity	Description
1	professional quality printed circuit board available from the author for $35 (includes a photograph of completed circuit board, encoder and LCD display datasheets, and a disk containing the hex files used to program U6-U8)
1	68 pin PLCC socket (for U2)
4	28 pin IC sockets (for U5-U8)
1	24 pin IC socket (for U15)
2	50 contact double row straight male headers (for J1-J5)
1	Hammond FH2BKBU sloped front enclosure
1	Grayhill 83BB1-006 matrix 16 key keypad
1	Sharp LM20255 LCD display (or LM202A02 with LED backlight)
1	16 contact double row right angle male header (for LCD display)
1	Display bezel
2	US Digital Corp. S1-1000 (0.09° resolution) optical encoders. Phone (800) 736-0194 or (206) 696-2468
1	SPST switch
3	Radio Shack 270-0401 'AA' cell holders
3	Ni-cad 'AA' cells
1	Radio Shack 273-060 beeper
1	DB-25S connector
1	DB-9P connector
1	DB-9S connector
4	10 pin IDC ribbon cable connector
2	16 pin IDC ribbon cable connector
2	Coaxial DC power jacks
2	Encoder mountings (telescope specific)
	Assorted wire and ribbon cable
	Assorted hardware

* or Zilog Z8018006VSC (available from author $10US)

QUICK USAGE INSTRUCTIONS
FOR THE MICRO-GUIDER I

Revision 1.2 - May 1, 1995

Written by David J. Lane

ALIGNING THE SYSTEM

The Micro-Guider can be aligned using either one or two stars as reference coordinates. The one-star alignment method can only be used with polar aligned equatorially mounted telescopes. The two-star method can be used with either alt-azimuth (including Dobsonians) or equatorial aligned telescopes (polar aligned or not). Just follow the appropriate instructions below:

One-Star Method:

1. Turn on the Micro-Guider (MG). The MG will make a "beep" sound briefly, and display the Main Menu.

2. The first step is to align the system. Press the "A" button to select the Set Menu (A>SET). The display will change to the Set Menu. Press the "A" button again to select a one-star alignment (A>ALN1). Do not use any other items except "D>EXIT" in the "Set Menu", since they are intended for use by the department technician only.

3. The display will request you to align the altitude encoder. Move the telescope Declination until the manual declination scale is set to either 0 or +90 degrees, within 0.5 degrees, whichever is more convenient. Press the "A" button to inform the MG that you have set the telescope to 0 degrees or press the "B" button to inform the MG that you have set the telescope to +90 degrees. If you are re-aligning the MG since it has been turned on, you can skip this step by pressing the "C" button (C>SKIP).

4. Select a bright star which the Micro-Guider will use as a reference. Pick a star which is has an altitude above the horizon of greater than 50 degrees. There are 32 bright stars programmed into the Micro-Guider distributed around the entire sky. Each star is referenced by a number ranging from 1 to 32. The table of stars with their reference numbers is shown at the end of this section.

5. Point the telescope at the star you have selected. Exactly centre it in the field of view of the telescope.

6. Press the "A" button to select a star. Enter the star's number using the number buttons. You can use the "*" button as a back-space, if you make a mistake. Press the "#" button when you are finished. This button is the "enter" key. The display will flash "Calculating..." momentarily, then return to the Set Menu. Press the "D" button (D>EXIT) to return to the Main Menu.

7. The Micro-Guider is now ready to use.

Two-Star Method:

1. Turn on the Micro-Guider (MG). The MG will make a "beep" sound briefly, and display the Main Menu.

2. The first step is to align the system. Press the "A" button to select the Set Menu (A>SET). The display will change to the Set Menu. Press the "B" button to select a two-star alignment (B>ALN2).

3. The display will request you to align the altitude encoder. Move the telescope Declination or Altitude until the manual scale is set to exactly either 0 or +90 degrees. Press the "A" button to inform the MG that you have set the telescope to 0 degrees or press the "B" button to inform the MG that you have set the telescope to +90 degrees. If you are re-aligning the MG since it has been turned on, you can skip this step by pressing the "C" button (C>SKIP).

4. Select two bright stars which the Micro-Guider will use as a reference. In order to obtain the best accuracy, these two stars should be selected so that they are widely separated (>30 degrees) in both axis of motion of the telescope. There are 32 bright stars programmed into the Micro-Guider distributed around the entire sky. Each star is referenced by a number ranging from 1 to 32. The table of stars with their reference numbers is shown at the end of this section.

5. Press the "A" button to select a star. Enter the first star's number using the number buttons. You can use the "*" button as a back-space, if you make a mistake. Press the "#" button when you are finished. This button is the "enter" key. Point the telescope at the first star you have selected. Exactly centre it in the field of view of the telescope and press the "A" button. The display will flash "Calculating..." momentarily, then prompt your to enter the second star.

6. Press the "A" button to select a star. Enter the second star's number using the number buttons. Point the telescope at the second star you have selected. Exactly centre it in the field of view of the telescope and press the "A" button. The display will flash "Calculating..." momentarily, then return to the Set Menu. Press the "D" button (D>EXIT) to return to the Main Menu.

7. The Micro-Guider is now ready to use.

The Alignment Stars

Micro-Guider Reference No.	**Star Proper Name**	**Micro-Guider Reference No.**	**Star Proper Name**
1	Polaris	2	Alderamin
3	Dubhe	4	Schedar
5	Mizar	6	Eltanin
7	Mirfak	8	Capella
9	Deneb	10	Vega
11	Alpheratz	12	Pollux
13	α Arietis	14	Arcturus
15	Aldebaran	16	Regulus
17	Altair	18	Betelgeuse
19	Procyon	20	α Hydrae
21	Rigel	22	Spica
23	Sirius	24	η Ophiuchi
25	Beta Cetus	26	Antares
27	Fomalhaut	28	Canopus
29	Achernar	30	α Pavonis
31	α Centauri	32	Miaplacidus

FINDING OBJECTS WITH THE SYSTEM

1. The MG has a database of 110 Messier Objects (Clusters, Nebulae, Galaxies, etc.), 7840 NGC objects (Clusters, Nebulae, Galaxies, etc.), and the Landolt Photometric Catalogue. You can also enter up to 5 other objects, where a specific RA and Declination are entered. All of these objects are selected by using the Select Menu. The Select Menu is accessed from the Main Menu by pressing the "C" button (C>SELECT).

2. From within the Select Menu, press the letter pertaining to the type of object that you wish to select:
   - "A" for alignment star (A>STAR)
   - "B" for deep sky object (Messier or NGC) (B>DEEP)
   - "C" for Landolt stars (C>LANDOLT)
   - "D" for other objects (D>OTHER)

3. Enter the desired object's number using the number buttons. You can use the "*" button as a back-space, if you make a mistake. Press the "#" button when you are finished.

   If "Other" objects was selected, another menu will be presented. You will be able to Set (B>SET) or Select (A>SELECT) an object by using its RA and Declination (J2000.0 coordinates). If the object's coordinates have not been previously been entered, press the "B" button. Enter the object number to change (1-5) and press "enter" (the "#" button). In sequence enter the RA hours, minutes, and seconds, then the declination degrees and minutes. In each case press the "enter" after entering in the number. If a negative declination needs to be entered, the "D" key is to be used as the "-" sign. The coordinates entered are non-volatile and will remain set even if the power to the MG is turned off.

   Select the object by pressing the "A" button (A>SELECT). Enter the object number and press "enter".

4. To test if you have selected the correct object, press the "B" button from the Main Menu (B>INFO). The coordinates of the object will be displayed as will its catalogue number. In some cases, the proper name will be displayed or its object type. Pressing any button will either provide more information about the object or return to the Main Menu.

   Messier objects provide their visual magnitude and size in minutes of arc. NGC objects provide the magnitude and the object type (galaxy, cluster, etc.). Landolt stars provide the V magnitude, and color index (B-V). Pressing any button for the second time will return to the Main Menu.

5. The final step used in locating an object is accomplished by using the Guide mode, which is selected by pressing the "D" button from the Main Menu (D>GUIDE).

   The Guide mode operates differently depending if you aligned the MG using the one or two-star method. Each mode is described below:

One-Star Method:

The top line of the display provides the instantaneous RA (in hours and minutes) and Declination (in degrees and minutes) of the telescope. As the telescope is moved, the display will track the telescope. If an object was previously selected with the Select Menu, the bottom line of the display, by default, provides the instantaneous difference between the objects coordinates and the telescope coordinates.

To center the selected object, move the telescope until coordinates on the bottom line of the display reads zero (or nearly so). When moving the telescope, do it relatively slowly, or the MG may not be able to keep up with the signals from its sensors.

You do not have to look at the display while you move the telescope. When the difference is less than 2 degrees in either RA or Declination, the MG will "beep". Pressing the "B" (for beep) button will silence the "beeps" (be careful not to press the "C" key - see below). After both axes of the telescope are positioned within 2 degrees, the final centering can be performed using the hand controller while watching the display.

The object should be visible in the field of view of the telescope with a low power eyepiece. Objects closer in angular distance to the alignment star will be positioned more accurately than those further away.

Two-Star Method:

By default, the top line of the display provides the instantaneous RA (in hours and minutes) and Declination (in degrees and minutes) of the telescope. As the telescope is moved, the display be updated after the telescope is stopped. If an object was previously selected with the Select Menu, the bottom line of the display provides the objects coordinates.

The best way to locate objects, however, is to use the alt/az mode. This is accomplished by press the "A" button. The top line of the display will provide the instantaneous azimuth and altitude (both in degrees) of the telescope. As the telescope is moved, the display will track the telescope. If an object was previously selected with the Select Menu, the bottom line of the display, provides the instantaneous difference between the objects coordinates and the telescope coordinates.

To center the selected object, move the telescope until coordinates on the bottom line of the display reads zero (or nearly so). When moving the telescope, do it slowly. Do not move it faster than about 20 degrees per second, or the MG may not be able to keep up with the signals from its sensors.

You do not have to look at the display while you move the telescope. When the difference is less than 2 degrees in either azimuth or altitude, the MG will "beep". Pressing the "B" (for beep) button will silence the "beeps" (be careful not to press the "C" key - see below). After both axes of the telescope are positioned within 2 degrees, the final centering can be performed using the hand controller while watching the display.

The object should be visible in the field of view of the main telescope (with the 50mm eyepiece). Objects closer in angular distance to the alignment star will be positioned more accurately than those further away.

The following buttons are used to control the Guide Mode (One and Two-Star Methods):

"A" in one star alignment mode, it toggles between the bottom line of the display showing the difference between the selected object or the actual coordinates of the object. In two star alignment mode, it toggles between the display showing coordinates in RA/Dec or Alt/Az format.

"B" silences the beeper, if it is on.

"C" this button re-initializes (syncs) the MG using the currently selected object. Before pressing "C", ensure that the selected object positioned exactly in the centre of the field of view of the main telescope. This feature is useful for refining the alignment especially if the next object to be found is closer in angular distance to the currently selected object than it is to the previous alignment star. Be very careful not to press this button by accident if the telescope is not exactly pointed at the selected object! In the two star alignment mode, you may not be able to “sync” on an object who’s angular position is too close to both original alignment stars.

"D" exits the Guide Mode and returns to the Main Menu.

Available Micro-Guider Parts

The following parts are currently available (its best to check with me before ordering) from Nova Astronomics to aid in building the do-it-yourself Micro-Guider I and Micro-Guider III telescope positioning devices.

Part Number	US Dollars	Canadian Dollars
MGI/MGIII Printed Circuit	$35	$47
Zilog Z8018006VSC (same as Hitachi HD64180RCP-8X)	$10	$13.50
MG III EPROM (programmed)	$15	$20
MG I three EPROM set	$35	$47
HM62256LP-12 (or equivalent)	$5	$6.50
12.288MHz crystal	$2	$2
74HC14 IC	$2	$2
74HC138 IC (two needed)	$2	$2
74HC373 IC	$2	$2
74HC374 IC	$2	$2
7805 IC	$2	$2
MAX232CPE IC	$5	$6.50
ICL8212 IC	$5	$6.50
Discounted ECU CD-ROM (must be ordered direct from Nova Astronomics with a MG pcb+programmed EPROM)	$45 (incl. postage) (regularly $55)	$55 (incl. postage) (regularly $70)

The above prices include postage. Canadians will have to add the GST or HST as appropriate. To order you can send a personal check to the address below (in the US, use the US amounts - if outside US/Canada you can use VISA or contact me).

I can also now accept VISA orders (which are billed in the Canadian amounts). I cannot accept Mastercard or AMEX. You can e-mail the order or if you are concerned about internet security, you can fax the order or call me.

ps. I'll be adding some of the capacitors as soon as I find out what I paid for them...

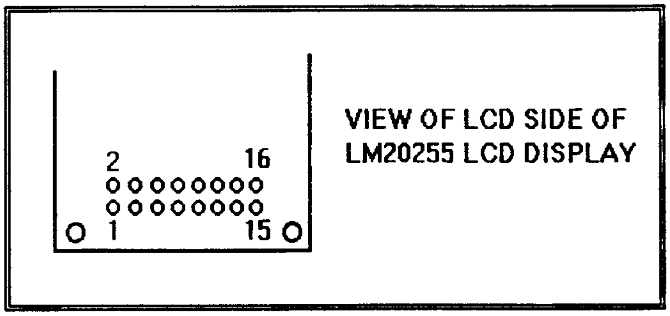
Note: Most (all) of the remaining parts are available from Jameco, Digikey, or US Digital (encoders).

MICRO-GUIDER TECH NOTE

Title: Drawings to aid in building the MG # 1
Date: September 7, *1993 (Updated October 31, 1995)* Total Pages: 1

Pin-out of the LCD Display

The drawing below depicts the view of one end of the LCD printed circuit board (in this case, the non-backlit Sharp LM20255) and viewed from the top (or the side that is viewed). The pins just alternate back and forth. Some displays only have 14 pins instead of 16. In this case just use the first 14 wires and leave wires 15 and 16 unconnected. Some displays may have numbering imprinted on them that will differ from that below (usually the exact opposite) — ignore these pin numbers as there are two standards for display numbering.

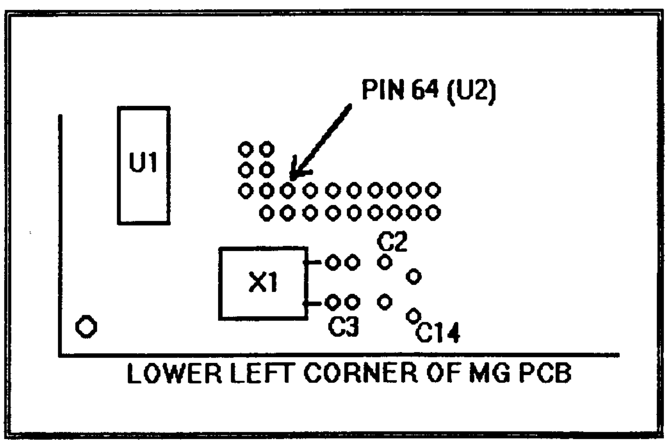


When soldering the connector to the display, always solder the connector on the top of the display.

If your display has an LED backlight, it must be connected in the correct polarity (pin-out varies with display) and have a series resistor installed. The resistor must be selected to give the correct brightess. Experment with different values until the brightness is comfortable to your dark-adapted eye.

Locating Pin 64 of U2

The drawing below depicts the lower left corner of the Micro-Guider PCB (the end towards the big crystal). Pin 64 is identified by the arrow.



US DIGITAL

S1 & S2 Series

Softpot

Optical Shaft Encoder

Technical Data, Rev. 1.12, Dec. 1993

The Softpot optical shaft encoder is a noncontacting rotary to digital converter. Useful for position feedback or manual interface, the Softpot converts realtime shaft angle, speed and direction into TTL-compatible outputs. Also available now with two channel quadrature outputs plus a third channel index output.

The Softpot utilizes an unbreakable mylar disk, metal shaft and bushing, LED light source, monolithic electronics and operates from a single +5 volt supply.

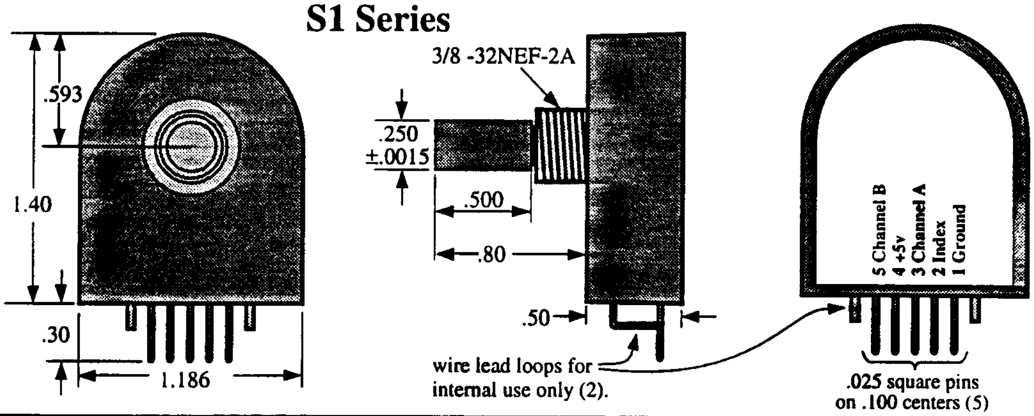
Available with ball bearings for motion control applications or torque-loaded to feel like a potentiometer for front-panel manual interface.

Features
- Small size
- Low cost
- 2-chajnel quadrature, TTL squarewave outputs
- 3rd channel index option
- $Tracks from 0 to 100,000 cycles/sec
- Ball bearing option tracks to 10,000 RPM
- -40 to +100°C operating temperature
- Single +5v supply

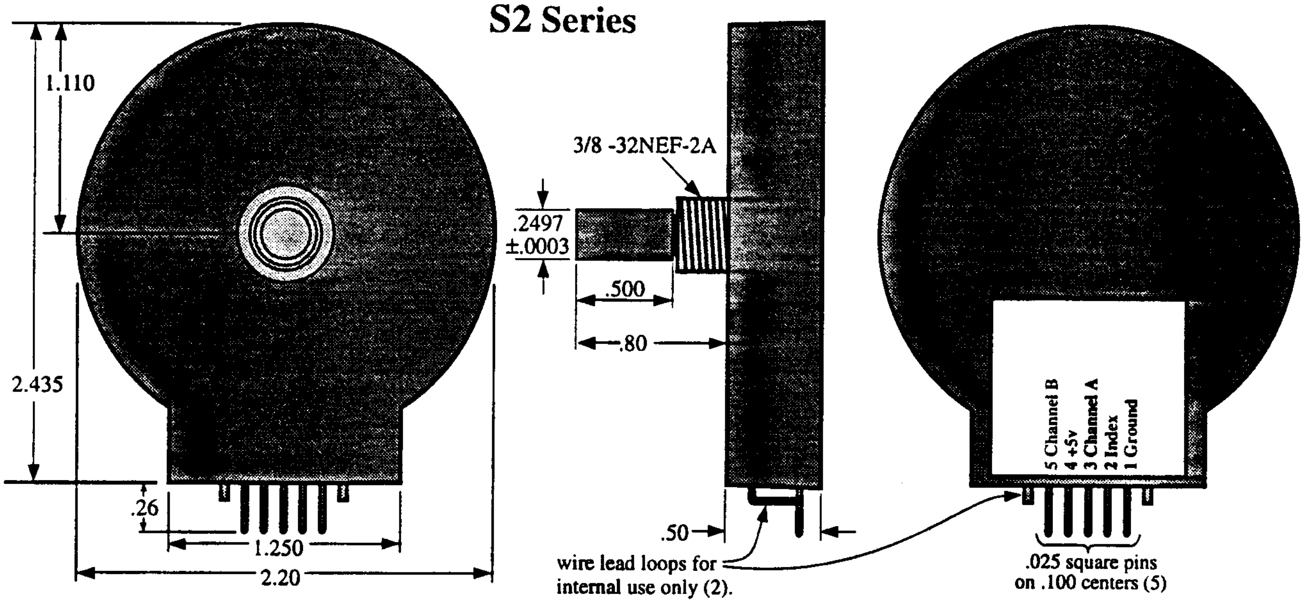
S1 Series
- 96 to 1024 cycles/rev.
- 384 to 4096 codes/rev.

S2 Series
- 1000 to 2048 cycles/rev., 4000, 8192 codes/rev.

S1 Series



S2 Series



(206) 696-2468 (800) 736-0194 Fax (206) 696-2469

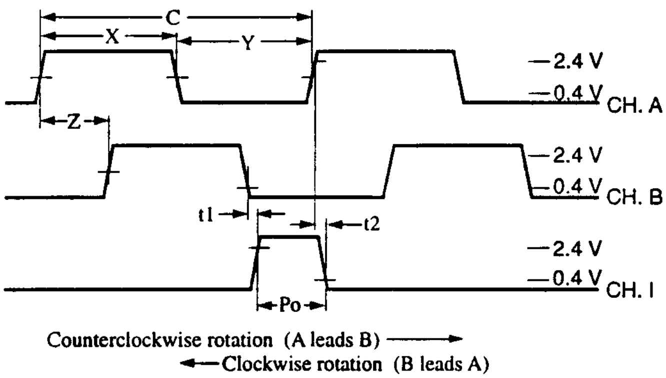
U.S. Digital Corp. • 3800 N.E. 68th St., Suite A3 • Vancouver, WA 98661-1353

Encoding Characteristics

Over Recommened Operating Range. Values are for the worst error over a full rotation.

Parameter	Note	Symbol	Min	Typ.	Max	Units
Symmetry	3-channel		150	180	210	°e
Symmetry	2-channel		145	180	215	°e
Quadrature	3-channel		60	90	120	°e
Quadrature	2-channel		55	90	125	°e
Position Error				5	20	min. of arc
Index Pulse width		Po	60	90	120	°e
CH. I rise after	-25°C to +100°C	t1	10	100	250	ns
CH. B or CH. A fall	-40°C to +100°C	t1	-300	100	250	ns
CH. I fall after	-25°C to +100°C	t2	70	150	300	ns
CH. A or CH. B rise	-40°C to +100°C	t2	70	150	1000	ns

TTL- Output Waveforms



Definitions

CPR (N): The number of Cycles Per Revolution.

Quadrant: The A and B outputs are displaced by 1/4 cycle, nominally 90°e. There are four quadrants (codes) per cycle. (example: 500 CPR = 2000 codes/rev.)

One Shaft Rotation: 360 mechanical degrees, N cycles.

One Electrical Degree (°e): 1/360 of one cycle.

One Cycle (C): 360 electrical degrees (°e).

Symmetry: A measure of the relationship between (X) and (Y) in electrical degrees, nominally 180°e.

Quadrature (Z): The phase lag or lead between channels A and B in electrical degrees, nominally 90°e.

Index (CH I.): The index output goes high once per revolution, coincindent with the low states of channels A and B, nominally 1/4 of one cycle (90°e).

Position error: The difference between the actual shaft position and the position indicated by the encoder cycle count.

Ordering Information

S1 Price	Cost adders
$23.00 / 10,000's $25.00 / 5,000's $27.00 / 1,000's $29.00 / 500's $31.00 / 100's	Add $7.00 for ball bearing option. On S1 Series, add 10% for index or resolutions =>1000 CPR. On S2 Series, add $1.00. Also add 10% for index or resolutions => 2000 CPR.
$34.00 / 50's $37.00 / 10's $43.00 / 1's	Purchase orders may schedule smaller quantity shipments to gain the advantage of these larger quantity price breaks.

Part Number

S — ☐ — ☐

Series
S1 (formerly SP-500 Series)
S2 (formerly SP-1000 Series)

Resolution
Cycles/Rev.

S1	S2
096	1000
100	1024
200	2000*
250	2048*
256	
360	
400	
500	
512	
540*	
1000*	
1024*	

Options
I = Index (3-channel)
B = Ball Bearings
NT = No added Torque

Index option is not yet available for resolutions marked by *

Sales Policy

- 2 year warranty on each encoder.
- Next day shipment is normal
- Terms: Net 30 upon approval.
- F.O.B. Origin.
- Connector terminating tools available.
- We can build to your specification.
- We have no minimum orders.
- Engineering orders (including special shafts) normally **ship within 24 hours.**

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