THE GPIO BUS INTERFACE UNIT
FOR THE
HP 9826 COMPUTER

Richard F. Bradley

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INTRODUCTION

The GPIO Bus Interface Unit was designed to be a versatile interface between the HP 9826 computer and the Universal Local Oscillator System. The interface also provides eight TTL switch outputs for general control applications. The modular design of the interface permits direct expansion for future projects.

This report describes the design and use of the GPIO Bus Interface Unit. Detailed information about the circuit design, unit construction and software support are provided in this report. Information concerning the circuit board wire layout is not included here but is available elsewhere.

CIRCUIT DESIGN DETAILS

The circuit for the GPIO Bus Interface Unit is divided into three sections. The GPIO BUFFER CARD contains all the necessary buffers and pull-up resistors for the data and control lines of the GPIO BUS. A path enable circuit and a pulse power-up circuit is also included on this card. The ULO DECODE CARD contains all the circuitry necessary to pass a group of ten 16-bit words to the Universal Local Oscillator System. The GENERAL PURPOSE OUTPUT (GPO) CARD contains the eight bit latch and supporting circuits for the buffered TTL switches. Two spare card locations are provided for future expansion. A block diagram indicating data flow is shown in Figure 1. A detailed discussion of each card now follows.
Figure 1
A. GPIO Buffer Card

A schematic diagram for the GPIO Buffer card is shown in Figure 2. The part list is given in Table 1. The "DO" lines, which transfer 16 bits of data from the computer to the external device, contains leveling resistors U1, U2, U3 and U4. Buffers U12, U13 and U14 are used to provide computer isolation for these lines. The "DI" lines directing 16 bits of data from the external device to the computer, are buffered by U6, U7 and U8 for isolation. The PCTL, I/O, PRESET, CTL0 and CTL1 control lines have leveling resistors U10 and U11 and buffers U14 and U9.

A binary-to-decimal decoder, U5, generates four enable signals from the CTL0 and CTL1 lines. These signals are used to enable the ULO decode and GPO output circuits. The power-up pulse circuit, U15 and U16, shown in Figure 3, generates a pulse on pin 5 at INITIAL POWER UP. The pulse is used to reset the GPO and ULO decode circuits for initialization. The GPO lines from the computer are connected to the GPIO buffer card through three ribbon wire lines. Figure 4 shows the physical layout of the IC chips for this board. Note the ribbon connections:

- DATA IN (DI) LINES ... 4F
- DATA OUT (DO) LINES ... 4B
- CONTROL LINES ........... 4D

All other connections to this card are through the card edge connector.
Figure 2

GPIO BUFFER CARD

IN

OUT
### TABLE 1

GPIO Buffer Card

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>Beckman 898-3-R220</td>
<td>4C</td>
</tr>
<tr>
<td>U2</td>
<td>Beckman 898-3-R220</td>
<td>4A</td>
</tr>
<tr>
<td>U3</td>
<td>Beckman 898-3-R330</td>
<td>3C</td>
</tr>
<tr>
<td>U4</td>
<td>Beckman 898-3-R330</td>
<td>3A</td>
</tr>
<tr>
<td>U5</td>
<td>7442</td>
<td>2C</td>
</tr>
<tr>
<td>U6</td>
<td>7407</td>
<td>1G</td>
</tr>
<tr>
<td>U7</td>
<td>7407</td>
<td>1F</td>
</tr>
<tr>
<td>U8</td>
<td>7407</td>
<td>1E</td>
</tr>
<tr>
<td>U9</td>
<td>7407</td>
<td>1D</td>
</tr>
<tr>
<td>U10</td>
<td>Beckman 898-3-R220</td>
<td>4E</td>
</tr>
<tr>
<td>U11</td>
<td>Beckman 898-3-R330</td>
<td>3E</td>
</tr>
<tr>
<td>U12</td>
<td>74365</td>
<td>2B</td>
</tr>
<tr>
<td>U13</td>
<td>74365</td>
<td>3B</td>
</tr>
<tr>
<td>U14</td>
<td>74365</td>
<td>2A</td>
</tr>
<tr>
<td>U15</td>
<td>74123</td>
<td>2F</td>
</tr>
<tr>
<td>U16</td>
<td>Discrete Components</td>
<td>2E</td>
</tr>
</tbody>
</table>
POWER-UP PULSE CIRCUIT

Discrete Components of U16:

1-16 220 KΩ, 1/4 watt
2-15 0.02 μF
3-14 100 KΩ, 1/4 watt
4-13 10 μF elect.

Figure 3
B. ULO Decode Card

The schematic diagram for the ULO decode circuit is shown in Figure 5. Table 2 contains the parts list. The data in (DI) lines are buffered by Tri-State enable buffers U8, U7 and U6. The "DO" line bits 0 and 1 are latched by U1 and inverted by U10 to provide the address to the ULO system. The words sent to the ULO are counted by the binary counter U2. Control of the address latch is done by flip-flop U3. This flip-flop allows either clocking of the latch or counting of the words. Operation of this system is described later. The power-up pulse is used to zero the counter and preset the flip-flop. The PCTL and PRESET lines from the GPIO are buffered by line drivers U5 to reduce any noise related problems in the line between the interface and the ULO. Resistor bank U11 provides pull-ups for the hard wired part of the address line. PFLG is generated by the PCTL pulse for handshaking with the computer.

<table>
<thead>
<tr>
<th>IC #</th>
<th>Type</th>
<th>Board #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>74194</td>
<td>1D</td>
<td>Shift Register</td>
</tr>
<tr>
<td>U2</td>
<td>74193</td>
<td>1E</td>
<td>Binary Counter</td>
</tr>
<tr>
<td>U3</td>
<td>7474</td>
<td>2E</td>
<td>D Flip-Flop</td>
</tr>
<tr>
<td>U4</td>
<td>7400</td>
<td>2F</td>
<td>NAND Gates</td>
</tr>
<tr>
<td>U5</td>
<td>8830</td>
<td>2D</td>
<td>Line Driver</td>
</tr>
<tr>
<td>U6</td>
<td>74365</td>
<td>1A</td>
<td>Tri-State Buffer</td>
</tr>
<tr>
<td>U7</td>
<td>74365</td>
<td>1B</td>
<td>Tri-State Buffer</td>
</tr>
<tr>
<td>U8</td>
<td>74365</td>
<td>1C</td>
<td>Tri-State Buffer</td>
</tr>
<tr>
<td>U9</td>
<td>7402</td>
<td>2B</td>
<td>NOR Gates</td>
</tr>
<tr>
<td>U10</td>
<td>7402</td>
<td>2C</td>
<td>Inverters</td>
</tr>
<tr>
<td>U11</td>
<td>898-3-R220</td>
<td>1F</td>
<td>220 Ω Resistors</td>
</tr>
</tbody>
</table>
ULO DECODE CARD

Figure 5
C. GPO Card

The schematic diagram for the GPO card is illustrated in Figure 7. The part list is given in Table 3. The "DI" lines are buffered by U7, U8 and U9 Tri-State buffers. These lines are not used in the switch circuit but are provided for future expansion. The first eight bits of the "DO" line (lower byte) are latched by registers U3 and U4. This latch provides local storage of the switch position. The PRESET pulse clears the register and the PCTL is used to clock the data onto the register. The output of the register is buffered by U5 and U6. The PFLG signal is generated from the PCTL signal for handshaking with the computer. The power-up line clears the register. The circuit shown in Figure 8 drives the LED indicators on the front panel of the interface unit. The component layout for this card is shown in Figure 9.

<table>
<thead>
<tr>
<th>IC #</th>
<th>Type</th>
<th>Board #</th>
<th>VCC</th>
<th>GND</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>7427</td>
<td>3F</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>U2</td>
<td>7404</td>
<td>3G</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>U3</td>
<td>74194</td>
<td>1B</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>U4</td>
<td>74194</td>
<td>1A</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>U5</td>
<td>74365</td>
<td>2C</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>U6</td>
<td>74365</td>
<td>2D</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>U7</td>
<td>74365</td>
<td>1D</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>U8</td>
<td>74365</td>
<td>1E</td>
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<td>8</td>
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<td>U9</td>
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<td>8</td>
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<tr>
<td>U10</td>
<td>7400</td>
<td>3D</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>U11</td>
<td>7404</td>
<td>3E</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>
Figure 7
ADDITIONAL CIRCUIT FOR THE LED INDICATORS

Figure 8
Figure 9
CIRCUIT OPERATION

A. Setting the ULO System

The ULO system used to control the HP synthesizer accepts ten 16-bit words of data. The ULO OTA0 command puts the ULO into the DATA RECEIVE MODE. This OTA0 command must be constructed in the following way. To set the ULO frequencies, the first thing to do is enable the ULO DECODE CIRCUIT. This is done by sending a control signal CTL0=1 and CTL1=1 to the interface. The software command is as follows:

\[
\text{CTL1}=1 \\
\text{CTL0}=1 \\
\text{CONTROL 12, 2; CTL1 * 2 + CTL0}
\]

Upon power-up or after ten words of data have been sent to or received from the ULO, the address register, Ul, will be clocked on each PCTL pulse. The PCTL pulse is provided by the computer when a word of data is on line. Thus, the next thing that should occur is a general GPIO output statement which contains the address information. The software statement is as follows:

\[
\text{OUTPUT @ GPIO USING "}\text{,W";\text{0}
\]

The address for the ULO is hard wired except for the two least significant bits which are taken from the GPIO. The address is sent over the GPIO "DO" lines bit 1 and bit 0. Note that if another word was sent to the interface, the address register would be clocked and its address changed. To lock the address on the register, a PRESET pulse should be sent to the interface. The software command is as follows:

\[
\text{PRESET}=1 \\
\text{GPIO}=12 \\
\text{CONTROL GPIO;PRESET}
\]

This command has locked the address register and has sent an OCP pulse to the ULO system. This pulse indicates to the ULO that ten words of data follows. This completes the OTA0 forming statements.
Each word of data is accompanied by a PCTL pulse which clocks the counter U2 and used as an OTP pulse for the ULO system. The software statements are as follows:

```
OUTPUT @ GPIO USING "#,W";OUT
```

where "OUT" is the variable containing the data to be sent to the ULO. Remember that ten such statements must follow the PRESET command. Details of the data word will be discussed later.

After the tenth word has been sent to the ULO system, the counter decode circuit then shifts the PCTL from the OTP pulse forming circuit, back to the address register. The ULO decode circuit is now ready to repeat the above series of commands to set the ULO again, or do any other function.

B. Reading Knob Position

To read the knob position from the ULO system, the INA3 statement must be formed. The first command sent to the interface must be the ULO decode circuit enable. The software for the procedure is:

```
CTL1=1
CTL0=1
CONTROL 12, 2; CTL1 * 2 + CTL0
```

Upon power-up or after ten words have been sent to or received from the ULO, the address register U1 will be clocked on each PCTL pulse. The PCTL pulse is provided by the computer when a word of data is on line. The next command to the interface must be a general GPIO output statement which contains the address information. The software is:

```
OUTPUT @ GPIO USING "#,W";3
```

The address for the ULO is hard wired except for the two least significant bits which are supplied by the computer. The address is sent over the GPIO "DO" lines bit 1 and bit 0. Note that if another word is sent to the interface at
this time, the address register would be clocked and the data changed. To lock
the address on the register, a PRESET pulse should be sent to the interface unit.
The software for this PRESET pulse is:

\[
\text{PRESET}=1 \\
\text{GPI0}=12 \\
\text{CONTROL GPIO;PRESET}
\]

This command has locked the address register, and has sent an OCP pulse to the
ULO system. This pulse indicates to the ULO that ten words of data follow. The
above statement completes the OTA3 command.

When the computer receives a word of data from the ULO, the corresponding
handshake PCTL pulse is used to clock the word counter U2 and to generate an OTP
pulse for the ULO. The software command for each word is as follows:

\[
\text{ENTER } @ \text{ GPIO USING "}\\text{,W}"; \text{ Word}
\]

where "word" is the variable containing the data received from the ULO. Remember
that ten statements of this form must follow the PRESET command. After the tenth
word has been sent to the computer, the counter decode circuit then shifts the
PCTL from the OTP pulse forming circuit, back to the address register. The ULO
decode circuit is now ready to repeat the above series, or change modes.

C. Setting the GPO Switches

Setting the TTL switch outputs of the interface is a rather simple process
as compared to setting the ULO. The interface must first be set to the GPO mode.
This is done by setting CTL0=0 and CTL1=1. The corresponding software is:

\[
\text{CTL0}=0 \\
\text{CTL1}=1 \\
\text{CONTROL 12, 2; CTL1 * 2 + CTL0}
\]

The GPO output card is now active. The next step is to decide on the switch
positions and generate a corresponding binary word using the software techniques
described later. Once the word is known, it can now be sent to the GPIO output card which latches the word to the BNC outputs. The data is also displayed on the front panel of the interface unit. The software to implement the above event is:

```
OUTPUT @ GPIO USING "#,B";GPO
```

where "GPO" is a variable containing the 8-bit binary coded switch positions. To set all switches to zero voltage, the PRESET pulse is used. This PRESET pulse can be used at any time as long as the GPO card is enabled. The software command is:

```
PRESET=1
CONTROL GPIO: PRESET
```

Note also that the power-up pulse will set all BNC outputs to zero voltage when the interface unit power is turned on.

**REQUIREMENTS FOR ADDITIONAL BOARDS**

When adding additional boards to the interface unit, the following circuit must appear on each new board. This circuit is the minimum needed for full handshaking. More complex handshaking signals may be used to replace this circuit, if desired.

```
PCTL
  E2 or E3
  NOR Gate
  Inverter Gate
  Enabled Tri-State Buffer
```

Remember that all Data In Lines should be isolated from the GPIO buffered bus by Tri-State buffers.

Furthermore, the following circuit may be added to the board if board status is required.

```
PSTS
  E2 or E3
  Enabled Tri-State Buffer
```
### Logic Levels (Interface)

<table>
<thead>
<tr>
<th>Line</th>
<th>Logic High</th>
<th>Logic Low</th>
<th>Pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO0-DO15</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>DI0-DI15</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>PCTL</td>
<td>-</td>
<td>-</td>
<td>(\uparrow)</td>
</tr>
<tr>
<td>I/O</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>PRESET</td>
<td>-</td>
<td>-</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>CTL0</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>CTL1</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>PFLG</td>
<td>-</td>
<td>-</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>PSTS</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>EIR</td>
<td>0 V</td>
<td>5 V</td>
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<tr>
<td>STI0</td>
<td>0 V</td>
<td>5 V</td>
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<tr>
<td>STI1</td>
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<td>-</td>
</tr>
<tr>
<td>PWR PULSE</td>
<td>-</td>
<td>-</td>
<td>(\uparrow)</td>
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</table>

### Logic Levels (ULO)

<table>
<thead>
<tr>
<th>Line</th>
<th>Logic High</th>
<th>Logic Low</th>
<th>Pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTB1-OTB16</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>INB1-INB16</td>
<td>0 V</td>
<td>5 V</td>
<td>-</td>
</tr>
<tr>
<td>ADB7-ADB16</td>
<td>5 V</td>
<td>0 V</td>
<td>-</td>
</tr>
<tr>
<td>OTP+A</td>
<td>-</td>
<td>-</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>OTB-A</td>
<td>-</td>
<td>-</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>OCP+A</td>
<td>-</td>
<td>-</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>OCP-A</td>
<td>-</td>
<td>-</td>
<td>(\downarrow)</td>
</tr>
</tbody>
</table>
PHYSICAL CONSTRUCTION DETAILS

The GPIO Bus Interface Unit was built in a 5 1/4" chassis designed by A. Shalloway. Figure 10 shows the physical layout of the parts. All circuit boards and most of the logic lines throughout the chassis are wirewrap. The 5 volt power supply is a Power Products PM 542. The fuse is a Buss GMW 2. The GPIO connection is a 56 pin exposed Elco. The ULO and GPO connectors are 56 pin protected Elco. The switch outputs for the GPO are through standard BNC connectors. Two additional edge card connectors with VCC and ground attached are included for future circuits. Tables 4, 5 and 6 list the pin layout for the interface unit and ULO unit.
GPO CARD

Input Lines

<table>
<thead>
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<th>Data</th>
<th>Pin #</th>
</tr>
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<td>D015</td>
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<tr>
<td>D014</td>
<td>38</td>
</tr>
<tr>
<td>D013</td>
<td>36</td>
</tr>
<tr>
<td>D012</td>
<td>34</td>
</tr>
<tr>
<td>D011</td>
<td>32</td>
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<tr>
<td>D01Ø</td>
<td>30</td>
</tr>
<tr>
<td>D09</td>
<td>29</td>
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<td>D08</td>
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<td>D07</td>
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<td>D06</td>
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<tr>
<td>D11</td>
<td>46</td>
</tr>
<tr>
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<table>
<thead>
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<th>Pin #</th>
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<tr>
<td>PSTS</td>
<td>78</td>
</tr>
<tr>
<td>EIR</td>
<td>90</td>
</tr>
<tr>
<td>STIØ</td>
<td>92</td>
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| DI10      | F    | 4F 11  |
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| DI8       | J    | 4F 9   |
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ULO DECODE CARD

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ULO Decode Card
SUPPORTING SOFTWARE

The manual operation and test program is included here to give the user an idea of how the various subroutines can be incorporated into a large program. The main program yields no direct GPIO bus usage. Various options are presented in menu form with the softkeys used as option selectors. The choice of a particular option sends control to the corresponding subprogram of the main program. This subprogram then loads the necessary subroutines from the disc, calls these subroutines, and then deletes the subroutines before control is sent back to the main program. It is in these subroutines that all the GPIO action takes place.

These subroutines fall into three categories:

A. Setting the ULO frequencies.
B. Reading the ULO knob position.
C. Setting the switches on the GPO.

Each of these categories will now be discussed in detail.
MANUAL OPERATE FOR THE
GPIB BUS INTERFACE UNIT

This program will allow manual control of the GPIB bus interface between the HP 9825 computer and the ULO. The general purpose output (GPO) BNC is also controlled by this program.

PROGRAM INPUTS:

SOFTKEYS:
k0: Flo : LOCAL OSCILLATOR FREQ. (MHZ)
Fref1: REFERENCE FREQ. ONE (MHZ)
Fref2: REFERENCE FREQ. TWO (MHZ)
k1: Flo : LOCAL OSCILLATOR FREQ. (HZ)
Fref1: REFERENCE FREQ. ONE (HZ)
Fref2: REFERENCE FREQ. TWO (HZ)
k2: Flo : LOCAL OSCILLATOR FREQ. (MHZ)
k3: NONE
k4: NONE
k5: Sw1$ : SWITCH 1 POSITION
Sw2$ : SWITCH 2 POSITION
Sw3$ : SWITCH 3 POSITION
Sw4$ : SWITCH 4 POSITION
Sw5$ : SWITCH 5 POSITION
Sw6$ : SWITCH 6 POSITION
Sw7$ : SWITCH 7 POSITION
Sw8$ : SWITCH 8 POSITION
k6: NONE
k7: Flo : X4 MULT. FREQ.
k9: NONE

PROGRAM OUTPUTS: NO DIRECT OUTPUT
GPIB OUTPUTS/INPUTS: NO DIRECT I/O

VARIABLES
I : counters
Flo : LO/MULT frequency
Fref1 : reference freq. one
Fref2 : reference freq. two
K : counter
X : temp. storage
Positions$ : knob position string
Sw1$ : switch 1 position
Sw2$ : switch 2 position
Sw3$ : switch 3 position
Sw4$ : switch 4 position
Sw5$ : switch 5 position
Sw6$ : switch 6 position
Sw7$ : switch 7 position
Sw8$ : switch 8 position
30

SUBROUTINES:

Mhz   gosub Mhz
Hz    gosub Hz
Flo    gosub Flo

Mhz    gosub multi
Hz    gosub Hz
Flo    gosub Flo

Bien        gosub Bye
Spin        gosub Spin

>>> CLEAR SCREEN <<<
FOR I=1 TO 20
PRINT
NEXT I
PRINT "GPIO Interface Support Software"
PRINT "MANUAL OPERATION AND TEST PROGRAM"

>>> SOFTKEY INITIALIZATION <<<
ON KEY 0 LABEL "ULO MHz" GOSUB Mhz
ON KEY 1 LABEL "ULO Hz" GOSUB Hz
ON KEY 2 LABEL "Flo ONLY" GOSUB Flo
ON KEY 3 LABEL "UCOUNT" GOSUB Count
ON KEY 4 LABEL "KNOB" GOSUB Knob
ON KEY 5 LABEL "SWITCH" GOSUB Switch
ON KEY 6 LABEL "GCCOUNT" GOSUB Gcount
ON KEY 7 LABEL "X4 OUT" GOSUB Multi
ON KEY 9 LABEL "EXIT" GOSUB Bye

Spin: DISP " *** MENU ***"
GOTO Spin

Mhz: FOR I=1 TO 20
PRINT
NEXT I
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in MHz",Flo
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
LOADSUB ALL FROM "mhzulost"(Flo,Fref1,Fref2)
DELSUB Mhzulset
RETURN

Hz: FOR I=1 TO 20
PRINT
NEXT I
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in Hz",Flo
LOADSUB ALL FROM "ulohz"(Flo,Fref1,Fref2)
DELSUB Ulohz
RETURN
FOR I=1 TO 20
PRINT
NEXT I
INPUT "ENTER LOCAL OSCILLATOR FREQUENCY in MHz", Flo
LOADSUB ALL FROM "Flo"
CALL Flo(Flo)

! Count:
PRINT
NEXT I
Flo=11111:111.1
LOADSUB ALL FROM "ulocet"
FOR K=0 TO 9
X=Flo*K
CALL Ulocet(X,X,X)
NEXT K
PRINT "END OF TEST"
DELSUB Ulocet
RETURN

FOR I=1 TO 20
PRINT
NEXT I
LOADSUB ALL FROM "knob"
Position$="off"
CALL Knob(Position$)
DELSUB Knob
RETURN

FOR I=1 TO 20
PRINT
NEXT I
PRINT "ENTER SWITCH POSITION AS"
PRINT "....on....", logic 0 5 volts"
PRINT "....off....", logic 1 0 volts"
INPUT "Enter position of switch 1",Sw1$  
INPUT "Enter position of switch 2",Sw2$  
INPUT "Enter position of switch 3",Sw3$  
INPUT "Enter position of switch 4",Sw4$  
INPUT "Enter position of switch 5",Sw5$  
INPUT "Enter position of switch 6",Sw6$  
INPUT "Enter position of switch 7",Sw7$  
INPUT "Enter position of switch 8",Sw8$  
LOADSUB ALL FROM "switch"
CALL Switch(Sw1$ ,Sw2$ ,Sw3$ ,Sw4$ ,Sw5$ ,Sw6$ ,Sw7$ ,Sw8$ )
DELSUB Switch
RETURN
Gcount: FOR I=1 TO 20
PRINT
NEXT I
LOADSUB ALL FROM "gppcount"
CALL Gpocount
DELSUB Gpocount
RETURN
!
Mult: FOR I=1 TO 20
PRINT
NEXT I
INPUT "X4 Mult. Freq. in MHZ", Flo
LOADSUB ALL FROM "knob"
Position$="off"
CALL Knob(Position$)
TF Position$<"flo" THEN
"NOT BE SET"
!
DELSUB Knob
LOADSUB ALL FROM "mult"
CALL Mult(Flo)
DELSUB Mult
RETURN
!
Bye: STOP
END
A. Setting the ULO Frequencies

One of the most important functions of the GPIO BUS INTERFACE UNIT and its supporting software is its ability to set the frequencies of the ULO. As described in the earlier section on circuit operation, the ULO is looking for ten words of information before it can take action on the data. These ten words must be of the following form:

<table>
<thead>
<tr>
<th>Bits</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>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Words</td>
<td>100's MHz</td>
<td>10's MHz</td>
<td>1's MHz</td>
<td>100's kHz</td>
<td>10's kHz</td>
<td>100's Hz</td>
<td>10's Hz</td>
<td>Function</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>FLO</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>REF1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>REF2</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>SPACER</td>
</tr>
</tbody>
</table>

Note that word ten is only a spacer word and the bits may be set to anything for this use of the ULO. However, this word does have special meaning in the context of the Cassegrain system.

Each word is divided into four BCD digits; thus, the software task is to take a decimal frequency number and convert it into three 16-bit composite BCD words for the ULO. The procedure for doing this is described below.

The best way to understand this algorithm is by way of an example. Assume that the ULO $F_{LO}$ frequency is to be set at 423610537.1 Hz. This number is first divided by 100,000 which moves the decimal point over 5 places yielding 4236.105371. This division is performed by the DIV command which only looks at the quotient of the division and ignores the remainder. Hence, by using this command, the first four digits of the first word have been found to be 4236. This result is then DIV by 1000 to produce a 4, and then MOD (which only looks
at the remainder of a division) by 1000 to produce 236. This result is then
DIV by 100 giving second digit of 2 and then MOD by 100 giving a result of 36.
A DIV by 10 then yields digit three of value 3 and a MOD by 10 yields digit
four of value 6.

To produce a composite word of data, the four individual digits are com-
bined in the following way:

Word = (DIGIT 1 * 4096) + (DIGIT 2 * 256) + (DIGIT 3 * 16) + DIGIT 4
where 16, 256, and 4096 are weighting factors for placement of the BCD digit
in the 16 bit binary word.

The original frequency input is then MOD by 100,000 to yeild 105371 and
this result DIV by 100 to give 1053 as the BCD digits of word two. Again,
the above procedure is used to break the word up into its four individual
digits and then recombine them forming the second word.

For the third word, the original frequency is MOD by 10 to give 7100 and
once again the above procedure is used to form word three.

The entire algorithm is used three times; \( F_{LO} \), \( F_{REF1} \), and \( F_{REF2} \). This
algorithm develops the first 9 words of data. The tenth word which consists
of all zeros, is used as a spacer word. This spacer word clocks the data into
the ULO memory.

Notice that in the example, all digits were less than or equal to 7.
This is important since the above algorithm runs into trouble if a number "8"
or "9" is used as DIGIT ONE in any word. The problem stems from the HP 16-bit
computer which uses the MSB as a sign bit. However, this problem can be over-
come if a number 0 is used in place of 8 and a 1 is used in place of a 9 as
the first digit in the word. The sign bit must also be set which implies a
negative number. In most computers, as with the HP 9826, negative numbers are
stored in two's complement form. Thus, an extra calculation need be performed
on the binary word before it is sent to the ULO. The calculation
NEWWORD = OLDWORD - 65,536

yielding a negative number in two's complement form. Note that OLDWORD was found using the previously mentioned word-forming procedure. The new word is thus sent to the ULO.

The subroutines that follow all use this corrected procedure.
Program inputs:
Flo : local oscillator frequency (Hz)
Fref1: reference frequency one (Hz)
Fref2: reference frequency two (Hz)

Program outputs: none
GPIO outputs: ten 16 bit words for ULO

Variables:
Gpio: set to 12
Ct10, Ct11: interface address
Preset: set to 1
Freqs(3): array of ULO frequencies
Flo: local oscillator freq.
Fref1: reference frequency one
Fref2: reference frequency two
I, J: counters
A: power of 10 position
Q: four digits for word
Dig1: MSD of word
Dig2: digit 2 of word
Dig3: digit 3 of word
Dig4: LSD of word
Out1: decimal equiv. of word

SUB Ulohz(Flo, Fref1, Fref2)

>>> CHECK BOUNDARY OF INPUTS <<<
IF Flo>500000000 OR Fref1>500000000 OR Fref2>500000000 THEN
PRINT "ILLEGAL FREQUENCY... ULO NOT SET"
SUBEXIT
END IF

Gpio=12
ASSIGN @Gpio TO 12; FORMAT OFF

>>> GIVE CONTROL TO ULO <<<
Ct10=1
Ct11=1
CONTROL 12, 2; Ct11*2+Ct10
E4 >>> SET ULO ADDRESS TO OTA COMMAND <<<

OUTPUT @Gpio USING "#,W":0

>>> SEND OCP PULSE TO ULO <<<

Preset=1
CONTROL Gpio:Preset

>>> PUT FREQUENCIES INTO AN ARRAY <<<

DIM Freqs(3)
Freqs(1)=Flo
Freqs(2)=Fref1
Freqs(3)=Fref2

PRINT "LOCAL OSCILLATOR FREQUENCY is",Flo
PRINT "REFERENCE FREQUENCY ONE is",Fref1
PRINT "REFERENCE FREQUENCY TWO is",Fref2

>>> CALCULATE WORDS AND SEND THEM TO ULO <<<

FOR J=1 TO 3
    A=100000
    FOR I=1 TO 3
        Q=Freqs(J) DIV A
        Dig1=Q DIV 1000
        Q=Q MOD 1000
        Dig2=Q DIV 100
        Q=Q MOD 100
        Dig3=Q DIV 10
        Dig4=Q MOD 10
        Out1=(Dig1*4096)+(Dig2*256)+(Dig3*16)+Dig4
        IF Dig1=8 OR Dig1=9 THEN Out1=-65536+Out1
        OUTPUT @Gpio USING "#,W":Out1
        Freqs(J)=(Freqs(J) MOD A)+.0001
        A=A/10000
    NEXT I
NEXT J

>>> SEND SPACER WORD TO ULO <<<

OUTPUT @Gpio USING "#,W":0
BEEP 1200,.1

PRINT
PRINT "ULO FREQUENCIES ARE SET"

SUBEND
ULO FREQUENCY SET SUBROUTINE!

MHZ

This subroutine will set the ULO frequencies. All three frequencies must be supplied to the subroutine. A boundary check is performed on the inputs.

PROGRAM INPUTS:
Flo : LOCAL OSCILLATOR FREQUENCY (MHZ)
Fref1: REFERENCE FREQUENCY ONE (MHZ)
Fref2: REFERENCE FREQUENCY TWO (MHZ)

PROGRAM OUTPUTS: NONE

GPIO OUTPUTS : TEN 16 bit words for ULO

VARIABLES
Gpio : set to 12
Cti0,Cti1: interface address
Preset : set to 1
Freqs(3) : array of ULO frequencies
Flo : local oscillator freq.
Fref1 : reference frequency one
Fref2 : reference frequency two
I,J : counters
A : power of 10 position
Q : four digits for word
Dig1 : MSD of word
Dig2 : digit 2 of word
Dig3 : digit 3 of word
Dig4 : LSD of word
Out1 : decimal equiv. of word

SUB Mhzuloset(Flo,Fref1,Fref2)

>>> CHECK BOUNDARY OF INPUTS <<<
IF Flo>=500 OR Fref1>=500 OR Fref2>=500 THEN
PRINT "ILLEGAL FREQUENCY.. ULO NOT SET"
SUBEXIT
END IF

>>> CHANGE INPUT (MHZ) to (HZ) <<<
Flo=Flo*1000000
Fref1=Fref1*1000000
Fref2=Fref2*1000000
Gpio=12
ASSIGN @Gpio TO 12;FORMAT OFF

>>> GIVE CONTROL TO ULO <<<
Cti0=1
Cti1=1
CONTROL 12,2:Cti1*2+Ct10
! >>> SET ULO ADDRESS TO OTA COMMAND <<<
OUTPUT @Gpio USING ",W";0

! >>> SEND DCP PULSE TO ULO <<<
OUTPUT @Gpio USING ",W";0

! >>> PUT FREQUENCIES INTO AN ARRAY <<<
DIM Freqs(3)
Freqs(1)=Flo
Freqs(2)=Fref1
Freqs(3)=Fref2

PRINT "LOCAL OSCILLATOR FREQUENCY IS",Flo,"Hz"
PRINT "REFERENCE FREQUENCY ONE IS",Fref1,"Hz"
PRINT "REFERENCE FREQUENCY TWO IS",Fref2,"Hz"

! >>> CALCULATE WORDS AND SEND THEM TO ULO <<<
FOR J=1 TO 3
    A=100000

! >>> I LOOP COUNTS WORDS PER GROUP <<<
    FOR I=1 TO 3
        Q=Freqs(J) DIV A
        Dig1=Q DIV 1000
        Q=Q MOD 1000
        Dig2=Q DIV 100
        Q=Q MOD 100
        Dig3=Q DIV 10
        Out1=(Dig1*4096)+(Dig2*256)+(Dig3*16)+Dig4
        IF Dig1=8 OR Dig1=9 THEN Out1=-65536+Out1
        OUTPUT @Gpio USING ",W";Out1
        Freqs(J)=(Freqs(J) MOD A)+.0001
        A=A/10000
    NEXT I

! >>> SEND SPACER WORD TO ULO <<<
OUTPUT @Gpio USING ",W";0
BEEP 1200,.1

PRINT
PRINT
PRINT "ULO FREQUENCIES ARE SET"

SUBEND
This program will set the local oscillator frequency of the ULO. ONLY the LO frequency is transferred to this subroutine. The other two frequencies are set to zero. A boundary check on the input is performed.

PROGRAM INPUTS:
Flo: LOCAL OSCILLATOR FREQUENCY (MHZ)

PROGRAM OUTPUTS: NONE

GPIO OUTPUTS: TEN 16 bit words for ULO

VARIABLES
Gpio : set to 12
Ctl0,Ctl1: interface address
Preset : set to 1
Freqs(3) : array of ULO frequencies
Flo : local oscillator freq.
Fref1 : set to 0
Fref2 : set to 0
I,J : Counters
A : power of 10 position
Q : four digits for word
Dig1 : MSD of word
Dig2 : digit 2 of word
Dig3 : digit 3 of word
Dig4 : LSD of word
Out1 : decimal equiv. of word

SUB Flo(Flo)

>>> CHECK BOUNDARY OF INPUTS <<<
IF Flo>=500 THEN
PRINT "ILLEGAL FREQUENCY.. ULO NOT SET"
SUBEXIT
END IF

>>> CHANGE INPUT (MHZ) to (HZ) <<<
Flo=Flo*1000000

Gpio=12
ASSIGN @Gpio TO 12;FORMAT OFF

>>> GIVE CONTROL TO ULO <<<
Ctl0=1
Ctl1=1
CONTROL 12.2;Ctl1*2+Ct10
! >>> SET ULO ADDRESS TO OTA COMMAND <<<
115  OUTPUT @Gpio USING ";W":0
116  
117  >>> SEND OCP PULSE TO ULO <<<
119  Preset=1
120  CONTROL Gpio;Preset
121  
122  >>> PUT FREQUENCIES INTO AN ARRAY <<<
130  DIM Freqs(3)
140  Freqs(1)=Flo
150  Freqs(2)=0
160  Freqs(3)=0
161  
163  PRINT "LOCAL OSCILLATOR FREQUENCY is",Flo,"Hz"
164  
165  >>> CALCULATE WORDS AND SEND THEM TO ULO <<<
166  
167  >>> J LOOP COUNTS GROUPS OF THREE WORDS <<<
170  FOR J=1 TO 3
180  A=100000
181  
182  FOR I=1 TO 3
190  
200  Q=Freqs(J) DIV A
220  Dig1=Q DIV 1000
230  Q=Q MOD 1000
250  Dig2=Q DIV 100
260  Q=Q MOD 100
280  Dig3=Q DIV 10
290  Dig4=Q MOD 10
310  Out1=(Dig1*4096)+(Dig2*256)+(Dig3*16)+Dig4
330  IF Dig1=8 OR Dig1=9 THEN Out1=-65536+Out1
340  OUTPUT @Gpio USING ";W":Out1
350  Freqs(J)=(Freqs(J) MOD A)+.0001
370  A=A/10000
390  NEXT I
400  NEXT J
401  
402  >>> SEND SPACER WORD TO ULO <<<
404  OUTPUT @Gpio USING ";W":0
405  BEEP 1200,.1
406  
408  PRINT
409  PRINT
410  PRINT "LOCAL OSCILLATOR FREQUENCY IS SET"
411  
413  SUBEND
This subroutine will set the ULO LOCAL OSCILLATOR frequency to a frequency that is 1/4 the input. Thus, the X4 multiplier frequency is the input. The input is limited to a range of 1000 to 2000 MHZ. A boundary check on the input is performed. The ULO KNOB must be in the "Flo" position for this program to function. The other two frequencies are set to zero. NOTE: ONLY ONE FREQUENCY IS TRANSFERED TO THE SUBROUTINE.

PROGRAM INPUTS:
Flo: THE X4 OUT FREQUENCY (MHZ)

PROGRAM OUTPUTS: NONE
GPIO OUTPUTS: TEN 16 bit words for ULO

VARIABLES
Gpio : set to 12
Cnt0,Cnt1: interface address
Preset : set to 1
Freqs(3) : array of ULO frequencies
Flo : Local oscillator freq.
Fref1 : set to 0
Fref2 : set to 0
I,J : counters
A : power of 10 position
Q : four digits for word
Dig1 : MSD of word
Dig2 : digit 2 of word
Dig3 : digit 3 of word
Dig4 : LSD of word
Out1 : decimal equiv. of word

SUB Mult(Flo)

>>> CHECK BOUNDARY OF INPUT <<<
IF Flo>=2000 OR Flo<1000 THEN
PRINT "ILLEGAL FREQUENCY... ULO NOT SET"
SUBEXIT
END IF

>>> CHANGE INPUT TO 1/4 OF VALUE <<<
Fref(Flo)=Fref(Flo)*250000
Gpio=12
ASSIGN @Gpio TO 12; FORMAT OFF

>>> GIVE CONTROL TO ULO <<<
Ct10=1
Ct11=1
CONTROL 12,2; Ct11*2+Ct10

>>> SET ULO ADDRESS TO OTA COMMAND <<<
OUTPUT @Gpio USING "#,W": 0

>>> SEND OCP PULSE TO ULO <<<
Preset=1
CONTROL Gpio; Preset

>>> PUT FREQUENCIES INTO AN ARRAY <<<
DIM Freqs(3)
Freqs(1)=Flo
Freqs(2)= 0
Freqs(3)= 0

PRINT "LOCAL OSCILLATOR FREQUENCY is", Flo, "Hz"

>>> CALCULATE WORDS AND SEND THEM TO ULO <<<

>>> J LOOP COUNTS GROUPS OF THREE WORDS <<<
FOR J=1 TO 3
A=100000
Freqs(J)=(Freqs(J) MOD A)+.0001
A=A/10000
NEXT J

>>> SEND SPACER WORD TO ULO <<<
OUTPUT @Gpio USING "#,W": 0
BEEP 1200,.1

PRINT
PRINT
PRINT "ULO FREQUENCY IS SET"
SUBEND
ULO FREQUENCY SET TEST SUBROUTINE!

NOTE: THIS SUBROUTINE FOR ULO TEST ONLY

This subroutine will set the ULO frequencies. All three frequencies must be supplied to this subroutine. No boundary check is performed on the input. Hence any number can be entered as a frequency.

PROGRAM INPUTS:
Flo : LOCAL OSCILLATOR FREQUENCY (Hz)
Fref1: REFERENCE FREQUENCY ONE (Hz)
Fref2: REFERENCE FREQUENCY TWO (Hz)

PROGRAM OUTPUTS: NONE

GPIO OUTPUTS : TEN 16 bit words for ULO

VARIABLES
Gpio : set to 12
Ct10.Ct11: interface address
Preset : set to 1
Freqs(3) : array of ULO frequencies
Flo : local oscillator freq.
Fref1 : reference frequency one
Fref2 : reference frequency two
I,J : counters
A : power of 10 position
Q : four digits for word
Dig1 : MSD of word
Dig2 : digit 2 of word
Dig3 : digit 3 of word
Dig4 : LSD of word
Out1 : decimal equiv. of word

SUB Uloset(Flo,Fref1,Fref2)

Gpio=12
ASSIGN @Gpio TO 12; FORMAT OFF

>>> GIVE CONTROL TO ULO <<<
Ct10=1
Ct11=1
CONTROL 12,2:Ct11*2+Ct10

>>> SET ULO ADDRESS FOR OTA COMMAND <<<
OUTPUT @Gpio USING ",W":0

>>> SEND OCP PULSE TO ULO <<<
Preset=1
CONTROL Gpio;Preset
62 ! >>> PUT FREQUENCIES INTO AN ARRAY <<<
70 DIM Freqs(3)
80 Freqs(1)=Flo
90 Freqs(2)=Fref1
100 Freqs(3)=Fref2
101 !
103 PRINT "LOCAL OSCILLATOR FREQUENCY is",Flo
104 PRINT "REFERENCE FREQUENCY ONE is",Fref1
105 PRINT "REFERENCE FREQUENCY TWO is",Fref2
106 !
107 ! >>> CALCULATE WORDS AND SENT THEM TO ULO <<<
109 !
110 ! >>> J LOOP COUNTS GROUPS OF THREE WORDS <<<
111 FOR J=1 TO 3
120 A=100000
121 !
122 ! >>> I LOOP COUNTS WORDS PER GROUP <<<
130 FOR I=1 TO 3
140 Q=Freqs(J) DIV A
150 Dig1=Q DIV 1000
160 Q=Q MOD 1000
170 Dig2=Q DIV 100
180 Q=Q MOD 100
190 Dig3=Q DIV 10
200 Dig4=Q MOD 10
210 Out1=(Dig1*4096)+(Dig2*256)+(Dig3*16)+Dig4
220 IF Dig1=8 OR Dig1=9 THEN Out1=-65536+Out1
230 OUTPUT @Gpio USING "#,W";Out1
240 Freqs(J)=(Freqs(J) MOD (-I)+.0001
250 A=A/10000
260 NEXT I
270 NEXT J
280 !
290 ! >>> SEND SPACER WORD TO ULO <<<
300 OUTPUT @Gpio USING "#,W";0
310 BEEP 1200,.1
320 !
330 PRINT
340 PRINT
350 PRINT "ULO FREQUENCIES ARE SET"
351 !
353 SUBEND
B. Reading the ULO Knob Position

This simple subroutine looks at the position of the ULO knob. Only one word of data is needed but the interface must transfer ten words of data to keep its internal counter synchronized. The subroutine looks at the first four bits of the word and decodes them into their corresponding knob position.

<table>
<thead>
<tr>
<th>Bit</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>MOD</td>
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<td>1</td>
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<td></td>
<td>FREF1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
<td>FLO</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td>FREF2</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>SYNTH IN LOCAL</td>
</tr>
</tbody>
</table>

The program then prints the position of the knob on the CRT.
This subroutine will determine the position of the ULO knob. The subroutine will print the position of the knob on the CRT and send a variable containing the positional info back to the main program.

PROGRAM INPUTS: NONE
PROGRAM OUTPUTS: Position$
GPIO INPUTS: TEN 16 bit words

VARIABLES
Gpio: set to 12
Ctl0,Ctl1: interface address
Preset: set to 1
Word(10): array of 10 ULO data words
Position$: string containing position info
I: word counter

SUB Knob(Position$)

>>> GIVE CONTROL TO ULO <<<
Ctl0=1
Ctl1=1
CONTROL 12,2;Ctl1*2+Ctl0
Gpio=12
ASSIGN @Gpio TO 12;FORMAT OFF

>>> SET ULO ADDRESS TO INA 3 COMMAND <<<
OUTPUT @Gpio USING "#,W";3

>>> SEND GCP PULSE TO ULO <<<
Preset=1
CONTROL Gpio;Preset

DIM Word(10)

>>> I LOOP COUNTS WORDS INPUT FROM ULO <<<
FOR I=1 TO 10
ENTER @Gpio USING "#,W":Word(1)
NEXT I

PRINT
48

142 ! >>> DECODE WORD TO DETERMINE POSITION <<<
150 SELECT Word(1)
160 CASE 1
170 PRINT "ULO switch in ""MOD"" position"
171 Position$="mod"
180 CASE 2
190 PRINT "ULO switch in ""Fref1"" position"
191 Position$="fref1"
200 CASE 3
210 PRINT "ULO switch in ""Flo"" position"
211 Position$="flo"
220 CASE 4
230 PRINT "ULO switch in ""Fref2"" position"
231 Position$="fref2"
240 CASE 7
250 PRINT "HP Synthesizer in ""LOCAL"" mode"
251 Position$="local"
260 END SELECT
261 !
270 SUBEND
C. Setting the Switches on the GPO

This subroutine controls the position or logic level of the BNC switch outputs. The switch positions are as follows:

<table>
<thead>
<tr>
<th>Position</th>
<th>Logic Level</th>
<th>LED Indicator</th>
<th>Voltage Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;ON&quot;</td>
<td>0</td>
<td>ON</td>
<td>5 V</td>
</tr>
<tr>
<td>&quot;OFF&quot;</td>
<td>1</td>
<td>OFF</td>
<td>0 V</td>
</tr>
</tbody>
</table>

The algorithm is straightforward. It takes each switch position as a bit in the binary word of the GPIO. The higher order byte is set to zero. Each bit is multiplied by a weighting factor and then the bits and weighting factors are added together to form the word. Only one word is sent through the GPIO for this operation.

The GPO count routine is a very simple program that counts from 0 to 255. The binary equivalent of the count forms the lower byte of the 16-bit word and it is then sent to the GPO.
This subroutine controls the GPO BNC output of the interface unit. Inputs to this subroutine are the switch positions. NOTE: SWITCH POSITIONS MUST BE ENTERED AS "ON" OR "OFF".

"ON" IS A LOGIC 0 WITH BNC VOLTAGE=5v
"OFF" IS A LOGIC 1 WITH BNC VOLTAGE=0v

Values not given to the subroutine are considered "OFF". A warning message is printed in response to such an input.

PROGRAM INPUTS:

Sw1$: SWITCH 1 POSITION
Sw2$: SWITCH 2 POSITION
Sw3$: SWITCH 3 POSITION
Sw4$: SWITCH 4 POSITION
Sw5$: SWITCH 5 POSITION
Sw6$: SWITCH 6 POSITION
Sw7$: SWITCH 7 POSITION
Sw8$: SWITCH 8 POSITION

PROGRAM OUTPUTS: NONE

GPIO OUTPUTS : 16 bit word to set GPO

VARIABLES

Sw1$: switch 1 position
Sw2$: switch 2 position
Sw3$: switch 3 position
Sw4$: switch 4 position
Sw5$: switch 5 position
Sw6$: switch 6 position
Sw7$: switch 7 position
Sw8$: switch 8 position
Sw1: switch 1 logic level
Sw2: switch 2 logic level
Sw3: switch 3 logic level
Sw4: switch 4 logic level
Sw5: switch 5 logic level
Sw6: switch 6 logic level
Sw7: switch 7 logic level
Sw8: switch 8 logic level
Ct10, Ct11: interface address
Gpo: decimal equiv. of word

SUB Switch(Sw1$, Sw2$, Sw3$, Sw4$, Sw5$, Sw6$, Sw7$, Sw8$)

>>> GIVE CONTROL TO GPO <<<
Ct10=0
Ct11=1
CONTROL 12.2;Ct11*2+Ct10
ASSIGN @Gpio TO 12;FORMAT OFF
78 ! >>> CONVERT SWITCH POSITION TO LOGIC LEVEL <<<
110 SELECT Sw1$
120 CASE "off"
130 Sw1=1
140 CASE "on"
150 Sw1=0
160 CASE ELSE
161 PRINT "WARNING.. SWITCH 1 set to "OFF" by default"
180 END SELECT
181
190 SELECT Sw2$
200 CASE "off"
210 Sw2=1
220 CASE "on"
230 Sw2=0
240 CASE ELSE
250 Sw2=1
260 PRINT "WARNING.. SWITCH 2 set to "OFF" by default"
270 END SELECT
271
280 SELECT Sw3$
290 CASE "off"
300 Sw3=1
310 CASE "on"
320 Sw3=0
330 CASE ELSE
340 Sw3=1
350 PRINT "WARNING.. SWITCH 3 set to "OFF" by default"
360 END SELECT
361
370 SELECT Sw4$
380 CASE "off"
390 Sw4=1
400 CASE "on"
410 Sw4=0
420 CASE ELSE
430 Sw4=1
440 PRINT "WARNING.. SWITCH 4 set to "OFF" by default"
450 END SELECT
451
460 SELECT Sw5$
470 CASE "off"
480 Sw5=1
490 CASE "on"
500 Sw5=0
510 CASE ELSE
520 Sw5=1
530 PRINT "WARNING.. SWITCH 5 set to "OFF" by default"
540 END SELECT
541
520 SELECT Sw6$  
530 CASE "off"  
540 Sw6=1  
550 CASE "on"  
560 Sw6=0  
570 CASE ELSE  
580 Sw6=1  
590 PRINT "WARNING.. SWITCH 6 set to "OFF" by default"  
600 END SELECT  
610 !
620 SELECT Sw7$  
630 CASE "off"  
640 Sw7=1  
650 CASE "on"  
660 Sw7=0  
670 CASE ELSE  
680 Sw7=1  
690 PRINT "WARNING.. SWITCH 7 set to "OFF" by default"  
700 END SELECT  
710 !
720 SELECT Sw8$  
730 CASE "off"  
740 Sw8=1  
750 CASE "on"  
760 Sw8=0  
770 CASE ELSE  
780 Sw8=1  
790 PRINT "WARNING.. SWITCH 8 set to "OFF" by default"  
800 END SELECT  
810 !
820 PRINT "switch 1",Sw1$,"logic",Sw1  
830 PRINT "switch 2",Sw2$,"logic",Sw2  
840 PRINT "switch 3",Sw3$,"logic",Sw3  
850 PRINT "switch 4",Sw4$,"logic",Sw4  
860 PRINT "switch 5",Sw5$,"logic",Sw5  
870 PRINT "switch 6",Sw6$,"logic",Sw6  
880 PRINT "switch 7",Sw7$,"logic",Sw7  
890 PRINT "switch 8",Sw8$,"logic",Sw8  
900 PRINT  
910 !
913 PRINT  
914 PRINT "switch 1",Sw1$,"logic",Sw1  
915 PRINT "switch 2",Sw2$,"logic",Sw2  
916 PRINT "switch 3",Sw3$,"logic",Sw3  
917 PRINT "switch 4",Sw4$,"logic",Sw4  
918 PRINT "switch 5",Sw5$,"logic",Sw5  
919 PRINT "switch 6",Sw6$,"logic",Sw6  
920 PRINT "switch 7",Sw7$,"logic",Sw7  
921 PRINT "switch 8",Sw8$,"logic",Sw8  
922 PRINT  
923 !
924 ! >>> CREATE DECIMAL EQUIVALENT <<<  
925 !
927 Gpo=(128*Sw8)+(64*Sw7)+(32*Sw6)+(16*Sw5)+(8*Sw4)+(4*Sw3)+(2*Sw:  
928 PRINT "binary output to gpo is",Gpo  
931 !
932 ! >>> SEND WORD TO GPO <<<  
933 OUTPUT @Gpio USING ",B",Gpo  
940 BEEP 1000,.1  
951 !
960 SUBEND
10 !!!!!!!!!!!!!!!!!!!!!!!!!!!!
20 ! GPO COUNT SUBROUTINE !
30 !!!!!!!!!!!!!!!!!!!!!!!!!!!!
40 ! This subroutine will test the GPO by
50 ! applying a binary count to the BNC output
60 !
70 ! PROGRAM INPUTS : NONE
80 ! PROGRAM OUTPUTS: NONE
90 ! GPIO OUTPUT : BINARY COUNT ON GPO BNC
100 ! VARIABLES
110 !
120 !
130 Ct10,Ct11 : interface address
140 I : counter
150 !
160 !
170 SUB Gpocount
180 !
190 PRINT "THIS PROGRAM WILL TEST THE GPO"
200 PRINT "BY COUNTING FROM 0 TO 255"
210 PRINT
220 DISP "FIVE SECONDS PAUSE"
230 PRINT
240 !
250 WAIT 5
260 !
270 ! >>> GIVE CONTROL TO GPO <<<
280 Ct10=0
290 Ct11=1
300 CONTROL 12,2:Ct11*2+Ct10
310 !
320 ! >>> BINARY COUNT FROM 0 to 255 <<<
330 ASSIGN @Gpio TO 12:FORMAT OFF
340 FOR I=0 TO 255
350 OUTPUT @Gpio USING ":,B":I
360 DISP "Output is a binary":I
370 WAIT .5
380 NEXT I
390 !
400 BEEP 1500,1
410 !
420 PRINT
430 PRINT "TEST COMPLETE"
440 !
450 SUBEND
USER NOTES

As a final note, the following points should be kept in mind when using or modifying the GPIO BUS INTERFACE UNIT:

1. The ULO must be in the computer control mode for this interface to work. Be sure to check the ULO switch position before using the interface.

2. Note that the voltage levels on the BNC outputs and the LED indicators correspond directly.

3. For a detailed description of the ULO circuit, see Electronics Division Internal Report No. 144 by D. Schiebel.

4. Remember that each additional board must include at least the simple handshaking circuit described in this report. A more complex circuit may be used in place of the simple one, if desired.

5. The power-up pulse line may be used on additional boards to clear registers, zero counters, etc.

6. The least significant digits of the address lines for the ULO are hard wired to 31. Digits 32 may also be used.

7. BE SURE THAT THE LOGIC LEVEL SWITCHES OF THE HP 98622A GPIO ARE SET TO CORRESPOND TO THE LOGIC LEVELS OF THIS INTERFACE UNIT. SEE PAGE 19.
I would like to thank the following people for their help and ideas concerning this project:

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