

CALCULATOR CONTROL of the 8660A/B/C SYNTHESIZED SIGNAL GENERATOR (Optional HP-IB Interface)



APPLICATION NOTE 164-2

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INTRODUCTION

The HP Model 8660A/B/C Synthesized Signal Generator is a **programmable** instrument. This means that most of the 8660A/B/C's functions (frequency, output level, modulation parameters) can be controlled by an external device such as a computer, calculator, or card reader.

When equipped with Option 005, the 8660A/B/C can be controlled by one of these external devices via the **Hewlett-Packard Interface Bus (HP - IB)**.

This application note provides the information necessary to write HP Model 9820A/21A or 9830A calculator programs which will control the 8660A/B/C Option 005 Synthesized Signal Generator, via the HP-IB. The emphasis in this application note will be on calculator programming examples. Hardware considerations will be included only in the chapters on **Instrument Configuration** (Chapter 2), **Hardware Connection** (Chapter 3) and **Instrument Timing** (Chapter 8).

It is assumed that the reader is already familiar with the operation of both the 8660A/B/C and at least one of the calculators. If not, consult these instruments' respective operating and service manuals.

CHAPTER 1

PROGRAMMABLE FUNCTIONS

CW FREQUENCY (Center Frequency)

Frequency may be programmed over the full frequency range of the RF plug-in being used. Below 1300 MHz, frequency resolution is 1 Hz (100 Hz with Option 004 8660A/B/C). Above 1300 MHz, resolution is 2 Hz (200 Hz with Option 004 8660A/B/C).

OUTPUT LEVEL

Output level is programmable in 1 dB steps over the full output range of the RF Section plug-in installed.

AMPLITUDE MODULATION (86632A/B, 86633A/B Modulation Section)

Amplitude modulation mode, modulation source, and modulation depth are all programmable. Modulation depth can be programmed in 1% steps from 0 to 99%.

FREQUENCY MODULATION (86632A/B, 86633A/B, 86635A Modulation Section)

FM mode, modulation source, and peak FM deviation can all be remotely programmed when using the above modulation section plug-ins.

The **resolution** to which FM deviation can be programmed depends on which plug-in is installed and, in the case of the 86603A RF Section, on whether the selected RF carrier frequency is above or below 1300 MHz. The **range** over which FM deviation can be programmed depends on which mode range is selected. (FM $\times 0.1$, FM $\times 1.0$, FM $\times 10$ —86632A/B, 86635A; FM $\times 0.1$, FM $\times 1.0$ —86633A/B).

Table 1 - 1 shows the resolution and range for each combination of modulation section plug-in, MODE, and center frequency range (<1300 MHz, ≥ 1300 MHz). In addition, because it is necessary to program half the desired deviation for certain combinations of plug-ins and center frequencies, the table also indicates when the actual FM deviation will be twice the programmed value.

Below 1300 MHz, the actual FM deviation must not exceed the range listed for each mode in Table 1 - 1, even though it may be possible to program outside that range.

Here is an example of how to use Table 1 - 1.

It is desired to program an **86632B** to an FM deviation of 18 kHz when the RF Section is at a frequency <1300 MHz. The table tells us to program **FM MODE** to **FM $\times 1.0$** , and to program 9 kHz deviation, i.e., one-half of the desired (actual) FM deviation.

It is also possible to program 9 kHz deviation in the **FM $\times 0.1$** mode. However, because the actual deviation would now be 18 kHz, and because this deviation exceeds the range of the **FM $\times 0.1$** mode (0 - 9.9 kHz), the modulation section would now be operating out of spec.

Table 1-1. FM Programming Ranges and Resolutions

| Plug-in | RF Center Frequency (MHz) | MODE (RANGE) | | |
|---------------|---------------------------|------------------------|-----------------------|-----------------------|
| | | FM x 0.1 (0 - 9.9 kHz) | FM x 1.0 (0 - 99 kHz) | FM x 10 (0 - 990 kHz) |
| 86632A | <1300 | 0.1 kHz | 1 kHz | 10 kHz |
| | ≥ 1300 | 0.2 kHz* | 2 kHz* | 20 kHz* |
| 86632B | <1300 | 0.2 kHz* | 2 kHz* | 20 kHz* |
| | ≥ 1300 | 0.2 kHz* | 2 kHz* | 20 kHz* |
| 86633A | <1300 | 0.1 kHz | 1 kHz | N. A. |
| | ≥ 1300 | 0.2 kHz* | 2 kHz* | N. A. |
| 86633B | <1300 | 0.1 kHz | 1 kHz | N. A. |
| | ≥ 1300 | 0.2 kHz* | 2 kHz* | N. A. |
| 86635A | <1300 | 0.2 kHz* | 2 kHz* | 20 kHz* |
| | ≥ 1300 | 0.2 kHz* | 2 kHz* | 20 kHz* |

* Actual FM deviation is **twice** the programmed value.

N. A. = Not Available

PHASE MODULATION (86634A, 86635A)

ϕ M mode, modulation source, and ϕ M deviation can all be remotely programmed when using the 86635A. Below 1300 MHz, the resolution to which ϕ M deviation can be programmed is 2° over a range of 0-100°. Above 1300 MHz, the resolution to which ϕ M deviation can be programmed is also 2°, but over a wider range of 0-200°. The actual ϕ M deviation is always twice the programmed value.

Only ϕ M mode can be programmed when using the 86634A.

FM CAL (86632A/B, 86635A)

The FM CAL function of the 86632A/B and the 86635A can be remotely programmed.

FREQUENCY STEPPING (8660B/C)

The frequency step function of the 8660B/C can be remotely programmed. Below 1300 MHz, minimum programmable step size is 1 Hz. Above 1300 MHz, minimum programmable step size is 2 Hz.

CHAPTER 2

INSTRUMENT CONFIGURATION

8660A/B/C SYNTHESIZED SIGNAL GENERATOR

In order to be HP - IB compatible the 8660A/B/C Synthesized Signal Generator must be equipped (either factory installed or retrofit) with Option 005.

9820A/21A CALCULATOR

In order to be HP - IB compatible, the 9820A/21A Calculator must be equipped with a 11144A ASCII Bus Interface Card, a 11224A Peripheral Control II ROM and a 10631A/B/C ASCII Interface Cable. The 11224A and the 10631C are available as standard accessories with the 11144A-020 ASCII Bus Interface Card.

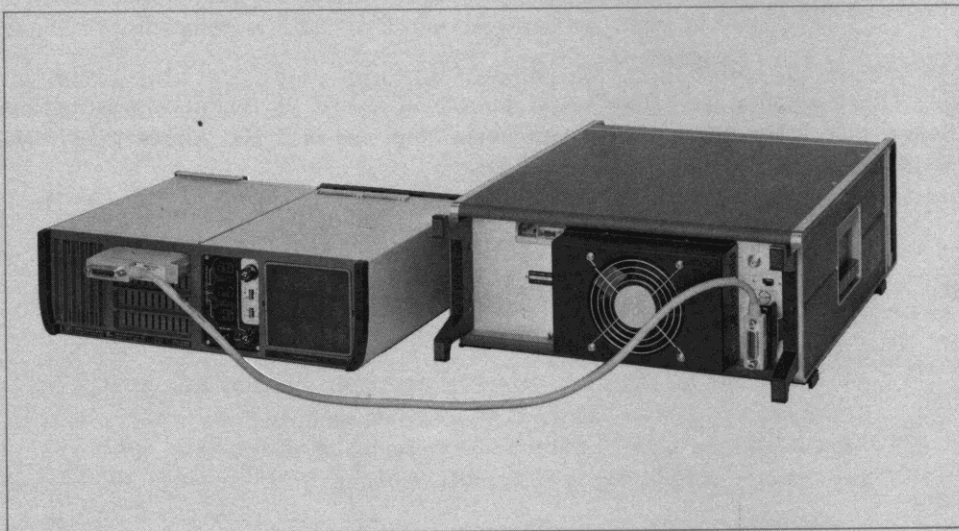
9830A CALCULATOR

In order to be HP - IB compatible, the 9830A Calculator must be equipped with a 11144A ASCII Bus Interface Card, a 11272B/F or Option 272 Extended I/O ROM, and a 10631A/B/C ASCII Interface Cable. The 11272B/F and the 10631C are available as standard accessories with the 11144A-030 ASCII Bus Interface Card.

CHAPTER 3

HARDWARE CONNECTION

The picture below shows the connections necessary between the 9820A/21A or 9830A Calculator and the 8660A/B/C.



CHAPTER 4

PROGRAMMING FORMAT

While the actual software commands used to program the 8660A/B/C depend on which calculator is being used, the general format of these commands does not. This chapter outlines the basic format. Programming examples are given in Chapters 6 and 7.

PUTTING THE 8660A/B/C INTO REMOTE

Before any of the 8660A/B/C's function can be controlled externally by a calculator, the 8660A/B/C must be placed in the **remote** mode of operation. In remote, all front panel controls except for the ON-OFF switch and FM CAL are locked out.

To place the 8660A/B/C in remote, the remote line must be enabled and, in addition, the instrument must be **addressed**.

ADDRESSING THE 8660A/B/C

Addressing is a convention for determining which instruments in an HP-IB system are to send, which are to receive and which are to ignore programming information.

The 8660A/B/C is capable of receiving and ignoring, but is not capable of sending, information on the HP-IB.

In order for the 8660A/B/C to receive programming information it must be addressed to **listen** and the calculator must be addressed to **talk**. In order to make the 8660A/B/C ignore programming information being sent to other instruments, it must be **unaddressed**. While unaddressed, the 8660A/B/C will remain insensitive to any information being sent to other instruments in a system.

8660A/B/C PROGRAMMING SEQUENCE

Once the 8660A/B/C is in remote and addressed to listen, its functions can be programmed. The format for programming the instrument's functions is as follows:

1. Output a setting for the function to be programmed. This setting will be either a frequency, output level, or modulation parameter depending on what **program code** follows.
2. Output a program code to tell the 8660A/B/C which function is to be programmed. Upon receipt of the program code the 8660A/B/C will switch the programmed function to its new state.

Program codes consist of a single character. These codes and their associated functions are shown in Table 4-1.

Table 4 - 1. Program Codes, Addresses, and Modulation Codes

| Program Codes | Calculator Character | |
|---|---|---|
| Center Frequency | (| |
| Frequency Step \uparrow ¹ | A | |
| Frequency Step \downarrow ¹ | B | |
| Frequency x2 ² | G | |
| Frequency x1 ² | I | |
| Output Level | C | |
| AM-FM- ϕ M Function | \$ | |
| Modulation Level | % | |
| FM CAL ³ | & | |
| Addresses | | |
| 8660A/B/C Listen (Factory Set) | 3 | |
| Other 8660A/B/C Listen | ; | |
| Other 8660A/B/C Listen | } for multiple units ⁴ | < |
| Other 8660A/B/C Listen | | = |
| Other 8660A/B/C Listen | | > |
| Universal Unlisten | | ? |
| Calculator Talk | U | |
| Device Clear ⁵ | DISPLAY 4 | |
| Modulation Source (Output Before Mode) | | |
| INT 1 kHz | 1 | |
| INT 400 Hz | 2 | |
| EXT DC | 4 | |
| EXT AC | 8 | |
| EXT AC Unleveled ⁶ | 9 | |
| Modulation Mode (Output After Source) | | |
| Modulation OFF | 0 | |
| FM x 10 ⁷ | 1 | |
| FM x 1.0 | 2 | |
| FM x 0.1 | 4 | |
| AM ⁸ | 8 | |
| ϕ M ⁹ | \leq | |

¹ 8660B/C only.

² 8660A/B equipped with 86603A (Option 003) RF Section.

³ 86632A/B, 86635A.

⁴ Listen address is changed by re-wiring jumpers on HP - IB Input Assembly board.

⁵ Sets frequency to 1 MHz, turns modulation OFF. Also sets attenuation to -140 dBm (RF Sections serial prefix 1335A and above).

⁶ 86633A/B only.

⁷ 86632A/B and 86635A only.

⁸ 86632A/B, 86633A/B only.

⁹ 86635A only.

CHAPTER 5

8660A/B/C PROGRAMMING CONVENTIONS

Several programming conventions unique to the 8660A/B/C are described below:

DIGIT REVERSAL (Inversion)

In order to satisfy the internal logic requirements of the 8660A/B/C, the least significant digits and the most significant digits of all **numerical** settings (frequency, output level, % AM, FM deviation) must be exchanged. In order to do this, the resolution for the function to be programmed and the maximum allowable number of significant digits must be known.

Resolution for each function is given in Chapter 1. The table below lists the allowable number of significant digits for each 8660A/B/C function.

Table 5 - 1. Programmable Significant Digits

| Function | Number of Significant Digits |
|------------------------------|------------------------------|
| Frequency | 10 |
| Output Level | 3 |
| % AM | 2 |
| FM Deviation (all ranges) | 2 |
| ϕM | 2 |

Thus to program the 8660A/B/C to 0012476538 Hz (10 significant digits), the number 8356742100 would be output to the 8660A/B/C. To program 07% AM modulation (2 significant digits), the number 70 would be output.

Chapters 6 and 7 will demonstrate short, fast software subroutines which do this digit reversal automatically.

FREQUENCY SCALE

All frequencies are expressed in Hz (as opposed to gigahertz or megahertz).

OUTPUT LEVEL SCALE

Output level is referenced to +13 dBm (1 V). This reference operation involves subtracting 13 from the desired output level. After this subtraction, the most and least significant digits are exchanged. For instance, to program the 8660A/B/C to -071 dBm, first subtract 13 to get -084, and then exchange the most and least significant digits to get -480. Thus outputting -480, followed by the proper program code, will program the 8660A/B/C to an output level of -071 dBm. (The minus sign need not be included in the output).

MODULATION SOURCE AND MODULATION MODE

Modulation **source** (EXT, INT, 400 Hz, etc.) and modulation **mode** (AM, FM x 0.1, FM x 1.0, FM x 10, ϕ M) can also be programmed. The various sources are represented by a single character and the various modes are also represented by a single character. The mode character must always be output **after** the source character. The **AM-FM- ϕ M Function** program is output after mode.

MODULATION LEVEL

In addition to source and mode, a third modulation parameter **Modulation Level**, must also be programmed. This two-digit parameter represents different quantities depending on what modulation mode is selected.

If AM mode is selected, (86632A/B, 86633A/B) then this third parameter represents AM depth, expressed as %. AM depth can be programmed in 1% steps from 0 to 99%.

If FM mode is selected, (86632A/B, 86633A/B, 86635A) then this parameter represents peak FM deviation, expressed in kilohertz. FM mode is split into three ranges, FM x 0.1, FM x 1.0, and FM x 10 (FM x 0.1, FM x 1.0 only on 86633A/B).

On FM x 0.1, the actual peak deviation is 0.1 times the programmed value; on FM x 10 the peak deviation is 10 times the programmed value.

The effects of the doubling system (see Table 1 - 1) and the mode range must be taken into account individually.

If ϕ M mode is selected (86635A), then the **Modulation Level** parameter represents phase deviation in degrees. Below 1300 MHz the resolution to which phase deviation can be programmed is 2° , over a range of 0-100°. Above 1300 MHz the resolution to which phase deviation can be programmed is also 2° , but over a wider range of 0-200°. The actual phase deviation is always **twice** the programmed value.

The next two chapters will present examples which show in more detail how modulation is programmed.

OUTPUT STATES AFTER LOCAL→REMOTE TRANSITION

When the 8660A/B/C is put into the REMOTE mode, frequency will remain unchanged, the modulation section will turn off and output level will go either to the last programmed value or, if level has not yet been programmed, to -140 dBm (serial prefix 1335A and above).

OUTPUT STATES AFTER REMOTE→LOCAL TRANSITION

When the 8660B/C is brought back from the REMOTE mode of operation into the LOCAL mode, all functions except frequency will return to the states specified by the instrument's front panel controls. However, frequency will remain at the last value entered in the REMOTE mode.

FIRST FREQUENCY CHANGE AFTER REMOTE→LOCAL TRANSITION

When the 8660B/C is switched back into LOCAL, the CLEAR key should be pressed before entering a new frequency. This ensures that the first manual command will be accepted and executed properly.

CHAPTER 6

9820A/21A CALCULATOR CONTROL OF THE 8660A/B/C

The Hewlett-Packard Model 9820A/21A Calculator provides all the control capabilities necessary to program the 8660A/B/C Synthesized Signal Generator. It is assumed in the following examples that the user has properly connected the 8660A/B/C to the 9820A/21A Calculator as shown in Chapter 3, and that the proper options and accessories are installed in both the 8660A/B/C and the 9820A/21A as described in Chapter 2.

This chapter is written so that the reader can follow along on the calculator while reading the text.

ADDRESSING THE 8660A/B/C

To put the 8660A/B/C into remote, store the following lines, and press END, EXECUTE, RUN PROGRAM. The front panel 8660A/B/C REMOTE indicator should light.

| Comments | |
|------------------------|-----------------------|
| 0: FMT Y3,Z;WRT 13F | ◀ Enables Remote Line |
| 1: CMD "?U3" F | ◀ Address Instruments |

The first line above (line 0) **enables** the remote line, thus allowing the 8660A/B/C to go into remote, as soon as it is addressed to listen. The second line above (line 1) accomplishes this addressing. The characters within the quote field in line 1 are addresses and they are automatically output to the HP-IB sequentially, starting with the leftmost character and ending with the rightmost. Thus by referring to the HP-IB coding table (Table 4-1) it can be seen that the effect of this statement is to first **unaddress** all instruments on the HP-IB ("?"), then address the 9820A/21A to talk ("U") and finally address the 8660A/B/C to listen ("3").

As stated in Chapter 2, the 8660A/B/C will not go into remote until it is addressed, which means the remote light on the 8660A/B/C will not go on until

```
CMD "?U3" F
```

is executed. To convince yourself of this, turn the 8660A/B/C off and then turn it back on again. This automatically puts the 8660A/B/C in LOCAL (front panel remote light off). Now store the following program:

| | Comments |
|------------------------------|---------------------|
| 0: FMT Y3,Z;WRT 13F | Enables Remote Line |
| 1: DSP "LINE 1"; STP F | Stop |
| 2: CMD "?U3" F | Address Instruments |

Press END, EXECUTE. When RUN PROGRAM is pressed, line 0 is executed, and the program halts at the STP instruction in line 1. At this point the 8660A/B/C is still in LOCAL. When RUN PROGRAM is pressed again, line (2) is executed and the 8660A/B/C goes into REMOTE (front panel REMOTE light on).

If other instruments are on the bus, it will be necessary to unaddress the 8660A/B/C so that information may be sent to these other instruments. To unaddress the 8660A/B/C, key in

```
CMD "?" F
```

and press EXECUTE. The 8660A/B/C is now unaddressed, and will ignore any information being transmitted to other instruments until it is once again addressed to listen.

The 8660A/B/C can also be unaddressed by pushing the calculator STOP key. This can lead to unexpected results, however, if the user did not intend to unaddress the 8660A/B/C when the STOP key was pressed.

A program executed STP statement does **not** unaddress the 8660A/B/C.

When the last statement was executed, (CMD "?") the 8660A/B/C remained in remote. If it is desired to bring the 8660A/B/C back into the local mode, execute the following line:

```
FMT Y4,Z;WRT 13F
```

As soon as this line is executed, the 8660A/B/C should return to LOCAL (front panel REMOTE light goes out).

PROGRAMMING THE 8660A/B/C WITH LITERALS (9820A/B/C Calculator)

Many times it is desirable to program the 8660A/B/C to a fixed frequency or a fixed output level, etc. This involves programming with **literals**, where a literal is defined as any character within a quote field. Programming with literals is useful any time an 8660A/B/C's functions need be programmed to only one state during a test, or when successive states of a function are not mathematically related.

In the examples that follow, it is assumed that the remote enable statement

```
FMT Y3,Z;WRT 13F
```

has already been executed. This statement need only be executed once unless a remote disable statement

```
FMT Y4,Z;WRT 13F
```

has been executed, thus putting the instrument back into LOCAL.

As a first example of how to control the 8660A/B/C, suppose that it is desired to program 57.34 MHz. The procedure for doing this is outlined below. The first three steps are done in the user's head and only the last step is done on the calculator. (The section on programming with variables will show how the first three steps below can also be done on the calculator.)

Programming the 8660A/B/C to 57.34 MHz

1. Change the frequency to Hertz (57340000)
2. Add enough leading zeroes to get 10 significant digits (0057340000)
3. Reverse the order of the most significant and the least significant digits to get the number 0000437500. (The leading zeroes can now be omitted).
4. Execute the line

```
CMD "?U3","/4375  
00("F
```

The 8660A/B/C will now read 57.34 MHz.

It is important that the above syntax be well understood, and therefore a detailed description follows.

The ?U3 in the first quote field performs the same addressing function as outlined in the last section. However, the machine treats characters in the second quote field differently. Instead of converting these characters into addresses, the calculator converts them into program data. This program data is sent to the 8660A/B/C one character at a time, starting with the /, then the 4, etc. The following paragraph describes the purpose of each of these characters in detail.

The / clears a temporary storage register inside the 8660A/B/C. It must be the first character output to the 8660A/B/C after it is put into remote. However, this temporary register is automatically cleared every time the 8660A/B/C receives a program code and therefore it is not necessary (although it won't hurt) to output the / more than this one time, after the 8660A/B/C has been placed in remote.

The digits 437500 which represent, in this case, the desired output frequency, go into the temporary storage register mentioned above. As soon as the program code [()] is received, the 8660A/B/C changes its output frequency and then clears the temporary storage register.

Because the 8660A/B/C is capable of storing information, and because this information is not erased until a program code is received, the following lines would also program the instrument to 57.34 MHz.

| | Comments |
|-----------------------|-------------------------------------|
| 0: CMD "?U3","43"␣ | Output 43 |
| 1: CMD "?U3","75"␣ | Output 75 |
| 2: CMD "?U3","00"␣ | Output 00 |
| 3: CMD "?U3","("␣ | Output frequency program code [(]. |

The following examples show how to program other 8660A/B/C functions. Refer to Table 4-1 to verify the program codes used.

21 MHz at -43 dBm

| | Comments |
|---|---|
| 0: CMD "?U3","1200(","?U3","650C"␣ | These three examples show that the syntax used to output literals is not unique. 650 is obtained by subtracting 13 from -43 and then reversing the order of the digits. |
| or | |
| 0: CMD "?U3","1200(650C"␣ | |
| or | |
| 0: CMD "?U3","1200("␣ | |
| 1: CMD "?U3","650C" ␣ | |

27% AM INT. 400 Hz (86632A/B, 86633A/B)

| | Comments |
|--------------------------------|---|
| 0: CMD "?U3","28\$72 %"␣ | 2 sets INT 400 Hz; 8 sets AM mode, \$ is AM-FM- ϕ M FUNCTION program code; 72 sets 27% AM depth; % is MODULATION LEVEL program code. |

**2.4 kHz FM, EXT AC LEV
(86632A, 86633A/B)**

```
0:
CMD "?U3", "84$42
%"F
```

Comments

8 sets EXT AC; 4 sets FM x 0.1 mode; \$ is AM-FM- ϕ M FUNCTION program code; 42 sets 2.4 kHz deviation; % is MODULATION LEVEL program code. (For center frequency ≥ 1300 MHz, and for 86632B and 86635A plug-ins, program 1.2 kHz deviation.)

**38 kHz FM, INT 1 kHz,
FM CAL (86632A)**

```
0:
CMD "?U3", "83%12
$&"F
```

Comments

83 sets 38 kHz deviation; % is MODULATION LEVEL program code; 1 sets INT 1 kHz; 2 sets FM x 1.0; \$ is AM-FM- ϕ M FUNCTION program code, & is FM CAL program code. (For center frequencies ≥ 1300 MHz and for 86632B plug-in, program 19 kHz deviation).

**48° Phase deviation, EXT DC
(86635A)**

```
0:
CMD "?U3", "42%42
$&"F
```

Comments

42 sets 48° deviation (remember actual deviation = 2 x programmed deviation); % is MODULATION LEVEL program code; 4 sets EXT DC, \leq sets phase modulation, \$ is AM-FM- ϕ M FUNCTION program code.

Modulation OFF

```
0:
CMD "?U3", "00$&"F
```

Comments

First 0 can be any number; second 0 turns modulation off; \$ is AM-FM- ϕ M FUNCTION program code.

PROGRAMMING THE 8660A/B/C WITH VARIABLES (9820A/21A Calculator)

Under most circumstances, it is desirable to change the frequency, output level, and modulation parameters many times during the course of a measurement. Under such circumstances it is convenient to output the contents of **variables**. The present section illustrates how this is done.

The first thing that needs to be understood is that once the 8660A/B/C is addressed to listen and the 9820A/21A is addressed to talk with

```
CMD "?U3"␣
```

it is **not** necessary to repeat this instruction until the 8660A/B/C is unaddressed. In the following discussion, it will be assumed that the 8660A/B/C has been addressed, and that it has received a \backslash , thus clearing its temporary register.

The general 9820A/21A syntax for programming the 8660A/B/C with variables is:

0) FMT *n*, FXD **.0*, "*x*₁", FXD **.0*, "*x*₂", . . .

1) WRT 13.*n*, R1, R2, . . .

where *n* is a format number, and can be any integer from 0 to 9; **R1**, **R2**, etc. are the variables to be output; **FXD *.0** is the format associated with these variables; and *x*₁, *x*₂, etc. are program codes. Line 0 must always be executed before line 1.

Before proceeding further, a short example may be helpful:

18.374 MHz, -92 dBm

Comments

```
0:
CMD "?U3"␣
1:
FMT 1,FXD *.0,"(
",FXD *.0,"C"␣
2:
4738100␣R1␣
3:
501␣R2␣
4:
WRT 13.1,R1,R2␣
```

Output the contents of R1 followed by (, the contents of R2, and C.

As seen in the last example, it is still necessary to reverse the order of the digits of both center frequency and level. The following subroutine will do this rearrangement quickly, efficiently and automatically. This subroutine requires that the number to be inverted be divided by a constant. This number is 10^9 for frequency, 10^2 for output level, and 10^1 for modulation level. After the number is divided by the appropriate constant, the result is placed in the C register. The inverted number is returned in the B register.

This subroutine, and most of the remaining programs in this chapter, require the use of the mathematics ROM (11221A).

Inversion Subroutine

Comments

```
0:
"INV":.1→A;0→B←
1:
GTO +0;(10A→A)
INT C+B÷B;IF ((C
-INT C)*10÷C)=0;
RET ←
```

This subroutine reverses the order of the digits of a number passed to it in the **C** register. The result is returned in the **B** register.

Using this subroutine, the 8660A/B/C could be programmed as follows:

105 MHz —73 dBm

Comments

```
0:
CMD "?U3"←
1:
105000000/1E9→C;
GSB "INV"←
2:
B←R1←
3:
(-73-13)/1E2→C;
GSB "INV"←
4:
B←R2←
5:
FMT 2,FXD *.0,"(
",FXD *.0,"C"←
6:
WRT 13.2,R1,R2←
7:
STP ←
8:
"INV":.1→A;0→B←
9:
GTO +0;(10A→A)
INT C+B÷B;IF ((C
-INT C)*10÷C)=0;
RET ←
```

◀ Invert 105 MHz and store result in **R1**.

◀ Subtract 13 from —73 dBm, invert, and store result in **R2**.

◀ Format statement.

◀ Output contents of **R1**, center frequency program code [(], contents of **R2**, output level program code (C).

◀ Digit inversion subroutine.

Modulation level can also be programmed with variables.

29% AM, INT 400 Hz
(86632A/B, 86633A/B)

Comments

```
0:
CMD "?U3"
1:
FMT 3,"28$";FXD
*.0,"%"
2:
29/1E1+C;GSB "IN
V"
3:
WRT 13.3,BH
4:
STP
5:
"INV";.1+A;0+BH
6:
GTO +0;(10A+A)
INT C+B+B;IF ((C
-INT C)*10+C)=0;
RET
```

Modulation format statement.

Invert 29.

Output 28\$, then contents of B, and modulation level program code (%).

Digit inversion subroutine.

Programming above 1300 MHz (86603A RF Section) is no different than programming below 1300 MHz when the 8660C mainframe is used. However, when an 8660A or 8660B mainframe is used, an extra programming step is necessary to switch the doubler into the circuit, and the user must remember that the actual output frequency will be twice the programmed frequency.

2340 MHz (8660A/B)

Comments

```
0:
CMD "?U3"
1:
2340E6/2/1E9+C;
GSB "INV"
2:
FMT 4,FXD *.0,"(
","G"
3:
WRT 13.4,BH
4:
STP
5:
"INV";.1+A;0+BH
6:
GTO +0;(10A+A)
INT C+B+B;IF ((C
-INT C)*10+C)=0;
RET
```

Divide 2340 MHz by 2 and invert.

Center frequency format.

Output frequency, followed by center frequency program code [()], and frequency doubler ON program code (G).

"Invert" subroutine.

The next three examples begin to illustrate the real power of programming with variables. All three are used to generate a frequency sweep, both linear and log. In an actual automatic test system a measurement might be made at each frequency.

**1-11 MHz, Linear Sweep
101 Points (8660A/B/C)**

Comments

```

0:
CMD "2U3" F
1:
FMT 5,FXD *.0,"(
" F
2:
1E6→R1 F
3:
11E6→R2 F
4:
(R2-R1)/100→R3 F
5:
"SWEEP";R1/1E9→C
;GSB "INV" F
6:
WRT 13.5,B F
7:
IF R2>R1;R1+R3→R
1;GTO "SWEEP" F
8:
STP F
9:
"INV";.1→A;0→B F
10:
GTO +0;(10A→A)
INT C+B→B;IF ((C
-INT C)*10→C)=0;
RET F

```

Center frequency format statement.

Initialize sweep end points.

Initialize sweep increment.

Invert start frequency.

Output new frequency.

End of sweep? No—change frequency.

"Invert" subroutine.

The next program does the same thing as the last program, but uses the **frequency step** of the 8660B/C mainframe to change the frequency. This method produces a faster sweep.

**1-11 MHz, Linear Sweep
101 Points (8660B/C)**

Comments

```

0:
CMD "?U3"␣
1:
FMT 6,FXD *.0,"(
"␣
2:
FMT 7,"A"␣
3:
1E6÷R1␣
4:
11E6÷R2␣
5:
(R2-R1)/100÷R3␣
6:
R1/1E9÷C;GSB "IN
V"␣
7:
WRT 13.6,B␣
8:
R3/1E9÷C;GSB "IN
V"␣
9:
FMT FXD *.0,Z;
WRT 13,B␣
10:
"SWEEP";IF R2>R1
;R1+R3÷R1;WRT 13
.7;GTO +0␣
11:
STP ␣
12:
"INV";.1÷A;0÷B␣
13:
GTO +0;(10A÷A)
INT C+B÷B;IF ((C
-INT C)*10÷C)=0;
RET ␣

```

Center frequency format statement.

Frequency STEP↑ format statement.

Initialize sweep end point and sweep increment.

Invert start frequency.

Output start frequency.

Invert sweep increment frequency.

Output increment frequency.

End of sweep? No—output frequency STEP↑ program code (A).

"Invert" subroutine.

Two things should be noted in the last example. First, in line 9, no format number is necessary because the FMT and WRT statements appear on the same line. Second, note that the increment frequency is output only once (line 9). Once the 8660B/C has stored this increment, its frequency can be changed merely by outputting the STEP↑ program (A). This is done with the WRT 13.7 statement in line 10.

The final frequency sweep example shows how to generate a logarithmic sweep.

**1-11 MHz Logarithmic Sweep,
101 Points (8660A/B/C)**

Comments

```

0:
CMD "?U3"␣
1:
FMT 8;FXD *.0;"(
"␣
2:
1E6→R1␣
3:
11E6→R2␣
4:
(11E6/1E6)↑(1/10
0)→R3␣
5:
"SWEEP";INT R1/1
E9→C;GSB "INV"␣
6:
IF R2>R1;R1→R3→R
1;WRT 13.8;B;
GTO "SWEEP"␣
7:
STP ␣
8:
"INV";.1→A;0→B␣
9:
GTO +0;(10A→A)
INT C+B→B;IF ((C
-INT C)*10→C)=0;
RET ␣

```

Center Frequency format statement.

Initialize sweep endpoints.

Generate logarithmic multiplier.

Invert start frequency.

End of sweep? No—change frequency.

"Invert subroutine."

The final example of this section shows how to use the User Definable Function ROM (11222A) to reduce programming of most of the 8660A/B/C's functions to a single, simple easy to use statement.

This function works with any 8660A/B/C provided that either a 86632A/B or 86633A/B is installed (unless modulation is not programmed, in which case any modulation section plug-in can be used). The user must still remember to program half the desired FM deviation for those plug-ins that require it (see Table 1 - 1). Also, at frequencies greater than 1300 MHz, half the desired frequency must be programmed when using an 8660A or 8660B mainframe.

To use this User Definable Function (UDF) load the following program into any one of the UDF keys:

8660A/B/C UDF

Comments

```

0:
"RFSET";FMT Y3,Z
;WRT 13;CMD "?U3
"
1:
IF 1300<P1;FMT "
G";WRT 13;GTO 3
2:
FMT "I";WRT 13
3:
IF P3=0;0+P6;
GTO "MOD"
4:
IF P3=1;8+P6;P5/
10+P7;GTO 7
5:
P5*TN+ (-INT
LOG (1+P5)+P6)+P
7
6:
2+(2+P6)+P6
7:
GSB "INV"
8:
"MOD";FMT FXD *.
0,FXD *.0,"$";
FXD *.0,"%";WRT
13,P4,P6,P8
9:
INT (P1*1E6)/1E9
+P7;GSB "INV"
10:
P8+P6
11:
INT (P2-13)/1E2+
P7;GSB "INV"
12:
FMT FXD *.0,"(",
FXD *.0,"C";WRT
13,P6,P8
13:
GTO 16
14:
"INV";.1+P9;0+P8
+
15:
GTO +0;(10P9+P9)
INT P7+P8+P8;IF
((P7-INT P7)*10+
P7)=0;RET +

```

Put 8660A/B/C into remote, address it.

If frequency is greater than 1300 MHz, throw frequency X2 switch.

Throw frequency X1 switch.

Turn off modulation? Yes—go to "MOD."

Is AM wanted? Yes—go to 7.

No, AM is not wanted—compute FM mode range.

Scale and invert FM deviation.

Output modulation parameters.

Scale and invert frequency.

Store inverted frequency in temporary register (P6).

Scale & invert output level.

Output both frequency & output level.

"Invert" subroutine.

Now that this program is loaded, all that is necessary to program the 8660A/B/C's previously mentioned functions is to execute the following syntax (either from the keyboard or from a program):

CLL RFSET x_1, x_2, x_3, x_4, x_5

where:

- x_1 = Frequency in MHz
- x_2 = Output level in dBm
- x_3 = 0 for no modulation (MODULATION OFF)
 - = 1 for AM
 - = 2 for FM
- x_4 = Source of modulation
 - 1 = INT 1 kHz
 - 2 = INT 400 Hz
 - 4 = EXT DC
 - 8 = EXT AC
 - 9 = EXT AC UNLEVELED (86633A/B)
- x_5 = % modulation, if AM;
Peak deviation, in kHz, if FM

x_1, x_2, x_3, x_4, x_5 can be variables (R1, R7, A, C, etc.) or constants (7, 354, 96, etc.).

As can be seen, this program does all the necessary conversions such as changing from MHz to Hz, referencing output level to +13 dBm, choosing the range for FM and, of course, exchanging the most and least significant digits of all numerical data output to the 8660A/B/C. However, the resolution and ranges available still depend on the individual plug-ins, and it is up to the user of this UDF to make sure that these ranges are not exceeded.

CHAPTER 7

9830A CALCULATOR CONTROL OF THE 8660A/B/C

The Hewlett-Packard Model 9830A Calculator provides all the control capabilities necessary to program the 8660A/B/C Synthesized Signal Generator. It is assumed in the following examples that the user has properly connected the 8660A/B/C to the 9830A Calculator as shown in Chapter 3, and that the proper options and accessories are installed in both the 8660A/B/C and the 9830A as described in Chapter 2.

This chapter is written so that the reader can follow along on the calculator while reading the text.

ADDRESSING THE 8660A/B/C

To put the 8660A/B/C into remote, store the following lines, then press RUN, EXECUTE. The front panel 8660A/B/C REMOTE indicator should light.

```
10 REM LINES 20-30 ENABLE THE REMOTE LINE.  
20 FORMAT B  
30 OUTPUT (13,20)768  
40 REM LINE 50 ADDRESSES THE 9830A TO TALK,  
41 REM THE 8660A/B/C TO LISTEN.  
50 CMD "?U3"  
60 END
```

As stated in the program, lines 20 and 30 **enable** the remote line, thus allowing the 8660A/B/C to go into remote, as soon as it is addressed to listen. Line 50 accomplishes this addressing. The characters within the quote field in this line are addresses and they are automatically output to the HP-IB sequentially, starting with the leftmost character and ending with the rightmost. Thus by referring to the HP-IB coding table (Table 4-1) it can be seen that the effect of this statement is to first **unaddress** all instruments on the HP-IB ("?"), then address the 9830A to talk ("U"), and finally address the 8660A/B/C to listen ("3").

As stated in Chapter 3, the 8660A/B/C will not go into remote until it is addressed, which means the remote light on the 8660A/B/C will not go on until

```
CMD "?U3"
```

is executed. To convince yourself of this, turn the 8660A/B/C off and then turn it back on again. This automatically puts the 8660A/B/C in LOCAL (front panel

remote light off). Now store the following program:

```
10 REM ENABLE THE REMOTE LINE.  
20 FORMAT B  
30 OUTPUT (13,20)768  
40 DISP "LINE 50"  
50 STOP  
60 REM ADDRESS THE 9830A TO TALK,  
61 REM THE 8660A/B/C TO LISTEN.  
70 CMD "?U3"  
80 END
```

When the program is run, lines 10 - 40 are executed, and the program halts at the STOP instruction in line 50. At this point the 8660A/B/C is still in LOCAL. When the keys CONTINUE, EXECUTE are pressed, lines 60 - 80 are executed and the 8660A/B/C goes into REMOTE (front panel REMOTE light on).

If other instruments are on the bus, it will be necessary to unaddress the 8660A/B/C so that information may be sent to these other instruments. To unaddress the 8660A/B/C key in

```
CMD "?"
```

and press EXECUTE. The 8660A/B/C is now unaddressed, and will ignore any information being transmitted to other instruments until it is once again addressed to listen.

The 8660A/B/C can also be unaddressed by pushing the calculator STOP key. This can lead to unexpected results, however, if the user did not intend to unaddress the 8660A/B/C when the STOP key was pressed.

A program executed STOP statement does **not** unaddress the 8660A/B/C.

When the last statement was executed, (CMD "?") the 8660A/B/C remained in remote. This is the way things are supposed to be. If it is desired to bring the 8660A/B/C back into the local mode, execute the following lines:

```
10 REM THESE LINES PUT THE 8660A/B/C  
11 REM BACK INTO LOCAL.  
20 FORMAT B  
30 OUTPUT (13,20)1024  
40 END
```

As soon as these lines are executed, the 8660A/B/C should return to LOCAL (front panel REMOTE light goes out).

There is an equivalent, single line, format which can be used to enable and disable the remote line:

```
10 REM THIS SINGLE LINE ALSO ENABLES
11 REM THE REMOTE LINE.
20 OUTPUT (13,*)WBYTE768
30 END
```

```
10 REM THIS SINGLE LINE ALSO PUTS THE
11 REM 8660A/B/C BACK INTO LOCAL.
20 OUTPUT (13,*)WBYTE1024
30 END
```

PROGRAMMING THE 8660A/B/C WITH LITERALS (9830A Calculator)

Many times it is desirable to program the 8660A/B/C to a fixed frequency or a fixed output level, etc. This involves programming with literals, where a literal is defined as any character within a quote field. Programming with literals is useful any time an 8660A/B/C's functions need be programmed to only one state during a test, or when successive states of a function are not mathematically related.

In the examples that follow, it is assumed that the remote enable statement

```
OUTPUT (13,*)WBYTE768
```

has already been executed. This statement need only be executed once unless a remote disable statement

```
OUTPUT (13,*)WBYTE1024
```

has been executed, thus putting the instrument back into LOCAL.

As a first example of how to control the 8660A/B/C, suppose that it is desired to program 57.34 MHz. The procedure for doing this is outlined below. The first three steps are done in the user's head and only the last step is done on the calculator. The section on programming with variables will show how the first three steps below can also be done on the calculator.

Programming the 8660A/B/C to 57.34 MHz

1. Change the frequency to Hertz (57340000)
2. Add enough leading zeroes to get 10 significant digits (0057340000)
3. Reverse the order of the most significant and the least significant digits to get the number 0000437500. (The leading zeroes can now be omitted).
4. Execute the line

```
CMD "?U3","/437500("
```

The 8660A/B/C will now read 57.34 MHz.

It is important that the above syntax be well understood, and therefore a detailed description follows.

The ?U3 in the first quote field performs the same addressing function as outlined in the last section. However, the machine treats characters in the second quote field differently. Instead of converting these characters into addresses, the calculator converts them into program data. This program data is sent to the 8660A/B/C one character at a time, starting with the /, then the 4, etc. The following paragraph describes the purpose of each of these characters in detail.

The / clears a temporary storage register inside the 8660A/B/C. It must be the first character output to the 8660A/B/C after it is put into remote. However, this temporary register is automatically cleared every time the 8660A/B/C receives a program code and therefore it is not necessary (although it won't hurt) to output the / more than this one time, after the 8660A/B/C has been placed in remote.

The digits 437500 which represent, in this case, the desired output frequency go into the temporary storage register mentioned above. As soon as the program code [(] is received, the 8660A/B/C changes its output frequency and then clears the temporary storage register.

Because the 8660A/B/C is capable of storing information, and because this information is not erased until a program code is received, the following lines will also program the instrument to 57.34 MHz.

```
10 REM THIS IS AN ALTERNATE WAY OF
11 REM PROGRAMMING THE 8660A/B/C TO 57.34 MHZ.
20 CMD "?U3","43"
30 CMD "?U3","75"
40 CMD "?U3","00"
50 CMD "?U3","("
60 END
```

The following examples show how to program other 8660A/B/C functions. Refer to Table 4-1 to verify the program codes used.

```
10 REM THIS IS A PROGRAM TO OUTPUT 21 MHZ, -043 DBM.
20 CMD "?U3","1200(", "?U3","650C"
30 END
```

```
10 REM THIS PROGRAM ALSO OUTPUTS 21 MHZ, -043 DBM.
20 CMD "?U3","1200("
30 CMD "?U3","650C"
40 END
```

```
10 REM THIS PROGRAM ALSO OUTPUTS 21 MHZ, -043 DBM.
20 CMD "?U3","1200(650C"
30 END
```

Comments

These preceding three examples show that the syntax used to output constants is not unique. Note that **650** is obtained by subtracting 13 from **-43** and then reversing the order of the digits.

```
10 REM THIS IS A PROGRAM TO OUTPUT 27% AM,
11 REM INT 400 HZ (86632A/B, 86633A/B)
20 CMD "?U3","28$72%"
30 END
```

Comments

2 sets INT 400 Hz; **8** sets AM mode, **\$** is AM-FM- ϕ M FUNCTION program code; **72** sets 27% AM depth; **%** is MODULATION LEVEL program code.

```
10 REM THIS IS A PROGRAM TO OUTPUT 2.4 KHZ FM,
11 REM EXT AC LEVELED (86632A, 86633A/B)
20 CMD "?U3","84$42%"
30 END
```

Comments

8 sets EXT AC; **4** sets FM x 0.1 mode; **\$** is AM-FM- ϕ M FUNCTION program code; **42** sets 2.4 kHz deviation; **%** is MODULATION LEVEL program code. (For center frequency ≥ 1300 MHz, and for 86632B and 86635A plug-ins, program 1.2 kHz deviation).

```

10 REM THIS IS A PROGRAM TO OUTPUT 38 KHZ FM,
11 REM INT 1 KHZ, FM CAL (86632A)
20 CMD "?U3", "83%12$&"
30 END

```

Comments

83 sets 38 kHz deviation; % is MODULATION LEVEL program code; 1 sets INT 1 kHz; 2 sets FM x 1.0; \$ is AM-FM- ϕ M FUNCTION program code, & is FM CAL program code. (For center frequencies ≥ 1300 MHz and for 86632B plug-in, program 19 kHz deviation).

```

10 REM THIS IS A PROGRAM TO OUTPUT 48 DEGREES
11 REM PHASE DEVIATION, EXT DC (86635A)
20 CMD "?U3", "42%4<$"
30 END

```

Comments

42 sets 48° deviation (remember actual deviation = 2 x programmed deviation); % is MODULATION LEVEL program code; 4 sets EXT DC, < sets phase modulation, \$ is AM-FM- ϕ M FUNCTION program code.

```

10 REM THIS IS A PROGRAM TO
11 REM TURN THE MODULATION SECTION OFF.
20 CMD "?U3", "00$"
30 END

```

Comments

First 0 can be any number; second 0 turns modulation off; \$ is AM-FM- ϕ M FUNCTION program code.

PROGRAMMING THE 8660A/B/C WITH VARIABLES (9830A Calculator)

Under most circumstances, it is desirable to change the frequency, output level, and modulation parameters many times during the course of a measurement. Under such circumstances it is convenient to output the contents of **variables**. The present section illustrates how this is done.

The first thing that needs to be understood is that once the 8660A/B/C is addressed to listen and the 9830A is addressed to talk with

```
CMD "?U3"
```

it is **not** necessary to repeat this instruction until the 8660A/B/C is unaddressed. In the following discussion, it will be assumed that the 8660A/B/C has been addressed, and that it has received a /, thus clearing its temporary register.

The general 9830A syntax for programming the 8660A/B/C with variables is:

```
N FORMAT F1000.0,"X1",F1000.0,"X2", . . .  
OUTPUT (13,N) A,B,C, . . .
```

where **N** is a line number; **A, B, C**, etc. are variables to be output; **F1000.0** is the format associated with these variables; and **X1, X2**, etc. are program codes.

Before proceeding further, a short example may be helpful.

```
10 REM THIS IS A PROGRAM TO OUTPUT 18.374 MHZ, -92 DBM.  
20 REM  
30 REM ADDRESS THE 9830A TO TALK;  
40 REM THE 8660A/B/C TO LISTEN.  
50 CMD "?U3"  
60 FORMAT F1000.0,"(",F1000.0,"C"  
70 F=4738100  
80 L=501  
90 REM OUTPUT THE CONTENTS OF F1, FOLLOWED BY (  
100 REM THE CONTENTS OF L, AND C.  
110 OUTPUT (13,60)F,L  
120 END
```

As seen in the last example, it is still necessary to reverse the order of the digits of both center frequency and level. The following function will do this rearrangement quickly, efficiently and automatically. This function requires that the number to be inverted be divided by a constant. This number is 10^9 for frequency, 10^2 for output level, and 10^1 for modulation level. This function can either

The next program does the same thing as the last program, but uses the **frequency step** of the 8660B/C mainframe to change the frequency. This method produces a faster sweep.

```
10 REM THIS ROUTINE SWEEPS 1-11 MHZ,
20 REM USING THE 8660B/C STEP FUNCTION.
30 CMD "?U3"
40 FORMAT F1000.0,"("
50 FORMAT F1000.0,"A"
60 REM SET THE ENDPOINTS OF THE SWEEP.
70 F1=1E+06
80 F2=1.1E+07
90 REM SET THE SWEEP INCREMENT.
100 F3=(F2-F1)/100
110 REM OUTPUT THE STARTING FREQUENCY,
120 REM FOLLOWED BY FREQUENCY PROGRAM CODE - (.
130 OUTPUT (13,40)FNI(F1/1E+09)
140 REM OUTPUT THE FREQUENCY STEP SIZE,
150 REM FOLLOWED BY PROGRAM CODE "A"
160 OUTPUT (13,50)FNI(F3/1E+09)
170 F1=F1+F3
180 REM OUTPUT THE FREQUENCY STEP PROGRAM CODE "A".
190 OUTPUT (13,*)"A"
200 REM TEST FOR THE END OF THE SWEEP.
210 IF F1+F3<F2 THEN 170
220 END
```

The final example shows how to generate a logarithmic sweep.

```
10 REM THIS ROUTINE SWEEPS 1-11 MHZ, LOGARITHMICALLY.
20 CMD "?U3"
30 FORMAT F1000.0,"("
35 REM SET THE ENDPOINTS OF THE SWEEP
40 F1=1E+06
50 F2=1.1E+07
60 REM GENERATE THE LOGARITHMIC MULTIPLIER.
70 F3=(F2/F1)^(1/100)
80 REM CHANGE FREQUENCY.
90 OUTPUT (13,30)FNI(INTF1/1E+09)
100 F1=F1*F3
110 REM TEST FOR THE END OF THE SWEEP.
120 IF F1 <= F2 THEN 90
130 END
```

CHAPTER 8

TIMING CONSIDERATIONS

All instruments have **programming response times**, where programming response time is defined here as the time delay between a programming input and the desired output. If such delays are not taken into account, it is possible that a measurement may be taken with a very fast programming response time instrument before the 8660A/B/C is providing the desired stimulus.

When the 8660A/B/C is programmed via the HP - IB and jumper J1 is installed on the HP - IB Output Assembly Board (see appropriate Operating and Service Manual), it is not necessary to take the programming response time of the 8660A/B/C into consideration. The reason for this is that with J1 in place, the 8660A/B/C inhibits both the operation of the HP - IB and the operation of the calculator until the 8660A/B/C is providing an output which is reasonably close to its programmed state.

Thus, in most instances no consideration need be given to programming response times. However, certain situations do exist in which it is of paramount importance to take these delays into account. These situations generally fall into one of the two following classifications:

1. 8660A/B/C inhibit feature defeated
2. Inhibit period too short to achieve desired resolution.

These two classifications are discussed below.

INHIBIT FEATURE DEFEATED

With jumper J1 in place, the 8660A/B/C automatically inhibits both data transfer on the HP - IB and also operation of the calculator for a period of:

- a. 5 msec after a frequency program code is received
- b. 5 msec after modulation program code is received (except FM CAL)
- c. 50 msec after an output level program code is received
- d. 5 seconds after an FM CAL program code is received
- e. Whatever time is required for the 86633A/B modulation section plug-in to acquire phase lock.

If it is desired to increase the speed of an HP - IB system, this inhibit feature can be defeated by removing jumper J1. Defeating this feature allows the calculator to either engage in computation or program other instruments on the bus at the same time that the 8660A/B/C is settling to its desired output state. However, the burden of making sure that a measurement is not made before the 8660A/B/C has indeed settled to its programmed state now rests with the person writing the calculator program.

INHIBIT PERIOD TOO SHORT

A few instances exist where the inhibit periods, described in the last section, are not long enough to allow the output of the 8660A/B/C to settle to the desired resolution. In such instances, an additional delay must be provided in the calculator program. The following table should provide the information necessary to calculate these additional delays. The times given are the total settling times. Therefore to find the additional software delays needed to achieve the desired result, subtract the inhibit time given in the previous section.

Table 8 - 1. Programming Response Times

| | |
|---|---|
| Frequency Settling Time | |
| Within 100 Hz of final value | <5 msec* |
| Within 5 Hz of final value | <100 msec |
| Output Level Settling Time | |
| Within 1 dB of final value | <50 msec* |
| Modulation Settling Time (86632A/B, 86635A) | |
| Switching from OFF to: | |
| INT. 400 Hz or 1 kHz | 5 seconds |
| EXT. AC | 5 seconds |
| EXT. DC | 2 - 3 msec* |
| Modulation level (with $\pm 5\%$ of setting) | 2 - 3 msec* |
| FM CAL | 5 seconds |
| Modulation Settling Times (86633A/B) | |
| Switching from OFF to: | |
| INT. 400 Hz or 1 kHz (AM only) | 5 seconds |
| EXT. AC LEV (AM only) | 5 seconds |
| EXT. AC UNLEV (AM only) | 5 seconds |
| EXT. DC (AM only) | 2 - 3 msec* |
| Changing % AM depth (within $\pm 5\%$ of settling) | 2 - 3 msec* |
| Changing FM deviation to new value on same mode range (within $\pm 5\%$ of setting) | 3 - 4 msec* |
| Changing FM deviation to new value on different range (within $\pm 5\%$ of setting) | 1.5 seconds |
| Switching from AM or OFF to: | |
| EXT AC LEV (FM only) | } Time required for 86633A/B to achieve phase lock* |
| EXT AC UNLEV (FM only) | |
| INT 400 Hz or 1 kHz (FM only) | |
| * These situations are completely covered by the 8660A/B/C's inhibit feature. | |

In some applications it is desirable to avoid the long modulation section turn-on times listed in Table 8 - 1. These turn-on times can be avoided by leaving the instrument in the desired modulation mode at all times, and programming zero modulation level when no modulation is desired. However, when FM mode is programmed with the 86632A/B or 86635A modulation section plug-in installed, the carrier will no longer be locked to the reference oscillator, resulting in loss of phase coherence and frequency stability.

APPENDIX A

Output Subroutines 9820A/21A

Each of the following programs provides control of one of the 8660A/B/C's major functions.

Each program is written as a subroutine and is called with a GSB statement. Before calling any of these subroutines, store the appropriate parameters in the indicated registers. Subroutine "INV" (see Chapter 6) is used in most of these subroutines.

Function Controlled: Frequency
Passing Parameter: Frequency, in MHz, is passed via the X register.
Registers Used: A,B,C,X
Compatibility: Works with all mainframe—RF plug-in combinations, except 8660A/B-86603A above 1300 MHz.

```
0:
"REQ";CMD "?U3"
;INT (X*1E6)/1E9
+C;GSB "INV"
1:
FMT FXD *.0,"("
WRT 13,B
2:
RET
```

Function Controlled: Frequency
Passing Parameter: Frequency, in MHz, is passed via the X register.
Registers Used: A,B,C,X
Compatibility: Works with all mainframes—RF plug-in combinations except 8660C-86603A above 1300 MHz.

```
0:
"REQ1";CMD "?U3"
;IF 1300<X;FMT
"G";WRT 13;2*B;
GTO +2
1:
FMT "I";WRT 13;1
+B
2:
INT (X*1E6/B)/1E
9+C;GSB "INV"
3:
FMT FXD *.0,"("
WRT 13,B
4:
RET
```

Function Controlled: Output Level
Passing Parameter: Output level in dBm, is passed via the X register.
Registers Used: A,B,C,X
Compatibility: Compatible with all mainframe—plug-in combinations.

```
0:
"LEV";CMD "?U3";
(INT X-13)/1E2+C
;GSB "INV"
1:
FMT FXD *.0,"C";
WRT 13,B
2:
RET
```

Functions Controlled: AM source, AM mode, % AM depth
Passing Parameters: Source is passed via X:
1—INT 1 kHz
2—INT 400 Hz
4—EXT DC
8—EXT AC
9—EXT AC (unleveled)
% AM depth is passed via Y, AM mode is programmed automatically
Registers Used: A,B,C,X,Y
Compatibility: Compatible with 86632A/B, 86633A/B modulation section plug-ins

```
0:
"AM";CMD "?U3";Y
/10+C;GSB "INV"
1:
FMT FXD *.0,"8#";
FXD *.0,"%";
WRT 13,X;B
2:
RET
```

Functions Controlled: FM source, FM mode, FM deviation

Passing Parameters: FM source—(see subroutine "AM");
FM deviation is passed via Y;
FM mode is programmed automatically

Registers Used: A,B,C,X,Y

Compatibility: Compatible with 86632A, 86633A/B below 1300 MHz carrier frequency

```
0:
"FM";CMD "?U3";
FMT FXD *.0,FXD
*.*,"$";WRT 13,X
,2*((-INT LOG (1
+Y)/C)+2)+
1:
Y*TN+ C+C+
2:
GSB "INV"+
3:
FMT FXD *.0,"%";
WRT 13,B+
4:
RET +
```

Functions Controlled: Same as subroutine "FM"

Passing Parameters: Same as subroutine "FM"

Registers Affected: A,B,C,X,Y

Compatibility: Compatible with 86632B, 86635A at all frequencies.
Compatible with all programmable modulation plug-ins above 1300 MHz.

```
0:
"FM1";CMD "?U3";
FMT FXD *.0,FXD
*.*,"$";WRT 13,X
,2*((-INT LOG (1
+Y)/C)+2)+
1:
Y/2*TN+ C+C+
2:
GSB "INV"+
3:
FMT FXD *.0,"%";
WRT 13,B+
4:
RET +
```

Functions Controlled: ϕ M source, ϕ M mode, ϕ M deviation

Passing Parameters: ϕ M source (same as subroutine "AM");
 ϕ M deviation, in degrees, is passed via Y

Registers Used: A,B,C,X,Y

Compatibility: Compatible with 86635A modulations section plug-in

```
0:
"PM";CMD "?U3";Y
/20+C;GSB "INV"+
1:
FMT FXD *.0,"$";
FXD *.0,"%";
WRT 13,X,B+
2:
RET +
R397
```

Functions Controlled: Modulation off

Passing Parameter: None

Registers Affected: None

Compatibility: Compatible with 86632A/B, 86633A/B, 86635A modulation section plug-ins

```
0:
"MODOFF";CMD "?U
3";FMT "00$";
WRT 13;RET +
```


APPENDIX B

Output Subroutines (9830A)

Each of the following programs provides control of one of the 8660A/B/C's major functions.

Each program is written as a subroutine and is called with a **GOSUB** statement. Before calling any of these subroutines, store the appropriate parameters in the indicated variables. Definable function **FNI** (see Chapter 7) is used in most of these subroutines.

Functions Controlled: Frequency
Passing Parameter: Frequency, in MHz, is passed via variable F1
Compatibility: Works with all mainframe—RF plug-in combinations, except 8660A/B-86603A above 1300 MHz.

```
1000 FORMAT F1000.0,"("
1010 CMD "?U3"
1020 OUTPUT (13,1000)FNI(INT(F1*1E+06)/1E+09)
1030 RETURN
```

Functions Controlled: Frequency
Passing Parameter: Frequency, in MHz is passed via variable F1
Compatibility: Works with all mainframe—RF plug-in combinations, except 8660C-86603A above 1300 MHz.

```
1100 FORMAT F1000.0,"("
1110 CMD "?U3"
1120 F2=INT(F1*1E+06)/1E+09
1130 IF F1 >= 1300 THEN 1160
1140 OUTPUT (13,1100)"I",FNI(F2
1150 GOTO 1170
1160 OUTPUT (13,1100)"G",FNI(F2/2)
1170 RETURN
```

Function Controlled: Output Level
Passing Parameters: Output level, in dBm, is passed via variable LI.
Compatibility: Compatible with all mainframe—plug-in combinations

```
1200 FORMAT F1000.0,"C"
1210 CMD "?U3"
1220 OUTPUT (13,1200)FNI((INT(LI-13)/1E+02)
1230 RETURN
```

Function Controlled: AM source, AM mode, % AM depth
Passing Parameters: Source is passed via variable S:
 1—INT 1 kHz
 2—INT 400 Hz
 4—EXT DC
 8—EXT AC
 9—EXT AC (unleveled)
 % AM depth is passed via variable M
 AM mode is programmed automatically
Compatibility: Compatible with 86632A/B, 86633A/B modulation section plug-ins.

```
1300 FORMAT F1000.0,"8$",F1000.0,"%"
1310 CMD "?U3"
1320 OUTPUT (13,1300)S,FNI(M/10)
1330 RETURN
```

Functions Controlled: FM source, FM mode, FM deviation
Passing Parameters: Source—(see AM subroutine); FM deviation is passed via variable M; FM mode is programmed automatically.
Compatibility: Compatible with 86632A, 86633A/B below 1300 MHz carrier frequency.

```
1400 FORMAT F1000.0,F1000.0,"$",F1000.0,"%"
1410 CMD "?U3"
1420 I1=-INTLGT(1+M)
1430 OUTPUT (13,1400)S,2*(1+2),FNI(M*10+I1)
1440 RETURN
```

Functions Controlled: FM source, FM mode, FM deviation
Passing Parameters: Same as previous FM subroutine
Compatibility: Compatible with 86632B, 86635A at all frequencies. Compatible with all program-mable modulation plug-ins above 1300 MHz.

```
1500 FORMAT F1000.0,F1000.0,"$",F1000.0,"%"
1510 CMD "?U3"
1520 I1=-INTLGT(1+M)
1530 OUTPUT (13,1500)S,2*(1+2),FNI(M/2*10+I1)
1540 RETURN
```

Functions Controlled: ϕ M source, ϕ M mode,
 ϕ M deviation
Passing Parameters: ϕ M source (same as AM sub-
 routine); ϕ M deviation, in de-
 grees, is passed via variable M.
Compatibility: Compatible with 86635A
 modulation section plug-in.

```
1600 FORMAT F1000.0,"<$",F1000.0,"%"
1610 CMD "?U3"
1620 OUTPUT (13,1600)S,FNI(M/20)
1630 RETURN
```

Functions Controlled: Modulation Off
Passing Parameters: None
Compatibility: Compatible with 86632A/B,
 86633A/B, 86635A modulation
 section plug-ins.

```
1700 CMD "?U3"
1710 OUTPUT (13,*)"?0$"
1720 RETURN
```



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