MARK 5 MEMO #056

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Subject: Performance characteristics and operation of Updown converter

Performance results based on the block diagram of figure 1 are as follows:

Input frequency range	1-13 GHz
Up conversion L.O. range	23-33 GHz
Up conversion I.F. range	20-22 GHz
Down conversion L.O.	22.5 GHz
I.F. range prior to Nyquist filters	0.5-2.5 GHz
Output Frequency[5]	22.5 – 4x luff + input GHz
Luff frequency range	5.75 – 8.25 GHz
Minimum step size for Luff	100 kHz
Minimum Luff step size for repeatable phase	1 MHz
Bandpass ripple	4 dB peak to peak
Nominal input power[1]/bandwidth	-30 dBm/12GHz
Spurious rejection[2] (excluding L.O. sidebands)	-70 dB
Spurious signals (Luff 3rd harmonic)[3]	-50 dB
Spurious signals (excluding Luff 3rd harmonic)	-70 dB
Conversion gain (atten. 0 dB) (atten. 30 dB)	60 dB 30 dB
Noise figure	8 dB
Cross-talk between pol'n channels	~-50 dB
Maximum input power[1]/bandwidth	-20 dBm/12GHz

Notes:

1] Nominal input power of – 30 dBm implies that a 12 GHz bandwidth LNA and 2nd stage with 50 K system needs 51 dB gain to supply the nominal signal level to the updown converter.

2] Spurious rejection is the rejection of unwanted responses due to images etc. relative to the desired signal.

3] Spurious signals levels are signals which originate within the updown converter and are measured relative to the nominal input level. The worst offender is the 3rd harmonic of the Luff synthesizer for settings between 6.667 and 7.333 GHz which lies within the I.F. passband

4] Recent measurements at the Westford site show radar signal levels can leak into the sidelobes of the broadband feed at a level of up to about -40 dBm. In this case it would be better to use an LNA with about 28 dB gain before the updown converter to ensure the first mixer sees no more than 0 dBm. The updown converter will contribute about 3K out of a 53K system. The interference free input level to the converter will be -41 dBm/12

GHz and the outputs to the DBE will be between -25 to +5 dBm/500 MHz, depending on the settings of the attenuators.

5] For an input frequency *x*, the output frequency *y* is given by

$$y = 22.5 - 4 * f_{Luff} + x$$

i.e. the effective LO frequency of the conversion is 22.5 -4*f_{Luff} GHz. The conversion is upper sideband. Frequencies are in GHz.

Inputs to the UDC are:

a. Two inputs in the range 1.0 to 13 GHz. Total input power in 12 GHz should be about -30 dBm. Maximum input power in 12 GHz is -20 dBm.

b. Reference frequency from the maser of 5 MHz or 10 MHz. For 5 MHz a doubler is used to produce 10 MHz for internal use. For 10 MHz input the doubler must be removed.

Outputs from the UDC are:

a. Two IF outputs are available on the front panel with signal in the range selected by the internal Nyquist zone filters. For this experiment the 2nd NZ is used, covering approximately 0.512 – 1.024 GHz. The filter has a center frequency of 768 MHz and a bandwidth of 480 MHz.

b. A second output is available internally for each IF. The output is before the 30 dB attenuator and Nyquist zone filter, so covers the range 0.5 – 2.5 GHz. The gain is +29 dB relative to the input. It can be routed to the connector on the rear panel for external access, perhaps as input to the Mk4 rack if a filter is included in the path, e.g. a 2nd NZ filter corresponding to that used internally.

c. There is a 10 MHz output available internally that is coherent with the 5 MHz or 10 MHz input reference frequency. It can be routed to the connector on the rear panel for external access if this connector is not being used to output the IF that is available for an additional Nyquist zone. See the UDC schematic below

Local control of the frequency and gain:

The gain through the UDC is 60 dB minus the attenuation in the programmable attenuator, which can take on values between 0 dB and 30 dB. So the net gain is 30 to 60 dB

The Luff frequency in MHz and the attenuator settings in dB are displayed on the front panel under control of the STAMP code. The display alternates between the frequency and attenuator settings. The attenuator values are given as channel A then channel B, separated by a period. To manually change the frequency or attenuators press and hold down the push button switch until the digit you want to change is flashing, then pulse the switch to increment the digits. When complete, hold down the button until the normal (not flashing) display is reached. An out-of-lock condition or illegal frequency is indicated by flashing decimal points.

Remote control:

To control remotely send at 9600 baud the keyword “freq” followed by the frequency (in MHz), attenuator 1 (in dB), attenuator 2 (in dB), followed by a CR.

The unit should respond with (this can easily be changed):

Freq xxxx yy zz OK CR
if in lock, or
Freq xxxx yy zz errcode CR
if there is an error or the unit doesn’t lock.

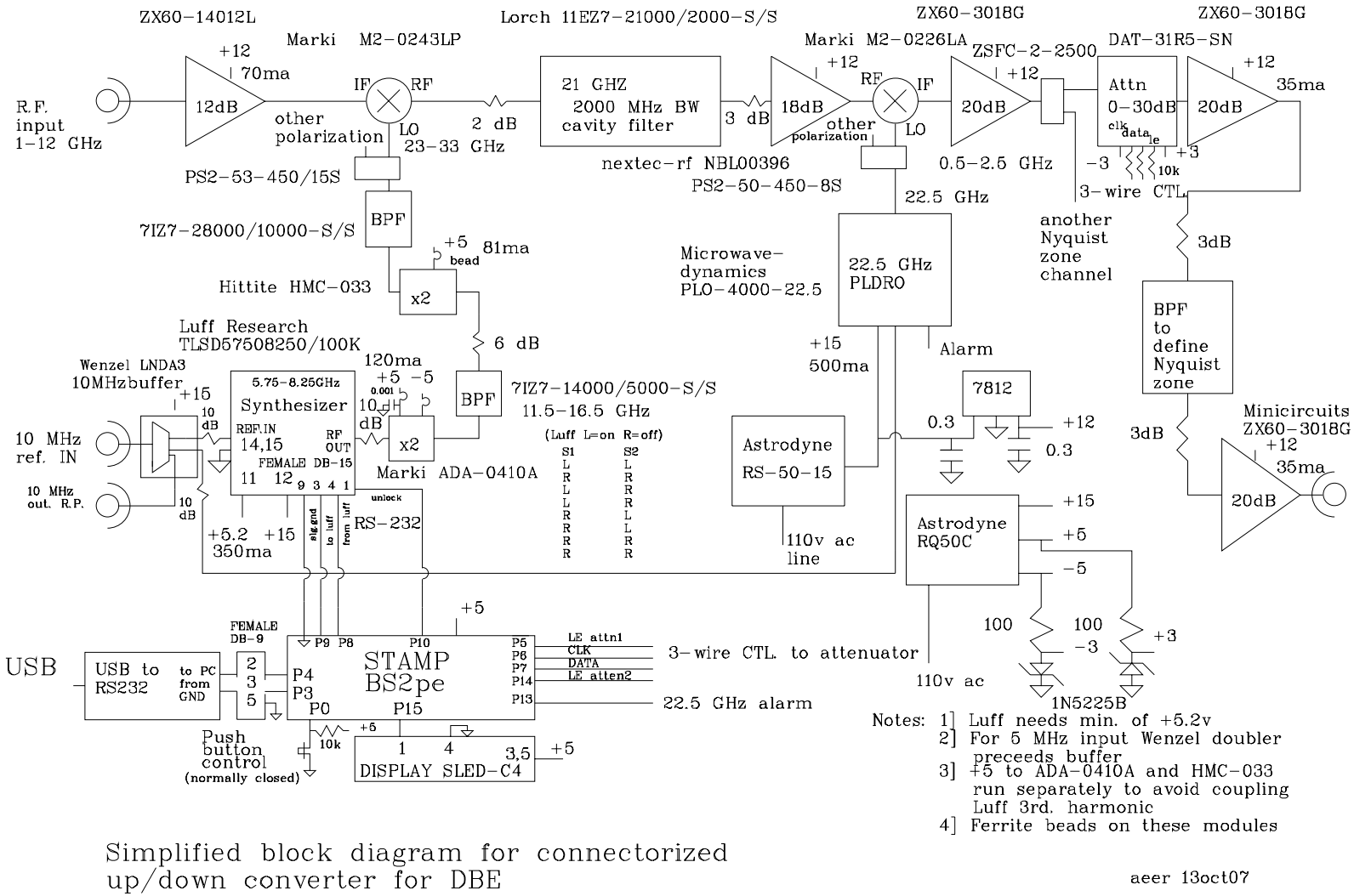

Figure 1 Block diagram

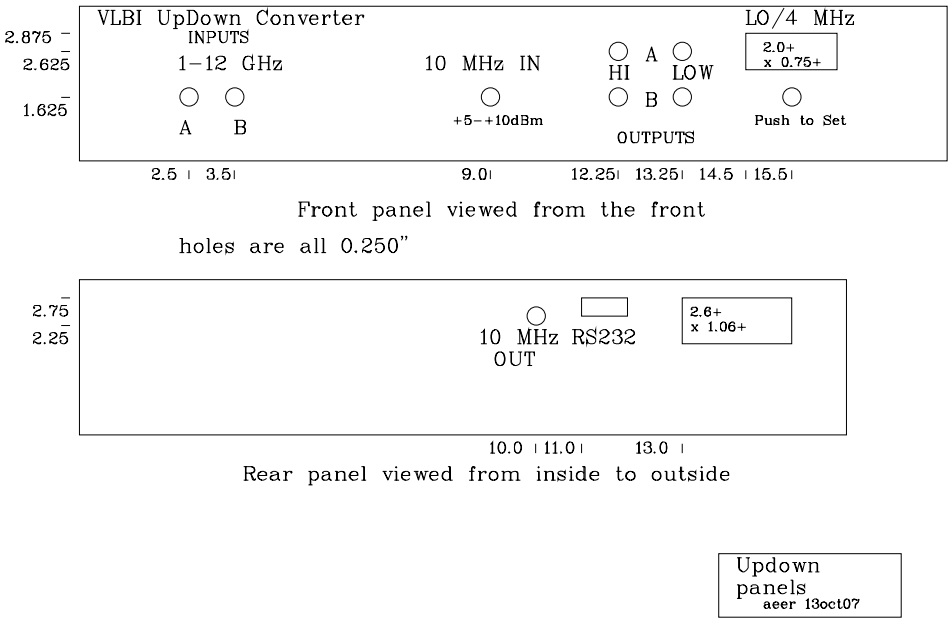

Figure 2 Updown panels

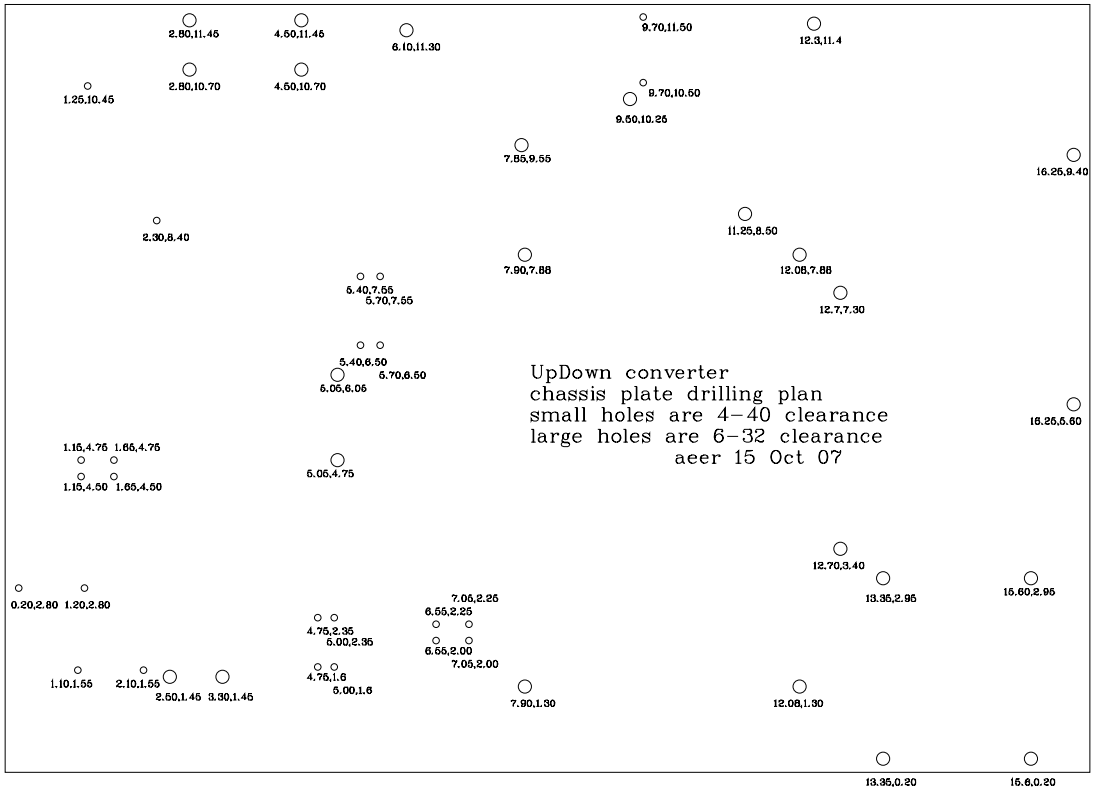

Figure 3 Drilling plan Photo

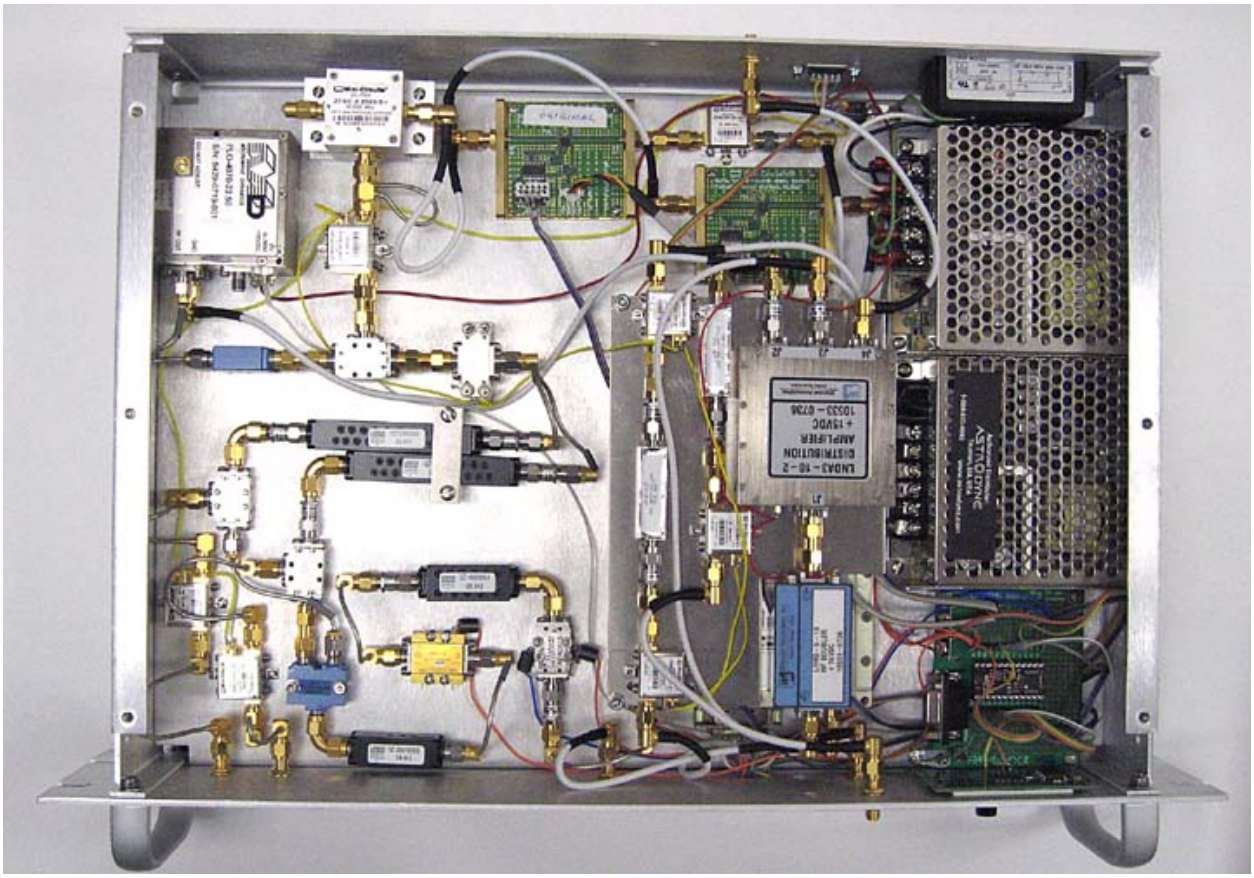

Figure 4 Photo

```
' {$STAMP BS2pe}
bb    VAR Nib
freq  VAR Word
freqp VAR Word
freq3 VAR Nib
freq2 VAR Nib
freq1 VAR Nib
freq0 VAR Nib
frq3  VAR Nib
frq2  VAR Nib
frq1  VAR Nib
frq0  VAR Nib
attn  VAR Byte
attn1 VAR Byte
attn2 VAR Byte
attn1p VAR Byte
attn2p VAR Byte
ttn11 VAR Nib
ttn10 VAR Nib
ttn20 VAR Nib
ttn21 VAR Nib
fh    VAR Nib
prs   VAR Bit
alt   VAR Bit
alt2  VAR Bit
attn11 VAR Nib
attn10 VAR Nib
attn21 VAR Nib
attn20 VAR Nib
cnt    VAR Byte
sw     VAR Bit
lock   VAR Bit
fhh    VAR Bit
outr   VAR Bit
lock2  VAR Bit
rcv    VAR Bit
pau    VAR Byte
serstr VAR Byte(4)

'p5 LE for attn1
'p6 CLK
'p7 DATA
'p14 LE for attn2
'p8 rs232 pin 2 from luff
'p9 rs232 pin 3 to luff
'p4 rs232 pin 2 to PC
'p3 rs232 pin 3 from PC
'p10 rs323 pin4 lock indicator from luff
'p13 alarm from 22.5 GHz PLO
'p0 button
'p15 display data

DIRS = %1100001011110000

freq = 5750   'default
attn1 = 6
```

```
attn2 = 7
fh = 0
alt = 0
alt2 = 0
prs = 0
cnt = 0
sw = 0
freqp = 0
fhh = 0
attn1p = 255
attn2p = 255
outr = 0
pau = 5
rcv = 0  'data received flag

start: IF (cnt > 0 AND fhh = 0) OR fh > 0 THEN skp
      SERIN 3,16780,1000,skp,[WAIT("freq"),DEC freq, DEC attn1, DEC attn2]
      rcv = 1
'      SEROUT 4,16780,["freq ",DEC freq," ",DEC attn1," ",DEC attn2,CR]
'       SERIN 3,84,1,defau,[DEC freq]
skp:    pau = 40
       IF cnt > 0 AND fh = 0 AND fhh = 0 THEN skpp
       IF cnt > 12 THEN skpp   'increment fh while pressed
       IF cnt > 0 AND cnt < 12 AND sw = 0 AND fhh = 0 THEN skp3
       GOTO skp2
skp3:   prs = 1
       cnt = 0
       GOTO skp2
skpp:   fh = fh + 1
       prs = 0
       cnt = 0
       fhh = 1
       IF fh < 7 THEN skp2
       fh = 0
       alt2 = 0
       alt = 0
skp2:   IF sw = 1 THEN skp4
       fhh = 0
       cnt = 0
skp4:
'      DEBUG "here fh=", DEC fh," cnt=", DEC cnt,"sw ", DEC sw," prs ",DEC prs,CR
       GOSUB disp
       GOSUB atten1
       GOSUB atten2
       GOSUB luff
       GOSUB plo
       IF rcv = 0 THEN skp5
       IF lock = 0 OR outr = 1 OR lock2 = 0 THEN skp6
       SEROUT 4,16780,["freq ",DEC freq," ",DEC attn1," ",DEC attn2," OK",CR]
       rcv = 0
       GOTO skp5
skp6:   SEROUT 4,16780,["freq ",DEC freq," ",DEC attn1," ",DEC attn2,"  ",DEC lock+lock2+outr,CR]
       rcv = 0
skp5:   IF fh > 0 THEN skp
       pau = 5
       GOTO start
```

```
disp:   freq3 = freq / 1000
        freq2 = freq / 100 - (freq3 * 10)
        freq1 = freq / 10 - (freq3 * 100) - (freq2 * 10)
        freq0 = freq - (freq3 * 1000) - (freq2 * 100) - (freq1 * 10)
        frq3 = freq3
        frq2 = freq2
        frq1 = freq1
        frq0 = freq0
        attn11 = attn1 / 10
        attn10 = attn1 - (attn11 * 10)
        attn21 = attn2 / 10
        attn20 = attn2 - (attn21 * 10)
        ttn11 = attn11
        ttn10 = attn10
        ttn21 = attn21
        ttn20 = attn20
'       DEBUG DEC freq3,DEC freq2,DEC freq1,DEC freq0,CR
        IF fh = 0 THEN disp0
        IF fh <> 1 THEN ddisp1
        frq0=10
        IF prs = 0 THEN f1
        freq0 = (freq0 + 1)//10
f1:     alt = 0
ddisp1: IF fh <> 2 THEN ddisp2
        frq1=10
        IF prs = 0 THEN f2
        freq1 = (freq1 + 1)//10
        frq1 = freq1
f2:     alt = 0
ddisp2: IF fh<> 3 THEN ddisp3
        frq2=10
        IF prs = 0 THEN f3
        freq2 = (freq2 + 1)//10
        frq2 = freq2
f3:     alt = 0
ddisp3: IF fh <> 4 THEN ddisp4
        frq3 = 10
        IF prs = 0 THEN f4
        freq3 = (freq3 + 1)//10
        frq3 = freq3
f4:     alt = 0
ddisp4: IF fh <> 5 THEN ddisp5
        ttn21 = 10
        ttn20 = 10
        IF prs = 0 THEN a1
        attn2 = (attn2 + 1)//32
        attn21 = attn2 / 10
        attn20 = attn2 - (attn21 * 10)
a1:     alt = 1
ddisp5: IF fh <> 6 THEN ddisp6
        ttn11 = 10
        ttn10 = 10
        IF prs = 0 THEN a2
        attn1 = (attn1 + 1)//32
        ttn11 = attn1 / 10
        ttn10 = attn1 - (attn11 * 10)
```

```
a2:     alt = 1
ddisp6: IF prs = 0 THEN disp0
        freq = (freq3 * 1000) + (freq2 * 100) + (freq1 * 10) + freq0
        prs = 0
disp0:  IF alt = 1 THEN disp2
        IF alt2 = 1 THEN sp0
        IF lock = 0 OR outr = 1 OR lock2 = 0 THEN spp0
        SEROUT 15,84,["P",0,"~","D",frq3,frq2,frq1,frq0]
        GOTO spp1
spp0:   SEROUT 15,84,["P",15,"~","D",frq3,frq2,frq1,frq0]
spp1:   alt2 = 1
        GOTO sp1
sp0:    SEROUT 15,84,["P",0,"~","D",freq3,freq2,freq1,freq0]
        alt2 = 0
sp1:    PAUSE pau
        alt = 1
        GOTO disp3
disp2:  IF alt2 = 1 THEN sp2
        SEROUT 15,84,["D",attn11,attn10,attn21,attn20,"P",2,"~"]
        alt2 = 1
        GOTO sp3
sp2:    SEROUT 15,84,["D",ttn11,ttn10,ttn21,ttn20,"P",2,"~"]
        alt2 = 0
sp3:    PAUSE pau
        alt = 0
disp3:  IF IN0 = 0 THEN disp4
        sw = 1
        cnt = cnt + 1
        RETURN
disp4:  sw = 0
        RETURN
luff:   lock = IN10
        IF freq = freqp THEN luff2
        SEROUT 9,16468,[">03F",DEC freq,"0",CR]
        SERIN 8,16468,100,luff2,[STR serstr\4]
'       DEBUG STR serstr
        outr = 1
        freqp = freq
        IF serstr(3) <> "A" THEN luff2
        outr = 0
'       freqp = freq
luff2:  RETURN
plo:    lock2 = IN13
        RETURN
atten1: IF attn1 = attn1p THEN atten11
        attn = attn1*2
'       DEBUG DEC attn, " "
        OUT5=0
        FOR bb = 1 TO 6                         'loop for 6 bits
        OUT7=attn.BIT5                           ' msb
        PAUSE 1
        PULSOUT 6,100                   'pulse clock line
        PAUSE 1
        attn=attn*2                     'left shift one bit
        NEXT
        OUT5=1
```

```
        PAUSE 1
        OUT5=0
'       PAUSE 1000
        attn1p = attn1
atten11: RETURN
atten2:  IF attn2 = attn2p THEN atten22
        attn = attn2*2
        OUT14=0
        FOR bb = 1 TO 6                 'loop for 6 bits
        OUT7=attn.BIT5
        PAUSE 1
'       DEBUG BIT7                      'msb of b0
        PULSOUT 6,100
        PAUSE 1                         'pulse clock line
        attn=attn*2                     'left shift one bit
        NEXT
        OUT14=1
        PAUSE 1
        OUT14=0
'       PAUSE 1000
        attn2p = attn2
atten22: RETURN
```

Figure 5 Stamp code listing