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To: Mark 5 Group
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Subject: Performance characteristics 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	22.5 – 4x luff + input GHz
Luff frequency range	5.75 – 8.25 GHz
Minimum step size	100 kHz
Bandpass ripple	4 dB peak to peak
Minimum size for repeatable phase	1 MHz
Nominal input power[1]	-30 dBm
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)	60 dB
(atten. 30 dB)	30 dB
Noise figure	8 dB
Cross-talk between pol. Channels	~-50 dB
Coherence loss due to phase noise	~0.5% (~5˚ rms)

Notes:
1] Nominal input power of -30 dBm implies that a 12 GHz bandwidth LNA and 2nd stage with 50 K system needs 50 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 in the updown converter measured relative to the nominal input level. The worst offender is the 3rd harmonic of the Luff synthesizer which lies with in the passband for L.O. settings between 6.667 and 7.333 GHz. These correspond to an input range of 6.667 to 7.333 GHz.
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 53 K system and 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 attenuator setting.

Local control:

The STAMP code displays the Luff frequency in MHz and the attenuator settings in dB. 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 flushing display) is reached. An out of lock condition or illegal frequency is indicated by flashing decimal points.

Remote control:
The control remotely send the keyword "freq" followed by the frequency (in MHz) attenuator 1 (in dB), attenuator 2 (in dB) followed by a CR at 9600 band.
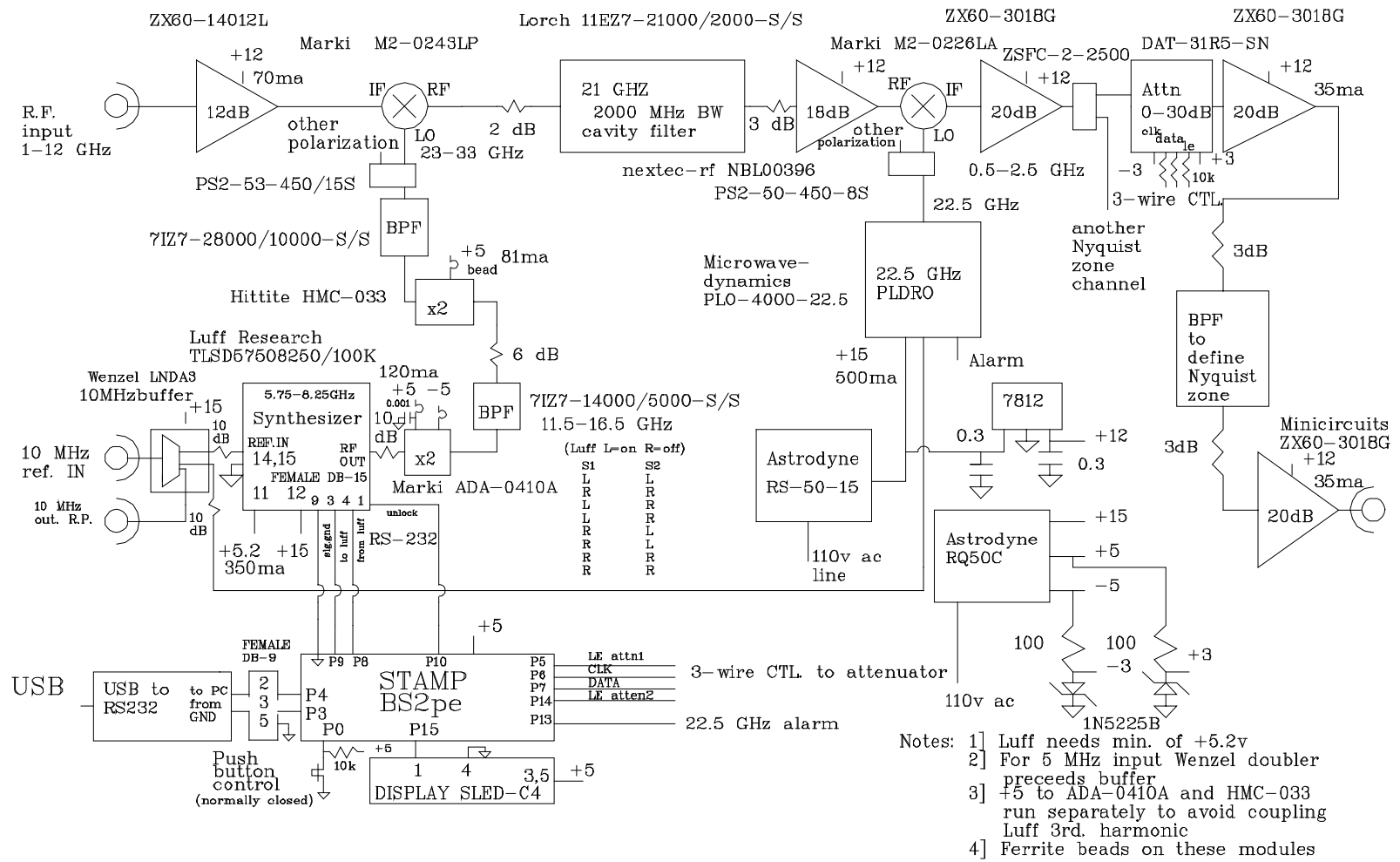The unit should respond with
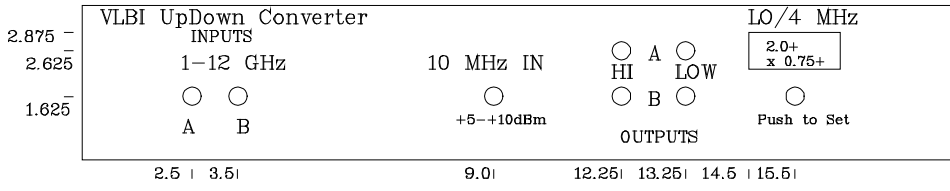Freq xxxx yy zz OK CR
In in lock or
Freq xxxx yy zz errcode CR
If there is an error or the unit doesn't lock. The local remote display will also show the settings.
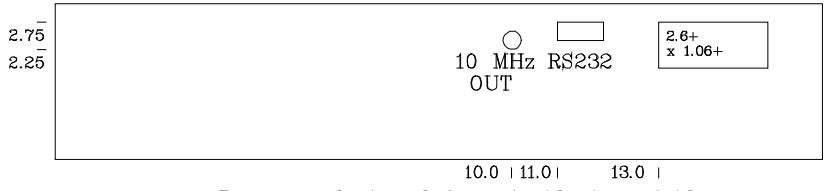
ZX60-14012L

Marki M2-0243LP

Lorch 11EZ7-21000/2000-S/S

Marki M2-0226LA ZSFC-2-2500

ZX60-3018G

DAT-31R5-SN

ZX60-3018G

+12
70ma

12dB

other
polarization

R.F.
input
1-12 GHz

IF RF

LO
23-33 GHz

2 dB

21 GHZ
2000 MHz BW
cavity filter

3 dB

+12

18dB

other
polarization

RF IF

LO

+12

20dB

Attn
0-30dB

clk
data
le

+3
-3

+12

20dB

35ma

PS2-53-450/15S

nextec-rf NBL00396
PS2-50-450-8S

0.5-2.5 GHz

3-wire CTL

another
Nyquist
zone
channel

7IZ7-28000/10000-S/S

BPF

+5 81ma
bead

22.5 GHz

Microwave-
dynamics
PLO-4000-22.5

22.5 GHz
PLDRO

3dB

Hittite HMC-033

x2

BPF
to
define
Nyquist
zone

Luff Research
TLSD57508250/100K

6 dB

+15
500ma

Alarm

Wenzel LNDA3
10MHzbuffer +15

5.75-8.25GHz
Synthesizer

120ma
+5 -5
0.001

10µH

10dB

x2

BPF

7IZ7-14000/5000-S/S
11.5-16.5 GHz

7812

3dB

Minicircuits
ZX60-3018G
+12

10 MHz
ref. IN

10
dB

REF.IN

14,15

FEMALE DB-15
11 12 9 3 4 1

RF
OUT

10
dB

(Luff L=on R=off)
S1   S2
L   L
R   L
L   R
L   R
L   R
R   R
R   L
R   L
R   R

Astrodyne
RS-50-15

0.3

+12
0.3

35ma

20dB

10 MHz
out. R.P.

10
dB

Marki ADA-0410A

unlock

+5.2 +15
350ma

sig.gnd
to luff
from luff

RS-232

Astrodyne
RQ50C

+15
+5
-5

110v ac
line

+5

100   100
-3   +3

1N5225B

USB

USB to
RS232

to PC
from
GND

FEMALE
DB-9

2
3
5

P9 P8

P4
P3

P0

STAMP
BS2pe

P10

+5

P15

P5
P6
P7
P14
P13

LE attn1
CLK
DATA
LE atten2

3-wire CTL. to attenuator

22.5 GHz alarm

110v ac

Push
button
control
(normally closed)

+5
10k

1   4
DISPLAY SLED-C4

3,5 +5

Notes: 1] Luff needs min. of +5.2v
2] For 5 MHz input Wenzel doubler
preceeds buffer
3] +5 to ADA-0410A and HMC-033
run separately to avoid coupling
Luff 3rd. harmonic
4] Ferrite beads on these modules

Simplified block diagram for connectorized
up/down converter for DBE

aeer 13oct07

Figure 1 Block diagram
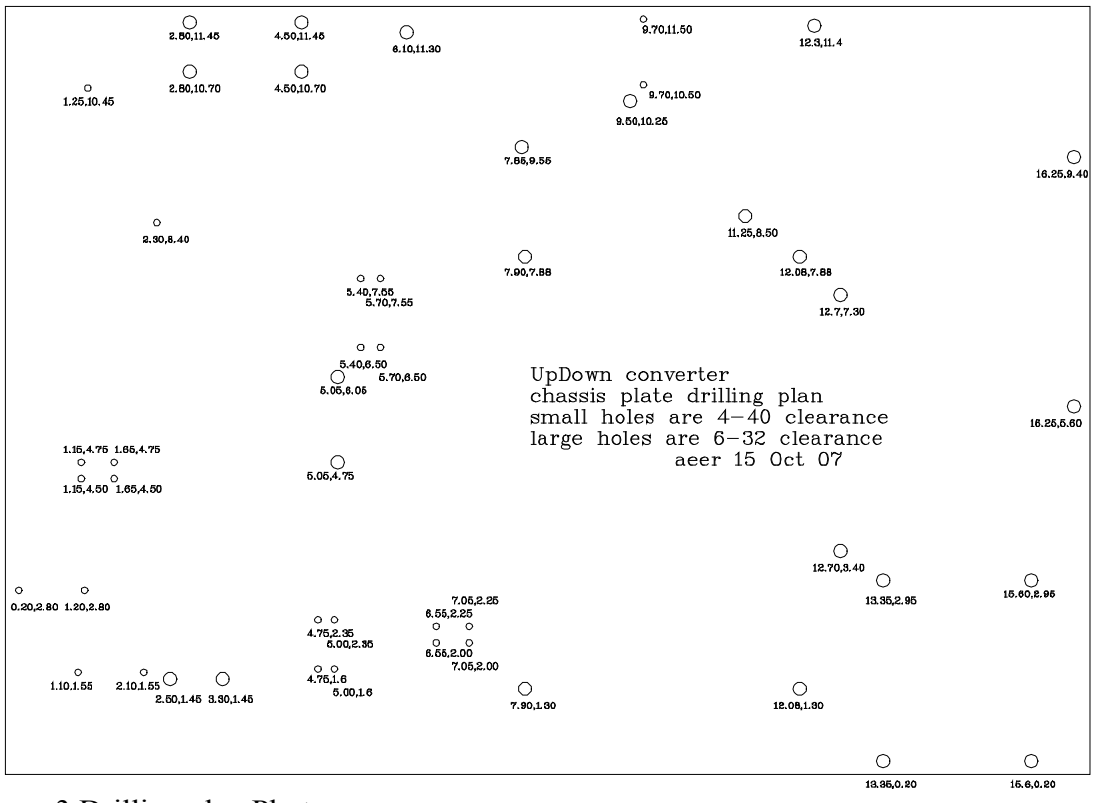
3

Figure 2 Updown panels
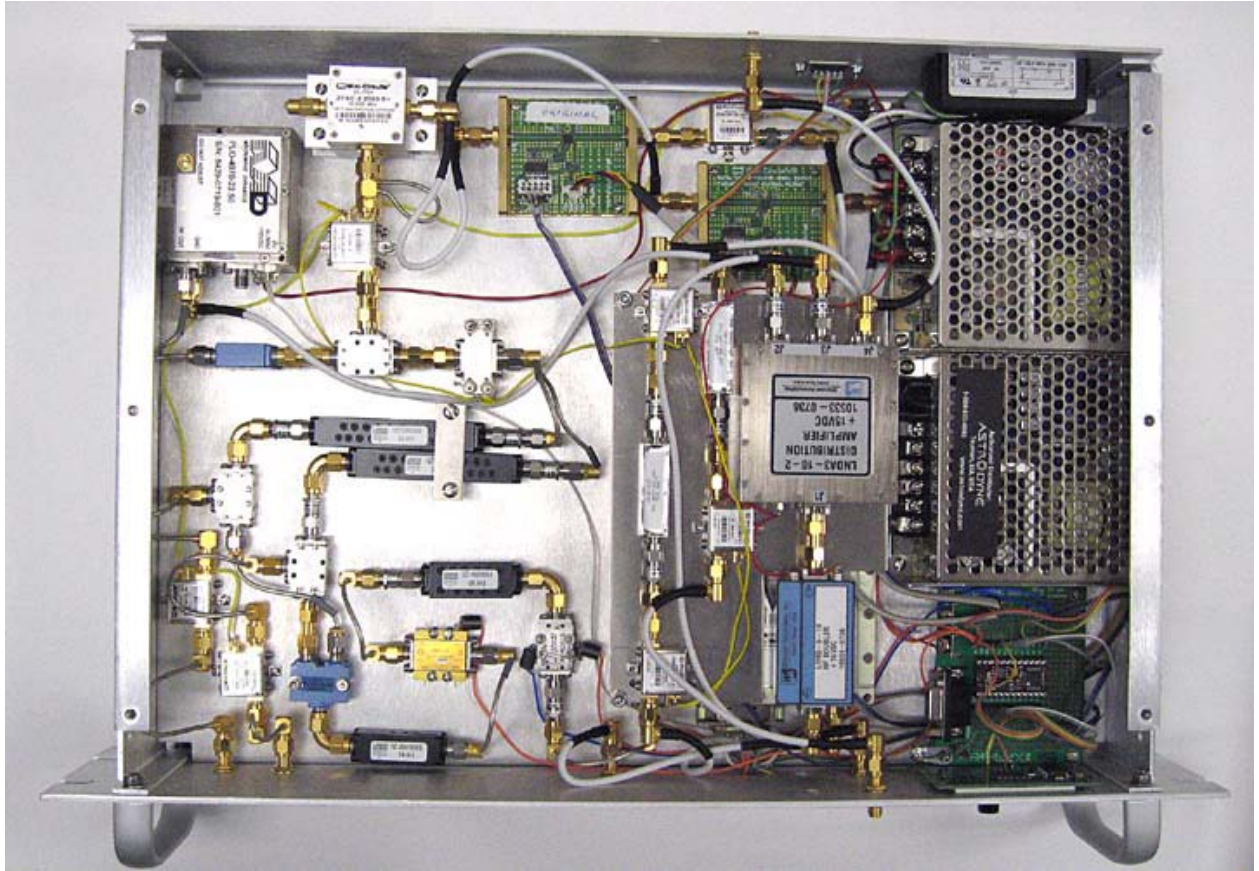

Figure 3 Drilling plan Photo

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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