UVLBI MEMO #023

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To: UVLBI Group
From: Geoff Crew, Vincent Fish, Alan E.E. Rogers
Subject: VLBI set-up at SMTO March 2011

The VLBI setup at SMTO was changed for the March/April 2011 VLBI session from the setup of 2010 (see UVLBI memo #18) to accommodate dual polarization. The VLBI down converter was modified to the new block diagram as shown in Figure 1 to provide "high" (aka IF1) and "low" (aka IF0) band outputs from the RCP and LCP receiver outputs. (We were using the upper sideband outputs of the receiver; the "Vpol" receiver output corresponds to LCP and the "Hpol" output to RCP.) A photo of the revised module is shown in Figure 2.

The station block diagram was changed from that of 2010 to a dual polarization configuration as shown in Figure 3. The external cabling is as shown in Figures 4-6. The 4 blue-connector cables lead to the IF and PPS inputs on the RCP Mark5's placed on the adjoining tables. After inserting pads (4 dB on LCP IF0, 3 dB RCP IF0) and tuning the attenuator knobs (3 on Ch.A, and 0 on Ch.B) the power levels measured on the monitor ports (down 15 dB from the input levels) were

LCP IF0 -21.2 dBm

LCP IF1 -22.1 dBm

RCP IF0 -22.0 dBm

RCP IF1 -23.0 dBm

Note that we were looking at room temperature (not sky) so we wanted to be on high end of the allowed range (-6dB to -12dB).

The 8672A synthesizer (not shown) was tuned to 10921 MHz to produce a 229341 MHz test tone input to the receiver which was readily observed on the Ch.A RF monitor port. The 8657B synthesizer was tuned to 1020.01 MHz and mixed (through LO2) to produce a 10 kHz test tone as shown in Figure 7.

According to note 7 in Figure 3, the baseband output was producing roughly 6 cycles of phase drift per hour in 2010 when mixed down to DC (1020.00 MHz). This year the drift was far less stable and not so easily characterizable. However, this may have partly been due to vibration and thermal cycle at synthesizer on rack (the 8672A).

The PPS provided to arm the DBEs did not come directly from the GPS unit as this had a 10 V pulse which is too strong to safely drive the inputs. (After the experiment we determined a 3 dB pad was probably safe to use to lower the voltage to 5 V.) The maser 10 MHz tone was fed to a clock and on day 82 was initialized to produce a "maser tick" that precedes the GPS tick by (arbitrarily) 12 μs. Later, the "dotmon" tick was measured on the scope and found to trail this by 1.2 μs. (Thus, at the setup on Day 82, "dotmon" preceded the GPS tick by 10.8 μs.) The scope was pretty hard to read--the relative tick timing is as shown in Figure 8. The relative timing of "dotmon" and "maser tick" was (checked daily and found to be) fixed for the duration of the experiment.

The delay of the GPS tick from the "maser tick" was automatically recorded and manually checked a few times per day. A plot of "clock early" is shown in Figure 9 together with the fit (green) for the data (red) captured after Day 82. The unfit portion (blue) had a different offset, but clearly can be adjusted to sit on the same fit line.

At the end of the normal SGRA/M87 observing run, the LO was retuned to allow observations of MWC349. From Shep Doeleman's email of April 3rd:

> You will note in Vincent's email below that we are considering a re-tune of parts of the VLBI array for brief test observations of the maser source MWC349. The rest frequency of the line is 231900.9 MHz.
>
> The maser is double peaked with the peaks roughly 37.5 km/s apart, or a spacing in frequency of 29 MHz. So if we put the center of the maser spectrum (10km/s vlsr) at a DBE channel boundary, then we'll catch each peak roughly centered in a full 32MHz DBE channel. On day 093 around 1600UT, the velocity of the Earth relative to vlsr is -18.2km/s, so we need to place a sky frequency of:
>
> nu_obs = 231900.9 MHz * (1- (10-28.2km/s)/c) = 231915 MHz
>
> at a DBE channel boundary.
>
> If we put this sky frequency at the boundary between DBE channels 7 and 8 in the LOW band, then we need a net LO of
>
> net LO = 231915 - 784 MHz = 231131 MHz.
>
> This places a sky frequency of 232155 MHz at an IF frequency of 1024 MHz.

This was implemented in the SMTO system (Figure 3) with the following retunings. A sketch of frequency space is shown in Figure 10.

Tuning	Normal	Special
8672A synthesizer	10921	11055
Test tone	229341 = 10921×21	232155 = 11055×21
E8257D synthesizer	9335	9452
LO	224340	227148
E4426B	3981	3983

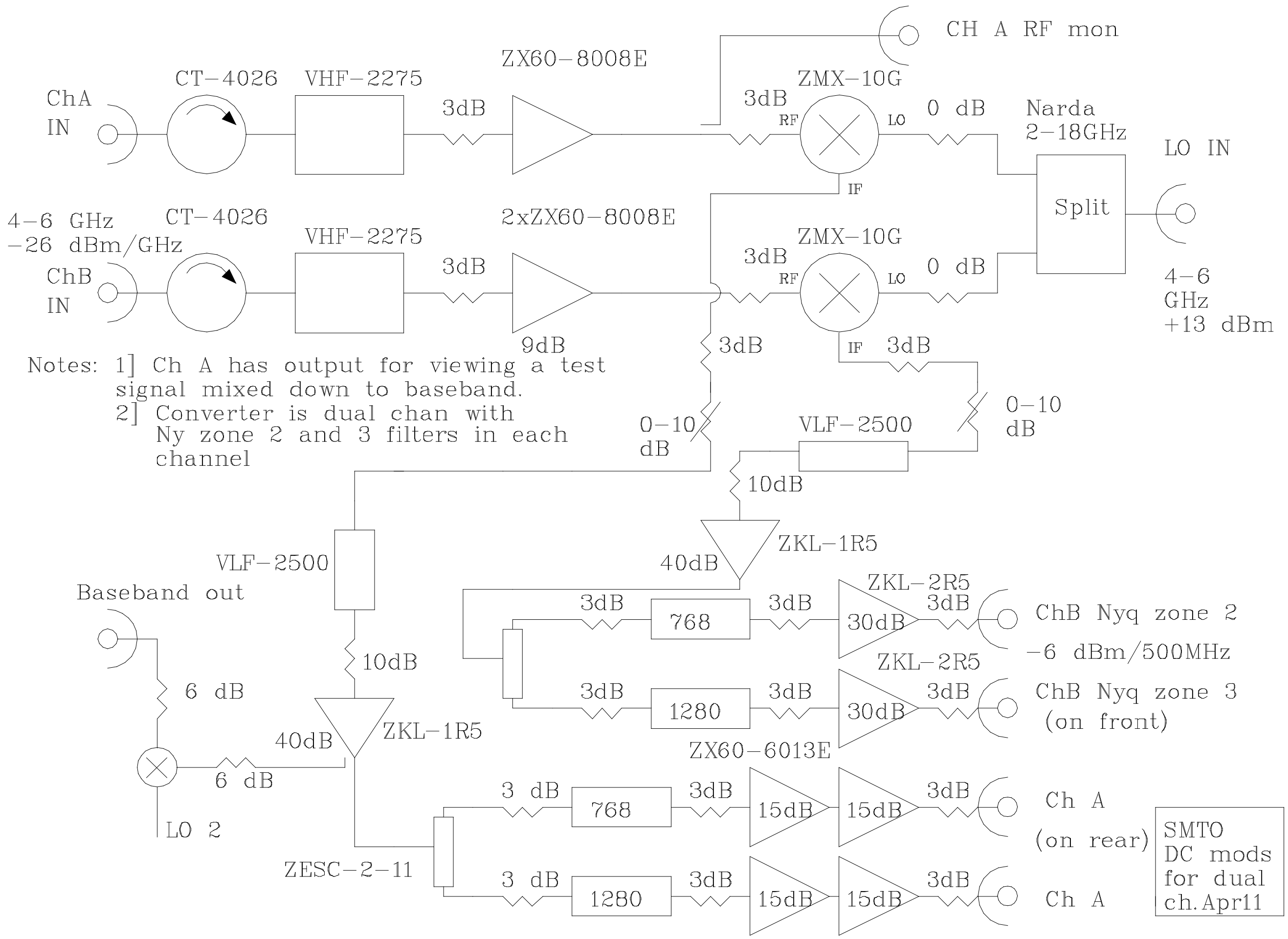

CH A RF mon
ZX60-8008E
ChA
IN
CT-4026
VHF-2275
3dB
3dB
ZMX-10G
RF
LO
0 dB
Narda
2-18GHz
LO IN
IF
Split
4-6 GHz
-26 dBm/GHz
CT-4026
2xZX60-8008E
ChB
IN
VHF-2275
3dB
3dB
ZMX-10G
RF
LO
0 dB
4-6
GHz
+13 dBm
9dB
3dB
IF
3dB
Notes: 1] Ch A has output for viewing a test
signal mixed down to baseband.
2] Converter is dual chan with
Ny zone 2 and 3 filters in each
channel
0-10
dB
VLF-2500
0-10
dB
10dB
ZKL-1R5
40dB
VLF-2500
Baseband out
3dB
768
3dB
ZKL-2R5
3dB
30dB
ChB Nyq zone 2
-6 dBm/500MHz
10dB
ZKL-2R5
3dB
1280
3dB
30dB
3dB
ChB Nyq zone 3
(on front)
6 dB
40dB
ZKL-1R5
6 dB
ZX60-6013E
3 dB
768
3dB
15dB
15dB
3dB
Ch A
(on rear)
LO 2
SMTO
DC mods
for dual
ch.Apr11
ZESC-2-11
3 dB
1280
3dB
15dB
15dB
3dB
Ch A

Figure 1.

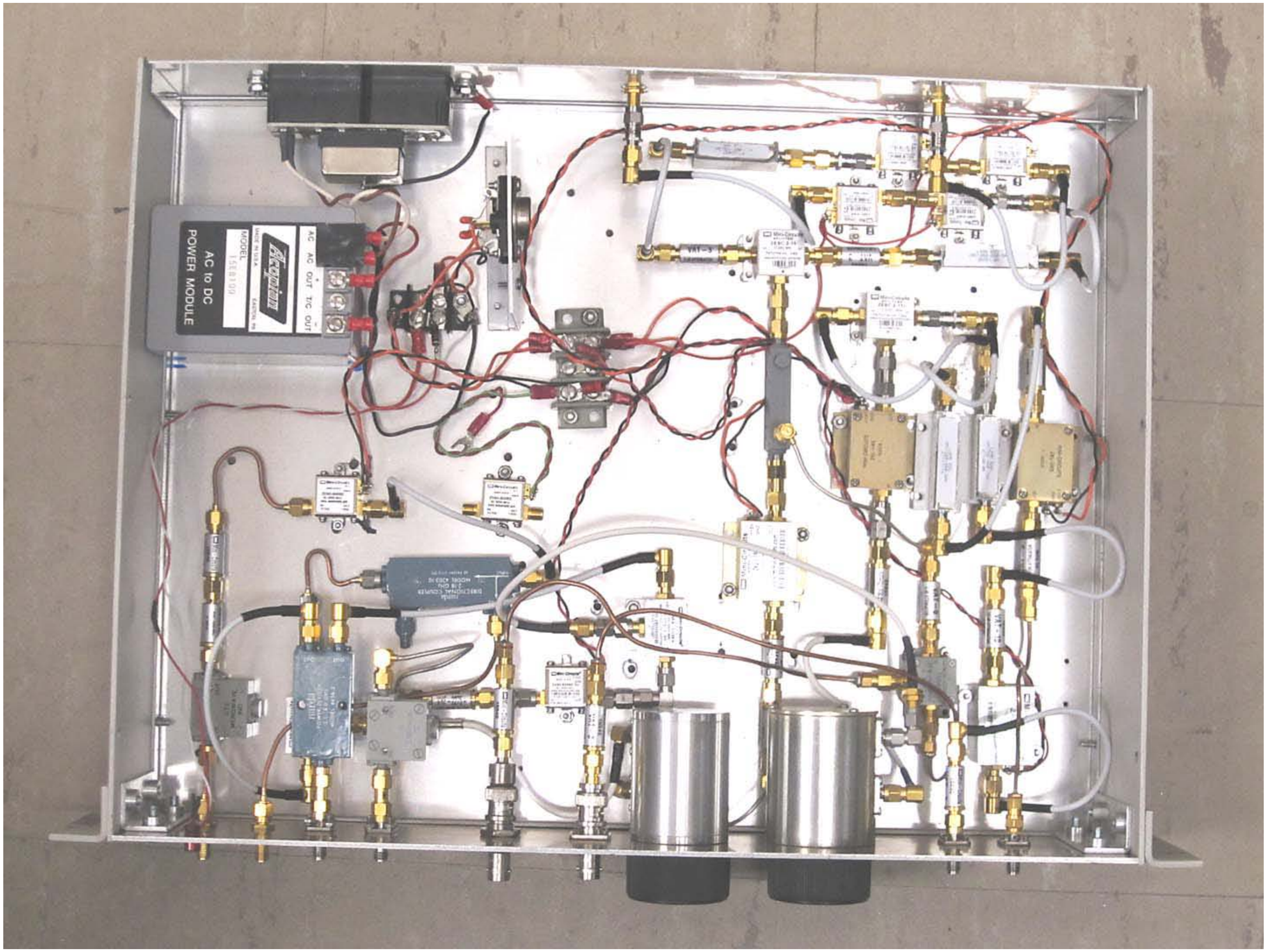
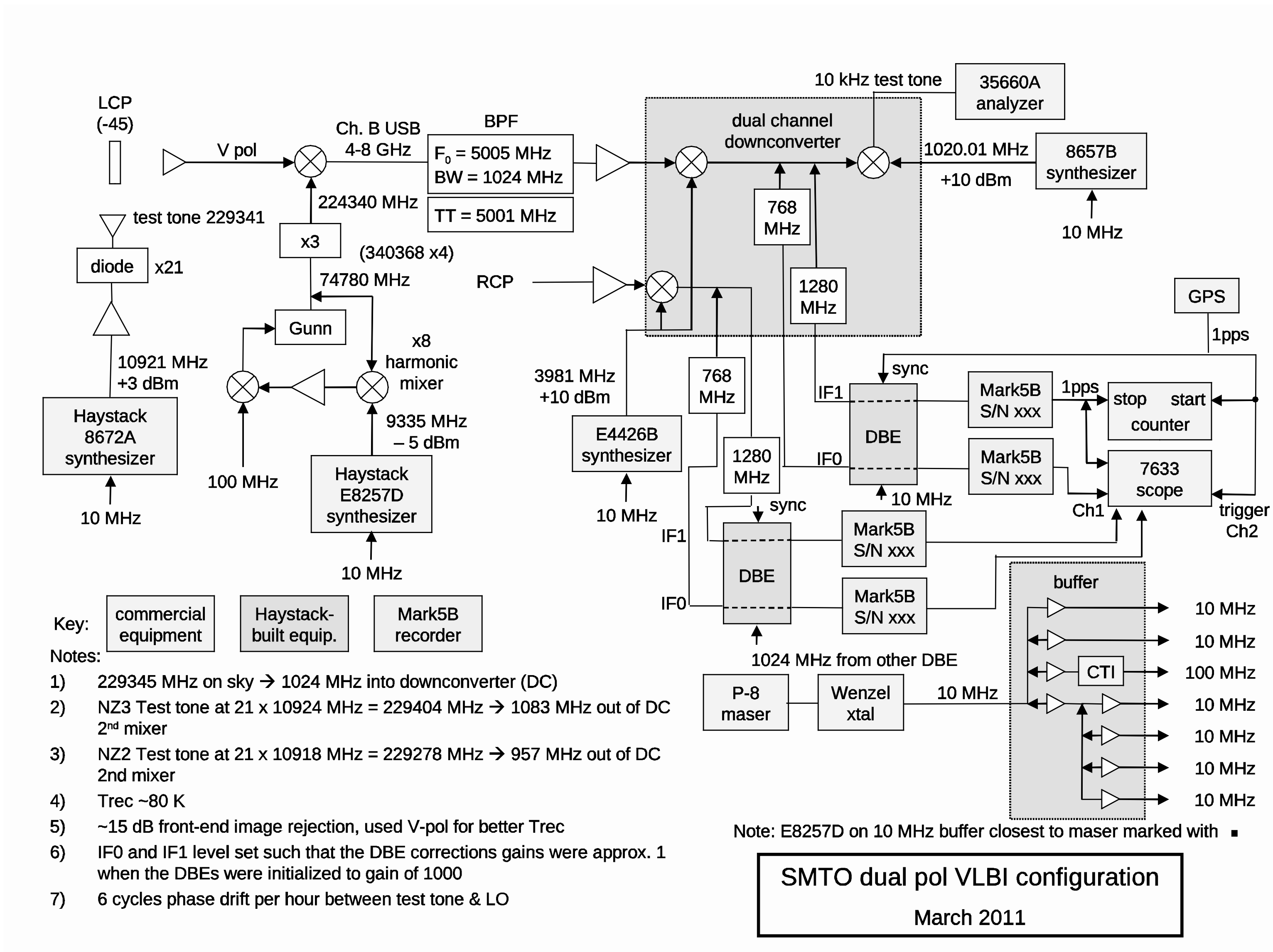


Figure 2.



LCP
(-45)
V pol
Ch. B USB
4-8 GHz
BPF
F0 = 5005 MHz
BW = 1024 MHz
TT = 5001 MHz
224340 MHz
test tone 229341
diode
x21
x3
(340368 x4)
74780 MHz
Gunn
x8
harmonic
mixer
10921 MHz
+3 dBm
Haystack
8672A
synthesizer
10 MHz
100 MHz
9335 MHz
– 5 dBm
Haystack
E8257D
synthesizer
10 MHz
RCP
dual channel
downconverter
10 kHz test tone
35660A
analyzer
1020.01 MHz
+10 dBm
8657B
synthesizer
10 MHz
768
MHz
1280
MHz
3981 MHz
+10 dBm
E4426B
synthesizer
10 MHz
768
MHz
1280
MHz
GPS
1pps
sync
IF1
IF0
DBE
10 MHz
Mark5B
S/N xxx
Mark5B
S/N xxx
1pps
stop start
counter
7633
scope
Ch1
trigger
Ch2
sync
IF1
IF0
DBE
Mark5B
S/N xxx
Mark5B
S/N xxx
1024 MHz from other DBE
buffer
10 MHz
10 MHz
CTI
100 MHz
10 MHz
10 MHz
10 MHz
10 MHz
P-8
maser
Wenzel
xtal
10 MHz
Note: E8257D on 10 MHz buffer closest to maser marked with ▪
Key:
commercial equipment
Haystack-built equip.
Mark5B recorder
Notes:
1) 229345 MHz on sky → 1024 MHz into downconverter (DC)
2) NZ3 Test tone at 21 x 10924 MHz = 229404 MHz → 1083 MHz out of DC 2nd mixer
3) NZ2 Test tone at 21 x 10918 MHz = 229278 MHz → 957 MHz out of DC 2nd mixer
4) Trec ~80 K
5) ~15 dB front-end image rejection, used V-pol for better Trec
6) IF0 and IF1 level set such that the DBE corrections gains were approx. 1 when the DBEs were initialized to gain of 1000
7) 6 cycles phase drift per hour between test tone & LO
SMTO dual pol VLBI configuration
March 2011

Figure 3.

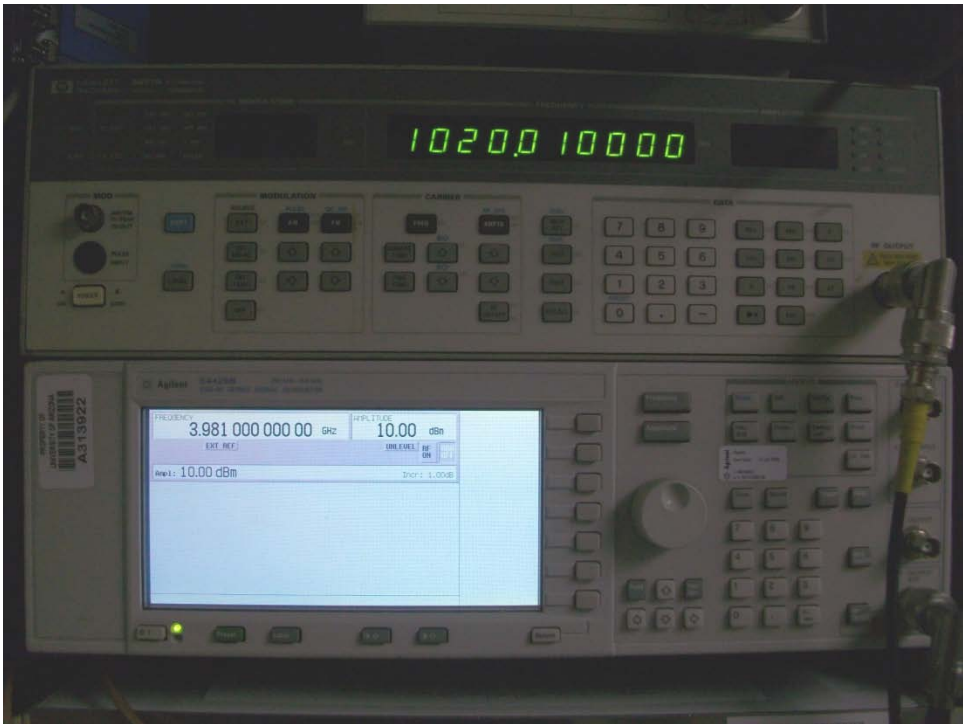


Figure 4.

Figure 5.

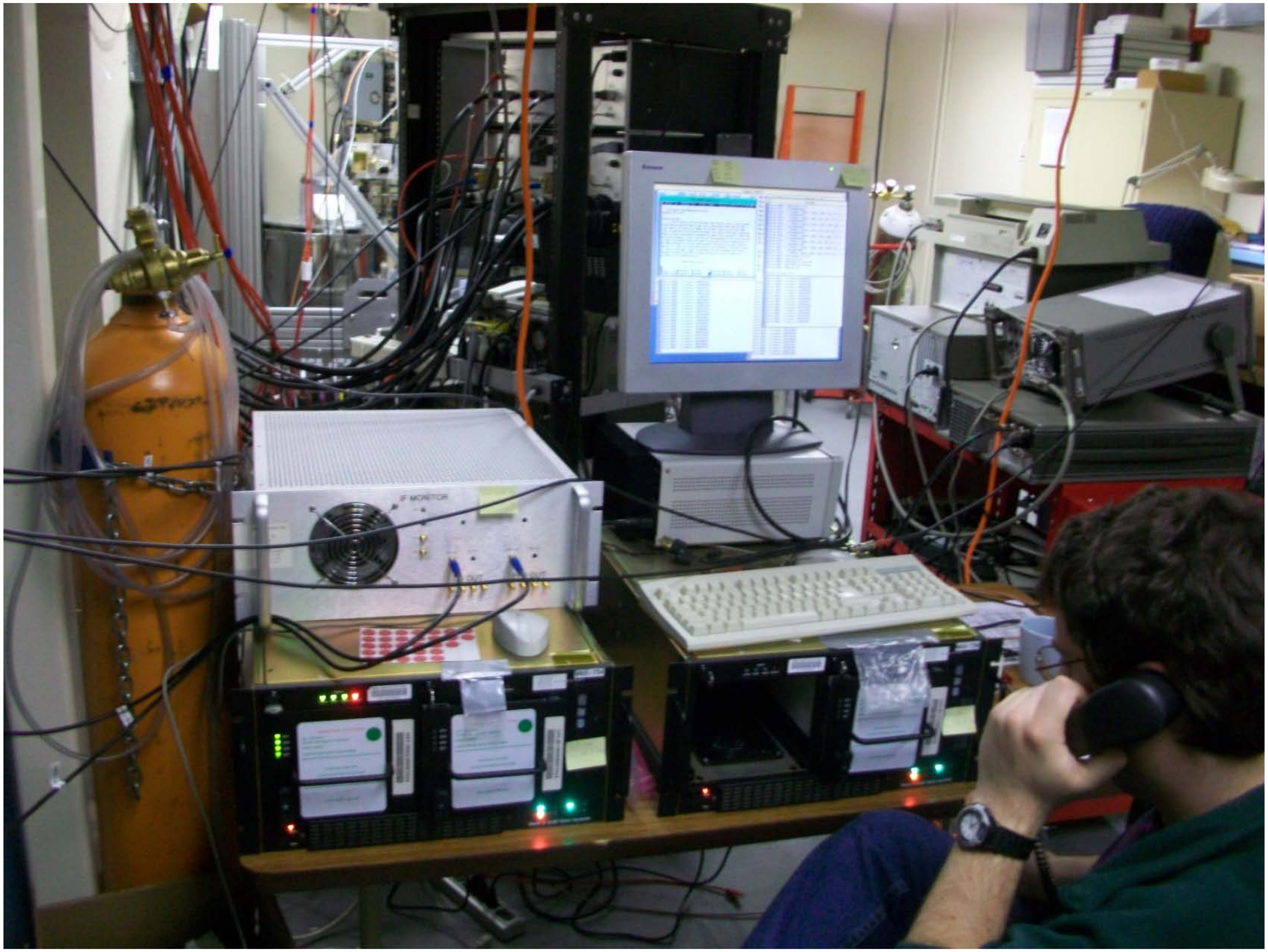
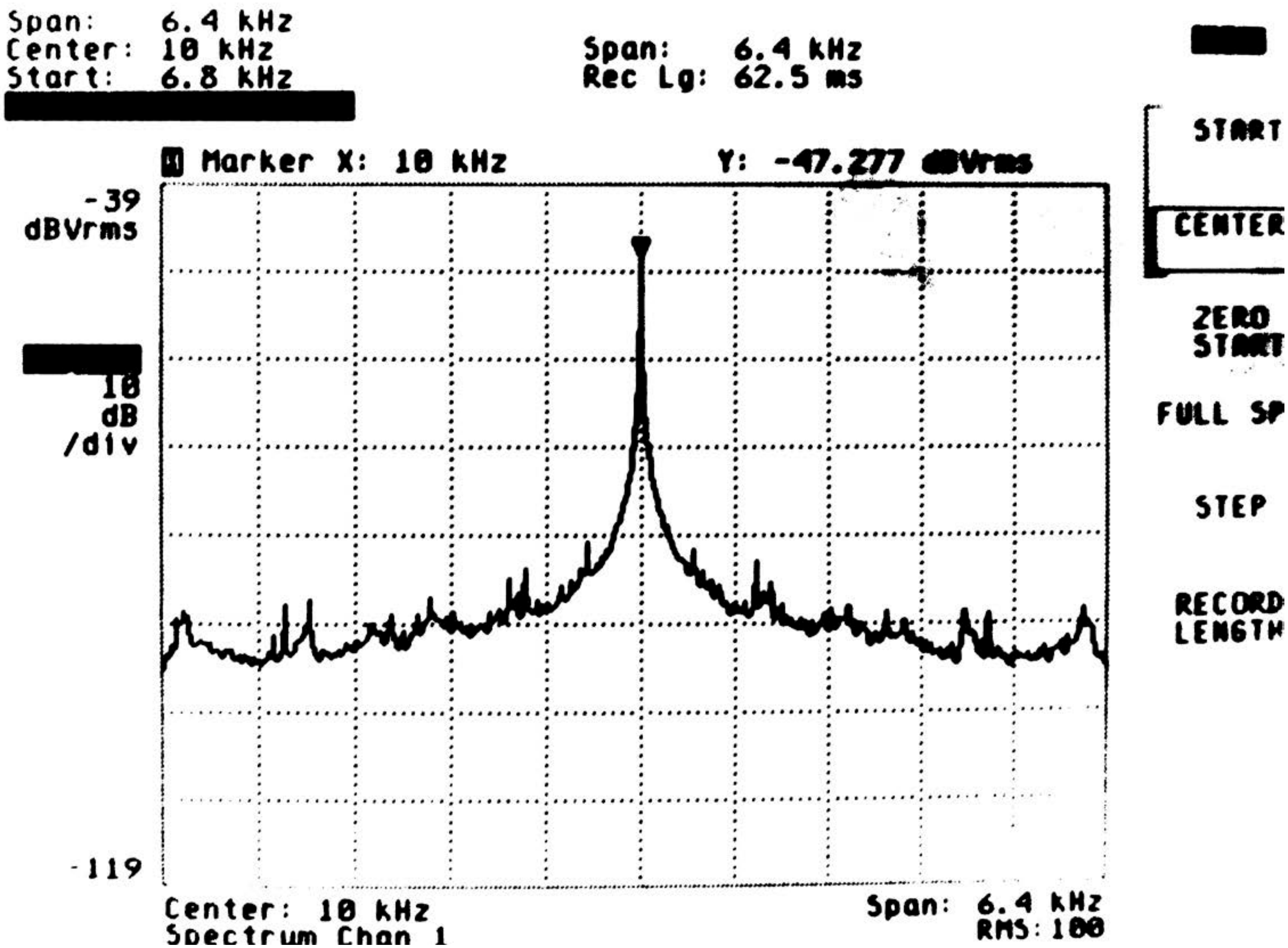


Figure 6.



Span: 6.4 kHz
Center: 10 kHz
Start: 6.8 kHz
Span: 6.4 kHz
Rec Lg: 62.5 ms
Marker X: 10 kHz
Y: -47.277 dBVrms
-39
dBVrms
10
dB
/div
-119
Center: 10 kHz
Spectrum Chan 1
Span: 6.4 kHz
RMS: 100
START
CENTER
ZERO
STEP
RECORD
LENGTH

Figure 7.

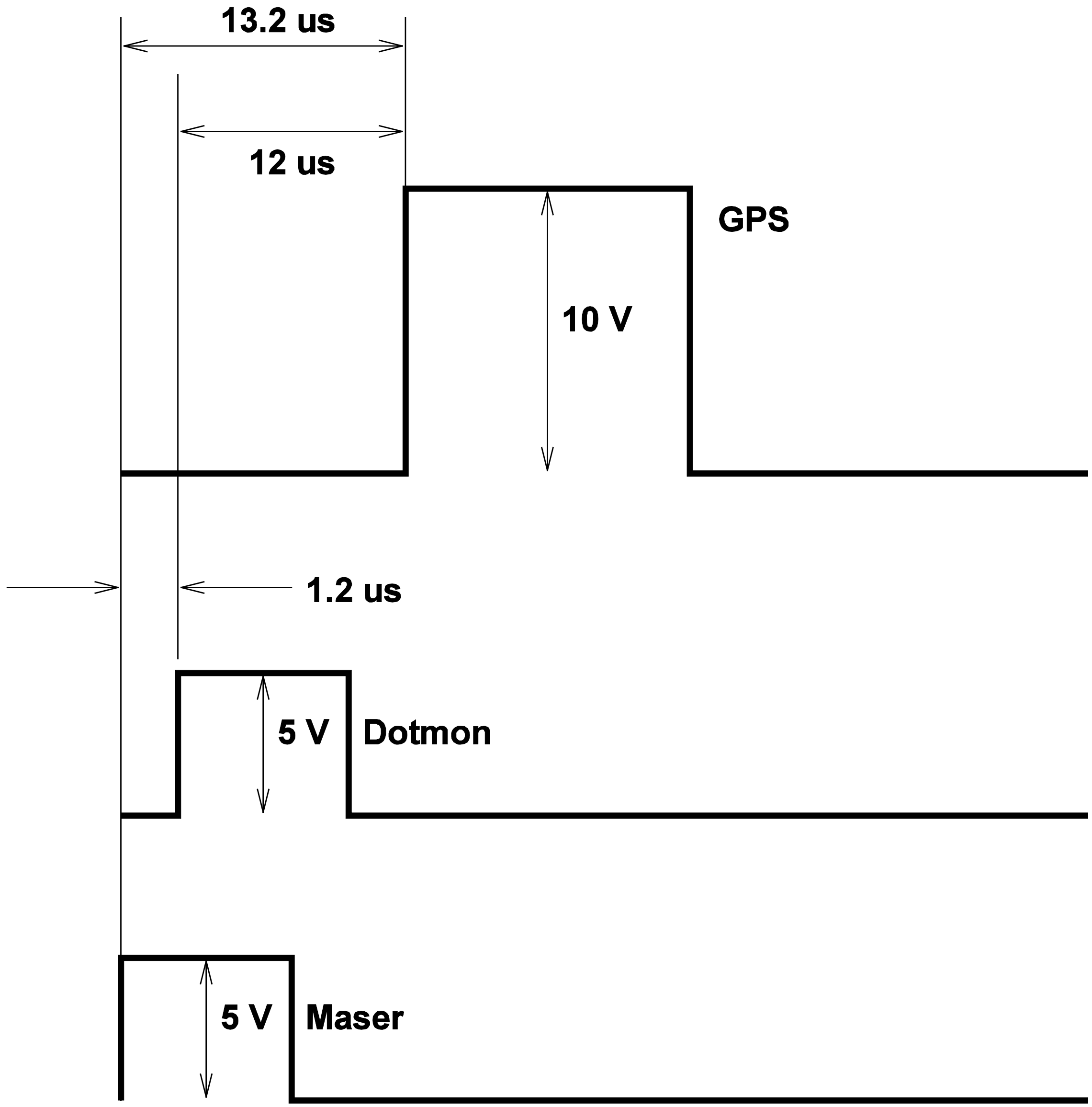


Figure 8.

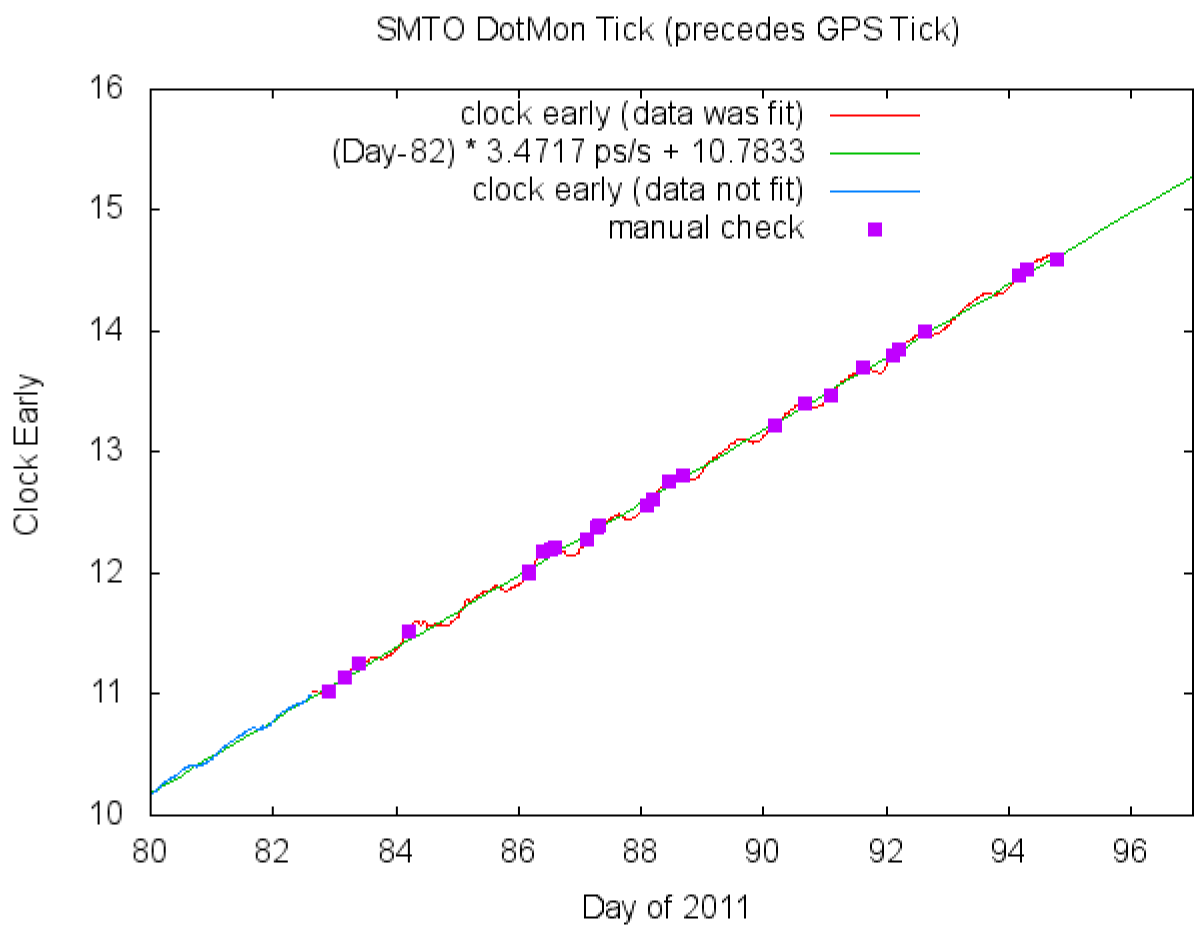

SMTO DotMon Tick (precedes GPS Tick)
clock early (data was fit)
(Day-82) * 3.4717 ps/s + 10.7833
clock early (data not fit)
manual check
Clock Early
Day of 2011
16
15
14
13
12
11
10
80
82
84
86
88
90
92
94
96

Figure 9.

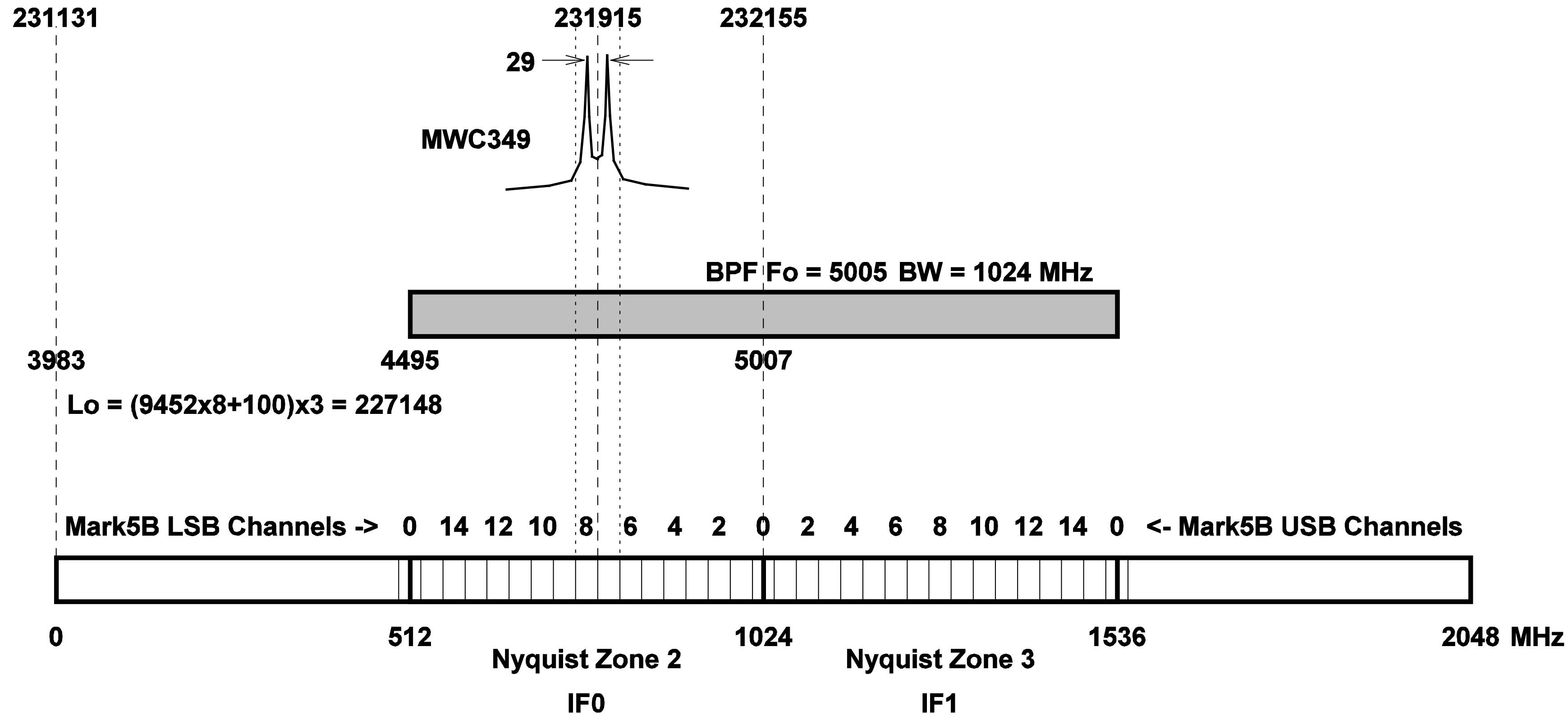

231131
231915
232155
29
MWC349
BPF Fo = 5005 BW = 1024 MHz
3983
4495
5007
Lo = (9452x8+100)x3 = 227148
Mark5B LSB Channels -> 0 14 12 10 8 6 4 2 0 2 4 6 8 10 12 14 0 <- Mark5B USB Channels
0
512
1024
1536
2048 MHz
Nyquist Zone 2
Nyquist Zone 3
IF0
IF1

Figure 10.