NOAA Technical Memorandum ERL WPL-232

A SECOND-GENERATION LARGE-APERTURE SCINTILLOMETER

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Wave Propagation Laboratory
Boulder, Colorado
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A SECOND-GENERATION LARGE-APERTURE SCINTILLOMETER

G. R. Ochs[1] and J. J. Wilson[2]

ABSTRACT

This report describes an instrument that measures C_n^2, and uses pulse-code modulation, noise correction circuitry and has an internal calibrator. The instrument is optimized for path lengths of 500m to 700m. Operation and calibration procedures are included.

1. INTRODUCTION

Since its conception in 1978 (Wang et al.), the large-aperture scintillometer technique of measuring the Refractive-Index structure parameter (C_n^2) has been used with a variety of methods and instruments (Hill and Ochs, 1978; Hill, 1981; Ochs and Hill, 1982). The methods have varied according to the application, and experience has led to improved versions. The earliest versions used unmodulated quartz-halogen light bulbs as a light source (Ochs, et al, 1977), and later models employed a modulated light-emitting diode (LED) (Ochs, et al, 1979; Ochs et al, 1985; Ochs et al, 1989). An integrated circuit designed to measure root-mean-square voltage (AD536) was used as a demodulator by setting it for an averaging time that was short compared to the frequency of the signal amplitude modulation to be measured. This chip was desirable and convenient to use as a demodulator because of its high linearity and its integral logarithmic amplifier.

An external unit that furnished calibrated optical signals was also employed to check the operation of the receiver.

When the need arose to design a system that could profile C_n^2 along the light path, it became necessary to pulse code transmissions so that transmitting and receiving arrays could be formed to make a system that could profile C_n^2 (Ochs, et al, 1977; Ochs, et al, 1989). With pulse-coded transmissions, it became impractical to design a suitable external calibrator, and an internal system was introduced that injected electrical signals of known calibration into the system just after the preamplifier.

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The new designs that were required by the profiler were incorporated in the improved circuitry now employed in the second-generation instrument. The AD536 demodulator still had a better signal-to-noise (S/N) ratio than the coded system. Potentially, however, a variation of the pulse-coded system appeared to offer advantages. The post-detection bandpass could be more uniform and there was the possibility of designing noise-correction circuitry. Also, the internal calibrator, though not testing the photodiode and preamplifier, proved to be a better compromise because it was more accurate and much more convenient to use, especially after the equipment was installed in the field.

2. DESCRIPTION OF THE SYSTEM

2.1 Transmitter

The transmitter driver and optical system is one unit as shown in Fig. 1. The incoherent illuminated aperture is formed by a 16A LED placed at the focus of a 15-cm-diameter f.2 mirror with a protected gold coating. A ground glass diffuser in front of the diode further improves the uniformity of the illumination across the aperture.

The circuitry that generates the 7 Khz carrier employs a current drive so that the diode current is nearly independent of temperature.

2.2 Receiver

The receiver electronics and optical system is one unit as shown in Fig. 2. A 2.5-mm-diameter detector is placed at the focus of a 15-cm-diameter f.2 gold coated mirror that defines the receiving aperture. A diffuser is also used in front of the detector to provide more uniform detection sensitivity over the receiver aperture. The alignment procedure is to place the detector photodiode active surface at the focus of the mirror and then put the diffuser (translucent Scotch tape) in place on the photodiode glass cover.

The receiver contains an internal calibration unit that generates a 7 Khz carrier. This carrier is amplitude modulated with a 10 Hz biased square-wave electrical signal that can be inserted just after the receiver preamplifier. The square-wave amplitude modulation is set so that the high level is exactly twice the amplitude of the low level. An oscilloscope was used previously to set the levels. In the new circuit, the high and low carrier levels can be set more accurately with an AC voltmeter.

The circuit employs a highly linear Automatic Gain Control circuit (AGC). The original locked up occasionally at very high gain. The circuit has been redesigned to prevent this.

A different circuit is employed to detect the amplitude fluctuations of the 7 Khz transmitter carrier. It operates by sampling and holding (S/H) the "on" portion of the square wave each cycle. Likewise, another S/H circuit samples the "off" portion of the carrier each cycle. The signal is the difference of these two. The logarithm of this signal is then taken separately. This circuit is able to do a first order removal of the noise within the passband since it is almost the same for the top and bottom of the waveform, whereas the desired signal is the difference. Unfortunately, some noise is introduced by the S/H circuits. A second advantage is that a flatter signal bandpass is obtained with this detector.

3. OPERATING PROCEDURE

Both the transmitter and the receiver should be mounted on solid, vibration-free mounts, and in enclosures for weather protection. If windows are used, optical quality is not critical. However, when there is a choice, Plexiglas is generally more transparent at 0.94μm than window glass.

This instrument is optimized for operation over 500 to 700m paths. It contains an internal calibration unit that introduces electrical signals just after the preamplifier. The circuit is also arranged so that a digital voltmeter can be used to measure the square-wave modulation depth on the carrier signal used for calibration. For the most accurate work, the following procedure should be carried out just prior to operating. It is assumed that the instrument, especially the AD 536 log circuits, have been aligned previously.

Set the digital pot to 594 and the RUN/CAL switch to CAL. Connect an AC digital voltmeter to the CAL BNC. Check that the AC voltage with the HIGH/TOGGLE/LOW switch in the HIGH position is 100 Mv, and in the LOW position is 50.0 Mv. What is important is that the ratio is 2:1; i.e., 110 and 55.0 or 90.0 and 45.0 is good. Pot 1 on the calibration board adjusts the calibration voltage gain, i.e., both voltages. Pot 2 on the same board adjusts the lower voltage. A board extender is required to get at these pots. Then set the HIGH/TOGGLE/LOW switch to TOGGLE and measure the DC voltage at the LOG C_n^2. This should be 2.00 V. The voltage may differ slightly from this value because some circuit gains are determined by 1% resistors and there is some temperature drift, probably mostly in the log circuits. To compensate for these errors, adjust the 2k blue pot (not yet numbered) on the edge of the C_n^2 board.

This pot has a range of +-50 Mv. If the output cannot be adjusted to 2.00 V with the 2k pot, a complete circuit calibration should be done.

The signal meter reading is linear with signal intensity rather than the logarithmic response used in the earlier instruments. The instrument can be pointed more accurately with the linear response, and the signal level can also be adjusted more accurately. The transmitter power should be set to 0.9 amp for a 500m path. With this setting, the signal meter should read between one-half and full scale. For shorter path lengths, the transmitter power should be reduced to keep the signal meter indication on scale. On paths longer than 500m, the signal meter may read less than one-half scale, but it is not advisable to increase transmitter power above 0.9 amp.

4. REFERENCES

Hill, R.J., and G.R. Ochs: Fine Calibration of Large Aperture Scintillometers and an Optical Estimate of Inner-scale. *Appl. Opt.*, 22, 3608-3612 (1978).

Hill, R.J.: Saturation resistance and inner-scale resistance of a large-aperture scintillometer: A case study. *Appl. Opt.*, 20, no. 22, 3822-3824 (1981).

Ochs, G.R., R.F. Quintana, and G.F. Miller: An Optical Device for Measuring Refractive-Index Fluctuation in the Atmosphere. NOAA Tech. Memo. ERL WPL-30 NOAA Environmental Research Laboratories, Boulder, Colorado (1977).

Ochs, G.R., W.D. Cartwright, and D.D. Russell, 1979. Optical C_n^2 Instrument Model II. NOAA Tech. Memo. ERL WPL-51, NOAA Environmental Research Laboratories, Boulder, Colorado.

Ochs, G.R., and R.J. Hill, 1982. A Study of Factors Influencing the Calibration of Optical C_n^2 Meters. NOAA Tech. Memo. ERL WPL- 106 NOAA Environmental Research Laboratories, Boulder, Colorado.

Ochs, G.R., D.S. Reynolds, and R.L. Zurawski, 1985. Folded-path Optical C_n^2 Instrument. NOAA Tech. Memo. ERL WPL-123 NOAA Environmental Research Laboratories, Boulder, Colorado.

Ochs, G.R., J.J. Wilson, and S.A. Abbott, 1989. A Refractive-Index Structure Parameter Profiling System. NOAA Tech. Memo. ERL WPL-161 NOAA Environmental Research Laboratories, Boulder, Colorado.

Wang, Ting-i, G.R., Ochs and S. F. Clifford, 1978. A saturation resistant optical scintillometer to measure C_n^2. *J. Opt. Soc. Am.*, 68, 334-338.

APPENDIX A
ALIGNMENT PROCEDURES

A.1. Optical Alignment

The optics of the transmitter and the receiver must be aligned so that the LED (transmitter) and the photodetector (receiver) are at the focus of their respective mirrors. The focusing procedure is the same for the transmitter and receiver. Refer to Fig. 3. We use a card and small flashlight bulb. Align the filament of the flashlight bulb so that it is in the same plane as the card. A 3x5 card works fine.

1. Remove the Plexiglas window that holds either the transmitter LED or the receiver photodiode.

2. Power the flashlight bulb and hold the card a distance of two times the focal length from the mirror. Move the light bulb somewhere close to the optical axis. Move the card and light bulb in and out until the image of the filament comes into a sharp clear image. This is exactly two times the focal length. Be careful not to scratch the front surface of the mirror. Record the distance from the center of the mirror to the card. Divide this number by two. This is the focal length of the mirror (f).

3. Without disturbing the card or mirror, reinstall the Plexiglas window. Measure from the card to the outside (detector or LED goes inside) of the Plexiglas window. Record this distance (d1).

4. The Plexiglas window is 0.25 in. thick.

5. Now figure the distance (d2) from the inside surface of the Plexiglas window to the active area of the LED or photodiode by the formula:

$$d2 = f - d1 - 0.25$$

where: f = focal length of the mirror
d1 = distance between the front of the window and the screen
0.25 = thickness of the window in inches
d2 = distance from the inside of the window to the active area of the LED or photodiode.

6. The active area of the transmitter LED is the small grey hemisphere in the center. Do not touch it because that will ruin the LED. The active area of the photodiode in the receiver is 0.090 in. below the glass cover. You will have to

remove the gel filter glued to the front of the photodiode cover. Just use a scalpel to cut the adhesive. When you have finished the focusing adjustment, reglue the filter on with a little black silicone adhesive. Use care not to smear the adhesive into the photodiode field of view. Adjust the LED or photodiode by screwing them in or out to the proper distance d2.

7. Replace the window and the optical alignment is completed.

A.2. Electronic Alignment

A.2.1. Transmitter

The only adjustment on the transmitter circuit board is the clock timing. Connect a frequency counter to pin 13 of the 2207 (U1). Adjust the 10K pot until you get a frequency as close to 7.00 Khz as possible. Refer to the schematic diagrams for these procedures.

A.2.2. Receiver

You will need to adjust the electronics for the receiver circuitry and the calibration electronics because the calibration circuit board is located in the receiver.

You will need a two channel oscilloscope, a frequency counter, an accurate voltmeter, a DC voltage source capable of +0.100 V and +1.000 V output and a card extender. Set RUN/CAL switch to CAL and HIGH/TOGGLE/LOW switch to TOGGLE.

First adjust the receiver electronics by adjusting the decoding pulses. See Fig. 4.

1. On the decoder board you will find four 4047 chips, U35, U36, U37, and U38, and two sample and hold chips, U31 and U39. U35 and U37 are positive edge triggered from the sync pulse and set the sample delay time. U36 and U38 generate the sample pulses for the sample and holds. Connect channel 1 of the oscilloscope to U31 pin 3. This is the signal input to both of the sample and holds. Connect channel 2 of the oscilloscope to U31 pin 8. This is the sample pulse from U36. Connect the sync pulse to the external trigger of the oscilloscope. Adjust pot 9 on U36 to change the delay time of the upper sample pulse. You want to adjust the delay time so that the sample pulse occurs at the center of the peak of the input signal. The delay time should be about 120 microseconds.

Connect channel 2 of the oscilloscope to U39 pin 8. Adjust pot 10 on U37 to change the delay time of the lower sample pulse. You want to adjust the delay time so that the sample pulse occurs in the center of the trough of the input signal. The delay time should be about 54 microseconds.

2. U36 and U38 are falling edge triggered from the pulse output from U35 and U37 respectively. U36 and U38 control the sample/hold chips that sample the incoming signal. The output pulses from U36 and U38 should both be about 5 microseconds long. There is no adjustment for these pulse lengths.

The next adjustment in the receiver electronics is to adjust the AD 536 chips for a 2 V per decade scale. There is an AD536 on the Decoder board and one on the C_n^2 circuit board. First, adjust the 536 on the Decoder board (U30).

1. Remove U40 from the board. Do this with the power off.

2. Connect the voltmeter to pin 8 U41C.

3. Connect the voltage source to pin 1 U30 (AD 536).

4. Set the voltage source to +0.100 V.

5. Observe the D.C. voltmeter. The output voltage should be a solid -2.00 V. If the voltage fluctuates make sure you have disconnected U40 and that you really have +0.100 V at pin 1 of U30. Adjust pot 8 to bring the output voltage to -2.00 V.

6. Adjust the voltage source to give +1.00 V.

7. Observe the voltmeter. It should read 0.00 V. If not, adjust Pot 7 to get 0.00 V.

8. Repeat these adjustments as they are slightly interactive.

The adjustment of the AD536 on the C_n^2 board is similar.

1. Remove the driving op amp (U15) of the AD 536 (U13).

2. Connect the voltmeter to pin 6 of U16.

3. Connect the voltage source to Test Point 1 (pin 1 U13) and set the voltage source to +0.100 V.

4. Observe the voltmeter reading. It should be 0.00 V. Adjust Pot 5 to bring this voltage to 0.00 V.

5. Set the voltage source to +1.00 V. The voltmeter should now read +2.00 V. Adjust Pot 6 to get +2.00 V.

6. Repeat steps 2 through 5 as these adjustments are slightly interactive.

The alignment of the calibration board is the final step in the electronic alignment of the receiver electronics. The desired output from this board is a 7 kHz square-wave carrier, amplitude modulated with a 10 Hz square wave to give a 50% modulation depth. The output is monitored at either the CAL BNC output or pin 7 of U5B.

1. Connect the frequency counter to pin 13 U6. Adjust Pot 4 until you read 7.00 kHz on the frequency counter.

2. Connect the frequency counter to pin 13 of U7. Adjust Pot 3 to get 10 Hz.

3. Set the HIGH/TOGGLE/LOW switch on the rear panel of the receiver to HIGH. Monitor the output of the CAL BNC with the voltmeter. Set the voltmeter to AC volts. Adjust Pot 1 until the voltmeter reads +0.110 V.

4. Set the panel switch to LOW. Adjust Pot 2 to get +0.055 V on the voltmeter. The important thing here is to get the HIGH reading exactly two times the LOW reading. This completes the electronic alignment of the calibrator board.

There is one final adjustment to make on the C_n^2 board.

1. Set the digital pot to 594 and the RUN/CAL switch to cal.

2. Connect the D.C. voltmeter to the LOG C_n^2 output.

3. Switch the HIGH/TOGGLE/LOW switch to TOGGLE.

4. The voltmeter should read 2.00 volts. If not, adjust the 2k blue pot (not numbered) on the C_n^2 board. This pot has a range of +- 50 Mv. If the output cannot be adjusted to 2.00 volts with the 2k pot, a complete electronic alignment needs to be done.

This completes the electronic alignment.

APPENDIX B
DERIVATION OF CALIBRATION

This system differs from the earlier ones as it uses synchronous detection. After demodulation, however, the signal processing circuitry is nearly identical to that used in the earlier systems. From Wang et al (1978),

$$C_n^2 = K\ \sigma_x^2\ D^{7/3} L^{-3} \quad , \tag{1}$$

where σ_x^2 is the log-amplitude variance of the irradiance, D is the clear aperture diameter, and L is the path length. By definition,

$$\sigma_x^2 = \langle \ln a - \langle \ln a \rangle \rangle^2$$

where a is the light amplitude. We measure irradiance I. Since I is proportional to a^2, and ln a = 2.3026 log a, we can write,

$$\sigma_x^2 = \frac{2.3026^2}{4} \langle \log I - \langle \log I \rangle \rangle^2 \tag{2}$$

Refer to Fig 5. In the log unit, 2 V = one decade and the bandpass unit subtracts off <log I> so that

$$\sigma_x^2 = \frac{2.3026^2}{4} (V_3/2)^2$$

$$\sigma_x^2 = 0.3314\ V_3^2. \tag{3}$$

Combining (1) and (3),

$$C_n^2 = 0.3314\ K\ D^{7/3}\ L^{-3}\ V_3^2. \tag{4}$$

Decide on the following instrument calibration:

$$C_n^2 = 10^{-12}\ V_4^2. \tag{5}$$

Determine gain G as a function of path length L. From the circuit,

$$V_4 = G\ V_3 \tag{6}$$

Combining (4), (5), and (6) to eliminate C_n^2, V_3, and V_4,

$$G = 5.757 \times 10^5\ K^{1/2}\ D^{7/6}\ L^{-3/2}. \tag{7}$$

Decide on the following log output calibration (V_5):

$$C_n^2 = 10^{(V5-14)}. \tag{8}$$

Combining (5) and (8),

$$V_5 = 2 + 2 \log V_4. \tag{9}$$

Thus the log unit should be set so that

$$V_5 = 0 \text{ when } V_4 = 0.1 \text{ V}$$

and

$$V_5 = 2 \text{ when } V_4 = 1.0 \text{ V (i.e., 2 V/decade)}$$

To determine the RMS voltage to be used to check the circuit gain, set V_4 = 1 V (V_5 = 2 V). Then from (7),

$$G = V_4/V_3 = 1/V_3 = 5.757 \times 10^5 K^{1/2} D^{7/6} L^{-3/2} \tag{10}$$

Now calculate the gain G as a function of pot position P. From the circuit,

$$G = 2 \times 2.62(100000 - R)/(4700 + R)$$

since

$$R = 10P$$

$$P = (5240 - 47G)/(G + 5.24) \quad , \tag{11}$$

where P is the digital pot setting. From (7) and (11) we can now calculate P as a function of K, D, and L.

K depends on the transmitter-receiver aperture geometry. We define K in (1) for D, the largest aperture in the system. In this instrument both apertures are 14.6 cm in diameter. From Wang et al. (1978), one can calculate K = 4.474. From (7) and (11), knowing D and K, we can calculate P as a function of L.

For K = 4.474 and D = 0.146 m,

$$P = (5240 - 6.068\times10^6 L^{-3/2})/(1.291\times10^5 L^{-3/2} + 5.24) \tag{12}$$

A tabulation of P for L is included in Table 1.

Derivation of Calibration Signal and Instrument Output Relationship

The calibration board generates a calibration signal that consists of a 7 Khz square-wave amplitude modulated by a 10 Hz square wave. This calibration signal is processed by the circuit as follows. When switched into the receiver, the pulse train is decoded and demodulated, the logarithm is taken with 1 decade = 2 V, and the mean is removed (V_3). Then in terms of the maximum-to-minimum square-wave voltage ratio (a/b), the root mean square output voltage V_3 is then (see Fig. 6)

$$V_3 = [(\log (a/b))^2]^{1/2}. \tag{13}$$

From (13), (9), (10), and (11) we can obtain the output voltage V_5 as a function of a/b and P.

$$V_5 = 2 + 2 \log \{(5240 - 5.24 P)[\log(a/b)]/(P + 47)\} \tag{14}$$

If a/b = 2, as set up in the calibration procedure in Appendix A, and P is set to 594, $V_5 = 2.0$ V.

Saturation Criteria

The limit imposed by the saturation of scintillation for equal aperture diameters is (Ochs, et al, 1985; Ochs et al, 1989)

$$L < 0.54 D^{5/8} \lambda^{1/8} (C_n^2)^{-3/8} \tag{15}$$

Where L is the maximum path length for a given C_n^2, $\lambda = 0.94$ μm is the optical wavelength, and D is the aperture diameter.

APPENDIX C
CIRCUIT DIAGRAMS

Figure 1. Transmitter

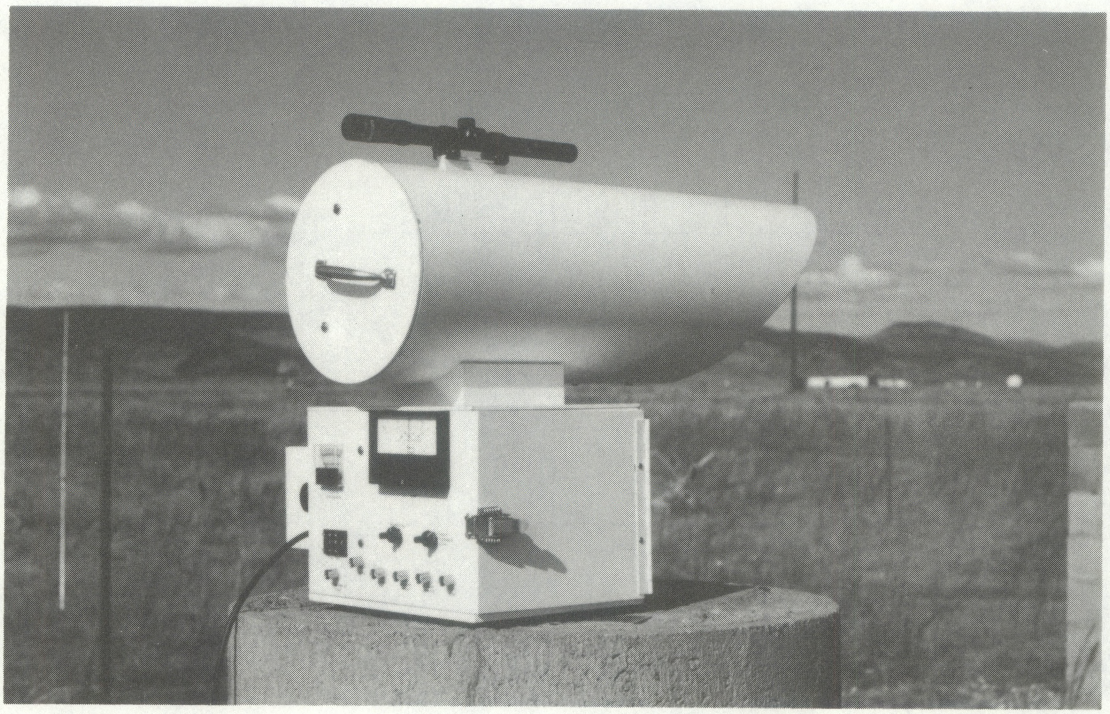


Figure 2. Receiver

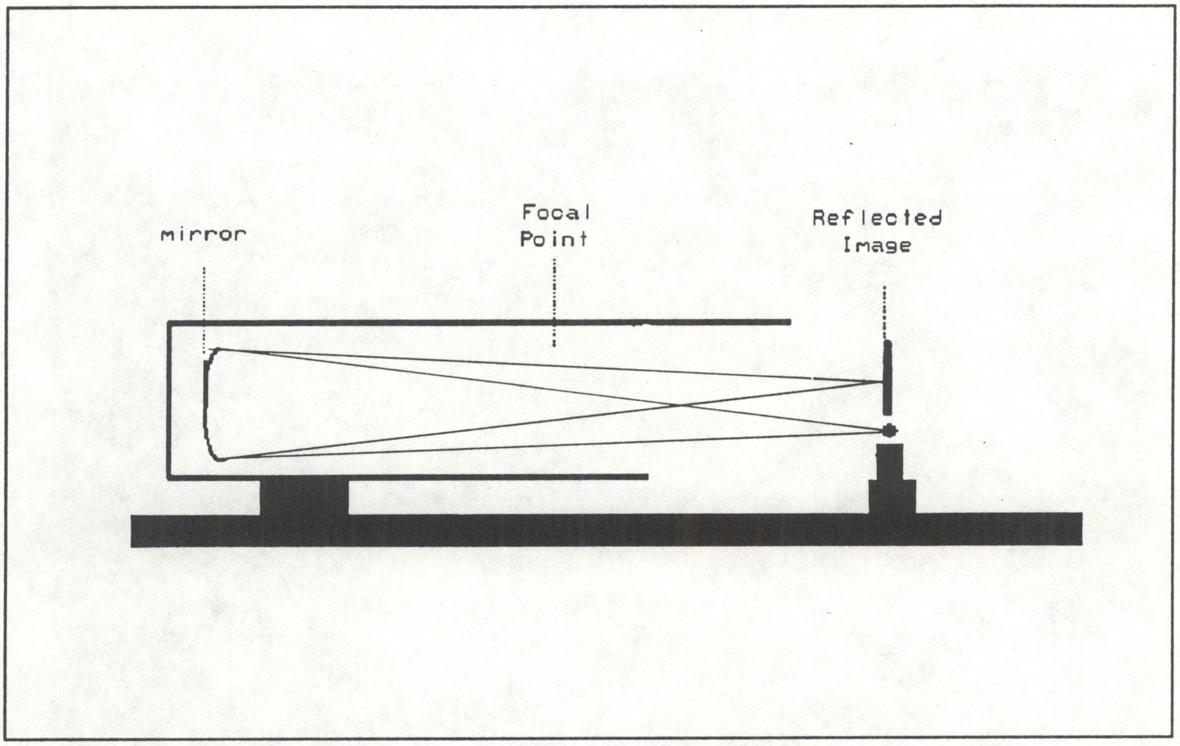


Figure 3. Focusing Configuration

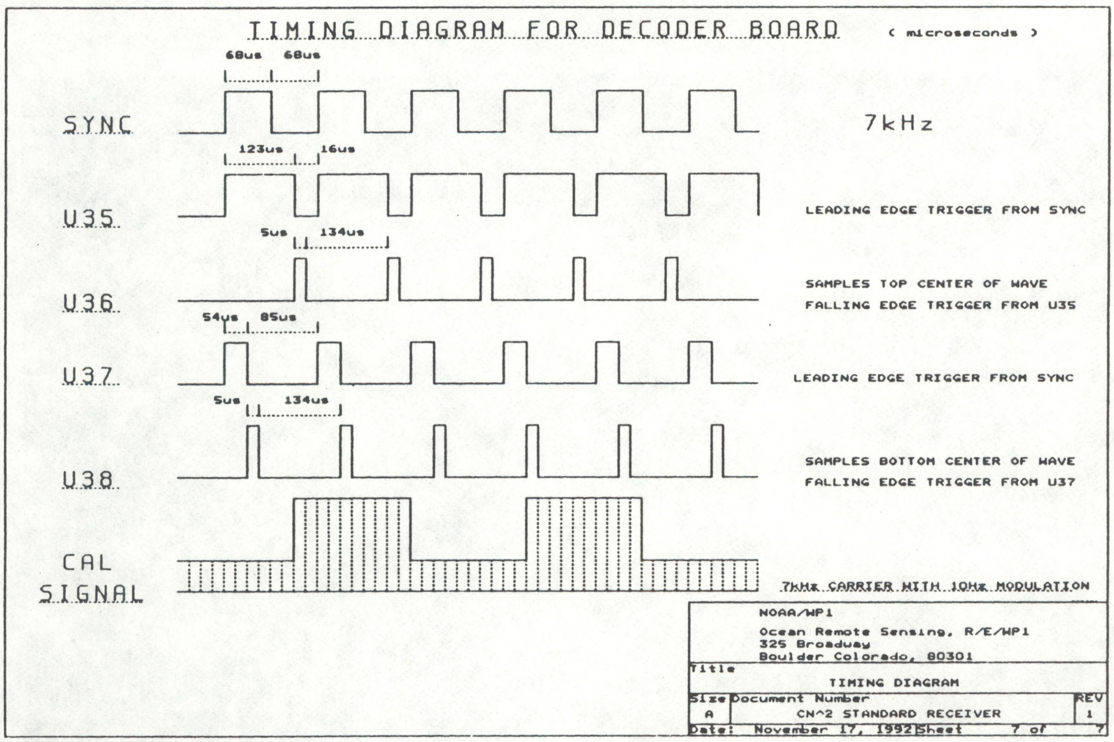


Figure 4. Receiver Timing Diagram

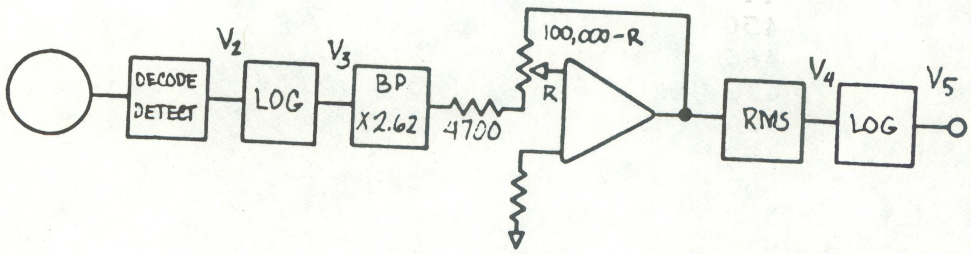


Figure 5. Receiver Simplified Block Diagram

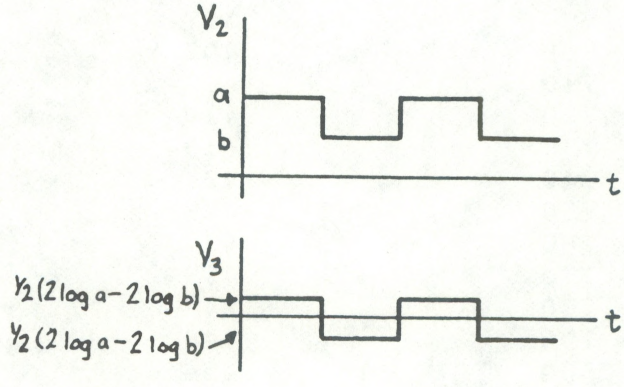


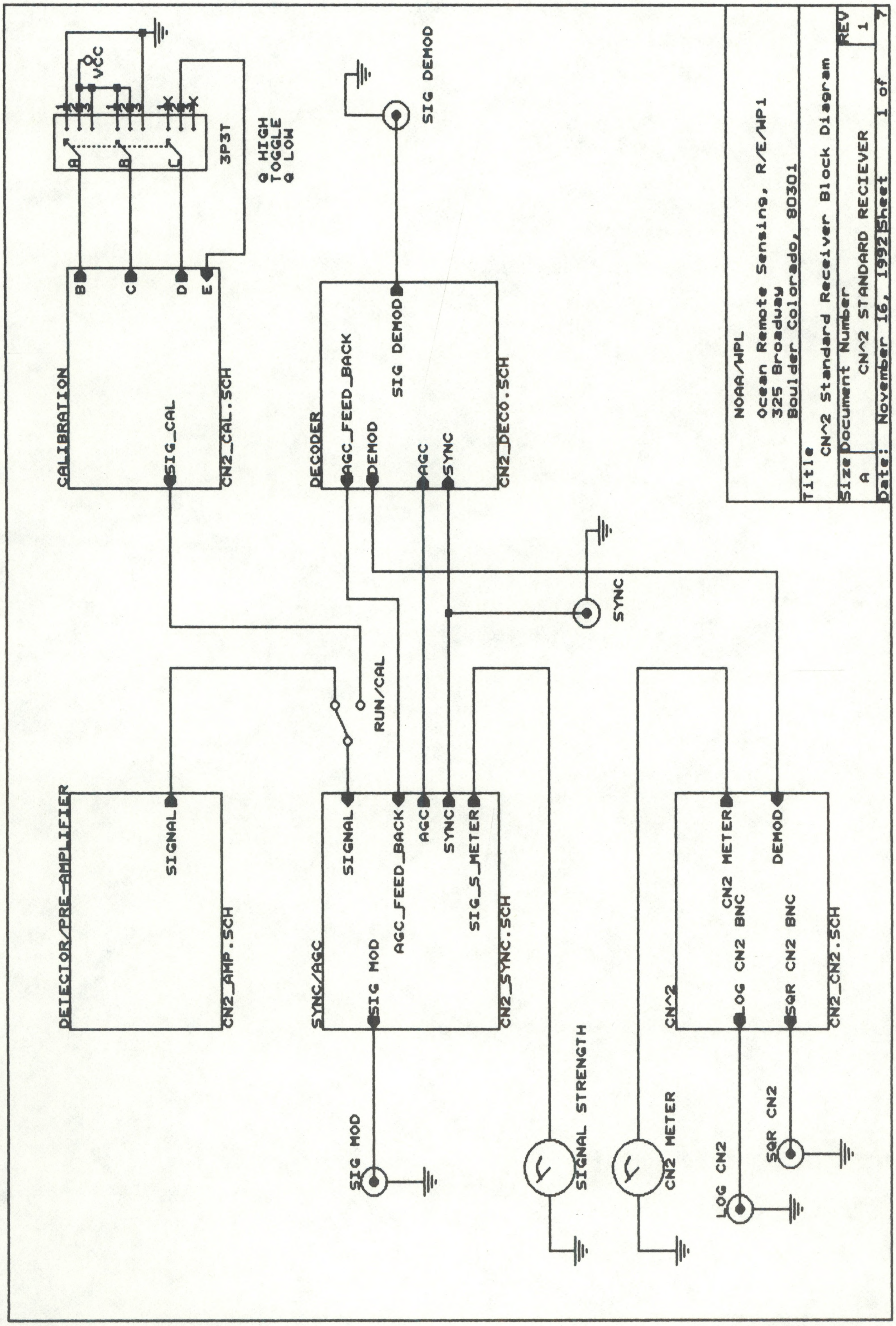
Figure 6. Derivation of Calibration Signal

Table 1. Calibration Pot Setting for Path Length

C_n^2 meter calibration for an aperture size of 0.146m.

L	P
400	210
410	217
420	224
430	231
440	238
450	245
460	252
470	259
480	266
490	273
500	280
510	287
520	293
530	300
540	306
550	313
560	319
570	326
580	332
590	338
600	344
610	350
620	356
630	362
640	368
650	374
660	380
670	386
680	391
690	397
700	402
710	408
720	419
730	419
740	424
750	429
760	434
770	439
780	444
790	449
800	454

APPENDIX C
CIRCUIT DIAGRAMS


3P3T
VCC
Q HIGH
TOGGLE
Q LOW
SIG DEMOD
CALIBRATION
SIG_CAL
CN2_CAL.SCH
B
C
D
E
DECODER
AGC_FEED_BACK
DEMOD
SIG DEMOD
AGC
SYNC
CN2_DECO.SCH
SYNC
RUN/CAL
DETECTOR/PRE-AMPLIFIER
SIGNAL
CN2_AMP.SCH
SYNC/AGC
SIG MOD
SIGNAL
AGC_FEED_BACK
AGC
SYNC
SIG_S_METER
CN2_SYNC.SCH
CN^2
LOG CN2 BNC
SQR CN2 BNC
CN2 METER
DEMOD
CN2_CN2.SCH
SIG MOD
SIGNAL STRENGTH
CN2 METER
LOG CN2
SQR CN2
NOAA/WPL
Ocean Remote Sensing, R/E/WP1
325 Broadway
Boulder Colorado, 80301
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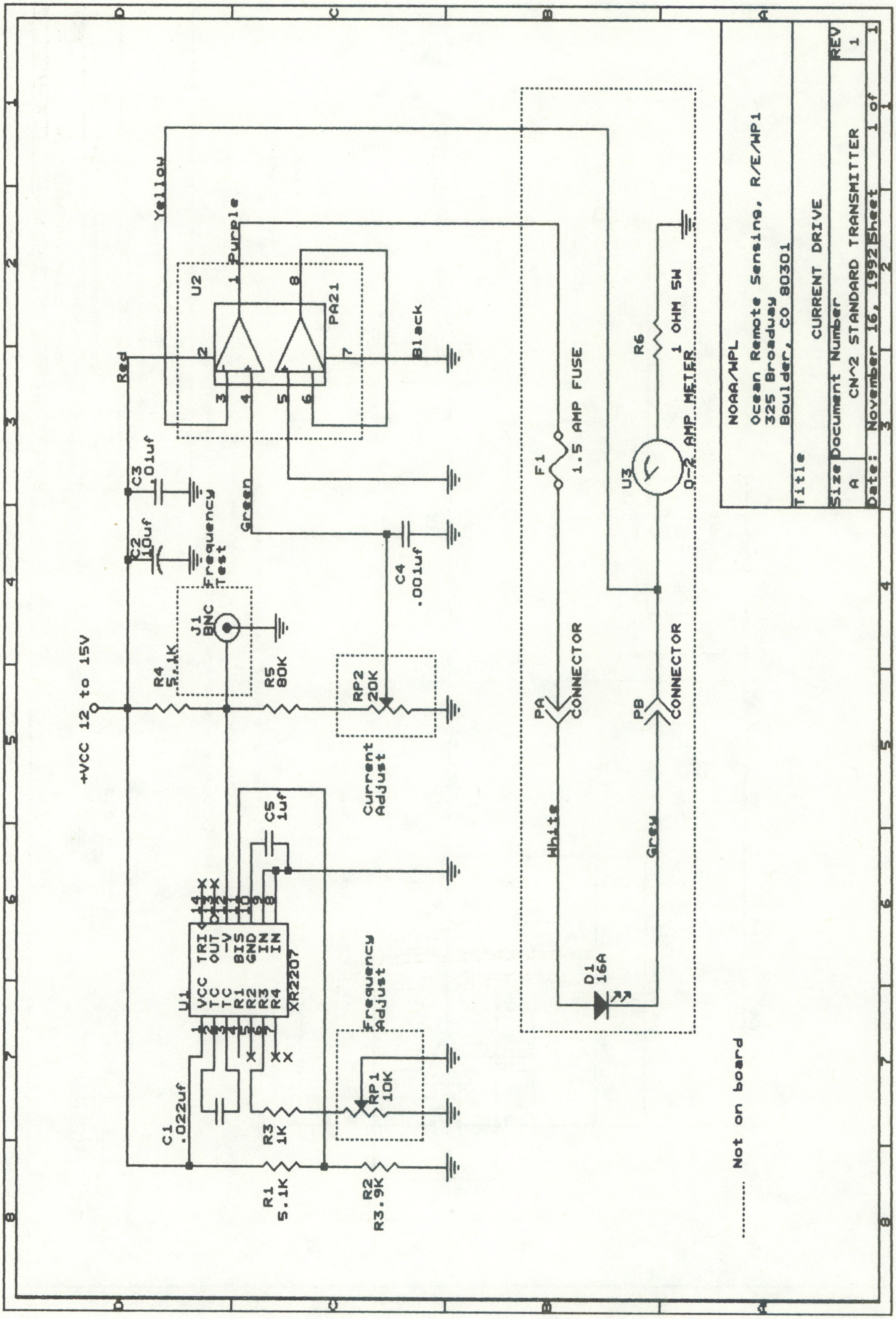
1
Date: November 16, 1992
Sheet 1 of 7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325 Broadway
Boulder, CO 80301
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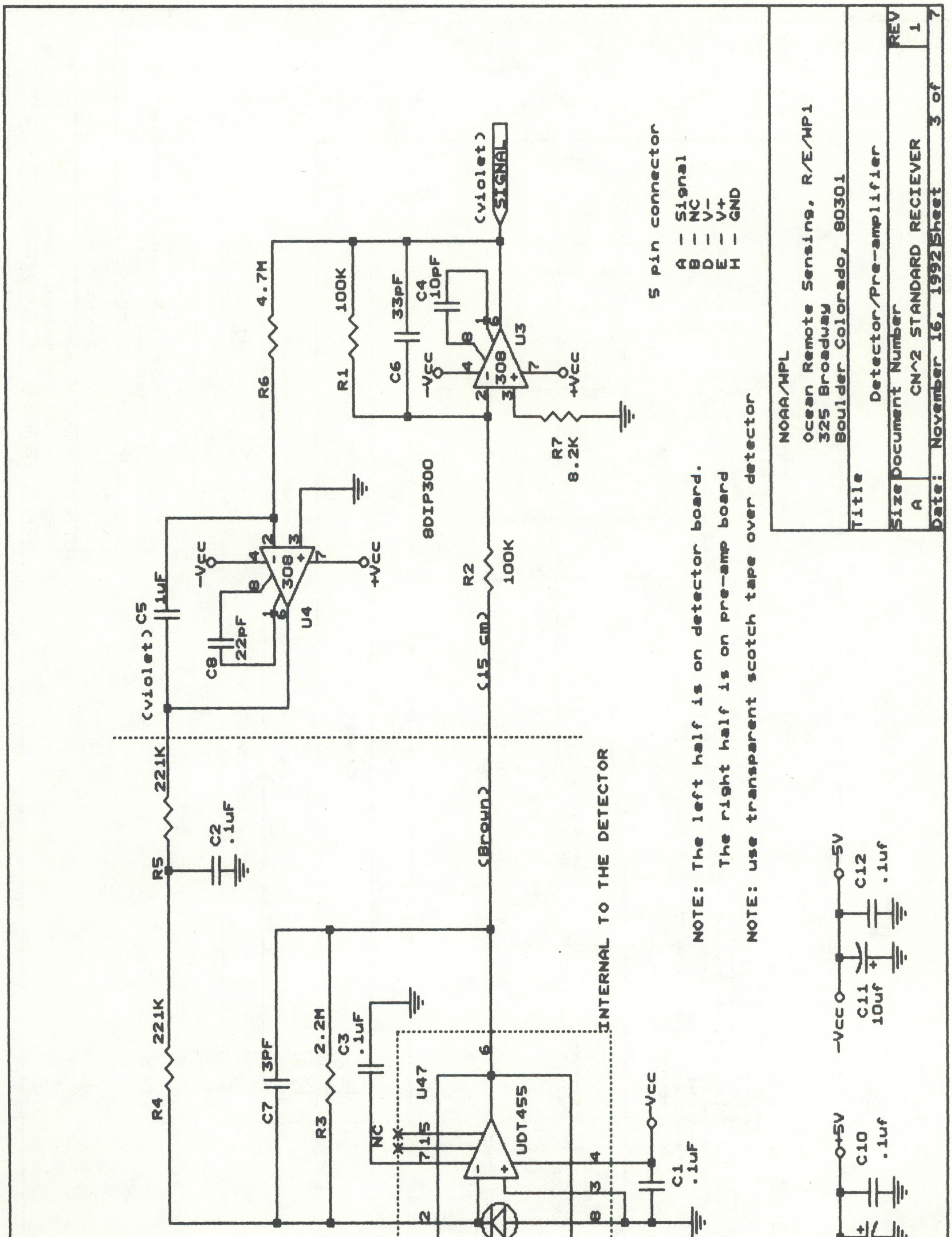
CURRENT DRIVE
Size
A
Document Number
CN^2 STANDARD TRANSMITTER
REV
1
Date: November 16, 1992
Sheet 1 of 1
+VCC 12 to 15V
R4 5.1K
J1 BNC
Frequency Test
C2 10uf
C3 .01uf
R5 80K
RP2 20K
Current Adjust
C4 .001uf
U2
PA21
Yellow
Purple
Red
Black
Green
F1
1.5 AMP FUSE
U3
0-2 AMP METER
R6
1 OHM 5W
PA
CONNECTOR
PB
CONNECTOR
White
Grey
D1
16A
U1
XR2207
VCC TC TC R1 R2 R3 R4
TRI OUT -V BIS GND IN IN
C5 1uf
Frequency Adjust
RP1 10K
C1 .022uf
R3 1K
R1 5.1K
R2 R3.9K
Not on board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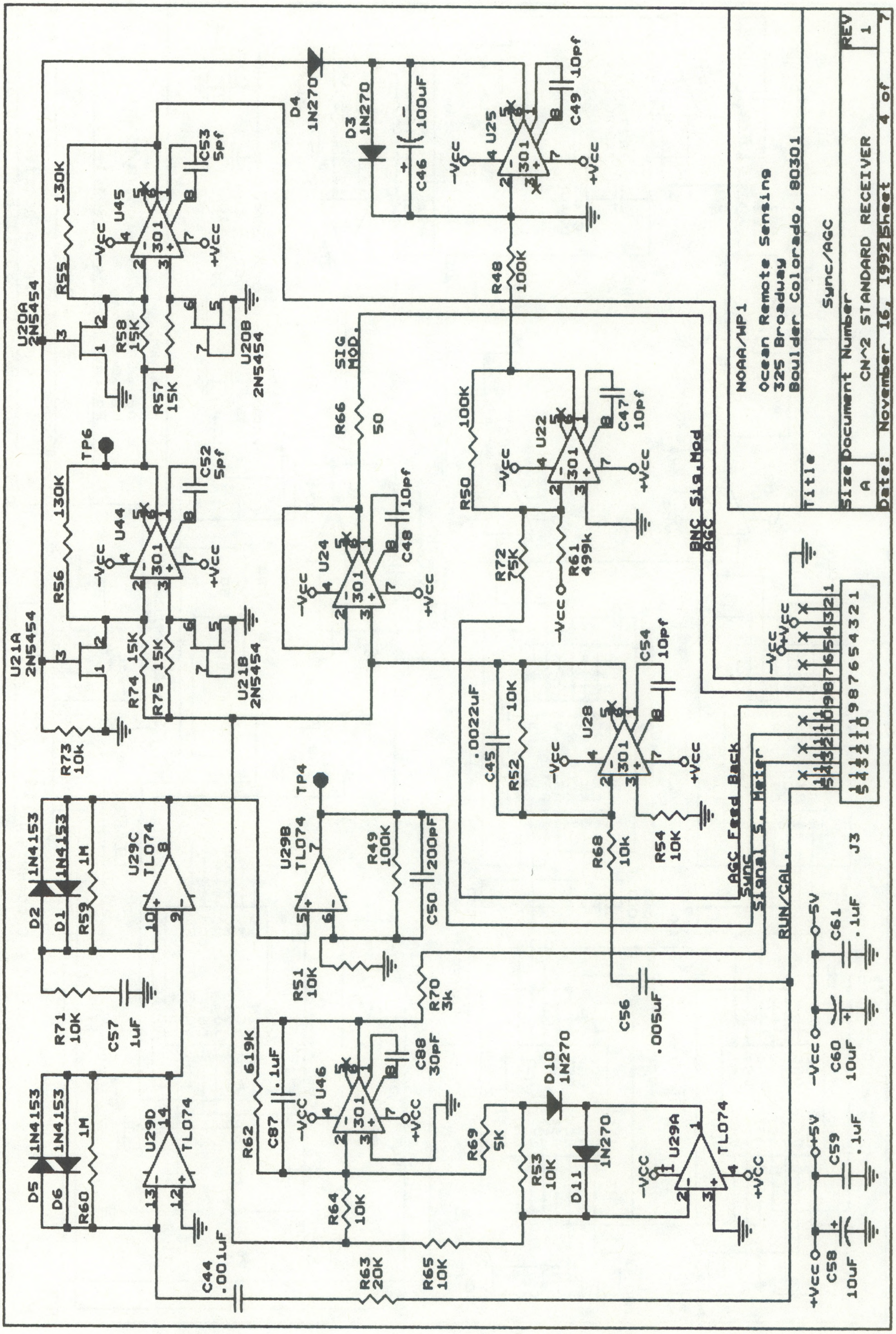
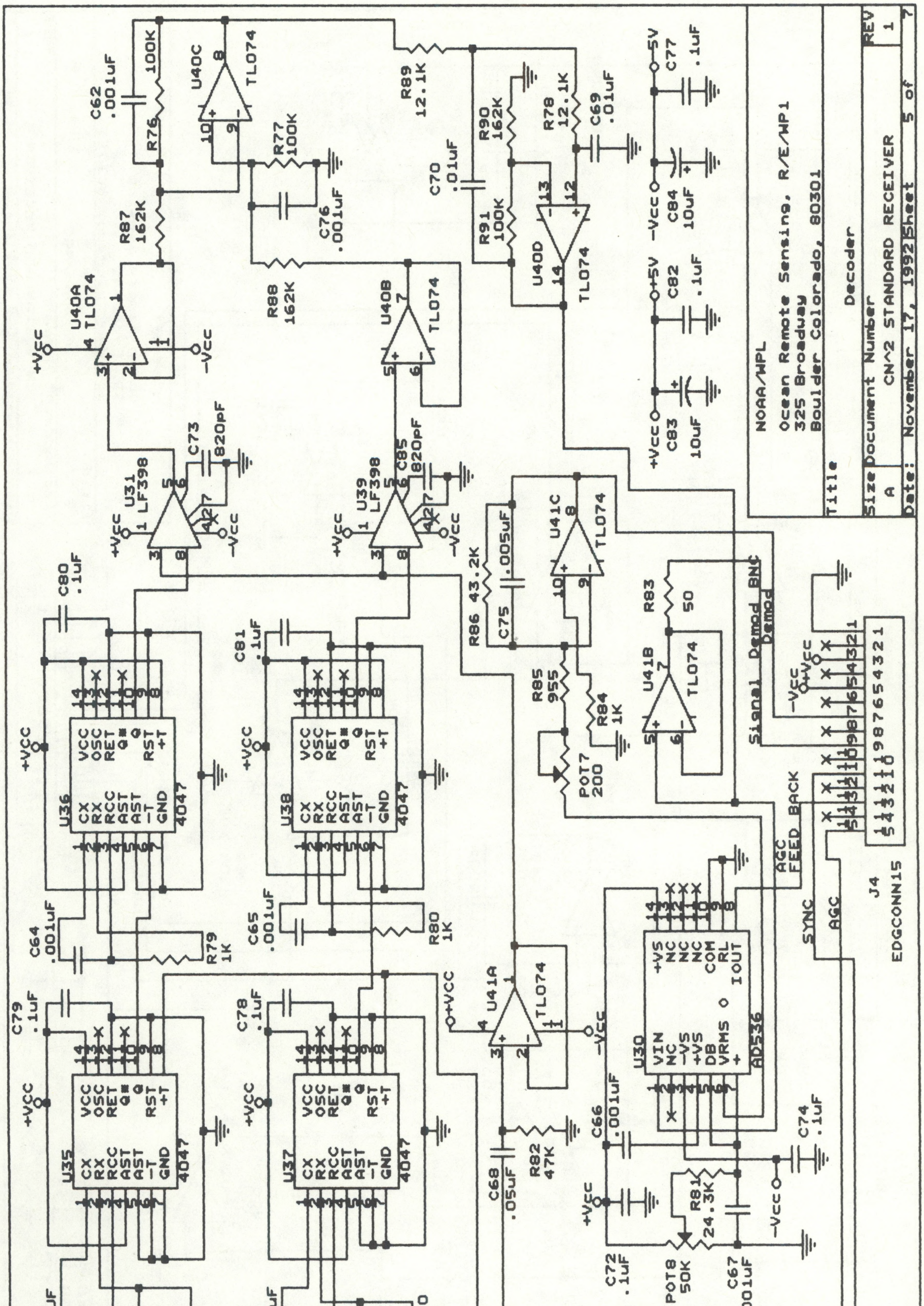
325 Broadway
Boulder Colorado, 80301
Title
Detector/Pre-amplifier
Size Document Number
A
CN^2 STANDARD RECIEVER
REV
1
Date: November 16, 1992 Sheet 3 of 7
5 pin connector
A - Signal
B - NC
D - V-
E - V+
H - GND
NOTE: The left half is on detector board.
The right half is on pre-amp board
NOTE: use transparent scotch tape over detector
INTERNAL TO THE DETECTOR
(violet)
SIGNAL
(violet)
(Brown)
(15 cm)
R6 4.7M
R1 100K
C6 33pF
C4 10pF
U3
308
R7 8.2K
R2 100K
8DIP300
C5 1uF
C8 22pF
U4
R5 221K
C2 .1uF
R4 221K
C7 3PF
R3 2.2M
C3 .1uF
U47
UDT455
NC
C1 .1uF
-Vcc
+Vcc
C9 10uf
C10 .1uf
C11 10uf
C12 .1uf
+5V
-5V


NOAA/WPL
Ocean Remote Sensing
325 Broadway
Boulder Colorado, 80301
Title
Sync/AGC
Size
A
Document Number
CN^2 STANDARD RECEIVER
REV
1
Date: November 16, 1992 Sheet 4 of 7


NOAA/WPL
Ocean Remote Sensing, R/E/WP1
325 Broadway
Boulder Colorado, 80301
Title
Decoder
Size
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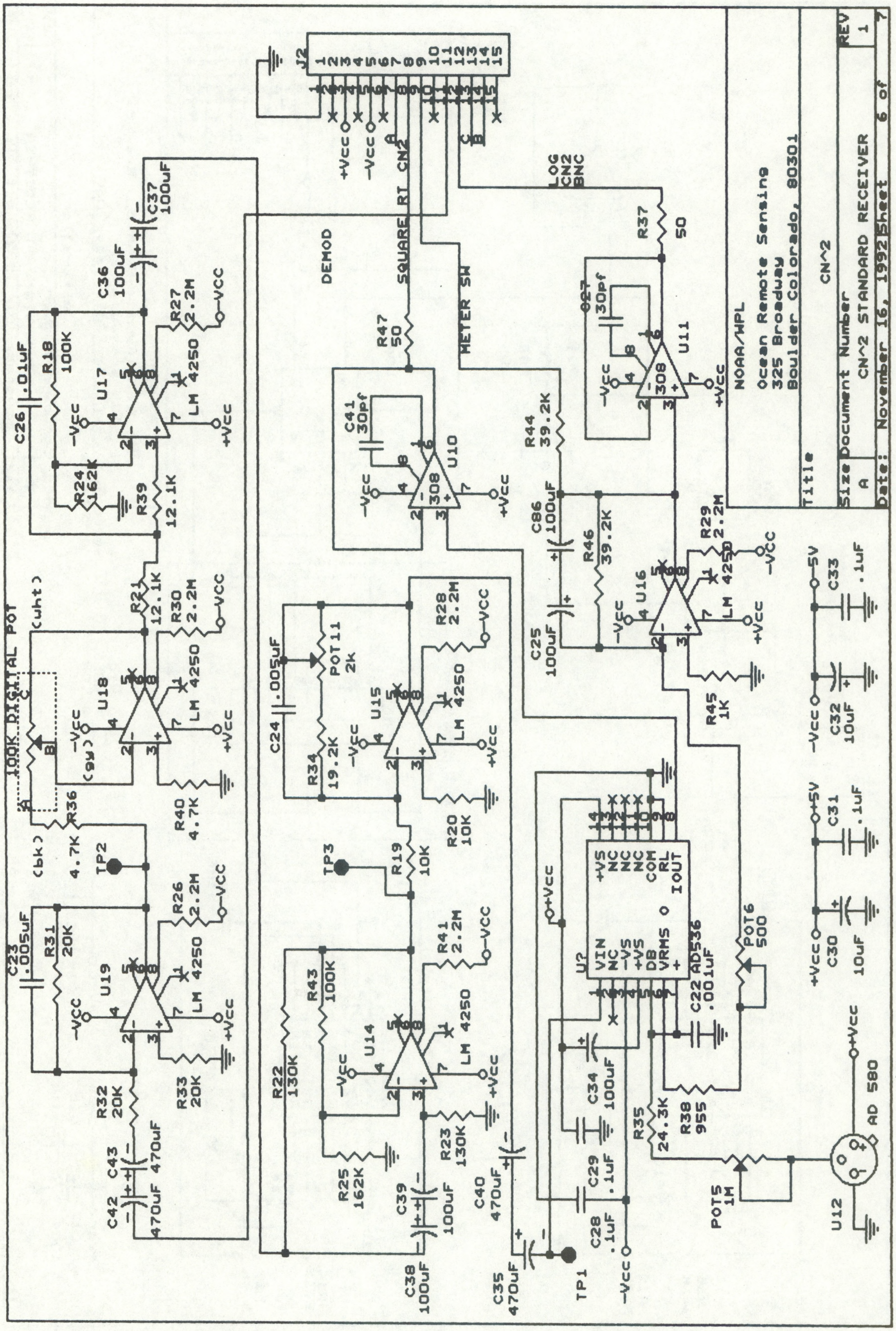
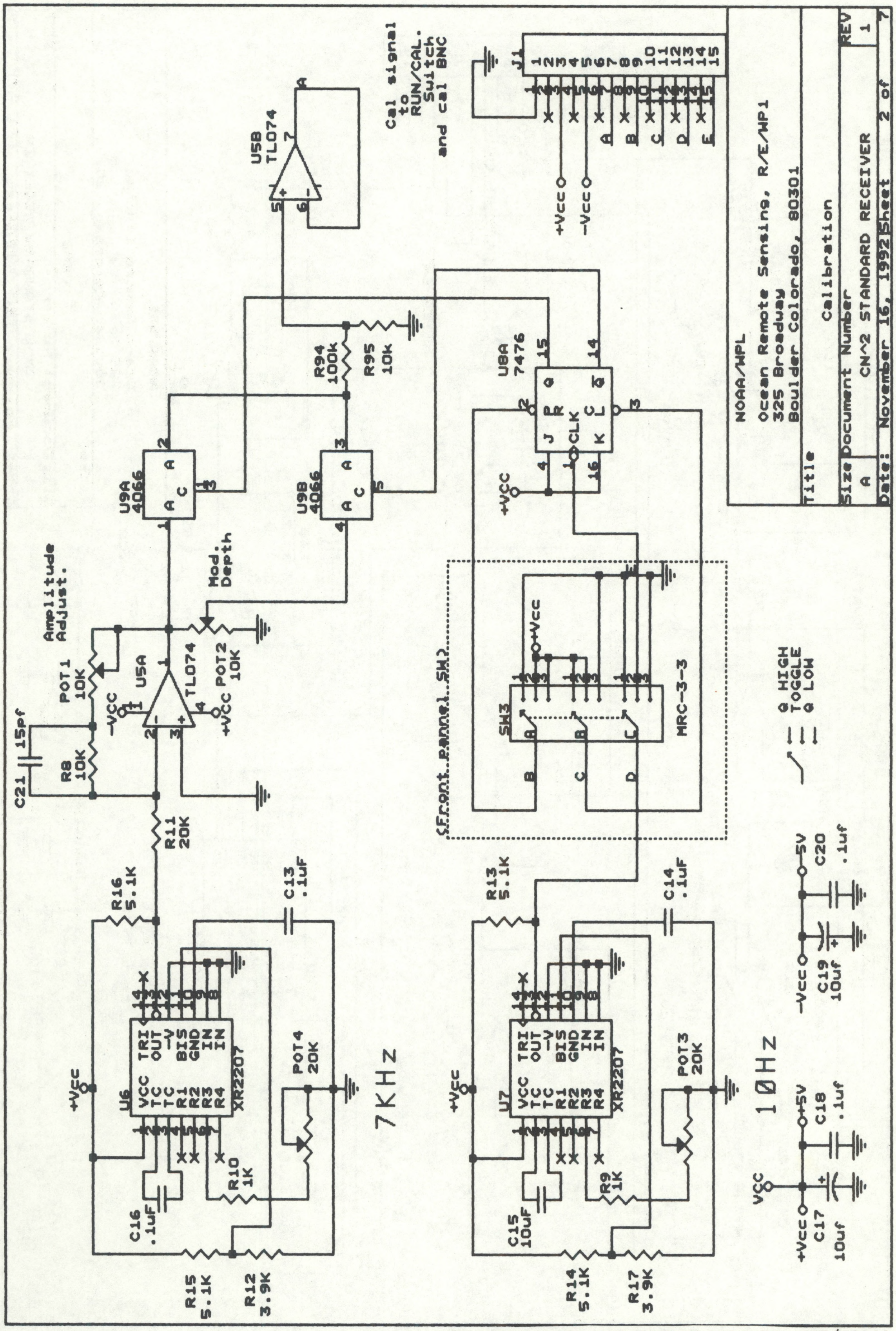
Document Number
CN^2 STANDARD RECEIVER
REV
1
Date: November 17, 1992
Sheet 5 of 7
J4
EDGCONN15


NOAA/WPL
Ocean Remote Sensing
325 Broadway
Boulder Colorado, 80301
Title
CN^2
Size Document Number
A CN^2 STANDARD RECEIVER
REV
1
Date: November 16, 1992 Sheet 6 of 7


NOAA/WPL
Ocean Remote Sensing, R/E/WP1
325 Broadway
Boulder Colorado, 80301
Title
Calibration
Size
A
Document Number
CN^2 STANDARD RECEIVER
REV
1
Date: November 16, 1992
Sheet 2 of 7
Cal signal to RUN/CAL. Switch and cal BNC
Amplitude Adjust.
Mod. Depth
(Front pannel SW)
7KHz
10Hz
XR2207
TL074
4066
7476
MRC-3-3
Q HIGH
TOGGLE
Q LOW