NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA ELECTRONICS MEMORANDUM NO. 143

VLA ELECTRONICS BLOCK DIAGRAM REVISIONS

S. Weinreb

March 22, 1974

The following changes have been made between March 1973 and March 1974:

1. Change 500, 1250, and 1750 MHz to 600, 1200, and 1800 MHz.

The original system required multiplying 250 MHz by x5 and x7. These multipliers are not as phase-stable as x2 and x3 units with input at 600 MHz. This change causes many frequencies throughout the system to change.

2. Provide Variable Bandwidth.

Computer-selectable bandwidths of 50, 24, 12, 4, 1.5 and 0.5 MHz have been incorporated in Unit 1016.

3. Antenna LO Simplification .

The original LO was tunable at the antenna in 5 MHz steps. A simplified system shown on page 2 of Block 04 allows tuning in 20 or 30 MHz steps at a cost savings of ∿$20,000 per antenna. A final LO in the control room allows tuning in steps of 10 Hz.

4. Lobe Rotation at Antenna.

The original system provided lobe rotation in the control room. By moving the lobe rotation to the antenna and increasing the phase-switching frequency the allowable level of spurious signals in the IF transmission system has been increased from -60 dB to -30 dB (See VLA Electronics Memos #116 and 122). Lobe rotation at the antenna is also a step needed for digital transmission of IF signals.

5. Phase-Switch Detection at Sampler.

The phase-switching pattern applied at the antenna will be removed by applying the same pattern at each sampler (in lieu of the computer as originally planned). This allows faster phase switching and reduces the computer load.

6. Alternate Front-End Input.

A computer-controlled coaxial switch to allow input of an alternate front-end having 1-2 GHz IF output has been provided in Block 02.

7. Polarization Transfer Switch.

A computer-controlled transfer switch has been incorporated at the input of the Frequency Converter, Block 02. This will allow the back-ends used for the

two polarizations to be exchanged. The purpose is to determine and eliminate effects due to small differences in the back-ends.

8. Alternate Digital-Data Transmission Channel.

Tests of the breadboard system indicated that the digital monitor and control data carried on the 1800 MHz carrier may interfere with LO phase information on this same carrier. A separate 1975 MHz carrier, FM modulated by digital data, has been incorporated as an alternative. Tests of the Antenna 1-2 system will determine which method will be used.

9. Low-Frequency LO Output.

An output from unit (0437) provides LO outputs at nx50 $\pm$10 MHz for n=1 to 20. This is a by-product of the 2.8 to 3.8 GHz LO and should be useful for low frequency front-ends.

10. Change IF Transmission Transmit-Receive Repetition Rate.

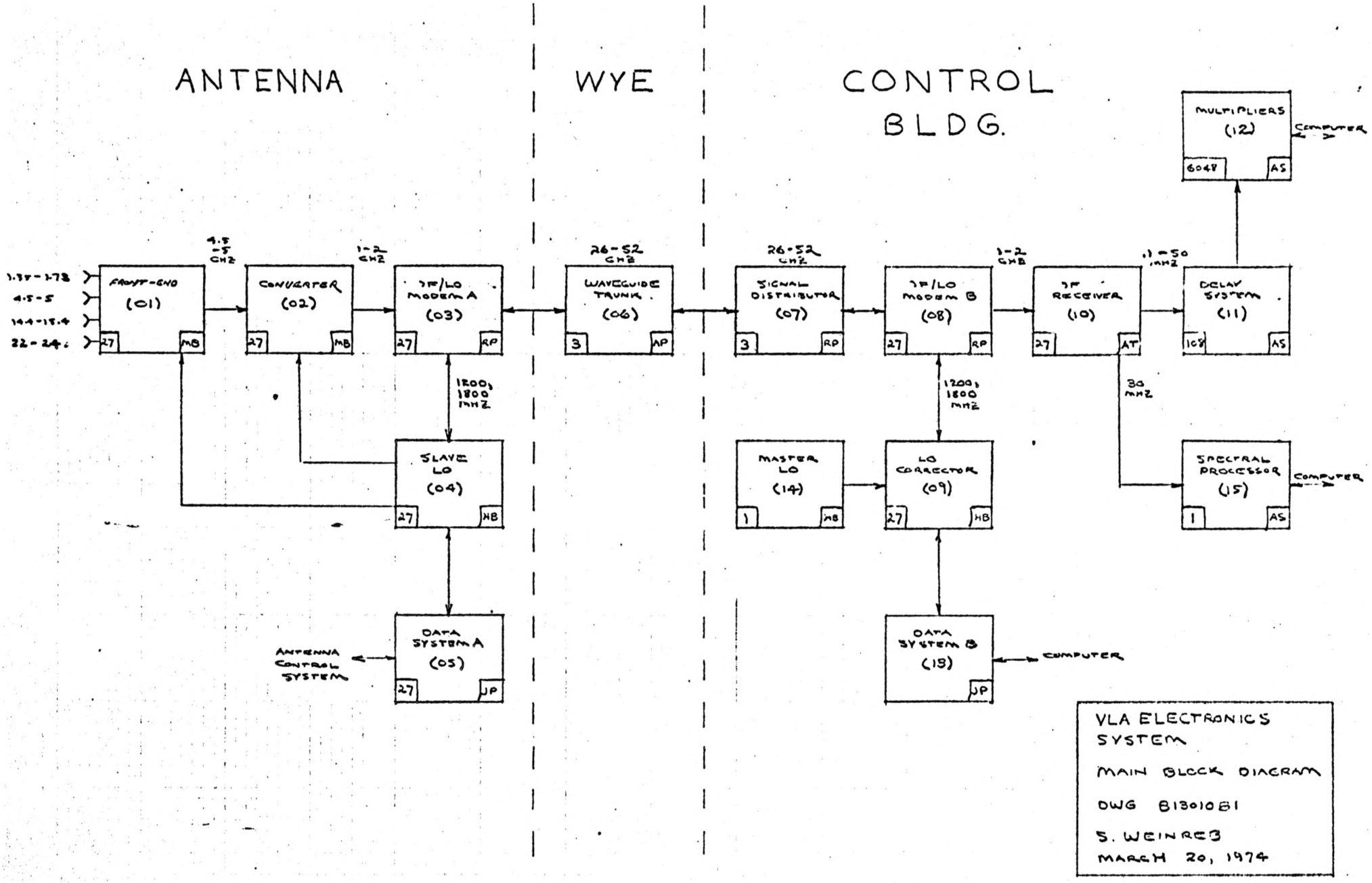
This rate has been changed from 20 Hz to 19.20 Hz to reduce the effect of 60 Hz power line pickup in the system. The 19.2 Hz has period 52.0833... ms and 192 cycles will give exactly 10 seconds of integration (in lieu of the original 9.6 seconds).

11. Transmission of Timing Pulse to Antenna.

A fast-rise time ($\sim$50 ns) pulse, labeled TP on block diagrams, will be provided by keying the 1200 and 1800 MHz carriers to each antenna at a 6.4 Hz rate. This pulse, in conjunction with the 5 MHz and 600 MHz LO signals and a 0.1 Hz bit in the data system, provides a fixed time relation between every antenna and the control room. This time relation is stable to 3 ps, unambiguous to 10s, and is recovered after a power failure. Without the timing pulse, ambiguities of 0.2 μs could exist and would effect the accuracy of the antenna lobe rotator. The TP pulse will occur 50 μs after the T/R pulse.

12. Additional Voltage-Controlled Oscillators (VCO's).

A crystal 50 MHz VCO has been added in the master and slave multiplier chains to eliminate spurious 5 MHz sidebands on high-frequency carriers. Cavity VCO's at 1200 and 1800 MHz have replaced voltage controlled phase-shifters in circuitry to narrow-band filter received carriers; the voltage controlled phase-shifter circuitry was too slow and unstable.



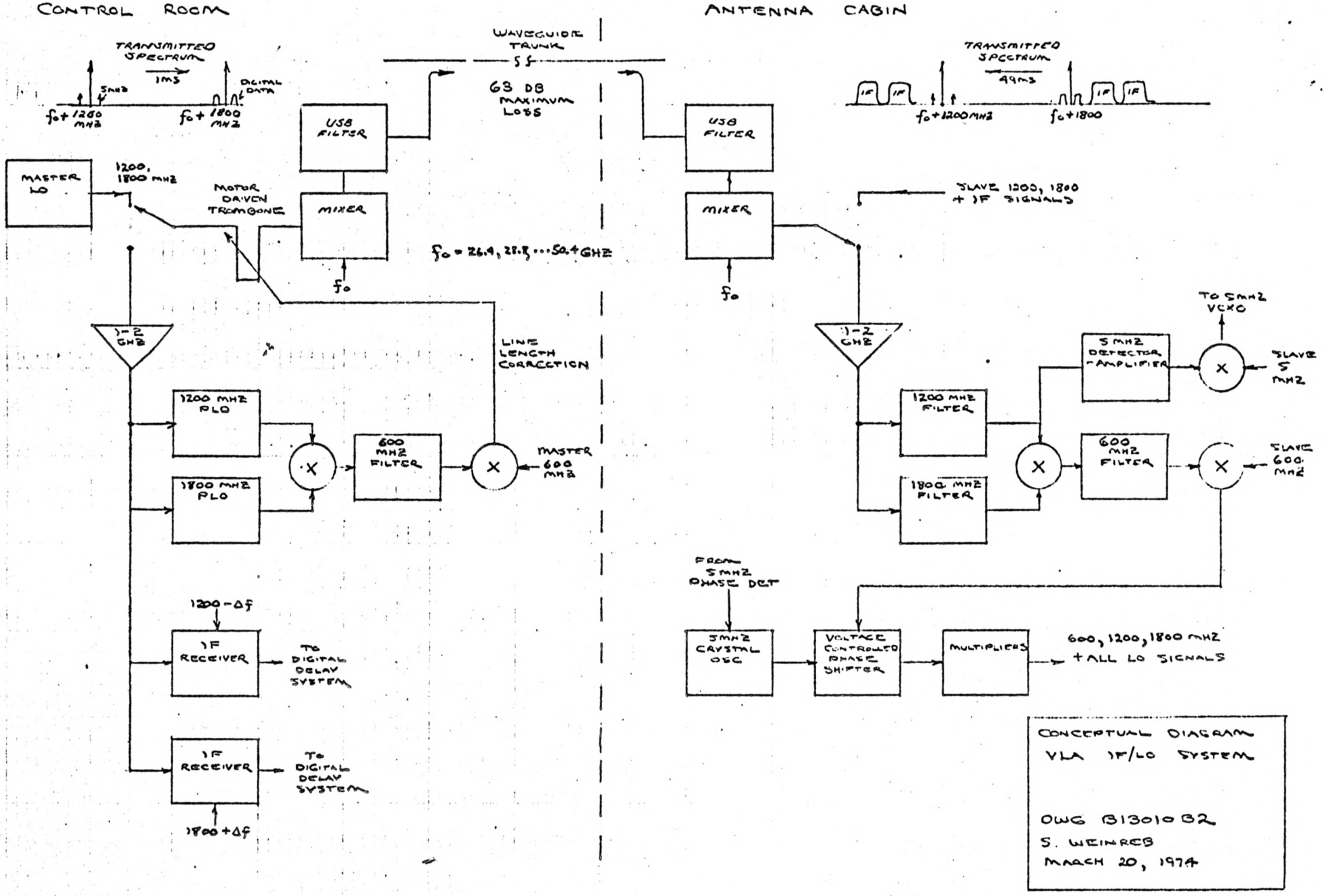
VLA ELECTRONICS SYSTEM

MAIN BLOCK DIAGRAM

DWG B1301081

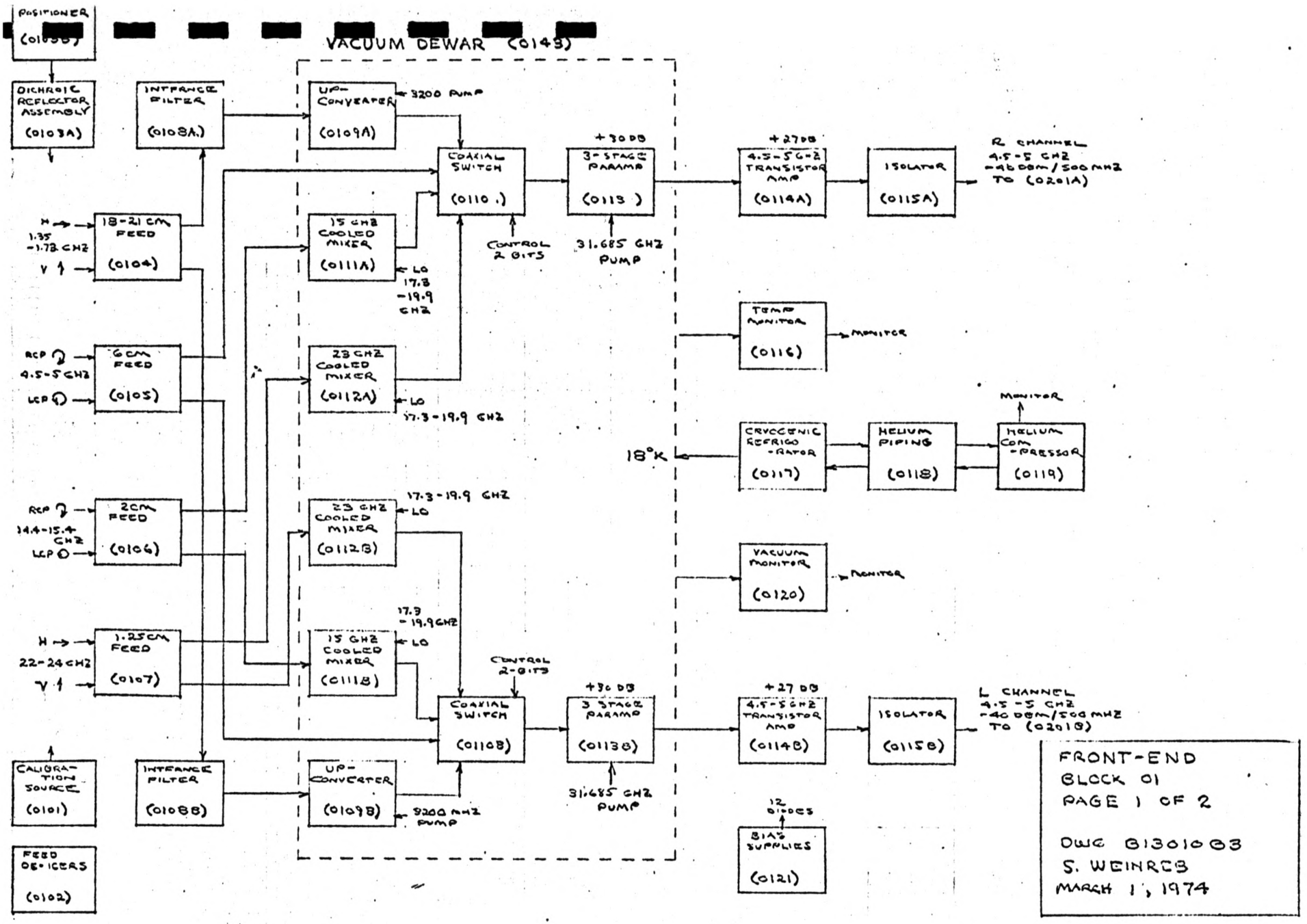
S. WEINREB

MARCH 20, 1974

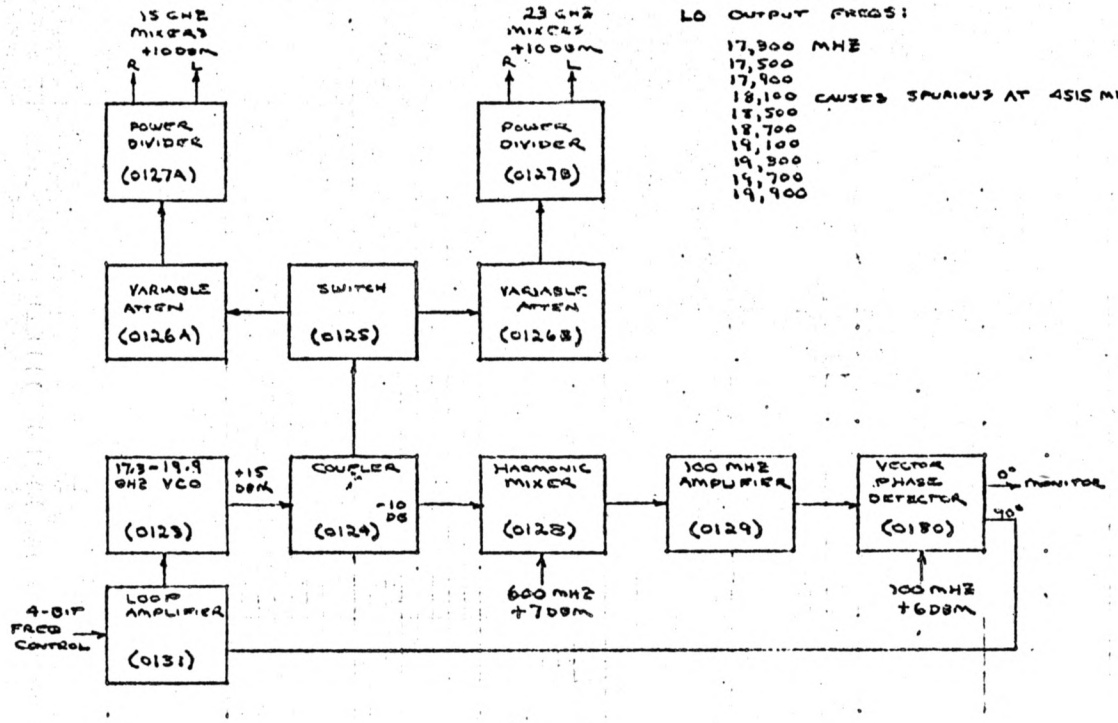


CONCEPTUAL DIAGRAM
VLA IF/LO SYSTEM

OWG B13010 B2
S. WEINREB
MARCH 20, 1974


POSITIONER
(0100)
VACUUM DEWAR (0143)
DICHROIC REFLECTOR ASSEMBLY (0103A)
INTERFACE FILTER (0108A)
UP-CONVERTER (0109A)
3200 PUMP
COAXIAL SWITCH (0110A)
CONTROL 2 BITS
+30 DB
3-STAGE PARAMP (0113)
31.685 GHZ PUMP
+27DB
4.5-5 GHZ TRANSISTOR AMP (0114A)
ISOLATOR (0115A)
R CHANNEL 4.5-5 GHZ -96 DBM/500 MHZ TO (0201A)
H 1.35-1.73 GHZ
V
18-21 CM FEED (0104)
15 GHZ COOLED MIXER (0111A)
LO 17.3-19.9 GHZ
RCP 4.5-5 GHZ
LCP
6CM FEED (0105)
23 GHZ COOLED MIXER (0112A)
LO 17.3-19.9 GHZ
TEMP MONITOR (0116)
MONITOR
18°K
CRYOGENIC REFRIGERATOR (0117)
HELIUM PIPING (0118)
HELIUM COMPRESSOR (0119)
MONITOR
RCP 14.4-15.4 GHZ
LCP
2CM FEED (0106)
23 GHZ COOLED MIXER (0112B)
17.3-19.9 GHZ
LO
VACUUM MONITOR (0120)
MONITOR
H 22-24 GHZ
V
1.25CM FEED (0107)
17.3-19.9 GHZ
15 GHZ COOLED MIXER (0111B)
LO
CONTROL 2-BITS
COAXIAL SWITCH (0110B)
+30 DB
3 STAGE PARAMP (0113B)
31.685 GHZ PUMP
+27 DB
4.5-5 GHZ TRANSISTOR AMP (0114B)
ISOLATOR (0115B)
L CHANNEL 4.5-5 GHZ -96 DBM/500 MHZ TO (0201B)
CALIBRATION SOURCE (0101)
INTERFACE FILTER (0108B)
UP-CONVERTER (0109B)
9200 MHZ PUMP
12 DIODES
BIAS SUPPLIES (0121)
FEED DE-ICERS (0102)
FRONT-END
BLOCK 01
PAGE 1 OF 2
DWG 8130103
S. WEINREB
MARCH 1, 1974

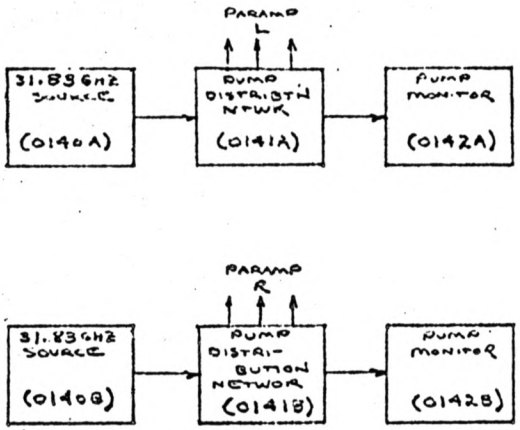
17.3 - 19.9 GHZ LOCAL OSCILLATOR



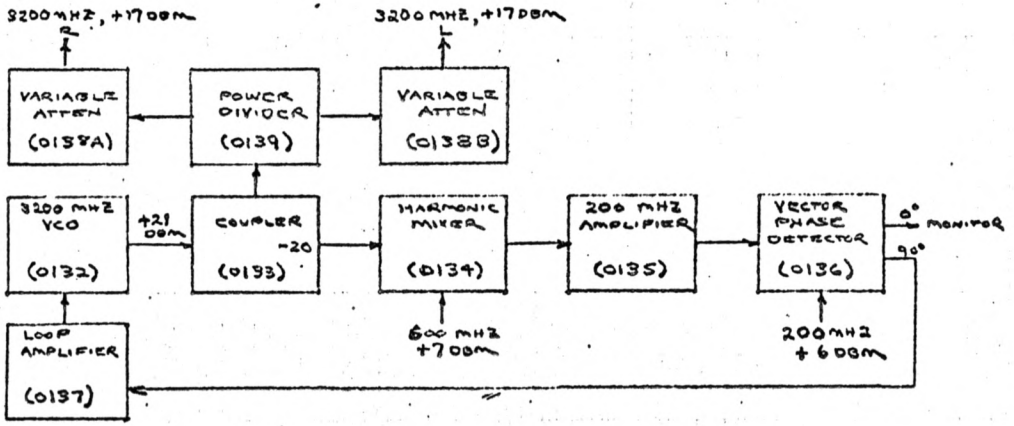
LO OUTPUT FREQS:

17,300 MHZ
17,500
17,900
18,100 CAUSES SPURIOUS AT 4515 MHZ
18,500
18,700
19,100
19,300
19,700
19,900

31.83 GHZ PARAMP PUMPS



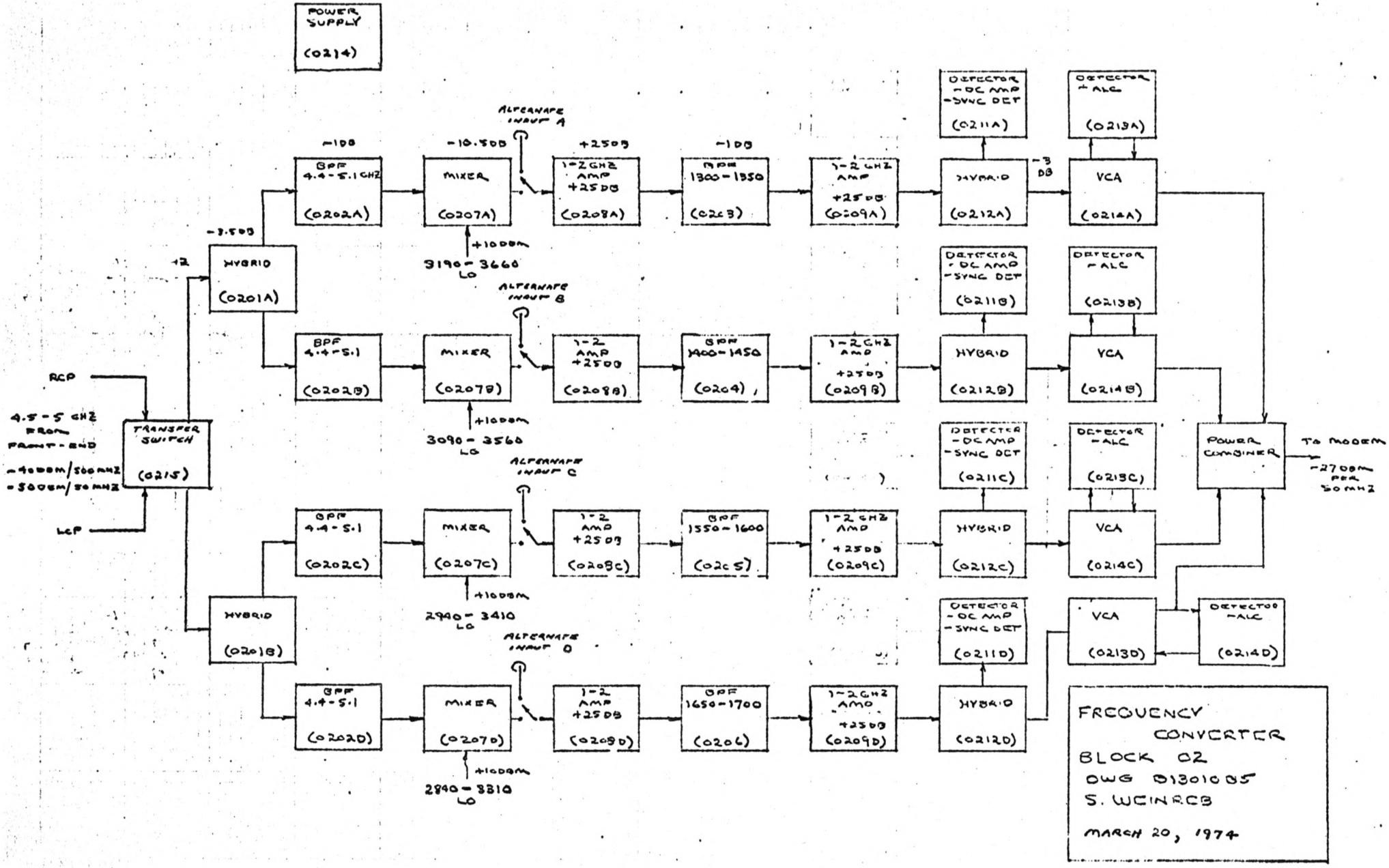
3.20 GHZ UP-CONVERTER PUMP

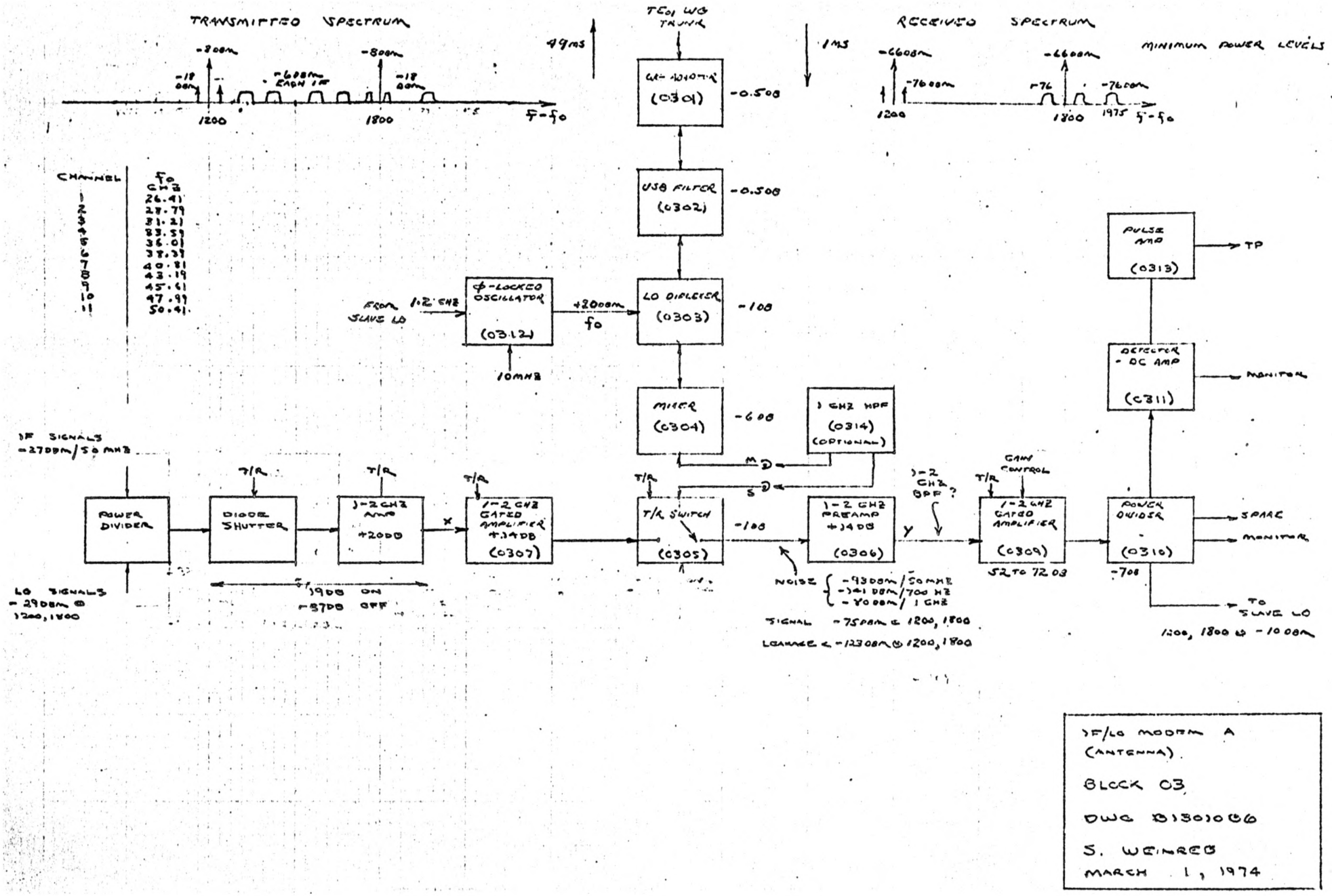


FRONT-END
BLOCK 01
PAGE 2 OF 2

DWG 013010 04

S. WEINREB
MARCH 20, 1974


POWER SUPPLY (0214)
ALTERNATE INPUT A
-10
-10.5DB
+25DB
-10DB
DETECTOR -DC AMP -SYNC DET (0211A)
DETECTOR -ALC (0213A)
BPF 4.4-5.1GHZ (0202A)
MIXER (0207A)
1-2GHZ AMP +25DB (0208A)
BPF 1300-1350 (0203)
1-2 GHZ AMP +25DB (0209A)
HYBRID (0212A)
-3 DB
VCA (0214A)
-3.5DB
+2
HYBRID (0201A)
+10DBM
3190-3660 LO
ALTERNATE INPUT B
DETECTOR -DC AMP -SYNC DET (0211B)
DETECTOR -ALC (0213B)
BPF 4.4-5.1 (0202B)
MIXER (0207B)
1-2 AMP +25DB (0208B)
BPF 1400-1450 (0204)
1-2GHZ AMP +25DB (0209B)
HYBRID (0212B)
VCA (0214B)
RCP
4.5-5 GHZ FROM FRONT-END
-40DBM/500MHZ
-50DBM/50MHZ
TRANSFER SWITCH (0215)
+10DBM
3090-3560 LO
ALTERNATE INPUT C
DETECTOR -DC AMP -SYNC DET (0211C)
DETECTOR -ALC (0213C)
POWER COMBINER
TO MODEM
-27DBM PER 50MHZ
LCP
BPF 4.4-5.1 (0202C)
MIXER (0207C)
1-2 AMP +25DB (0208C)
BPF 1550-1600 (0205)
1-2GHZ AMP +25DB (0209C)
HYBRID (0212C)
VCA (0214C)
+10DBM
2940-3410 LO
HYBRID (0201B)
ALTERNATE INPUT D
DETECTOR -DC AMP -SYNC DET (0211D)
VCA (0213D)
DETECTOR -ALC (0214D)
BPF 4.4-5.1 (0202D)
MIXER (0207D)
1-2 AMP +25DB (0209D)
BPF 1650-1700 (0206)
1-2GHZ AMP +25DB (0209D)
HYBRID (0212D)
+10DBM
2840-3310 LO
FREQUENCY CONVERTER
BLOCK 02
DWG 8130100 05
S. WEINRCB
MARCH 20, 1974



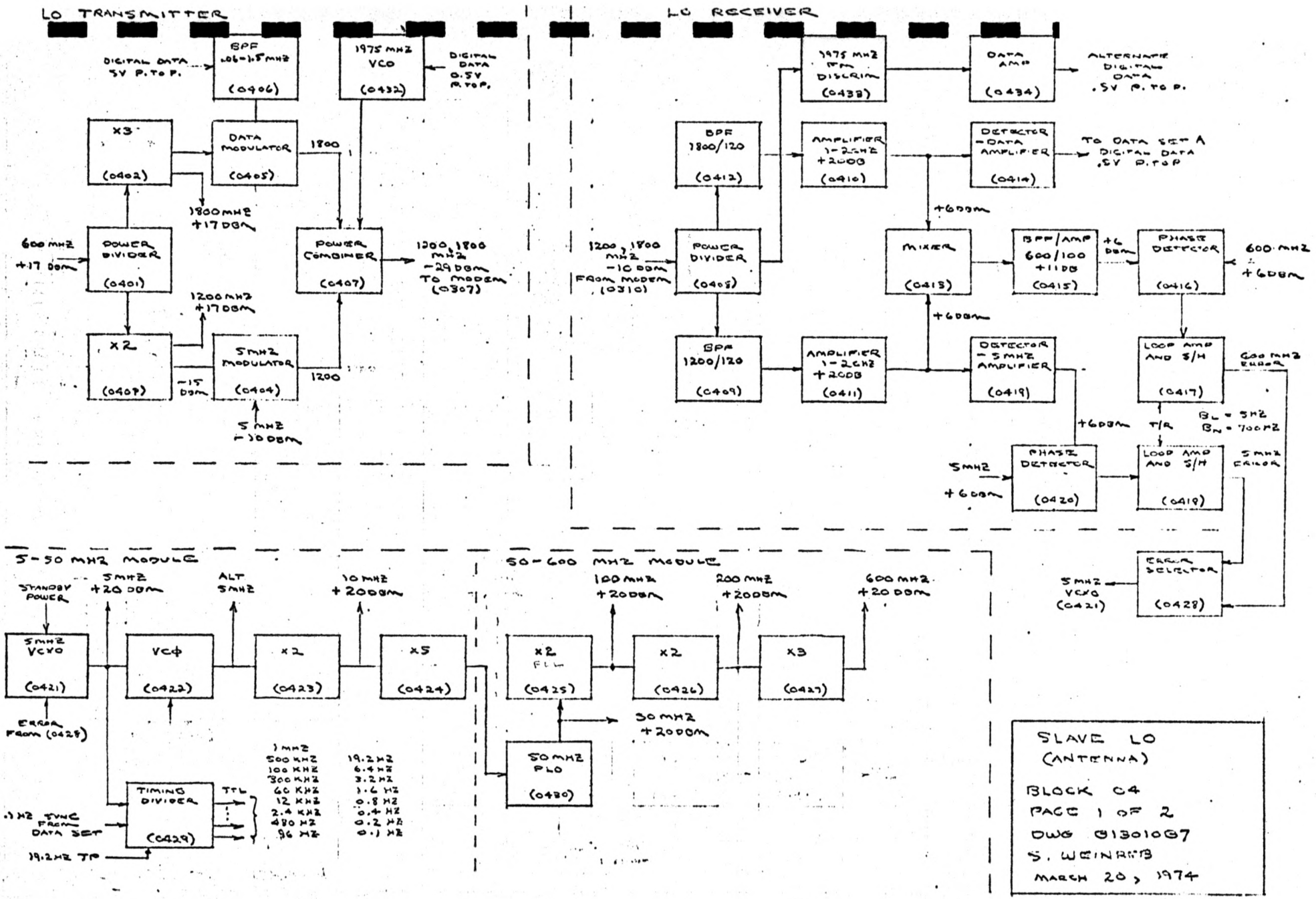
IF/LO MODEM A (ANTENNA)

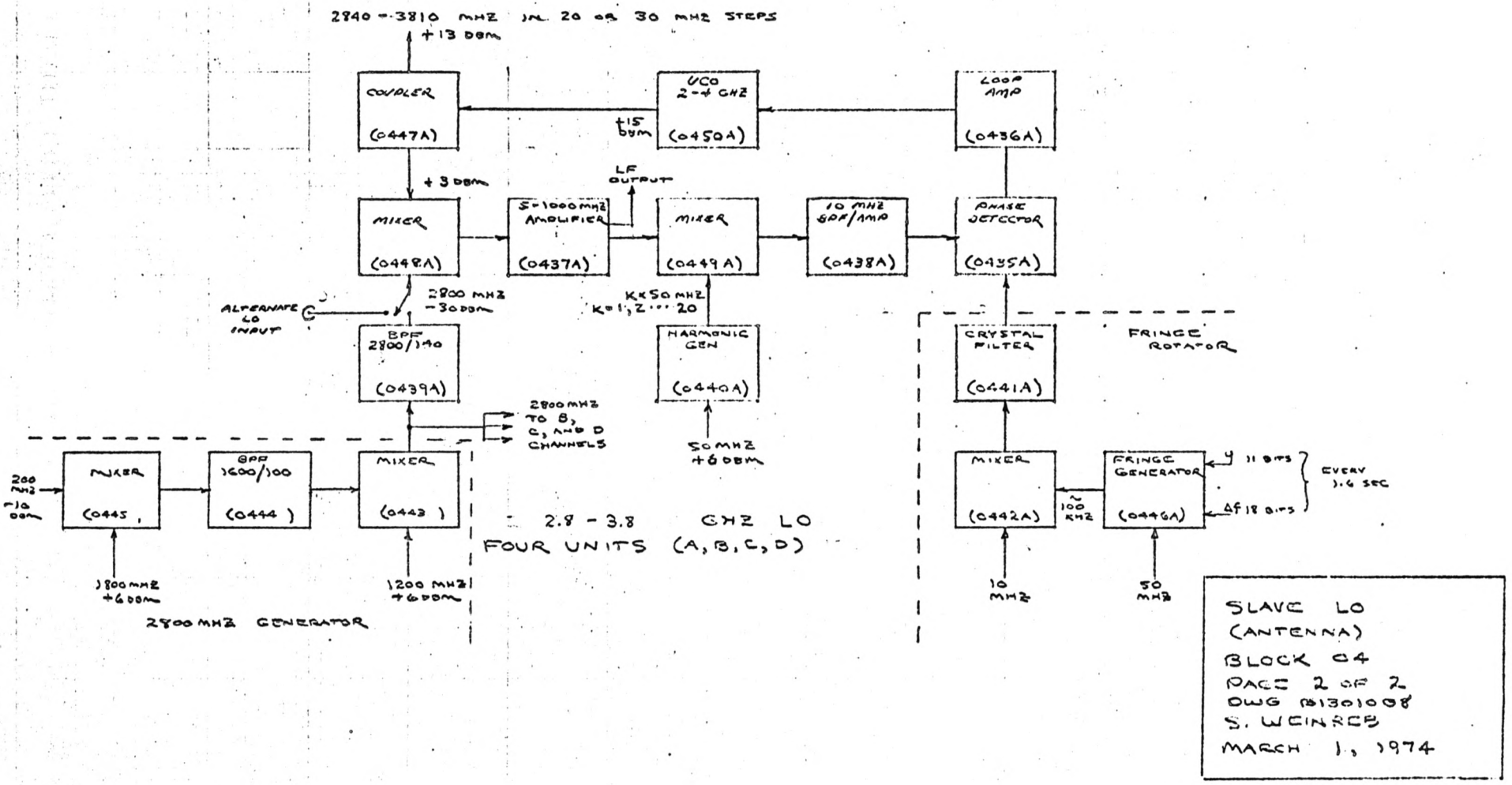
BLOCK 03

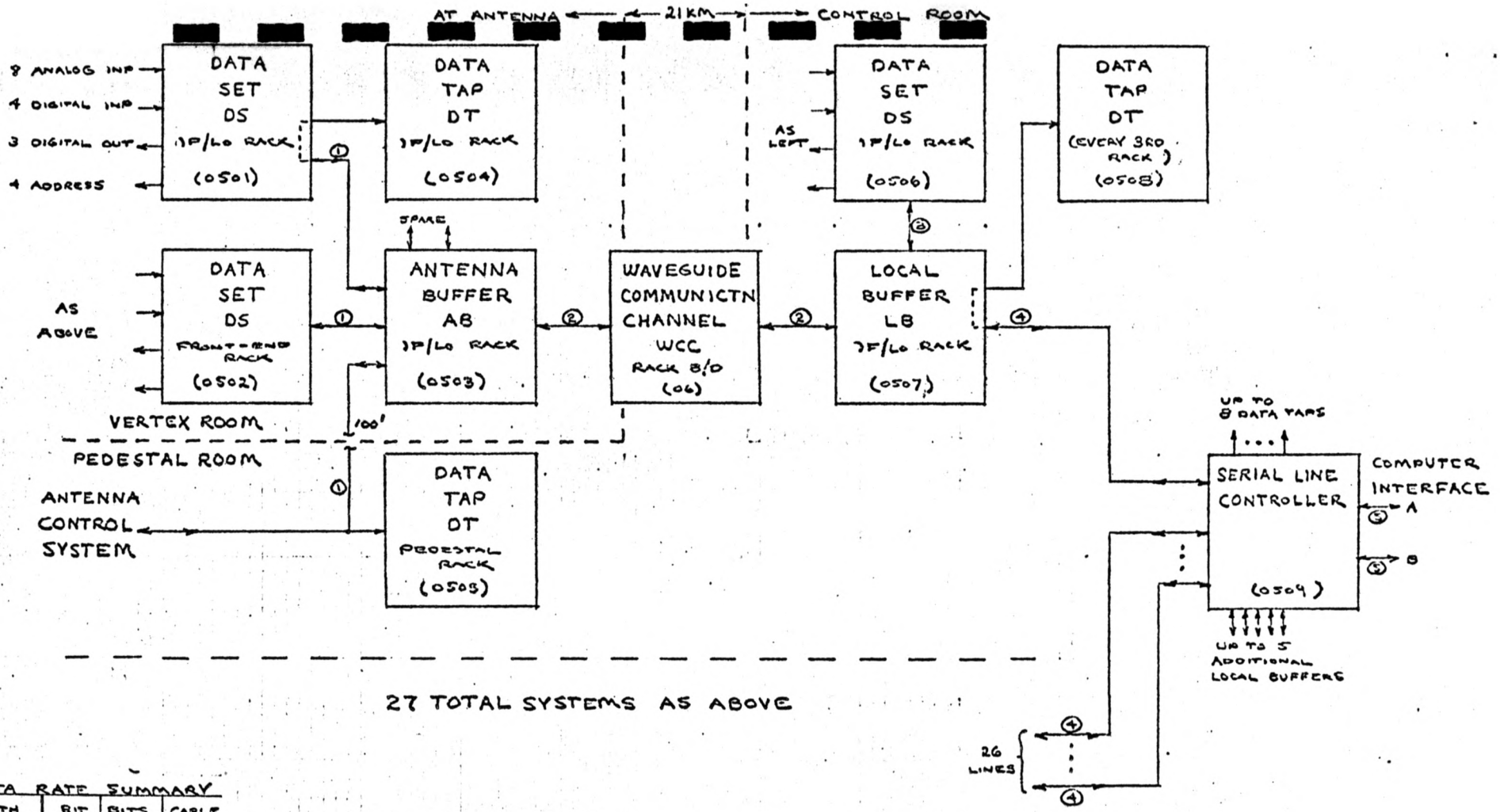
DWG D1301066

S. WEINREB

MARCH 1, 1974


LO TRANSMITTER
DIGITAL DATA 5V P.TO P.
BPF 1.6-1.8 MHZ (0406)
1975 MHZ VCO (0432)
DIGITAL DATA 0.5V P.TO P.
X3 (0402)
DATA MODULATOR (0405)
1800
1800 MHZ +17 DBM
600 MHZ +17 DBM
POWER DIVIDER (0401)
POWER COMBINER (0407)
1200, 1800 MHZ -29 DBM TO MODEM (0307)
1200 MHZ +17 DBM
X2 (0407)
-15 DBM
5 MHZ MODULATOR (0404)
1200
5 MHZ -30 DBM
LO RECEIVER
1975 MHZ FM DISCRIM (0438)
DATA AMP (0434)
ALTERNATE DIGITAL DATA .5V P. TO P.
BPF 1800/120 (0412)
AMPLIFIER 1-2GHZ +20DB (0410)
DETECTOR - DATA AMPLIFIER (0414)
TO DATA SET A DIGITAL DATA .5V P.TO P
+6DBM
1200, 1800 MHZ -10 DBM FROM MODEM (0310)
POWER DIVIDER (0408)
MIXER (0413)
BPF/AMP 600/100 +11DB (0415)
+6 DBM
PHASE DETECTOR (0416)
600 MHZ +6DBM
+6DBM
BPF 1200/120 (0409)
AMPLIFIER 1-2GHZ +20DB (0411)
DETECTOR - 5MHZ AMPLIFIER (0419)
LOOP AMP AND S/H (0417)
600 MHZ ERROR
+6DBM
T/R
BL = 5HZ
BN = 700HZ
5MHZ
+6 DBM
PHASE DETECTOR (0420)
LOOP AMP AND S/H (0419)
5MHZ ERROR
5-50 MHZ MODULE
STANDBY POWER
5MHZ +20 DBM
ALT 5MHZ
10 MHZ +20DBM
5MHZ VCXO (0421)
VCΦ (0422)
X2 (0423)
X5 (0424)
ERROR FROM (0428)
1 MHZ
500 KHZ
100 KHZ
300 KHZ
60 KHZ
12 KHZ
2.4 KHZ
480 HZ
96 HZ
19.2HZ
6.4 HZ
3.2 HZ
1.6 HZ
0.8 HZ
0.4 HZ
0.2 HZ
0.1 HZ
TIMING DIVIDER (0429)
TTL
1 HZ SYNC FROM DATA SET
19.2HZ TP
50-600 MHZ MODULE
100 MHZ +20DBM
200 MHZ +20DBM
600 MHZ +20 DBM
X2 FLL (0425)
X2 (0426)
X3 (0427)
50 MHZ +20DBM
50 MHZ PLO (0430)
5MHZ VCXO (0421)
ERROR SELECTOR (0428)
SLAVE LO (ANTENNA)
BLOCK 04
PAGE 1 OF 2
DWG 8130107
S. WEINRIB
MARCH 20, 1974


2840 - 3810 MHZ IN 20 OR 30 MHZ STEPS
+13 DBM
COUPLER (0447A)
VCO 2-4 GHZ (0450A)
LOOP AMP (0436A)
+15 DBM
+3 DBM
LF OUTPUT
MIXER (0448A)
5-1000 MHZ AMPLIFIER (0437A)
MIXER (0449A)
10 MHZ BPF/AMP (0438A)
PHASE DETECTOR (0435A)
ALTERNATE LO INPUT
2800 MHZ -30 DBM
K*50 MHZ K=1, 2 ... 20
BPF 2800/140 (0439A)
HARMONIC GEN (0440A)
CRYSTAL FILTER (0441A)
FRINGE ROTATOR
2800 MHZ TO B, C, AND D CHANNELS
50 MHZ +6 DBM
280 MHZ -10 DBM
MIXER (0445)
BPF 1600/100 (0444)
MIXER (0443)
MIXER (0442A)
100 KHZ
FRINGE GENERATOR (0446A)
11 BITS
Δf 18 BITS
EVERY 1.6 SEC
1800 MHZ +6 DBM
1200 MHZ +6 DBM
10 MHZ
50 MHZ
2800 MHZ GENERATOR
2.8 - 3.8 GHZ LO
FOUR UNITS (A, B, C, D)
SLAVE LO (ANTENNA)
BLOCK 04
PAGE 2 OF 2
DWG B1301008
S. WEINREB
MARCH 1, 1974

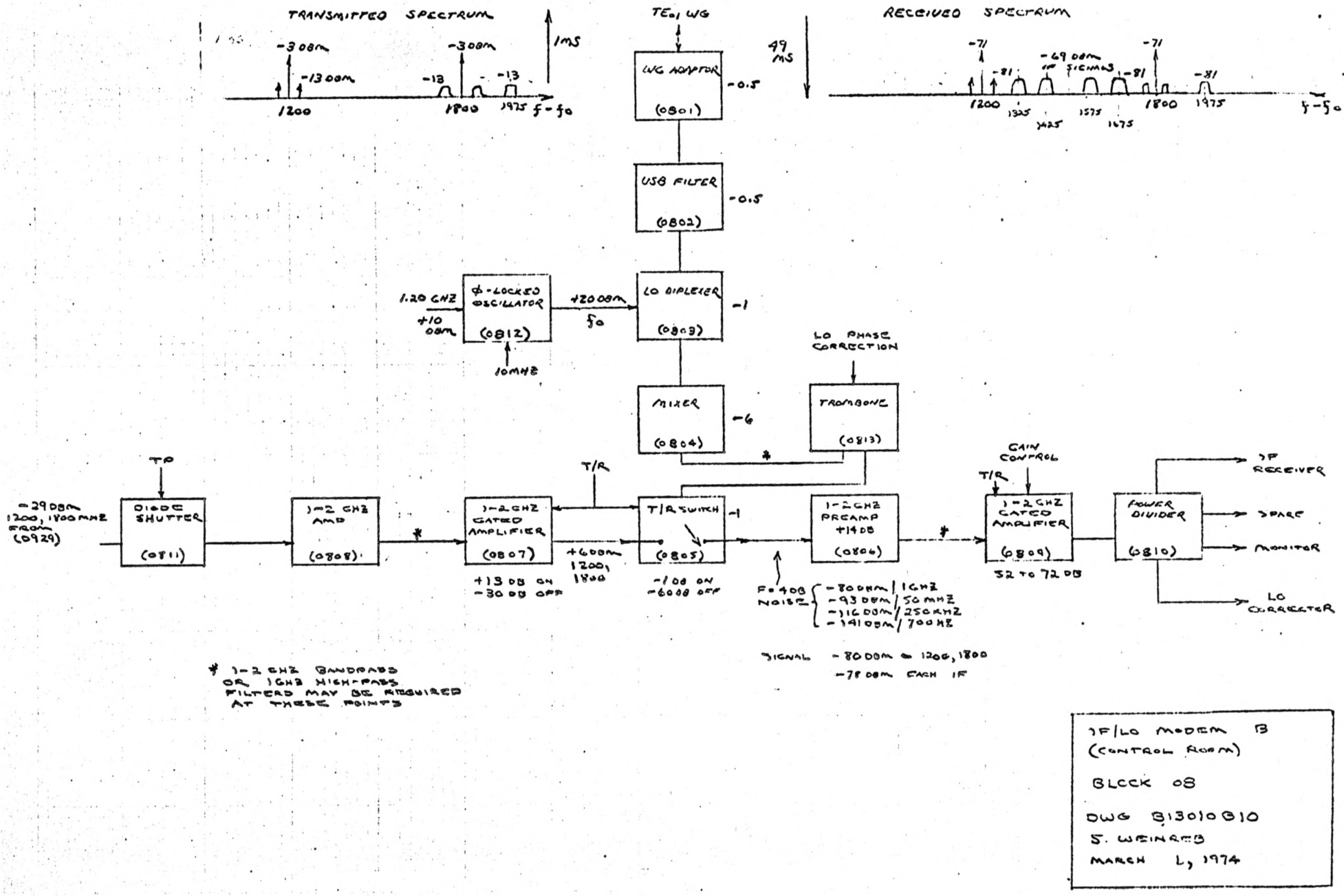


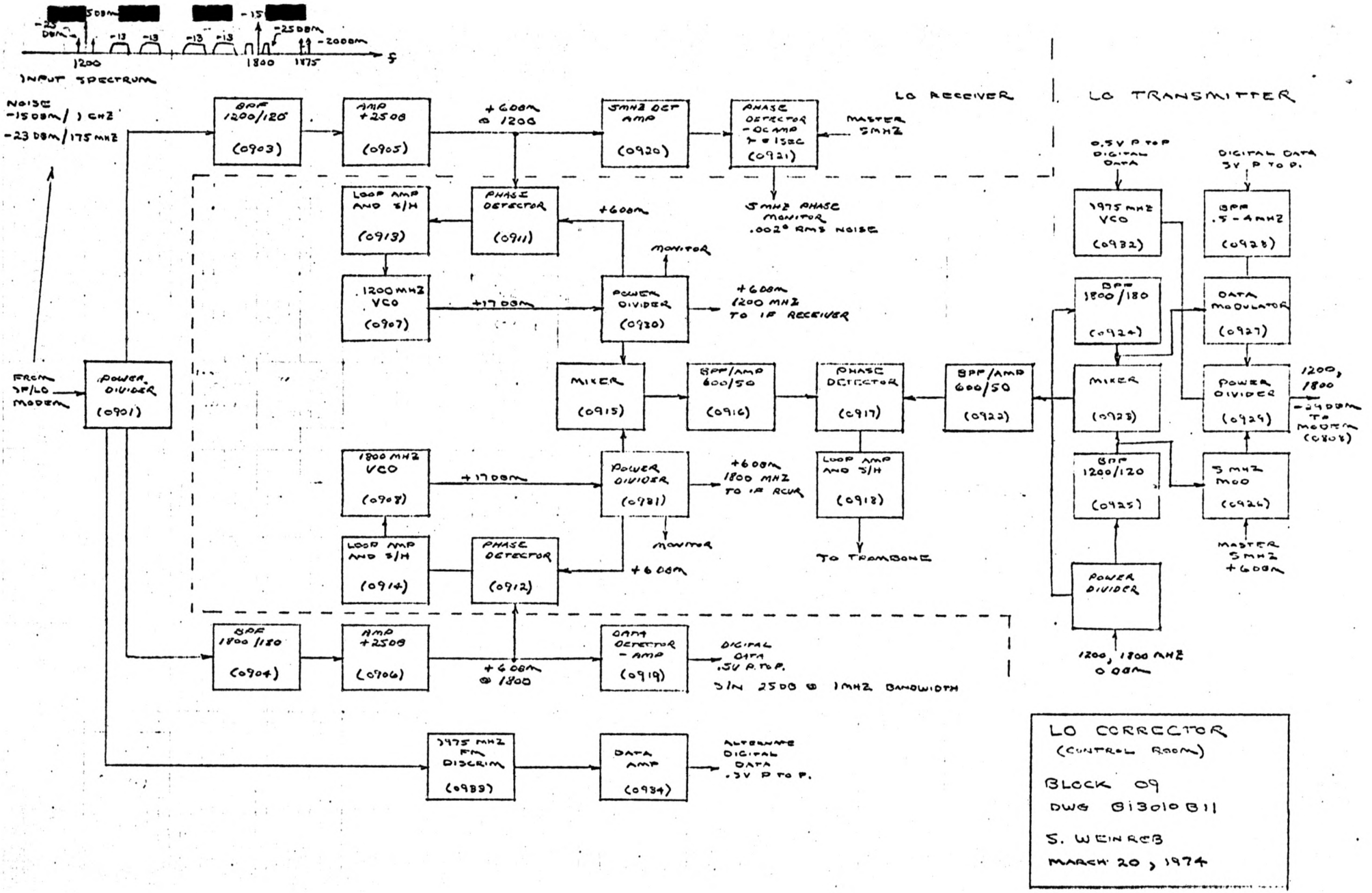
DATA RATE SUMMARY

PATH	BIT TIME μS	BITS PER SEC (AVERAGE)	CABLE
① →	10	1800	PAIR
① ←	10	3600	PAIR
② →	50	9000	COAX
② ←	4	3600	COAX
③ ↓	10	1800	PAIR
③ ↑	10	5400	PAIR
④ →	1	10,800	PAIR
④ ←	1	5,400	PAIR
⑤ →	1	307KB	MULT WIRE
⑤ ←	1	153KB	MULT WIRE

MONITOR AND CONTROL SYSTEM
BLOCKS 05 AND 13

OWG B1305009
S. WEINREB
JUNE 27, 1973

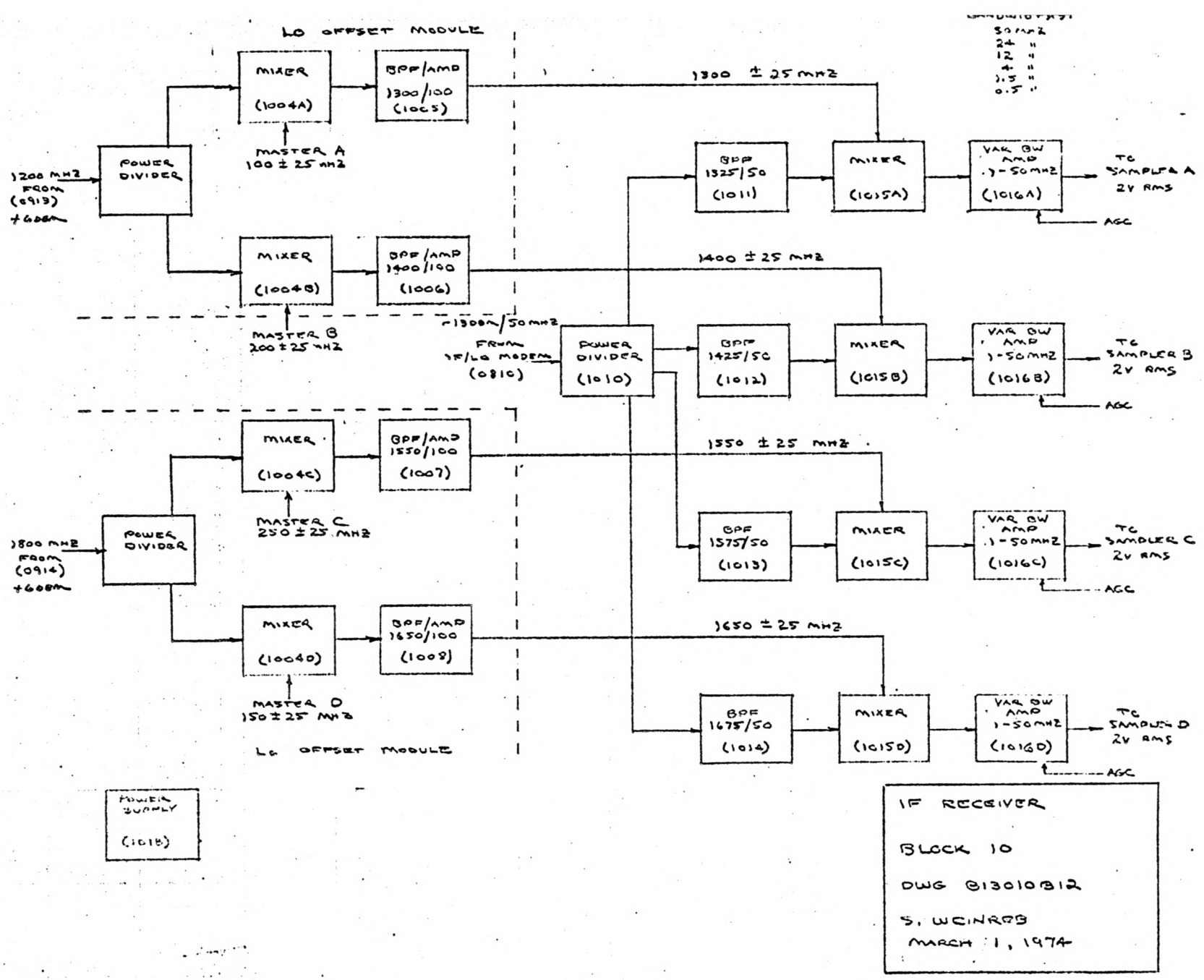

TRANSMITTED SPECTRUM
-30 dBm
-13 dBm
-30 dBm
-13
-13
1 mS
1200
1800
1975 f - fo
TE01 WG
WG ADAPTOR (0801) -0.5
49 mS
RECEIVED SPECTRUM
-71
-81
-69 dBm OR BICHMAN
-81
-71
-81
1200
1325
1425
1575
1675
1800
1975
f - fo
USB FILTER (0802) -0.5
1.20 GHZ +10 dBm
Φ-LOCKED OSCILLATOR (0812)
10MHZ
+20 dBm fo
LO DIPLEXER (0803) -1
LO PHASE CORRECTION
MIXER (0804) -6
TROMBONE (0813)
TO
T/R
CAIN CONTROL
T/R
IF RECEIVER
SPARE
MONITOR
LO CORRECTOR
-29 dBm 1200, 1800 MHz FROM (0929)
DIODE SHUTTER (0811)
1-2 GHZ AMP (0808)
1-2 GHZ GATED AMPLIFIER (0807)
+13 dB ON -30 dB OFF
+6 dBm 1200, 1800
T/R SWITCH (0805) -1
-1 dB ON -60 dB OFF
1-2 GHZ PREAMP +14 dB (0806)
F = 4 dB NOISE
-80 dBm / 1 GHZ
-93 dBm / 50 MHZ
-116 dBm / 250 KHZ
-141 dBm / 700 HZ
1-2 GHZ GATED AMPLIFIER (0809)
32 TO 72 dB
POWER DIVIDER (0810)
SIGNAL -80 dBm @ 1200, 1800
-78 dBm EACH IF
1-2 GHZ BANDPASS OR 1 GHZ HIGH-PASS FILTERS MAY BE REQUIRED AT THESE POINTS
IF/LO MODEM B (CONTROL ROOM)
BLOCK 08
DWG B13010810
S. WEINREB
MARCH 1, 1974



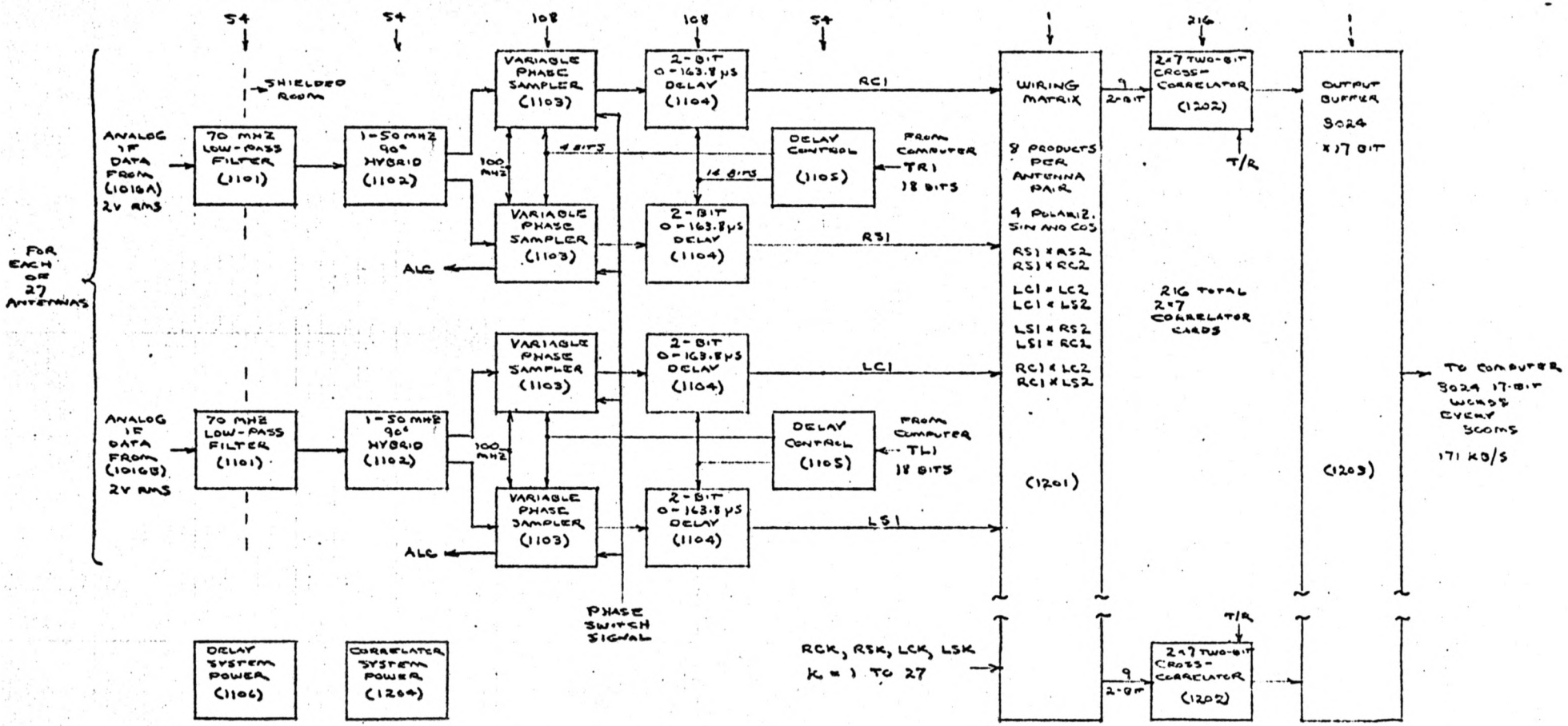
LO CORRECTOR
(CONTROL ROOM)

BLOCK 09
DWG B13010B11

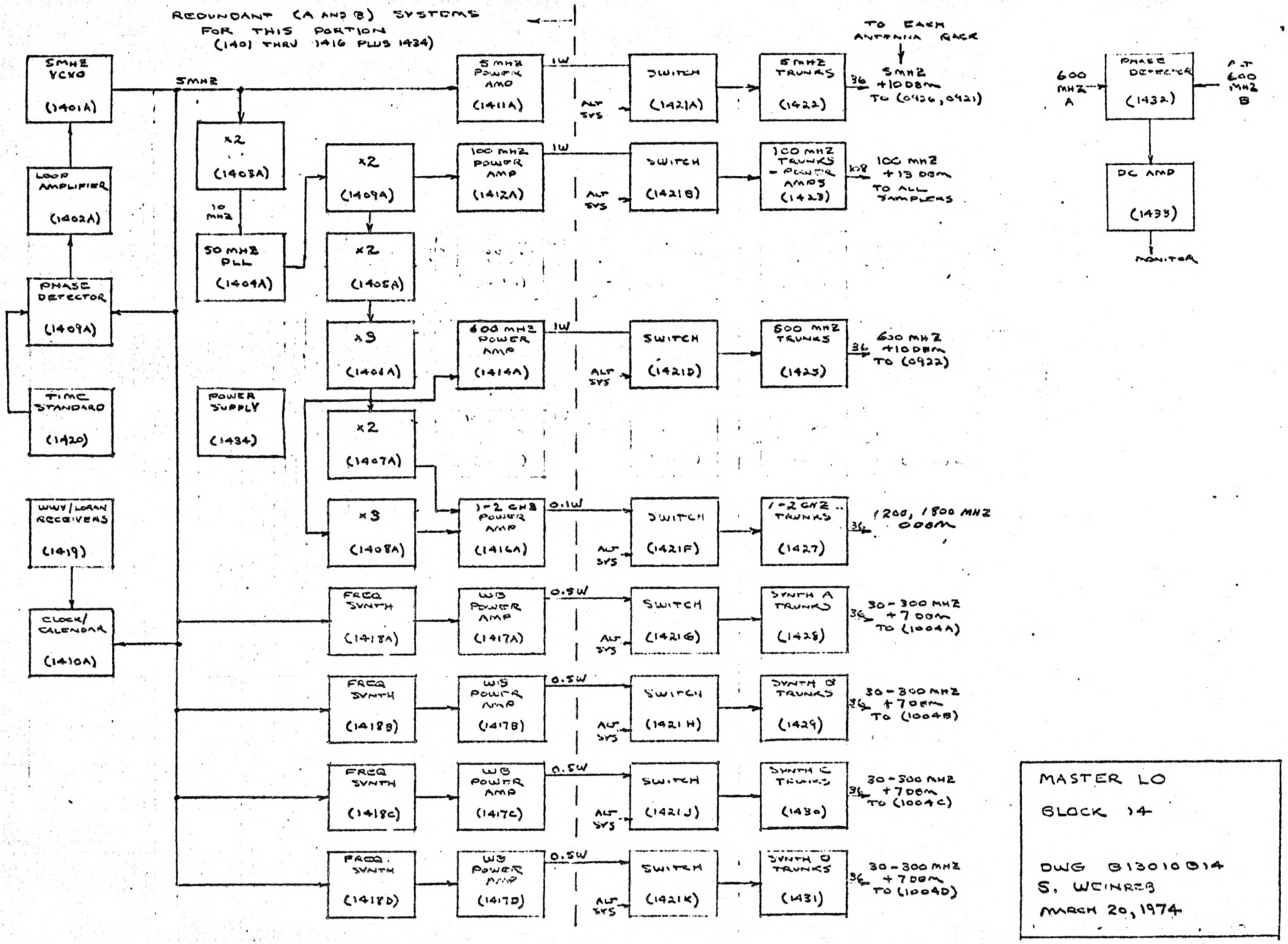
S. WEINREB
MARCH 20, 1974


LO OFFSET MODULE
MIXER (1004A)
BPF/AMP 1300/100 (1005)
1300 ± 25 MHZ
MASTER A 100 ± 25 MHZ
1200 MHZ FROM (0913) +6DBM
POWER DIVIDER
MIXER (1004B)
BPF/AMP 1400/100 (1006)
1400 ± 25 MHZ
MASTER B 200 ± 25 MHZ
1500 MHZ/50 MHZ FROM IF/LO MODEM (0810)
POWER DIVIDER (1010)
MIXER (1004C)
BPF/AMP 1550/100 (1007)
1550 ± 25 MHZ
MASTER C 250 ± 25 MHZ
1800 MHZ FROM (0914) +6DBM
POWER DIVIDER
MIXER (1004D)
BPF/AMP 1650/100 (1008)
1650 ± 25 MHZ
MASTER D 150 ± 25 MHZ
LO OFFSET MODULE
BPF 1325/50 (1011)
MIXER (1015A)
VAR BW AMP 1-50MHZ (1016A)
TO SAMPLER A 2V RMS
AGC
BPF 1425/50 (1012)
MIXER (1015B)
VAR BW AMP 1-50MHZ (1016B)
TO SAMPLER B 2V RMS
AGC
BPF 1575/50 (1013)
MIXER (1015C)
VAR BW AMP 1-50MHZ (1016C)
TO SAMPLER C 2V RMS
AGC
BPF 1675/50 (1014)
MIXER (1015D)
VAR BW AMP 1-50MHZ (1016D)
TO SAMPLER D 2V RMS
AGC
POWER SUPPLY (1018)
50 MHZ
24 "
12 "
4 "
1.5 "
0.5 "
IF RECEIVER
BLOCK 10
DWG 8130108I2
S. WEINROB
MARCH 1, 1974

ALL SHOWN BELOW IS FOR ONE 50 MHZ BANDWIDTH; DOUBLE ALL QUANTITIES FOR SECOND CHANNEL



DIGITAL DELAY AND CORRELATOR SYSTEM
BLOCKS 11 AND 12
DWG B13010B13
S. WEINREB
APRIL 6, 1973



MASTER LO

BLOCK 14

DWG B13010014

S. WEINREB

MARCH 20, 1974