<u>VLA Technical Report No. 50</u>

MODULE L22 MODEM OFFSET OSCILLATOR

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1.0 GENERAL DESCRIPTION

The L22 Modem Offset Oscillator provides the offset 10 MHz reference signal to the L19 Master Local Oscillator Driver for distribution to the T1 modem Gunn oscillator phase lock loop circuit.

One of five asynchronous (with the MLO system) crystal oscillators at 10.001, 10.003, 10.010, 10.030, or 10.100 MHz, along with provision for an external synthesizer input can be selected by a front panel rotary switch.

Antenna to Central Electronics Room delay is measured as follows: 1200 MHz and 1800 MHz carriers derived from a 600 MHz reference in the Master Local Oscillator is transmitted single sideband on a millimeter wave channel through the waveguide to the antenna. At each antenna, the received 1200 and 1800 MHz carriers are mixed together to produce a 600 MHz output which is used to phaselock the internal 120th harmonic of a 5 MHz voltage controlled crystal oscillator in a sample and hold phaselock loop. 1200 and 1800 MHz carriers are then generated synchronous with the antenna 600 MHz and retransmitted single sideband back to the Central Electronics Room where the received 600 MHz difference is phase compared with the original master local oscillator 600 MHz signal.

Because the 1800 MHz carrier is 600 MHz above the 1200 MHz carrier, it accumulates phase at a 600 MHz rate faster than the 1200 MHz carrier which is then used to make a round trip phase error measurement to compensate for waveguide length changes with temperature and gas pressure. Unfortunately when the 1200 - 1800 are mixed to obtain 600 at both the antenna and the Central Electronics Room a spurious 600 MHz is generated from 2 x 1200 MHz -1800 MHz = 600 MHz. This can cause a significant phase error to the round trip measurement.

By offsetting the Central Electronics Room modem local oscillator by a small frequency difference Δ through the use of the L22 module reference to the T1 LO phaselock loop, both the antenna and Central Electronics Room spurious signals can be placed well outside the effective loop bandwidths of the receivers at both ends and thus suppressed.

Because both the 1200 MHz and 1800 MHz signals are transmitted to the antenna with an offset of Δ, and because the antenna 600 MHz is derived from the difference of the two carriers, the spurious signal is now Δ Hz from the legitimate 600 MHz as follows:

$$(1200 + \Delta) \times (1800 + \Delta) = 600 \text{ MHz} \quad \text{(Legitimate)}$$

$$2 \times (1200 + \Delta) \times (1800 + \Delta) = 600 \text{ MHz} + \Delta \quad \text{(Spurious)}$$

The antenna modem however, transmits 1200 MHz and 1800 MHz without any offset back to the Control Building, since the antenna 600 MHz reference is derived from the incoming difference of the two offset signals, as shown above.

The Central Electronics Room modem in receive has its local oscillator Δ higher than normal. When the upper sideband received 1200 and 1800 MHz signals are downconverted they are offset by $-\Delta$. When the received 600 HMz is derived from the negatively offset 1200 and 1800 the following relationships hold:

$$(1200 - \Delta) \times (1800 - \Delta) = 600 \text{ MHz} \quad \text{(Legitimate)}$$

$$2 \times (1200 - \Delta) \times (1800 - \Delta) = 600 \text{ MHz} - \Delta \quad \text{(Spurious)}$$

Therefore both problems are eliminated.

Two additional problems are however, created. One is that the received "Front End IF" signals are also offset by $-\Delta$. Therefore in downconversion to baseband the received 1200 MHz $-\Delta$ and 1800 MHz $-\Delta$ have to be used to eliminate the 30 MHz difference. This is accomplished by mixing one or the other of these received offset carriers in the T3 IF to baseband with the received offset "Front End IF" signals.

The other procedure involves the path difference encountered because the millimeter wave signals transmitted to the antenna are offset by Δ, while the millimeter wave signals transmitted to the Central Electronics Room are not offset by Δ. The paths are not identical for both cases and therefore an increasing phase measurement error is encountered with increasing Δ. Thus a compromise must be reached between spurious response phase error and path difference error.

This is accomplished for different antenna configurations with a different offset, after careful tests. In the "A" array, where the waveguide path lengths are much greater, a smaller offset is required. In the "D" array where the path lengths are much shorter, a larger offset can be used. Therefore the L22 can be varied from 10.001 MHz (1 KHz offset) to 10.100 MHz (100 KHz offset) in 5 steps.

In actuality the phase measurement does not occur at 600 MHz directly in the Central Electronics Room because of the limited dynamic range and linearity of a modulo π phase detector which would be required for such a system. A 600 MHz + 19.2 Hz signal synchronous with the 5 MHz reference at the Central Electronics Room is generated which is then mixed with the incoming 600 MHz from the antenna. This produces a 19.2 Hz clock signal synchronous with the 5 MHz. It is compared using a period counter type of modulo 2π phase detector which is linear over the entire 2π range to 12 bit resolution.

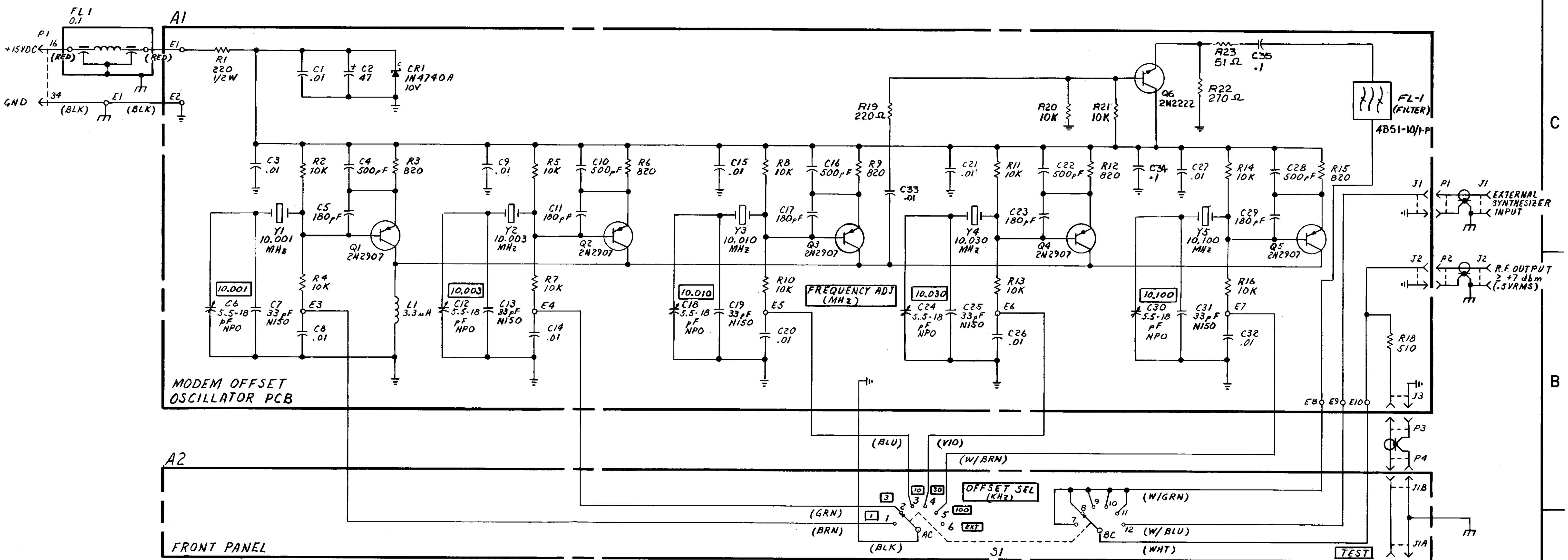
THe 600 MHz $-\Delta$ offset spurious signal is cancelled in this system becasue a large number of individual measurements are averaged together to produce a single correction phase output.

At the antenna however, the 1 second loop bandwidth of the LO receiver phase locked loop which locks the 5 MHz antenna VCXO to the incoming 600 MHz difference suppresses the incoming 600 MHz $+\Delta$ spurious signal.

2.0 CIRCUIT DETAILS

The modem offset oscillator Schematic is shown in D13820S9B. High stability crystals are used in single transistor Colpitts oscillators. Since only one oscillator is powered at one time, the collectors can be tied together to provide a common output without loading. An emitter follower Q6 provides a 50Ω output. Because the oscillator outputs have considerable second harmonic power the duty cycle is considerably less than 50%. The lock detector in the T1 modem phase lock loop is dependent on a 50% duty cycle 10 MHz reference for proper operation. Therefore a 10 MHz bandpass filter, FL-1, is added to provide a 50% duty cycle by suppressing the second harmonic.

REV.	DATE	DRAWN BY	APPR'V'D BY	DESCRIPTION
A	4/17/78			ADDED R19 THRU R23, C34 & C35, Q6, AND FL-1. ZONES C2,C3,C4
B	9/13/78			CORRECTED DWG ERROR



NOTES:

1. DESIGNATIONS SHOWN THUSLY [x--] ARE MARKED ON THE FRONT PANEL
2. UNLESS OTHERWISE INDICATED RESISTOR VALUES ARE IN OHMS AND CAPACITOR VALUES ARE IN MICROFARADS.

	L22
	D13220P8
NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
3 PLACE DECIMALS (.XXX): ±
2 PLACE DECIMALS (.XX): ±
1 PLACE DECIMALS (.X): ±

MATERIAL:

FINISH:

VLA PROJECT: L22

TITLE: MODEM OFFSET OSCILLATOR SCHEMATIC

NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO 87801

DRAWN BY — DATE 12/0/77
DESIGNED BY — DATE 12/14/77
APPROVED BY — DATE 12/14/77

SHEET NUMBER — DRAWING NUMBER D13220S9 — REV. B — SCALE

Phase stability of this system is not important since it is not synchronous with the phase measurement system.

3.0 FRONT PANEL ADJUSTMENTS AND CONTROLS

3.1 OFFSET SEL switch supplies DC voltage to selected crystal oscillator as well as transferring output to external synthesizer in the "EXT" position.

3.2 FREQ ADJ trimmer capacitors used for fine tuning of each crystal oscillator.

3.3 Test BNC Jack

Monitor point connected to RF output through 510Ω resistor. Can be connected to frequency counter for oscillator frequency adjustment.

4.0 MODULE ADJUSTMENTS

Each L22 crystal oscillator should be periodically checked and adjusted with a frequency counter to compensate for oscillator aging. While this is not significant from a system standpoint it might help in the future diagnoses of spurious signals in various parts of the system.

5.0 DRAWING LIST

MODEM OFFSET OSCILLATOR (L22)
DRAWING LIST

12/15/77

Project No. 13220

	Number	Revision	Status
Schematic and Logic Diagrams			
Modem Offset Oscillator Schematic	D13220S9	B	OK
Bill of Materials			
Modem Offset Oscillator PCB Assy.	A13220Z4	A	OK
Modem Offset Oscillator	A13220Z5		OK
Assembly Drawings			
Modem Offset Oscillator PCB Assy.	D13220P7	A	OK
Modem Offset Oscillator Assy.	D13220P8	A	OK
Wire Lists			
Block Diagrams			
Printed Circuit Board Artwork			
Modem Offset Oscillator PCB Artwork	D13220AB8	A	OK
Printed Circuit Board Silk Screen			
Modem Offset Oscillator PCB Silk Screen	D13220AB9	A	OK
Printed Circuit Board Drill Drawings			
Modem Offset Oscillator PCB Drill Dwg.	D13220M19	A	OK
Mechanical Drawings			
Panel, Front	C13220M20		OK
Plate, Left Side	D13220M21		OK
Mounting Angle, Filter	B13220M22		OK
Spacer	B13440M38	A	OK
Specifications			

6.0 DATA SHEETS

BUYER: Jorgensen
ORDER NO. S-04753

SHEET 1 OF 1

PURCHASE ORDER

XX

DATE August 10, 1977

VENDOR:
Sentry Mfg. Co.
Dept. G
Crystal Park
Chichasha, Okla. 73018

Attn: David Priddle

SHIP TO:

- [XX] NATIONAL RADIO ASTRONOMY OBSERVATORY
RECEIVING DEPARTMENT
1000 BULLOCK BLVD.
SOCORRO, NEW MEXICO 87801
TELE 505-835-2924
TELEX 910-988-1710
- [ ] NATIONAL RADIO ASTRONOMY OBSERVATORY
RECEIVING DEPARTMENT
- [ ]

VENDOR BEST DELIVERY:	TERMS	F.O.B. POINT	SHIP VIA	TRANSPORTATION CHARGES
N.R.A.O. REQUESTED DELIVERY 10/22/77	Net 30	Shipping point	UPS	Prepay and add

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT	ITEM NO.	RECEIVED PARTIAL QTY.	RECEIVED PARTIAL DATE	RECEIVED COMPLETE QTY.	RECEIVED COMPLETE DATE
		SP grade fundamental mode crystals at ±.001 temperature tolerance, ±.0005 calibration tolerance, special aging at 2ppm/year maximum, SC-6 holder, 43 pf load capacitance (Attention: David Priddle) at following frequencies:							
1	2	10.001000MHz	$50.00	$100.00					
2	2	10.003000MHz	50.00	100.00					
3	2	10.010000MHz	50.00	100.00					
4	2	10.030000MHz	50.00	100.00					
5	2	10.100000MHz	50.00	100.00					
		TOTAL ----------------------		$500.00					

ACCOUNT/PROJECT NO. 493/13220

R.F.Q. NO.
DELIVER TO B. Dumke - Site

N.R.A.O. TECHNICAL INSPECTION APPROVAL REQUIRED BEFORE PAYMENT.