NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

300-FOOT COMPUTER CONTROL MEMO NO. 20

UNIVERSAL LOCAL OSCILLATOR

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This task is a two part sequence, SET and READ. Electronics Division Internal Report No. 144 describes the hardware for this device. I have included the first four pages of that report for reference.

The **SET** task is activated at the following times:

(1) 'L' card encountered in observe deck.

(2) Manually activated.

(3) End of integration period (line).

The **READ** task is activated after a SET ULO command is executed and continues to read at 200 ms intervals. A new commanded LO setting causes the READ accumulators to reinitialize. Between setting the ULO and reading, there is a 250 ms delay. When a new setting is updated, the average ULO and IF values are checked against the commanded values for the previous period. Errors are printed on TTY if the actual readings differ from the commanded by more than 300 Hz. The commanded LO's are stored on tape header. Presently, only LA and LC are checked at the 300-ft due to space available. All four need to be checked. The IF's are read at intervals of 1.2 seconds and a complete IF reading cycle takes 6.0 seconds.

L1, L1F1, L1F2 are the synthesizer settings (or readings) in BCD. The settings are computed using input parameters from various sources and evaluating the LO equation for L1. L1F1 and L1F2 are computed by adding the frequency or velocity offset to L1. Conversions must be made from a 30-bit word (D.P.) to BCD for output for each setting. Three output words are used for

each synthesizer setting (nine words total).

The following parameters and source for each are used:

Name	Definition	Source
RUSYS	Radial Velocity System	H316
VRED	Reference Frame (LSR, Sun, Earth, None)	S-Card
VDEF	Velocity Definition (Radio, Optical, None)	S-Card
RESTFREQ	Source Rest Frequency	S-Card
M	Box Multiplier	S-Card
N	Synthesizer Multiplier	S-Card
LOMODE	(VFS) LO Setting Mode (Velocity, Frequency, Synth)	L-Card
FSOURCE	Source Frequency	L-Card
VELOCITY	Source Velocity	L-Card
VREF1	Reference Velocity Offset 1	L-Card
VREF2	Reference Velocity Offset 2	L-Card
FREF1	Reference Frequency Offset 1	L-Card
FREF2	Reference Frequency Offset 2	L-Card
L1	LO 1 Synthesizer Setting	L-Card
L1F1	LO 1 Reference Synth. Setting 1	L-Card
L2		L-Card
L2F1	Same as LO 1 except	L-Card
L2F2	for LO 2	L-Card
LA	IF Receiver A	L-Card
LB	IF Receiver B	L-Card
LC	IF Receiver C	L-Card
LD	IF Receiver D	L-Card
CFF	Center Frequency Formula	S-Card
NT	Noise Tube Values	S-Card
INV	Sideband Indicator	S-Card
LOSTVL	Velocity of Light	Constant
ΔV	Delta Velocity/Channel	Calculated
BW	Bandwidth	L-Band
MODEAC	A/C Configuration	L-Card
TIMEMODE	Dump Time of A/C 1 = 10 sidereal seconds 2 = Solar oscillator 0 = Front panel settings	L-Card

The LO equation is evaluated before output to give correct synthesizer frequency. The H116 did not have enough accuracy for calculations.

The LO equation is: (L1)

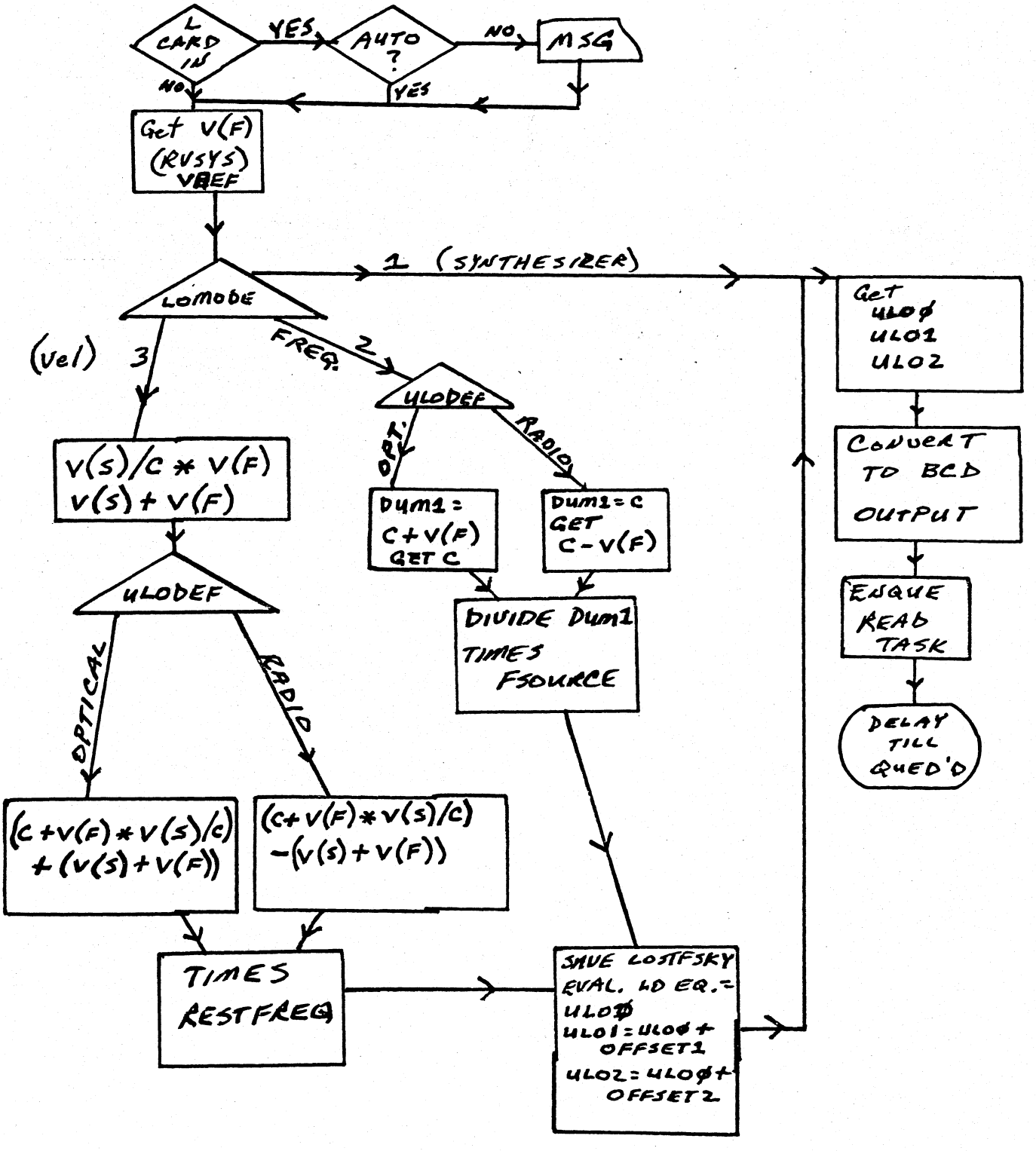
$$ULOO = D*(Fsky - (C + E * LA + F * LB))/M*N$$

where D = ± 1;
E = 1 or 0;
F = 1 or 0; and
C = constant for upconverter frequency.

Default values are:

C = 0;
D = 1;
E = 1; and
F = 0.

LO SET TASK


L CARD IN
YES
AUTO ?
NO
MSG
NO
YES
Get V(F) (RVSYS) VREF
LOMODE
1 (SYNTHESIZER)
Get ULO∅ ULO1 ULO2
(Vel) 3
FREQ. 2
ULODEF
OPT.
RADIO
V(S)/C * V(F) V(S) + V(F)
Dum1 = C + V(F) GET C
Dum1 = C GET C - V(F)
CONVERT TO BCD OUTPUT
ULODEF
DIVIDE Dum1 TIMES FSOURCE
ENQUE READ TASK
OPTICAL
RADIO
DELAY TILL QUED'D
(C + V(F) * V(S)/C) + (V(S) + V(F))
(C + V(F) * V(S)/C) - (V(S) + V(F))
TIMES RESTFREQ
SAVE LOSTFSKY EVAL. LO EQ.= ULO∅
ULO1 = ULO∅ + OFFSET1
ULO2 = ULO∅ + OFFSET2

LO SET ROUTINE

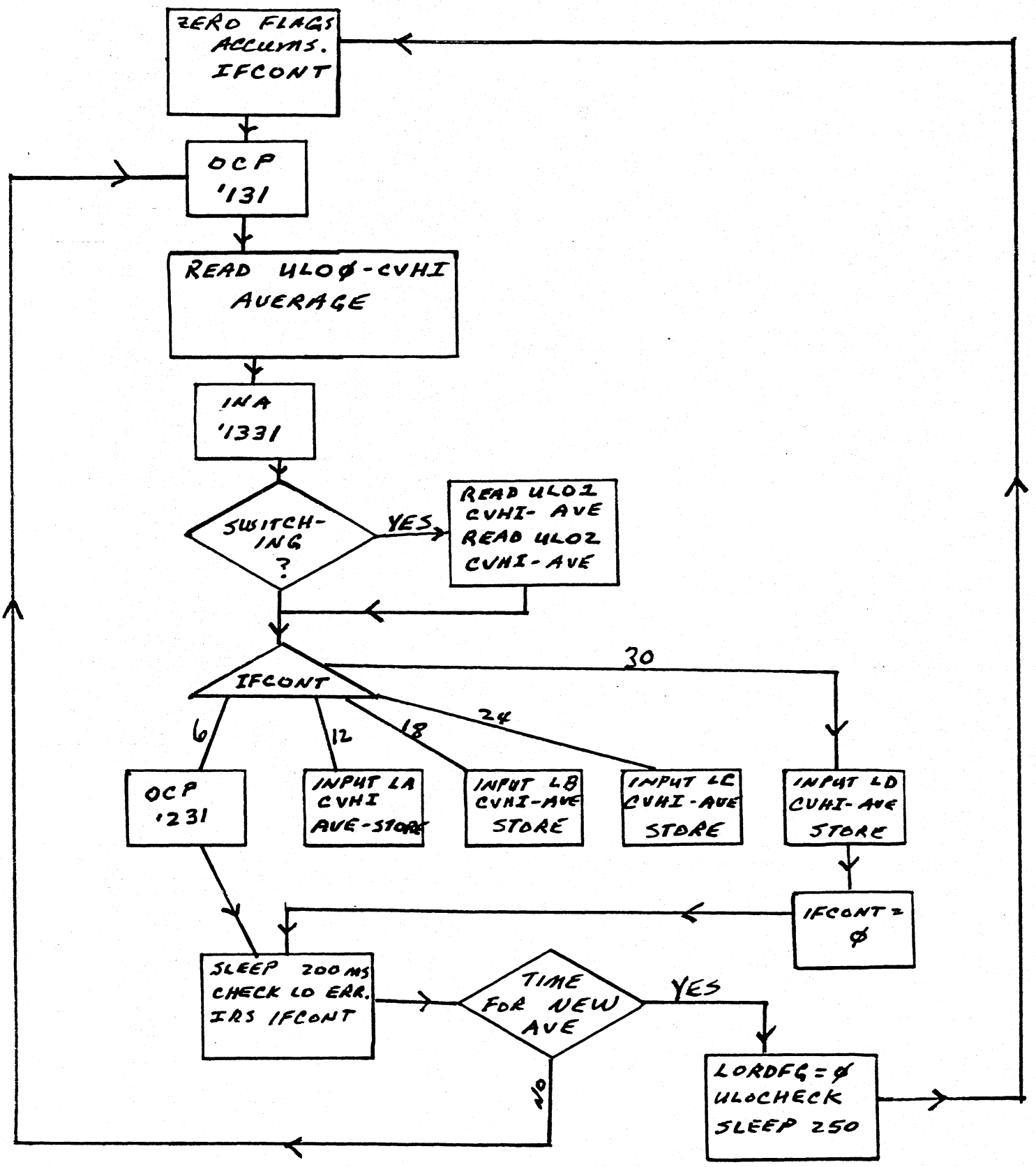
The data can be put on line (buffered) when calculated. The ULO will only be updated at the next transition of the signal/reference switch signal of the A/C.

LOSTBCD is the routine to convert a D.P. No. BB30 to BCD xxxx xxxxx000 and output it to ULO.

```
            DLD       #BB30          350123456
            STD       DUM1
            DD1V      1000000        350,123456
            STA       DUM2           350
            CVIH                     Convert to BCD
            LGL       4              3500
            STA       LOSTBN         3500
            MPY       = 0            Clear A-B
            LDA       DUM2           350
            MPY       1000000        350000000
            TCD                      -350000000
            ADD       DUM1           350123456
            STD       DUM1              123456
            DIV       1000           123,45600
            STA       DUM2           00123
            CVIH                     Convert to BCD 0123
            LRL       8              0001, 2300
            ERA       LOSTBN         3500
            STA       LOSTBN         3501
            IAB                      2300
            STA       LOSTBN+1       2300
            MPY       0              Clear A-B
            LDA       DUM2           0123
            MPY       1000           123000
            TCD                      -123000
            ADD       DUM1           123456
            IAB                      456
            CVIH                     0456
            IAB                      xxxx 0456
            CRA                      0000 0456
            IAB                      0456 0000
            LRL       4              0045 6000
            ERA       LOSTBN+1       2300
            STA       LOSTBN+1       2345
            IAB                      6000
            STA       LOSTBN+2       6000
            LDX       -3
LOSTUP      LDA       LOSTBN+2       6000
            OTA       '31            Output Word
            JMP       * - 1          Not Ready
            IRS       0              More
            JMP       LOSTUP         Yes
            Return                   No

LOSTBN      3501
LOSTBN+1    2345
LOSTBN+2    6000
```

LO READ TASK


ZERO FLAGS ACCUMS. IFCONT
OCP '131
READ ULOØ-CVHI AVERAGE
INA '1331
SWITCH-ING ?
YES
READ ULO1 CVHI-AVE READ ULO2 CVHI-AVE
IFCONT
30
6
12
18
24
OCP '231
INPUT LA CVHI AVE-STORE
INPUT LB CVHI-AVE STORE
INPUT LC CVHI-AVE STORE
INPUT LD CVHI-AVE STORE
IFCONT = Ø
SLEEP 200 MS CHECK LO ERR. IRS IFCONT
TIME FOR NEW AVE
YES
NO
LORDFG = Ø ULOCHECK SLEEP 250

IF INPUT ROUTINE

```
INA         '1231           Input 4 BCD (low)
LGR         4               LO # (not used)
CVHI
MPY         = 100           To Hz
STD         ULOBUF
INA         '1231           Input 4 BCD (high)
MPY         100000          To Hz
ADD         ULOBUF          Add lows
RETURN
```

LO INPUT ROUTINE

```
OCP         '131
INA         '1131           Get High 4 BCD
STA         ULOBUF+1        Save
INA         '1131           Get Low 4 BCD
LRL         4               Extract Band Indicator
STA         ULOBUF+2        Save 3 BCD
LGR         12              Get Band Indicator
STA         ULOBUF
INA         '1131           Input 3rd Word - Ignore
LDA         ULOBUF+2        Get High
CVHI
STA         ULOBUF+2
IMA         ULOBUF+1        Get Low
CVHI
MPY         1000
ADD         ULOBUF+2
*GET        ULOBUF
    = 1     Use input as is.
    = 2     Add  900 MHz to input.
    = 4     Add 1300 MHz to input.
    = 8     Add 1700 MHz to input.
```

COMPUTER CONTROL OF THE UNIVERSAL LOCAL OSCILLATOR

1. Introduction

This report describes the new computer control system for the Universal Local Oscillator. The system also provides a means for checking four frequency synthesizers in the IF Processor rack and control signals for the Cassegrain system.

2. Programming

The six least significant bits of the device address (bits 11-16) are selected by two digi-switches located in the digital drawer in the ULO rack. The following two addresses have been selected for ULO control:

31 Local Oscillator 1

32 Local Oscillator 2

The following commands are applicable to both ULO's. The only change would be in the six least significant bits of the address which will be represented by XX. Bit 7 of the address does not matter but it must be cautioned that when doing an INA it must be a "1" to clear the A register before doing the INA.

OTA $0XX_8$. This OTA can output 16 words of information; the first 9 words set the ULO, the 10th word is for the proposed Cassegrain system, words 11-13 are spare buffered words, and words 14-16 are unused. The format for the ULO is listed below. The ULO will only be updated at the next transition of the signal/reference signal. If the front panel switch is in manual it will be possible to do an OTA but the data will not be taken.

	Bits	1 2 3 4	5 6 7 8	9 10 11 12	13 14 15 16	
Words	1	100's MHz	10's MHz	1's MHz	100's kHz	
	2	10's kHz	1's kHz	100's Hz	10's Hz	F_{LO}
	3	1's Hz	.1 Hz			
	4					
	5		Same as	above.		$F_{REF\ 1}$
	6					
	7					
	8		Same as	above.		$F_{REF\ 2}$
	9					

Word 10 - Bits 1-14 are available as data and bits 15-16 are used to tell the Cassegrain system if $F_{REF\ 1}$ and $F_{REF\ 2}$ are greater or less than F_{LO}. Bit 15 is for $F_{REF\ 1}$ and bit 16 is for $F_{REF\ 2}$. The bit should be set to a "1" if it is greater.

INA $1XX_8$. This INA will input the frequency read by the counter in the ULO rack. (This counter measures the output of the multiplier.) An OCP $1XX_8$ must be executed before doing the INA's. There are two times the INA cannot be completed. One time is while a new counter reading is being stored (about 40 μsec). The other time is when the computer has read a set of readings. It will not be possible to take another reading until all three frequencies have been updated. This takes a maximum of 200 millisec, when switching at a 10 Hz rate. Listed below is the format for the input words.

	Bits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Words	1		MSD				---				---				---			F_{LO}
	2		---				---				LSD				BANDS*			
	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	4																	$F_{REF\ 1}$
	5						Same			as	above.							
	6																	
	7																	$R_{REF\ 2}$
	8						Same			as	above.							
	9																	

* Bands - Bits 13 = 1 = add 1700 MHz to counter reading.

14 = 1 = add 1300 MHz to counter reading.

15 = 1 = add 900 MHz to counter reading.

16 = 1 = take counter reading as it is.

Only one bit should be on at a time.

INA $2XX_8$. This INA reads the offset LO. At the 300-ft four LO's will be read. Only one will be read at the 140-ft. The input word will contain a count to tell the computer which LO was read. This count should be ignored at the 140-ft. Before reading a sequence of LO's, an OCP 2XX should be issued. This OCP will reset a counter to the first LO and cause the offset LO counter to count, after $\sim$ 1 sec the computer should be able to do two INA's. (It takes two INA's for each offset LO reading.) The system will then switch to another offset LO and count and the computer should be able to input two more words in $\sim$ 1 sec. The format for the input words is listed below.

	Bit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Word	1	10's kHz				1's kHz				LSD				BA*			
	2	100's MHz				10's MHz				1's MHz				100's kHz			

*BA contains a count to tell the computer which offset LO was read

B	A	LO#
0	0	A
0	1	B
1	0	C
1	1	D

INA $3XX_8$. This INA will input the status of the front panel rotary switch. The format is listed below.

Bits	13	14	15	16	
	0	0	0	1	Mod.
	0	0	1	0	$F_{REF\ 1}$
	0	0	1	1	F_{LO}
	0	1	0	0	$F_{REF\ 2}$
	0	1	1	1	Synth. in Local

SKS $4XX_8$. This SKS will skip if the front pane switch is in computer.

3. General Description

The new computer control system for the ULO contains four basic systems (see Figure 1). The first system is control and storage for the frequency synthesizer. The second system consists of a Balentine counter and storage for the computer. The third system controls an RF switch and a Systron Donner counter in the IF Processor rack for input into the computer. The fourth system is control and data for the Cassegrain system. The entire system uses wire-wrap cards and associated chassis designed by A. Shalloway.