NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION INTERNAL REPORT NO. 188

A DIGITAL RADIOMETER

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JULY 1978

NUMBER OF COPIES: 150

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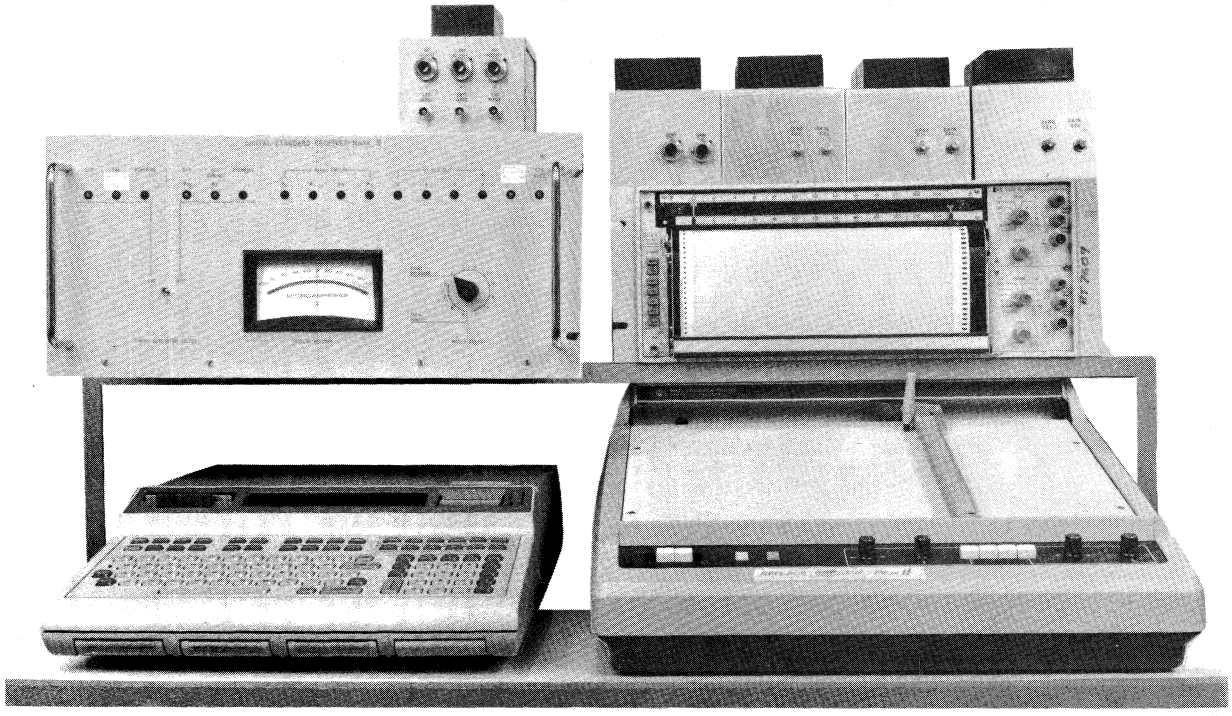
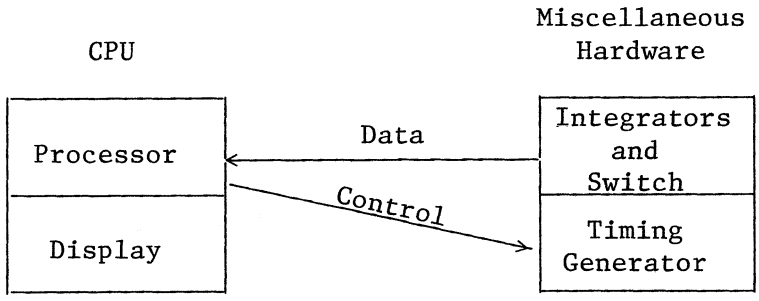
Described herein is a new modular system providing many modern features and improvements over the present system which is entirely analog and hence limited to only elementary computational functions such as simple gain modulation balancing and analog subtraction for the Dicke switch mode while occasionally also providing for short term integration features. The new digital system does all of this but also many complex computations are performed in real time as well as using novel digital techniques for gain modulation Dicke switching, thus providing very stable and reliable operating characteristics.



The Digital Standard Receiver Mark III has been tested at the 300-foot with the host data taking DDP-116 computer. All interface is complete. Only the DDP-116 programs need completion before the radiometer system can be released for observer runs.

The digital receiver comprises two major subsystems which may be thought of as three or four subsystems, as shown:



The CPU is presently a Hewlett Packard 9825A which provides all control and processing functions for the system as well as the data display function. The miscellaneous hardware comprises digital Dicke switch and integrator functions as well as a timing generator providing control of the receiver front-end and digital-to-analog converters for up to eight channels of strip chart displays.

HP 9825A CPU	$ 9,900
Miscellaneous Hardware	3,000
	$12,900

A system can be built around a Varian V77-400 computer as follows, offering a throughput input improvement from 333 ms to better than 100 ms per data point for a full 4-channel receiver system:

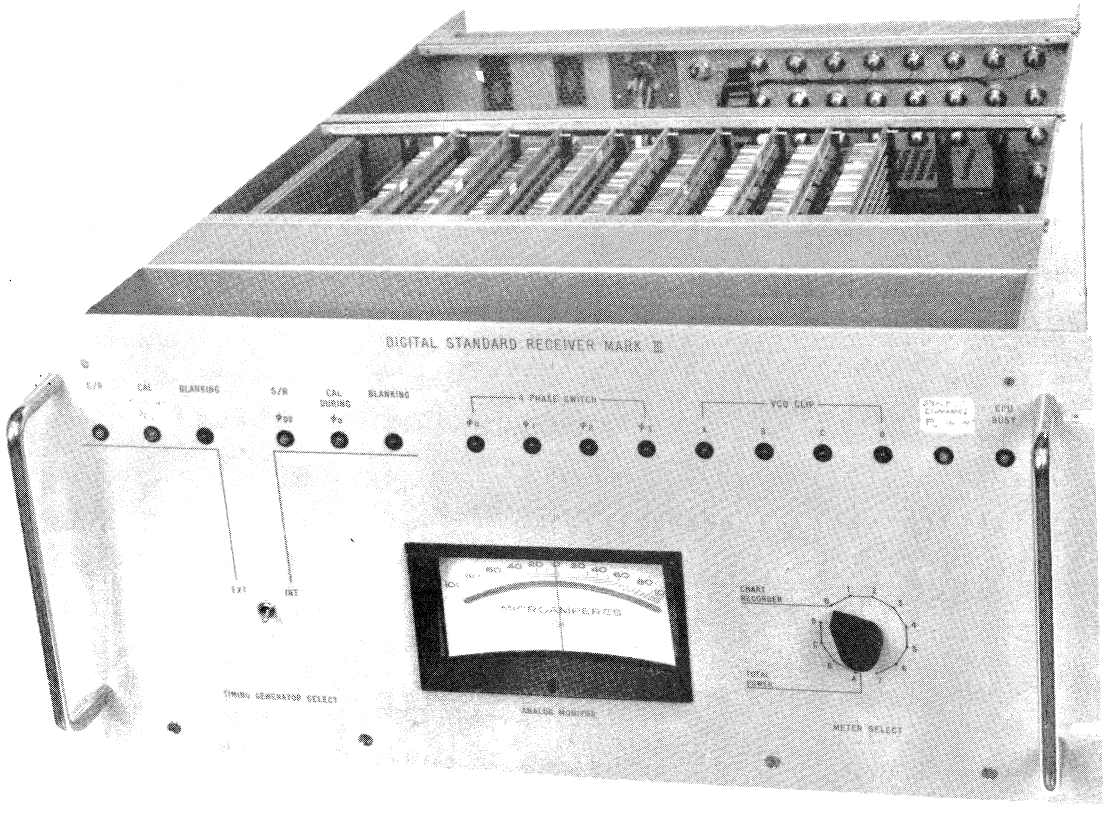
V77-400 CPU	$ 9,305
Miscellaneous Hardware	3,000
TEC CRT Terminal	2,500
2 DC 300 Tape Drives	1,100
3 Interface Cards	500
	$16,405

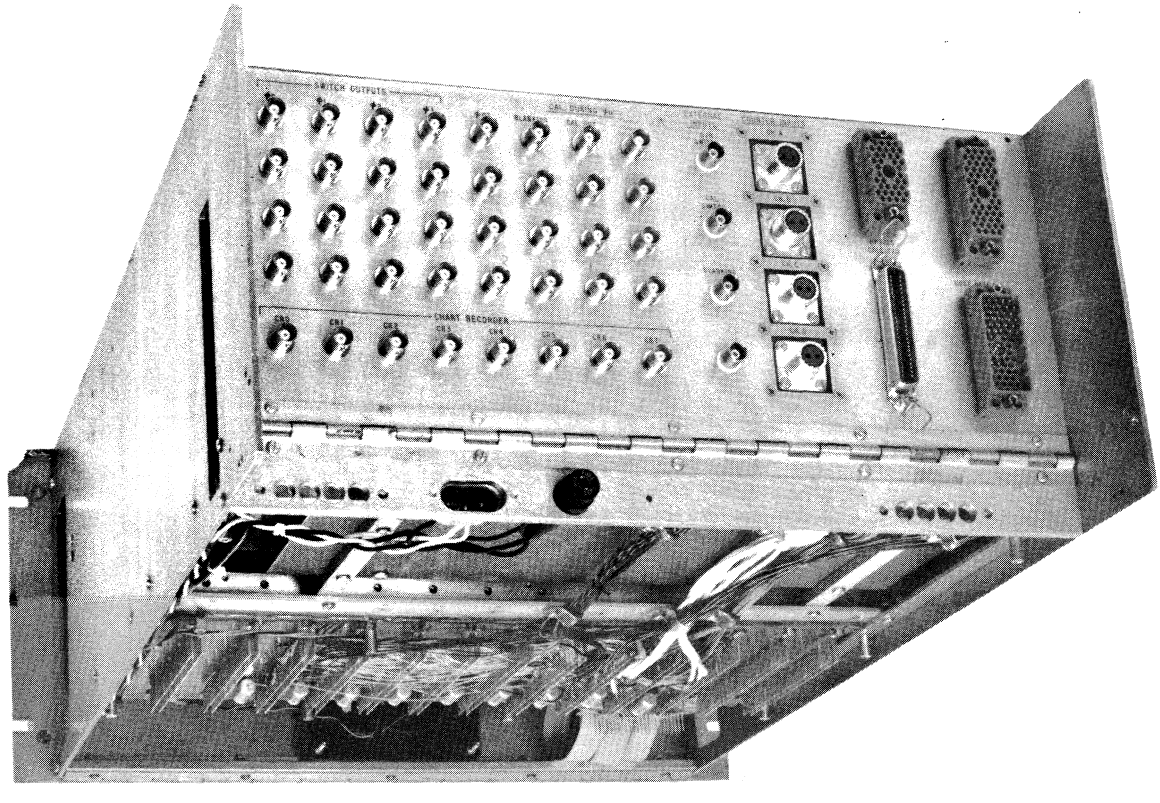
The HP system is more easily programmed but the V77-400 Varian is much faster, easily offering a 10 Hz throughput. Both systems are capable of displaying the following for 4-channel receivers as well as sending switch power data to the host computer:

1. Switch power in °K
2. Normalized gain
3. System temperature °K
4. Sensitivity (measured) °K
5. Sensitivity (theoretical) °K
6. Digital data to host (integer)
7. Gain balancing constant
8. Raw data counts (integer)

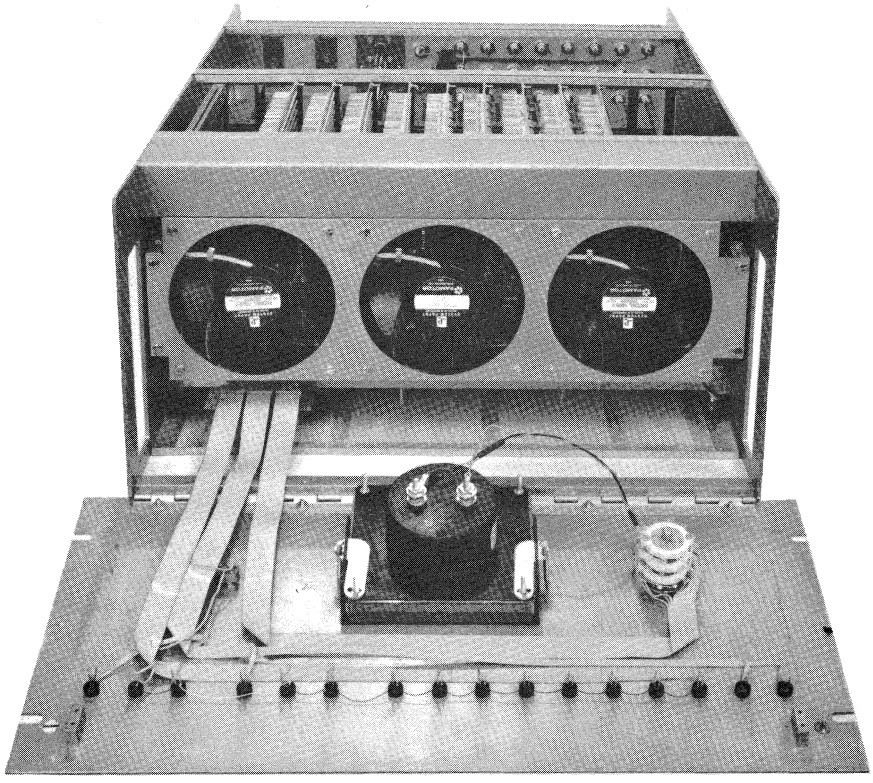
The Digital Integrator/Switch Module

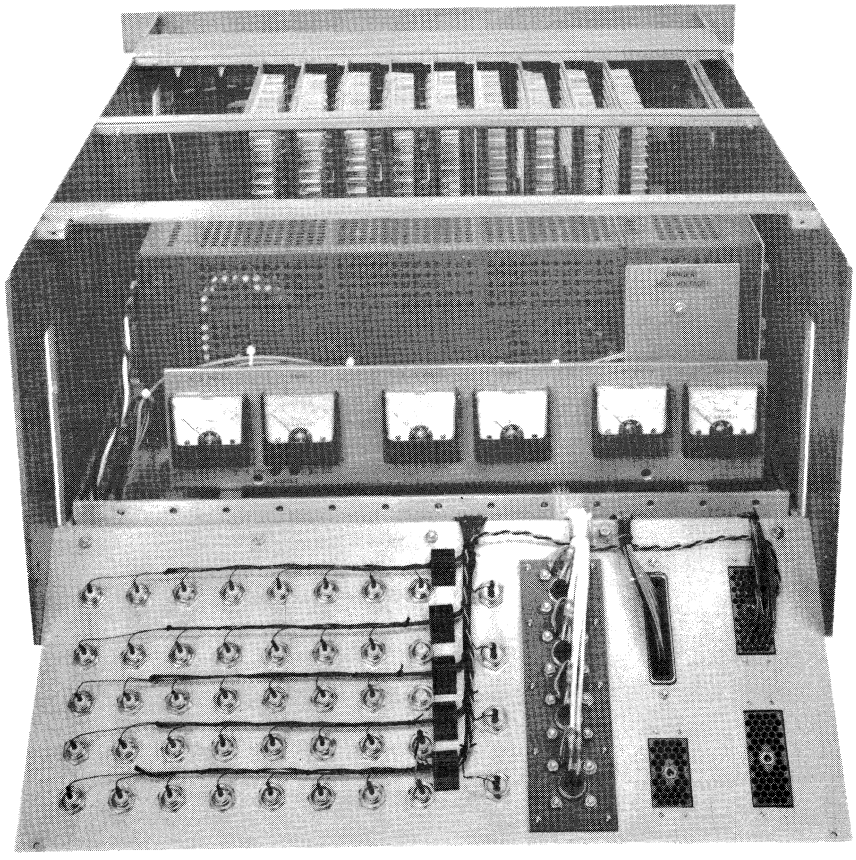
This is the main electronics unit including the integrator and Dicke switch functions as well as eight digital to analog outputs (for chart records) and interfaces for the CPU (HP 9825A) and host data taking computer (DDP 116) and switch driver logic functions.





Digital Receiver





System Operation

The system wakes up automatically when the power is applied to all devices simultaneously if one condition is met: The program tape must be inserted in the reader slot with the record tab enabled. As power is applied, this start up sequence occurs:

1. The system program is loaded from file "Ø" with execution beginning at line Ø.

2. The system program directs the following sequence:

   A. System parameters initialized.

   B. Selected parameters are loaded from tape.

   C. The special function keys are loaded from tape.

   D. The hardware is initialized.

   E. The gain balancing phase is executed (if called for).

   F. The data acquisition phase commences.

Verifying System Normal Operation

Following the completion of the above sequence, the operator may verify the proper connection of the radiometer system by depressing the "CRS" special function key f_6 which displays the raw counts for the cal, ref, and sig phases. Normally, finite, non-zero integer values are shown with approximately 10^6 counts/second of integration time. The VCO is capable of 5 MHz output full scale but normally operates about 10-20% of full scale as indicated by the panel meter with selector on A, B, C, or D for any of 4 channel total power indications. The meter is connected to the output of a frequency to voltage converter which is digitally selected to 1 of 4 frequencies inputs from the above-mentioned VCO's. In the "CRS" values mentioned above normally C > S > R. If this is not true, the cal or switch signals may be inverted or the wrong logic type (TTL or 3C).

Reinitializing the System

At any time the radiometer control parameters may be altered by depressing the upper case function key f_{12} (init) and entering the appropriate values as called for in the displays. If you wish to leave a parameter unaltered then only the "continue" key should be depressed, thus skipping to the next parameter request. Permanently depressing the continue key will skip to the end of the parameter request sequence ending with beeps as the calculator re-enters the gain balancing phase. Depressing the f_{17} key labeled "rcv bal" will cause the gain balancing phase to be re-entered directly. This may also be accomplished by the host computer via the "OCP" control line.

New Scan Sequence

When the host data taking computer executes the "new scan" OCP, the following sequence occurs:

1. The present scan is terminated following the present integration data acquisition phase with this data sent to the host computer.

2. The "FIFO" buffer interface is reset a few milliseconds later to make ready for a new "header" sequence.

3. The 47 word (maximum) header is transmitted to the host. Termination is caused by the device going "not ready".

4. The 4 word (maximum) switch power (sync det output) data sequence commerces, for the duration of the scan.

5. Some eroneous data interrupts may occur during the above 4 step sequence due to the hardware period generators being altered during switching between gain balancing and data acquisition phases. This is easily detected by the host computer by testing if data is ready after the interrupt. If the device is not ready following an interrupt, it is assumed eroneous.

Analog Monitor

The front panel has the panel meter monitoring function with selector switch allowing the total power of any of the 4 channels to be monitored as mentioned above. Also, the eight D/A converter (chart recorder) outputs may be monitored by selection of "CR0" to "CR7".

Ext Time Base Generator (Slave Mode)

Normally the internal timing generator function is used in radiometers but, ocasionally it is necessary to allow another receiver system to assume control of radiometer timing. This is required in spectral line work (A/C receiver system provides timing) and VLB where timing is slaved to the video recorder head switch intervals. This and other slave applications may be accomplished by setting the front panel timing generator switch to "EXT" and connecting the cal, Dicke switch, and blanking signals appropriately to "TTL" sources. For "3-C" logic levels adapters are inserted in these lines that interpose the pairs to reverse polarity of the optically isolated inputs to the digital receiver system.

Several programs are now described as an aid in understanding the system operation from both the user's and programmer's standpoint. Each program is organized in "modules" and may be modified functionally by altering a specific module. The "control" module is generally not modified unless the digital receiver hardware has been modified.

See special section on page 74 for more on the slave mode.

Program Description: "Gain Balancing Switched with Cal"

The "gain balancing switched with cal" program is the general purpose observing program developed for use with the digital standard receiver in a four phase configuration using from 1 to 4 channels.

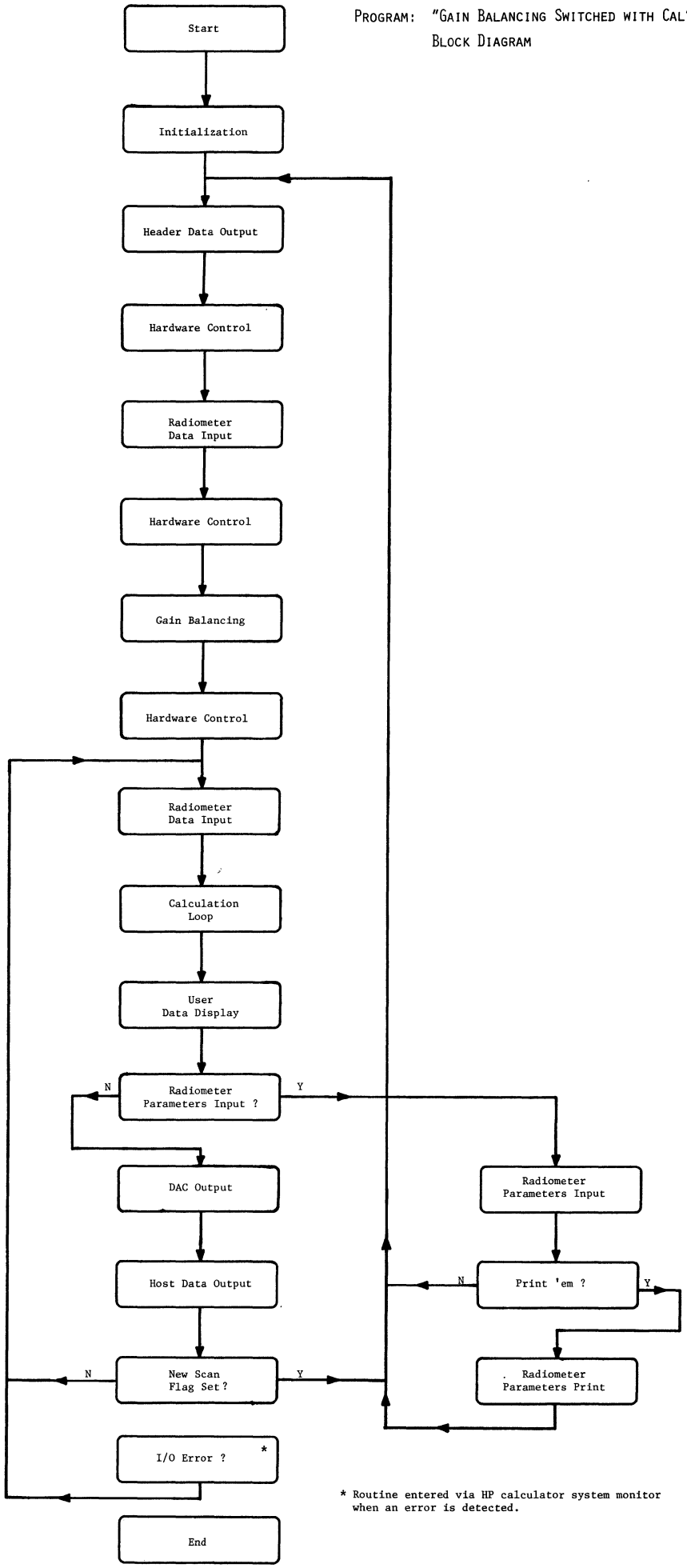
The system may be "cold started" by turning the power on after a tape is inserted into the tape drive slot. After the system is running with the "switch power" being displayed, new operating parameters may be entered after depressing the "upper case" f_0 key (f_{12}) which starts the "constants entry" phase. After this phase, the system returns to the data acquisition phase displaying switch power. Depressing the "CRS" function key (f_6) causes the display to indicate the raw counts C, R, and S. This is used in starting up the system, to determine at a glance if the switch signals (sig/ref, cal, etc.) are connected properly. If they are, generally the "C" value is largest, "S" next, and "R" is smallest.

As mentioned above, the program passes through several phases during normal execution.

Step Number	Program Phase
0-10	1. Initialization
11-37	2. Gain Balancing
38-52	3. Calculation Loop
53-60	4. User Data Display
61-81	5. DAC Output
82-86	6. Host Data Output
92-104	7. Hardware Control
105-152	8. Radiometer Parameters Input
153-161	9. Radiometer Data Input
162-164	10. I/O Error
165-182	11. Radiometer Parameters Print
183-207	12. Header Data Output
208	13. End

Each program phase is executed in the sequence as shown in the block diagram. (Some program phases are actually subroutines which occur in two or more positions in the program sequence.)

PROGRAM: "GAIN BALANCING SWITCHED WITH CAL"
BLOCK DIAGRAM



* Routine entered via HP calculator system monitor when an error is detected.

Program Lists

"Gain Balancing Switched with Cal"

May 25,1978
Ray Hallman

```
0: dsp "GAIN
 BALANCING SWITC
 HED WITH CAL"
1: sfg 14;sfg 5
2: on err "I/O
 ERROR"
3: dim C[4],D[4]
 ,E[4],G[4],R[4]
 ,S[4],U[4]
4: dim M[4],N[4,
 50],P[4],Q[4,
 50],H[4]
5: dim A[4],B[4]
 ,F[4],I[4],K[4]
 ,T[4],W[4],X[8]
 ,P,R,M,O,Q,N,T,
 E,L
6: ldf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
7: ldk 12
8: 1→J;0→A;2→B;
 0→D
9: gsb "CONTROL"
10:
*9771
```

Initialize Statistics Table →

← Start

← Program Initialization

Gain Balancing Calculations →

← Load Parameters

← Load Keys

← Initialize Hardware

Record Parameters →

```
11: "NEW ALPHA":
12: dsp "
 GAIN BALANCING
 NOW"
13: for I=1 to R
14: for D=1 to N
15: 0→N[I,D]→Q[I
 ,D]
16: next D
17: 0→M[I]→P[I]
18: next I
19: 0→D;1→J
20: 1→F;M→K;int(
 1000L/4P)→M;
 gsb "CONTROL";
 0→F
21: gsb "READ
 RCVR"
22: for I=1 to R
23: (C[I]+S[I])/
 R[I]→A[I]
24: (C[I]-S[I])/
 M→F[I]
25: F[I]/T[I]→K[
 I]
26: A[I]R[I]→R[I
 ]
27: S[I]T[I]/
 (C[I]-S[I])→B[I
 ]
28: 2PB[I]/(P-
 Q)r(W[I]K4P/
 1000)→I[I]
29: next I
30: K→M;gsb "CON
 TROL"
31: rcf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
32: if B=7;2→B;
 gsb "HEADER"
33: if A#2;0→A;
 gto "LOOP"
34: spc
35: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
36: spc 2;0→A
37:
*17513
```

```
38: "LOOP":wtc
 15,32+1
39: D+1→D;if
 D=N+1;1→D
40: wsb "READ
 RCVR"
41: if B=1;fxd
 0;dsp "C=",C[R+
 1-J],"R=",R[R+
 1-J]/2,"S=",
 S[R+1-J],J
42: for I=1 to R
43: A[I]R[I]→R[I
 ]
44: (C[I]+S[I]-
 R[I])/2M→D[I]
45: (C[I]-S[I])/
 MF[I]→G[I]
46: S[I]T[I]/
 (C[I]-S[I])→U[I
 ]
47: M[I]-N[I,D]+
 D[I]D[I]→M[I]
48: D[I]D[I]→N[I
 ,D]
49: P[I]-Q[I,D]+
 D[I]→P[I]
50: D[I]→Q[I,D]
51: √((M[I]-P[I]
 P[I]/N)/N-1)→H[
 I]
52: next I
*     3
```

Main Calculation Loop

User Display Phase

```
53: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[R+1-J],J
54: if B=2;fxd
 4;dsp "    SWIT
 CH POWER=",D[R+
 1-J]/K[R+1-J],
 "*K",J
55: if B=3;fxd
 4;dsp "
 NORMALIZED GAIN
 =",G[R+1-J],J
56: if B=4;fxd
 4;dsp "    SYST
 EM TEMP=",U[R+
 1-J],"*K",J
57: if B=5;fxd
 4;dsp " DELTA
 TEMP)meas=",
 H[R+1-J]/K[R+1-
 J],"*K",J
58: if B=6;fxd
 4;dsp " DELTA
 TEMP)theo=",
 I[R+1-J],"*K",J
59: if B=7;gto
 "INIT"
60: if B=8;fxd
 0;dsp "DIGITAL
 OUTPUT=",ED[R+
 1-J]/K[R+1-J],J
*18824
```

```
61: int(X[2](G[R
 ]-1))+128→X
62: if X>127;X-
 256→X
63: X[1](D[R]/
 K[R])+128+256X→
 X
64: if X>-32768;
 if X<32767;wtb
 15,X;gto +2
65: wtb 15,0
66: int(X[4]H[R]
 /K[R])+128→X
67: if X>127;X-
 256→X
68: X[3](U[R]-
 B[R])+128+256X→
 X
69: if X>-32768;
 if X<32767;wtb
 15,X;gto +2
70: wtb 15,0
71: if R<2;wtb
 15,0;wtb 15,0;
 gto "NO CH 2"
72: int(X[6](G[R
 -1]-1))+128→X
73: if X>127;X-
 256→X
74: X[5](D[R-1]/
 K[R-1])+128+
 256X→X
75: if X>-32768;
 if X<32767;wtb
 15,X;gto +2
76: wtb 15,0
77: int(X[8]H[R-
 1]/K[R-1])+128→
 X
78: if X>127;X-
 256→X
79: X[7](U[R-1]-
 B[R-1])+128+
 256X→X
80: if X>-32768;
 if X<32767;wtb
 15,X;gto +2
81: wtb 15,0
*3247
```

Host Data Output Phase →

← DAC Output (Chart Recorders)

```
82: "NO CH 2":
83: for I=1 to R
84: ED[R+1-I]/
 K[R+1-I]→X;if
 X<32767;if X>-
 32768;wtb 15,X;
 gto +2
85: wtb 15,0
86: next I
*28238
```

```
87: if S>31;gto
 "NEW ALPHA"
88: if A=1;gto
 "NEW ALPHA"
89: gto "LOOP"
90:
91:
*4597
```

New Scan Now ? →

```
92: "CONTROL":
93: wtc 15,2+1
94: wtc 15,32+2+
 1
95: wtb 15,0
96: wtb 15,P-1
97: wtb 15,P-1
98: wtb 15,P-1
99: wtb 15,P-1
100: wtb 15,1638
 4F+(R-1)4096+
 512+256+M-1
101: wtc 15,32+
 2+1
102: wtc 15,32+1
103: ret
104:
*10590
```

Hardware Control →

```
105: "INIT":dsp
 "INITIALIZE
 SEQ--2CH,CRSR
 MODE"
106: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?",R
107: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;sto "R"
108: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;sto "R"
109: "P":ent
 "DICKE SWITCH
 PHASE PERIOD
 IN MS?",P;if
 flg13=0;sfg 0
110: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;sto
 "P"
111: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;sto "P"
112: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
113: if flg13=0;
 int(4096Q/P)→O;
 cfg 0
114: if flg0=1;
 int(4096Q/P)→O;
 cfg 0
115: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 sto "Q"
116: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;sto
  "Q"
  `<0
```

Radiometer

Parameters

Input

Phase

```
117: "M":ent
 "HOW MANY SAMPL
 ES/INTEGRATION?
 ",M
118: if M<1;prt
 "MUST BE AT
 LEAST 1 SAMPLES
 /INTEGRATION";
 spc 2;sto "M"
119: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
120: "L":ent
 "RCVR BAL TIME
 (SEC)=",L;int(1
 000L/4P)4P/1000
 →K
121: if int(250L
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/250;spc 2;
 sto "L"
122: if int(250L
 /P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;sto
 "L"
123: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
124: "N":ent
 "DELTA T)meas
 SUMATION TIME?
 SEC",T
125: int(1000T/
 4MP)→N
126: if N<2;fxd
 3;beep;prt "REQ
  MIN SUMMATION
 TIME=",4MP2/
 1000,"SEC";sto
 "N"
127: if N>50;
 beep;prt "MAX
 SUMATION TIME="
 ,4MP50/1000,
 "SECONDS";sto
 "N"
128: if T#4MPN/
 1000;4MPN/1000→
 T;beep;fxd 3;
 prt "ACTUAL
 SUMATION TIME="
 ,T;spc
*27962
```

```
129: ent "WHAT
 IS CAL *K FOR
 CHANNEL 1?",
 T[R]
130: if R-1>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 2?",T[R-1]
131: if R-2>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 3?",T[R-2]
132: if R-3>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 4?",T[R-3]
133: ent "BANDWI
 DTH (MHz) FOR
 CHANNEL 1?",
 W[R];if fl≥13=0
 ;W[R]1e6→W[R]
134: if R-1>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 2?",W[R-1]
135: if R-1>0;
 if fl≥13=0;W[R-
 1]1e6→W[R-1]
136: if R-2>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 3?",W[R-2]
137: if R-2>0;
 if fl≥13=0;W[R-
 2]1e6→W[R-2]
138: if R-3>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 4?",W[R-3]
139: if R-3>0;
 if fl≥13=0;W[R-
 3]1e6→W[R-3]
*20411
```

Radiometer

Parameters

Input

Phase

(Continued)

```
140: ent "CRSF
 0=?  CH1--SWITC
 H POWER",X[1];
 if fl≥13=0;25.5
 /X[1]→X[1]
141: ent "CRSF
 1=?  CH1--GAIN"
 ,X[2];if fl≥13=
 0;25.5/X[2]→X[2
 ]
142: ent "CRSF
 2=?  CH1--T
 SYS",X[3];if
 fl≥13=0;25.5/
 X[3]→X[3]
143: ent "CRSF
 3=?  CH1--DELTA
  T",X[4];if
 fl≥13=0;25.5/
 X[4]→X[4]
144: ent "CRSF
 4=?  CH2--SWITC
 H POWER",X[5];
 if fl≥13=0;25.5
 /X[5]→X[5]
145: ent "CRSF
 5=?  CH2--GAIN"
 ,X[6];if fl≥13=
 0;25.5/X[6]→X[6
 ]
146: ent "CRSF
 6=?  CH2--T
 SYS",X[7];if
 fl≥13=0;25.5/
 X[7]→X[7]
147: ent "CRSF
 7=?  CH2--DELTA
  T",X[8];if
 fl≥13=0;25.5/
 X[8]→X[8]
148: ent "DIGITA
 L OUTPUT SCALE
 FACTOR, ie: 1=
 *K, 10= *K×10",
 E
149: ent "INIT
 VALUES PRINTED,
  ENT 1, CONT",A
15⁰: if A=1;≥sb
 "INIT PRINT"
15: ≥to "NEW
 PHA"
15
*18511
```

```
153: 'READ RCVR"
 :for I=1 to R
154: rdb(15)*
 32768+rdb(15)→R
 [I]
155: rdb(15)*
 32768+rdb(15)→S
 [I]
156: R[I]+rdb(15
 )*32768+rdb(15)
 →R[I]
157: rdb(15)*
 32768+rdb(15)→C
 [I]
158: next I
159: rdb(15)→S
160: ret
161:
*2=443
```

Radiometer Data Input

```
162: "I/O ERROR"
 :
163: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line";
 erl;beep;9→B;
 sto "LOOP"
164:
*29950
```

I/O Error Recovery

Radiometer Parameters Print Out

```
165: "INIT PRINT
 ":
166: fxd 0;spc
167: prt " NUMBE
 R OF RCVR CHANN
 ELS=";R;spc
168: prt "SWITCH
  PERIOD INMS
 =";P;spc
169: fxd 4;prt
 "BLANKING TIME
   MS =";P0/4096
 ;spc
170: fxd 0;prt
 "SAMPLES/INTEGR
 ATION=";M;spc
171: fxd 3;prt
 "SAMPLE PERIOD
   (SEC)=";4MP/
 1000;spc
172: fxd 3;prt
 "RCVR BAL TIME
   (SEC)=";(4P/
 1000)int(1000L/
 4P);spc
173: fxd 3;prt
 "DELTA T)meas
 SUMATION TIME
 (SEC)=";4MPN/
 1000;spc
174: for I=1 to
 R;fxd 0;prt
 "Channel";I;
 fxd 4;prt "CAL=
 ";T[R+1-I];next
  I
175: spc 2
176: for I=1 to
 R;fxd 0;prt
 "Channel";I;
 fxd 4;prt "BW="
 ;W[R+1-I]/1e6;
 next I
177: spc 2
178: for I=1 to
 8;fxd 0;prt
 "FOR CR";I-1;
 fxd 5;prt "CRSF
 =";25.5/X[I];
 next I
179: spc ;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=";E
180: 2→A;spc
181: ret
182:
*1845
```

```
183: "HEADER":if
  fl=5=1;cf 5;
 ret
184: wtb 15,E
185: wtb 15,K
186: wtb 15,L
187: wtb 15,M
188: wtb 15,N
189: wtb 15,O
190: wtb 15,P
191: wtb 15,Q
192: wtb 15,R
193: wtb 15,S
194: wtb 15,T
195: for I=1 to
 R
196: wtb 15,A[R+
 1-I]
197: wtb 15,B[R+
 1-I]
198: wtb 15,G[R+
 1-I]
199: wtb 15,H[R+
 1-I]
200: wtb 15,I[R+
 1-I]
201: wtb 15,K[R+
 1-I]
202: wtb 15,T[R+
 1-I]
203: wtb 15,U[R+
 1-I]
204: wtb 15,W[R+
 1-I]/1e6
205: next I
206: ret
207:
*2927
```

Header Data Output

```
  May 25,1978
  Ray Hallman

list k

f0: *1→J

f1: *if R>1;2→J

f2: *if R>2;3→J

f3: *if R>3;4→J

f4: *0→B

f5: *8→B

f6: *1→B

f7: *2→B

f8: *3→B

f9: *4→B

f10: *5→B

f11: *6→B

f12: *7→B

f15: *prt "P=",P
 ,"Q=",Q,"O=",O

f17: *1→A

f21: *rck12

f23: *prt"  May
 25,1978     Ray
  Hallman";spc2
```

Special Functions Key List

End

```
208: end
*21151
```

```
 NUMBER OF RCVR
CHANNELS=       4

SWITCH PERIOD IN
MS =           10

BLANKING TIME
MS =       0.9985

SAMPLES/INTEGRAT
ION=           25

SAMPLE PERIOD
(SEC)=      1.000

RCVR BAL TIME
(SEC)=      2.000

DELTA T)meas SUM
ATION TIME (SEC)
=          10.000

Channel          1
CAL=       15.2000
Channel          2
CAL=       15.2000
Channel          3
CAL=       15.2000
Channel          4
CAL=       15.2000


Channel          1
BW=        60.0000
Channel          2
BW=        60.0000
Channel          3
BW=        60.0000
Channel          4
BW=        60.0000
```

This typical print out is obtained when "1" is entered for print out of radiometer parameters during "Radiometer Parameters Input Phase".

Note: The cals and bandwidths are shown equal; however, they may all be different, for different channels.

```
FOR CR           0
CRSF=    10.00000
FOR CR           1
CRSF=     0.10000
FOR CR           2
CRSF=    25.00000
FOR CR           3
CRSF=     6.00000
FOR CR           4
CRSF=    10.00000
FOR CR           5
CRSF=     0.10000
FOR CR           6
CRSF=    25.00000
FOR CR           7
CRSF=     6.00000

DIGITAL OUTPUT
SCALE FACTOR=
        1000.0000


Channel          1
S/R=        1.4261
Channel          2
S/R=        1.4258
Channel          3
S/R=        1.4216
Channel          4
S/R=        1.4125
```

Program Title: "Gain Balancing Switched with Cal"

Internal Constants List

A	If A = 1; re balance	A	[4]	Gain mod constants
B	User display selector	B	[4]	T_{sys} offsets
C	Statistics data array index	C	[4]	Cal phase raw count ϕ_0
D	" " " "	D	[4]	Switch power in counts
E	Host data scale factor	E	[ ]	
F	If F = 1; reset Fifo buffer	F	[4]	$(C - S)_0$
G		G	[4]	Relative gain
H		H	[4]	ΔT meas
I	For I loops (init seq)	I	[4]	ΔT theo
J	User data channel select	J	[ ]	
K	Rx balance time factor	K	[4]	Scale factor counts/°K
L	" " " "	L	[ ]	
M	No. of samples/integ period	M	[4]	Statistics Data Array
N	No. of samples in statistics	N	[4, 10]	" " "
O	Blanking time parts	O	[ ]	
P	Phase interval in msec	P	[4]	Statistics Data Array
Q	Blanking time in msec	Q	[4, 10]	" " "
R	No. of rx channels active	R	[4]	Ref Phase Raw Count --- $\frac{\phi_1 + \phi_3}{2}$
S	Status input	S	[4]	Sig Phase Raw Count ϕ_2
T	Summation time for statistics	T	[4]	Cal Value in °K
U		U	[4]	T_{sys} in °K
V		V	[ ]	
W		W	[4]	Channel bandwidth
X	Buffer register	X	[8]	Chart recorder scale factors
Y		Y		
Z		Z		

Flag	0	Constant entered
	1	
	2	
	3	
	4	
	5	Skip header if cold start
	6	
	7	
	8	
	9	
	10	
	11	
	12	
	13	Constant entered
	14	Error inhibit
	15	

CALCULATIONS IN ENGLISH!

PROGRAM NAME: "GAIN BALANCING SWITCHED WITH CAL"

RADIOMETER PARAMETERS INPUT

Step No.

113/114 $0 = \text{Blanking Time Parts} = \text{Integer}\left(\frac{4096 \times \text{Blanking Time}}{\text{Dicke Switch Phase Period}}\right)$

120 $K = \text{Number of Samples for Gain Balance Integration} = \text{Integer}\left(\frac{1000 \times \text{Rcvr Bal Time}}{4 \times \text{Dicke Sw Phase Period}}\right) \times \left(\frac{4 \times \text{Dicke Sw Phase Period}}{1000}\right)$

121 $\text{Minimum Rcvr Bal Time} = \frac{\text{Dicke Switch Phase Period} \times 4}{1000}$

122 $\text{Maximum Rcvr Bal Time} = 256 \times \frac{\text{Dicke Switch Phase Period} \times 4}{1000}$

125 $N = \text{Number of Samples for Statistics Table} = \text{Integer}\left(\frac{1000\ \Delta T)_{meas}\ \text{Summation Time}}{\text{Number of Samples per Integration} \times \text{Dicke Switch Phase Period} \times 4}\right)$

126 $\text{Minimum } \Delta T)_{meas}\ \text{Summation Time} = \frac{2 \times \text{Number of Samples per Integration} \times \text{Dicke Switch Phase Period} \times 4}{1000}$

127 $\text{Maximum } \Delta T)_{meas}\ \text{Summation Time} = \frac{50 \times \text{Number of Samples per Integration} \times \text{Dicke Switch Phase Period} \times 4}{1000}$

128 $T = \text{Actual Summation Time for } \Delta T = \frac{4 \times \text{Dicke Switch Phase Period} \times \text{Number of Samples per Integration} \times \text{Number of Samples for Statistics Table}}{1000}$

140 $CRSF = X(i) = \frac{25.5 \text{ Counts per Volt}}{X(i)}$ NOTE: For 8-bit D/A converters full scale count is 255.

RADIOMETER PARAMETERS PRINTED:

169 $\text{Blanking Time} = \frac{\text{Dicke Switch Phase Period} \times \text{Blanking Time Parts}}{4096}$

171 $\text{Sample Period} = \frac{\text{Number of Samples per Integration} \times \text{Dicke Switch Phase Period} \times 4}{1000}$

172 $\text{Receiver Balance Time} = \frac{\text{Dicke Switch Phase Period} \times 4}{1000} \times \text{Integer}\left(\frac{1000 \times \text{Receiver Balance Time}}{\text{Dicke Switch Phase Period} \times 4}\right)$

173 $\Delta T)_{meas}\ \text{Summation Time} = \frac{\text{Number of Samples for Statistics Table} \times \text{Number of Samples per Integration} \times \text{Dicke Switch Phase Period} \times 4}{1000}$

RADIOMETER DATA INPUT:

Note: The data input sequence is repeated from 1 to 4 times as required for the number of active receiver channels.

154 R = Reference Switch Phase Raw Count = First Input Transfer x 32768 + Second Input Transfer

155 S = Signal Switch Phase Raw Count = Third Input Transfer x 32768 + Fourth Input Transfer

156 R = Reference Switch Phase Raw Count = $R)_{\substack{\text{from}\\154}}$ + Fifth Input Transfer x 32768 + Sixth Input Transfer

157 C = Cal Switch Phase Raw Count = Seventh Input Transfer x 32768 + Eighth Input Transfer

GAIN BALANCING PHASE:

20 $M = \text{Samples per Integration} = \text{Integer} \dfrac{1000 \times \text{Receiver Balance Time}}{\text{Dicke Switch Phase Period} \times 4}$

23 $\alpha = \text{Gain Modulation Constant} = \dfrac{\text{Cal} + \text{Sig}}{\text{Ref}}$ NOTE: Values in counts.

24 $F = \text{Cal Value in Counts} = \dfrac{\text{Cal} - \text{Sig}}{\text{Samples/Integration}}$

25 $K = \text{Counts per } ^\circ K = \dfrac{\text{Cal Value in Counts}}{\text{Cal Value in } ^\circ K}$

26 R = Gain Balanced Ref Count = Gain Modulation Constant x Ref Count

27 $B = \text{System Temp Offset Values for Charts} = \dfrac{\text{Sig Counts} \times \text{Cal Value } ^\circ K}{\text{Cal Counts} - \text{Sig Counts}}$

28 $I = \dfrac{\text{Theoretical } \Delta T}{\text{(sensitivity)}} = \dfrac{2 \times \text{Dicke Switch Phase Period} \times \text{System Temperature}}{\left(\text{Dicke Switch Phase Period} - \text{Blanking Time}\right) \times \sqrt{\dfrac{\text{Receiver Bandwidth} \times \text{Samples per Integration} \times \text{Dicke Switch Phase Period} \times 4}{1000}}}$

CALCULATION LOOP:

41 The Adjusted Channel Number = Number of Receiver Channels + 1 - Channel Data Display Select Constant

43 R = Gain Balanced Ref Count = Gain Modulation Constant x Ref Count

44 $D = \text{Switch Power in Counts} = \dfrac{\text{Cal Counts} + \text{Sig Counts} - \text{Ref Counts}}{2 \times \text{Number of Samples per Integration}}$

45 $G = \text{Normalized Gain} = \dfrac{\text{Cal Counts} - \text{Sig Counts}}{\text{Cal Value in Counts} \times \text{Number Samples per Integration} \times 2}$

46 $U = \text{System Temp in } ^\circ K = \dfrac{\text{Sig Counts} \times \text{Cal Value in } ^\circ K}{\text{Cal Counts} - \text{Sig Counts}}$

47 $M = \text{Sum of Square of Switch Power} = \sum_{1}^{N} (\text{Switch Power} \times \text{Switch Power})$

48 N_D = Last Value of Switch Power Squared = (Switch Power x Switch Power)$_D$

49 P = Sum of Value of Switch Power = $\sum_{1}^{N}$ Switch Power

50 Q_D = Last Value of Switch Power = (Switch Power)$_D$

51 H = ΔT measured = $$\sqrt{\frac{1}{N-1}\left(\Sigma\ (\text{Switch Power}) - \frac{(\Sigma\ \text{Switch Power})^2}{N}\right)}$$

User Data Display:

54 $$\text{Switch Power in °K} = \frac{\text{Switch Power in Counts}}{\text{Scale Factor in Counts/°K}}$$

57 $$\Delta T \text{ measured in °K} = \frac{\Delta T)_{meas} \text{ in Counts}}{\text{Scale Factor in Counts/°K}}$$

60 $$\text{Switch Power Digital Output} = \text{Host Data Scale Factor} \times \frac{\text{Switch Power in Counts}}{\text{Scale Factor in Counts/°K}}$$

D/A Converter Data Output:

61 CR1 = X = Integer (Chart Recorder Scale Factor #1 x Normalized Gain) + 128

63 D/A Converter CRO & CR1 Composit Output = X = Chart Recorder Scale Factor #0 x $\frac{\text{Switch Power in Counts}}{\text{Scale Factor Counts per °K}}$ + 128 + 256 x CR1

66 CR3 = X = Integer Chart Recorder Scale Factor #3 x $\frac{\Delta T)_{meas}}{\text{Scale Factor in Counts/°K}}$ + 128

68 D/A Converter CR2 & CR3 Composit Output = X = Chart Recorder Scale Factor #2 x $\left(T_{sys} - T_{sys})_{offset}\right)$ + 128 + 256 x CR3

72 Similar to 61. : But for receiver "B" channel.

74 Similar to 63. :

77 Similar to 66. : NOTE: In the program only channels A and B have data sent to chart recorders.

79 Similar to 68. :

Host Data Output:

84 Host Data = X = $\frac{\text{Host Data Scale Factor x Switch Power}}{\text{Scale Factor}}$

Header Data Output:

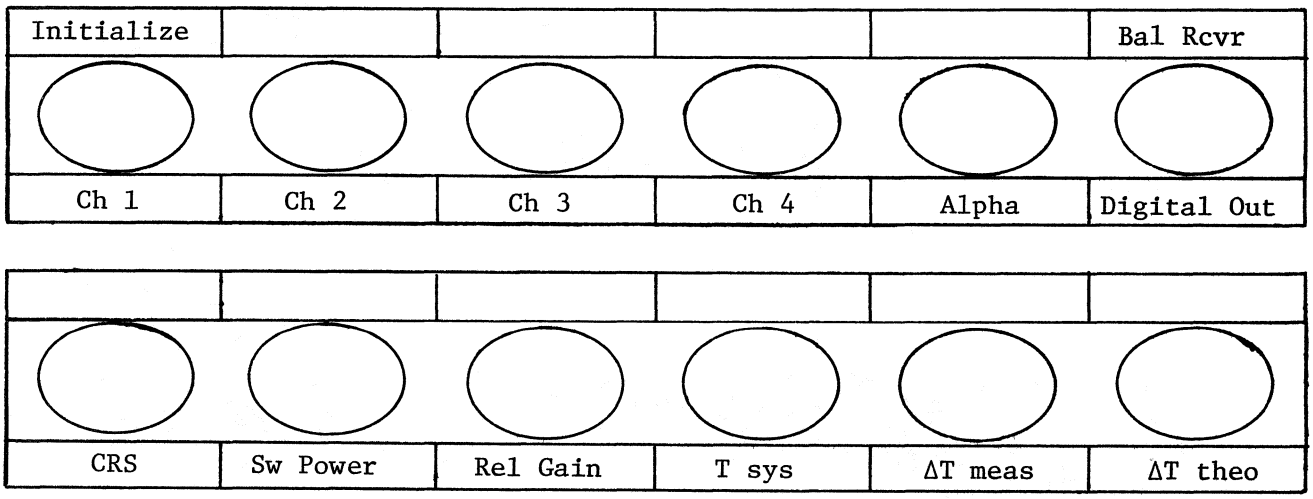
204 Bandwidth = W = W/10^6 MHz

Notes on the Header Phase:

Generally, subscripted array variables that have (R + 1 - I) as the subscript may instead be A(X), B(X), etc., with X = R + 1 - I being calculated at the start of the phase.

Also, some values (i.e., T_{sys}, $\Delta T)_{meas}$) may be stale or bad if a new scan is ordered when the telescope is off source or being slewed to a new one. This problem is fixed by calculation during the previous gain balancing phase and stored as separate constants for reading at header transmit time.

Special Function Keys:



Shown above is a copy of the function keys bezel overlay for the program titled: "Gain Balancing Switched with Cal". The channel keys labeled Ch 1 - Ch 4 (f_0 - f_3) allow selection of the particular channel for which data is to be displayed. The other lower case keys direct which data is displayed:

Key		Displayed Data
f_4	-	Gain Modulation Constant, Alpha
f_5	-	Digital Output (Host Data Raw Count)
f_6	-	CRS Raw Count for C, R, and S
f_7	-	Switch Power (Synchronous Detected Power)
f_8	-	Relative Gain
f_9	-	System Temperature
f_{10}	-	$\Delta T)_{meas}$ (measured sensitivity)
f_{11}	-	$\Delta T)_{theo}$ (theoretical sensitivity)

The upper case (shift) keys provide only two useful functions: Initialize the radiometer parameters (f_{12}) and the receiver balance function (f_{17}).

HP9825A Input Data Format: 4ϕ, 4 Ch System Mode

R [1]	ϕ_3	MS	
[2]	ϕ_3	LS	
[3]	ϕ_2	MS	
[4]	ϕ_2	LS	
[5]	ϕ_1	MS	... CHAN 'D'
[6]	ϕ_1	LS	
[7]	ϕ_0	MS	
[8]	ϕ_0	LS	
[9]	ϕ_3	MS	
[10]	ϕ_3	LS	
[11]	ϕ_2	MS	
[12]	ϕ_2	LS	
[13]	ϕ_1	MS	... CHAN 'C'
[14]	ϕ_1	LS	
[15]	ϕ_0	MS	
[16]	ϕ_0	LS	
[17]	ϕ_3	MS	
[18]	ϕ_3	LS	
[19]	ϕ_2	MS	
[20]	ϕ_2	LS	
[21]	ϕ_1	MS	... CHAN 'B'
[22]	ϕ_1	LS	
[23]	ϕ_0	MS	
[24]	ϕ_0	LS	
[25]	ϕ_3	MS	
[26]	ϕ_3	LS	
[27]	ϕ_2	MS	
[28]	ϕ_2	LS	
[29]	ϕ_1	MS	... CHAN 'A'
[30]	ϕ_1	LS	
[31]	ϕ_0	MS	
[32]	ϕ_0	LS	
[33]	Receiver Status (15 normal)		14 Ch A OVLD, etc. 13 Ch B OVLD 11 Ch C OVLD 7 Ch D OVLD

The input data format above, for the 4 channel, 4 phase mode requires that 33 16-bit data words be transferred to the processor. If the system is reprogrammed to the 3 channel mode, only 25 words are necessary, thus eliminating the Chan "D" group (R[1] - R[8]) where the input data block would then start with R[9].

If this hardware is set up into a 4 channel, 3 phase mode, then all ϕ_3 inputs would be eliminated from the block with all data moving up to fill in the blank slots vacated by the ϕ_3 inputs, thus requiring only 25 words. Of course, a 1 channel, 1 phase system requires only 3 words input or 2 words input if status is not wanted.

Output Data Format

	Function	Word Address Counter State
Start 1:	Blanking Time	10
	Period Phase 0	9
	Period Phase 1	8
	Period Phase 2	7
	Period Phase 3	6
	Mode Control (Note 2)	5
Start 2:	CR0 & CR1	4
	CR2 & CR3	3
	CR4 & CR5	2
	CR6 & CR7	1
(Note 3)	Host Data 1	0
	Host Data 2	0
	Host Data 3	0
	Host Data 4	0
	Host Data N	0

NOTE 1: If CTLϕ is set, the cal signal is sent during the next ϕ_0. When CTLϕ is reset, the cal signal is turned off after the next ϕ_0. If CTLϕ is pulsed, you get cal for the next ϕ_0 period only. This is true if the "2048" bit of the mode control is zero. If this bit is set, i.e., if 2048 is added to the mode control output value, then the cal operation is changed from the above "pulsed" operation to continuous operation which lasts during the entire switch cycle.

NOTE 2: The "mode control" output word has the format shown:

Function → X	F	C_2	C_1	P	X	M_1	M_0	S_7	S_6	S_5	S_4	S_3	S_2	S_1	S_0
——————→	1	8	4	2	1	5	2	1	6	3	1	8	4	2	1
Value added	6	1	0	0	0	1	5	2	4	2	6				
to mode con-	3	9	9	4	2	2	6	8							
trol output	8	2	6	8	4										
	4														

F - Fifo Buffer Reset

C_2C_1 - Number of Channels - 1

M_1M_0 - Number of Phases - 1

S_7 - S_0 - Number of Integration Cycles per Interrupt Generated

P - Pulsed/Continuous Cal Control Bit

NOTE 3: If CTL1 set, sequential data from "Start 1" as shown.

If CTL1 is reset, sequential data output seating from Start 2 as shown.

NOTE 4: All data is binary integer at the 16-bit I/O interface connector but specified from the HP9825A keyboard in decimal.

Header Data Format:

The following information is transmitted, via the header, to the host data taking computer at the start of scan, except during cold start:

Header Data Block Sequence:

Designation	Parameter
E	Host data scale factor
K	Receiver balance time factor
L	Receiver balance time in seconds
M	Number of samples/integration period
N	Number of samples in statistics summation
O	Blanking time parts
P	ϕ Interval in msec (all equal phase periods)
Q	Blanking time in msec.
R	Number of receiver channels in use
S	Status input
T	Summation time for statistics data
A_1	Gain modulation factor for Channel 1
B_1	Initial system temperature offset for Channel 1
G_1	Relative gain for Channel 1
H_1	Measured radiometer sensitivity for Channel 1
I_1	Theoretical radiometer sensitivity
K_1	Radiometer data scale factor counts/°K
T_1	Cal value in °K
U_1	System temperature in °K
W_1	Channel bandwidth

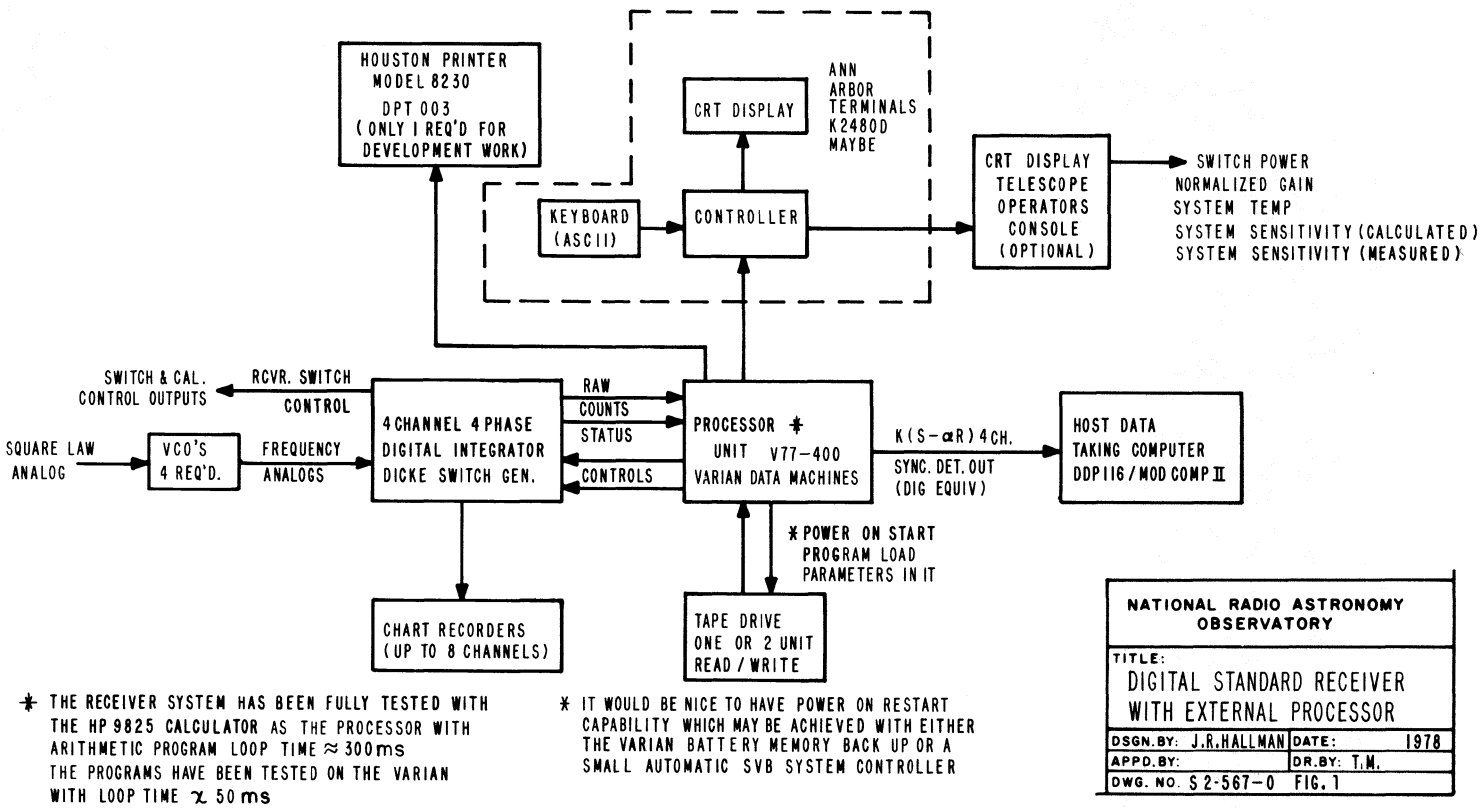
Continued --

Designation	Parameter
A_2	Gain modulation constant for Channel 2
B_2	Initial system temperature offset for Channel 2
G_2	Relative gain for Channel 2
	REPEATS THROUGH ALL CHANNELS ABOVE.

NOTE: All data in the header block is transmitted in binary 16-bit, 2's compliment format. An error "G3" and line number 184-204 will be displayed if the data value is out of range -32768 to +32767.

The Suggested Varian V77-400 Minicomputer Based Digital Radiometer System Configuration and Fortran Program:

The present digital receiver CPU (HP9825A) may be replaced with more powerful but less easily programmed Varian V77-400 processor system as shown:



The introductory notes at the front of this EDIR draw some comparisons of the two systems. Reproduced next is the Fortran/Varian compatible program equivalent of the HP9825A program:

```
 PAGE     1                  31/03/78

    1
    2          DIMENSION C(4),D(4),E(4),G(4),R(4),S(4),U(4)
    3          DIMENSION FM(4),FN(4,50),P(4),Q(4,50),H(4)
    4          DIMENSION A(4),B(4),F(4),FI(4),FK(4),T(4),W(4),X(8)
    5          WRITE (0,99)
    6       99 FORMAT ( 33H GAIN BALANCING SWITCHED WITH CAL)
    7          DO 10 I=1,4
    8          A(I)=1.
    9          B(I)=15.
   10          F(I)=1000.
   11          FI(I)=1.
   12          FK(I)=1.
   13          T(I)=21.5
   14          W(I)=6.E5
   15          X(I)=20.
   16          X(I+4)=20.
   17       10 CONTINUE
   18          IP=150
   19          IR=4
   20          IM=1
   21          IO=435
   22          QQ=5.
   23          NN=25
   24          TT=5.
   25          EE=1.
   26          FL=5.
   27          JJ=1
   28          AA=0.
   29          BB=2.
   30          CALL CONTR (IO,IP,IR,IM)
   31    C     NEW ALPHA:
   32          WRITE (0,98)
   33       98 FORMAT (19H GAIN BALANCING NOW)
   34          DO 20 I=1,IR
   35          DO 15 ID=1,NN
   36          FR(I,ID)=0.
   37          Q(I,ID)=0.
   38       15 CONTINUE
   39          FM(I)=0.
   40          P(I)=0.
```

NOTE: This test Fortran equivalent of the 9825A system executes on the V77-400 in 42 seconds from the last write operation at line 61. This is a 42 msec loop time for calculations!

```
PAGE    2                31/03/78
-----------------------------------------------------------------------
  41      20 CONTINUE
  42         ID=0
-----------------------------------------------------------------------
  43         JJ=1
  44         KK=IM
  45         IM=IFIX(1000.*FL/FLOAT(4*IP))
-----------------------------------------------------------------------
  46         CALL CONTR (IO,IP,IR,IM)
  47         CALL RDRCV (R,S,C,IS,IR)
  48         DO 30 I=1,IR
-----------------------------------------------------------------------
  49         A(I)=(C(I)+S(I))/R(I)
  50         F(I)=(C(I)-S(I))/FLOAT(IM)
  51         FK(I)=F(I)/T(I)
-----------------------------------------------------------------------
  52         R(I)=A(I)*R(I)
  53         B(I)=S(I)*T(I)/(C(I)-S(I))
  54      30 CONTINUE
-----------------------------------------------------------------------
  55         IM=KK
  56         CALL CONTR (IO,IP,IR,IM)
  57         WRITE (0,97)(A(I),B(I),F(I),FI(I),FK(I),T(I),W(II),I=1,IR)
-----------------------------------------------------------------------
  58      97 FORMAT (7F16.7)
  59         WRITE (0,96) IP,IR,IM,IO,QQ,NN,TT,EE,FL
  60      96 FORMAT (4I4,F14.7,I4,3F16.7)
-----------------------------------------------------------------------
  61         DO 150 III=1,1000
  62      50 IREST=32+1
  63         ID=ID+1
-----------------------------------------------------------------------
  64         IF (ID-NN+1) 56,55,55
  65      55 ID=1
  66      56 CALL RDRCV (R,S,C,IS,IR)
-----------------------------------------------------------------------
  67         IF (BB-1.) 58,57,58
  68      57 CONTINUE
  69      58 DO 60 I=1,IR
-----------------------------------------------------------------------
  70         R(I)=A(I)*R(I)
  71         D(I)=(C(I)+S(I)-R(I))/2.
  72         G(I)=(C(I)-S(I))/F(I)
-----------------------------------------------------------------------
  73         U(I)=S(I)*T(I)/(C(I)-S(I))
  74         FM(I)=FM(I)-FN(I,ID)+D(I)*D(I)
  75         FN(I,ID)=D(I)*D(I)
-----------------------------------------------------------------------
  76         P(I)=P(I)-Q(I,ID)+D(I)
  77         Q(I,ID)=D(I)
  78         H(I)=SQRT((FM(I)-P(I)*P(I)/FLOAT(NN))/FLOAT(NN-1))
-----------------------------------------------------------------------
  79      60 CONTINUE
  80         IF (BB) 64,63,64
```

```
PAGE    3                31/03/78

 81      63 CONTINUE
 82      64 IF (BB-2.) 66,65,66
 83      65 CONTINUE
 84      66 IF (BB-3.) 68,67,68
 85      67 CONTINUE
 86      68 IF (BB-4.) 70,69,70
 87      69 CONTINUE
 88      70 IF (BB-5.) 72,71,72
 89      71 CONTINUE
 90      72 IF (BB-6.) 74,73,74
 91      73 CONTINUE
 92      74 IF (BB-7.) 76,75,76
 93      75 CONTINUE
 94      76 IF (BB-8.) 77,77,77
 95      77 DO 140 IIII=1,2
 96         IX=IFIX(X(2)*(G(IR)-1.)+128.)
 97         IF (IX-127) 121,121,120
 98     120 IX=IX-256
 99     121 IX=IFIX(X(1)*D(IR)/FK(IR)+128.)+256*IX
100         IF (FLOAT(IX)+32768.) 124,124,122
101     122 IF (FLOAT(IX)-32767.) 123,123,124
102     123 IOUT=IX
103         GO TO 125
104     124 IOUT=0
105     125 IX=IFIX(X(4)*H(IR)/FK(IR))+128
106         IF (IX-127) 127,127,126
107     126 IX=IX-256
108     127 IX=IFIX(X(3)*(U(IR)-B(IR)))+128+256*IX
109         IF (FLOAT(IX)+32768.) 130,130,128
110     128 IF (IX-32767) 129,129,130
111     129 IOUT=IX
112         GO TO 131
113     130 IOUT=0
114     131 CONTINUE
115     140 CONTINUE
116     150 CONTINUE
117         STOP
118         END
ENTRY/COMMON BLOCK NAMES
004361 R
```

PAGE 4

EXTERNAL NAMES

002722	E	$WR
002772	E	$ND
004163	E	$DO
002570	E	CONTR
004114	E	IFIX
004122	E	FLOAT
004027	E	$QN
004106	E	$QM
003035	E	RDRCV
004125	E	$QK
004103	E	$QL
002766	E	$I3
002752	E	$I1
003473	E	SQRT
004072	E	$HM
004171	E	$ST

SYMBOL TABLE

004175	R	000001
004357	R	000002
004225	R	000004
000002	R	C
000012	R	D
000022	R	E
000032	R	G
000042	R	R
000052	R	S
000062	R	U
000072	R	FM
000102	R	FN
000722	R	P
000732	R	Q
001552	R	H
001562	R	A
001572	R	B
001602	R	F
001612	R	FI
001622	R	FK
001632	R	T
001642	R	W

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001652	R	X	
002722	E	$WR	
004174	R	000000	
001702	R	99	
002772	E	$ND	
002062	R	10	
004176	R	I	
004201	R	040300	000000
004177	R	001560	
004200	R	$I	
004204	R	041170	000000
004203	R	001570	
004207	R	042575	000000
004206	R	001600	
004211	R	001610	
004212	R	001620	
004214	R	041325	077777
004213	R	001630	
004217	R	045111	017400
004216	R	001640	
004222	R	041320	000000
004221	R	001650	
004224	R	001660	
004163	E	$DO	
004227	R	IP	
004226	R	000226	
004230	R	IR	
004231	R	IM	
004233	R	IO	
004232	R	000663	
004236	R	QQ	
004234	R	040720	000000
004241	R	NN	
004240	R	000031	
004242	R	TT	
004244	R	EE	
004246	R	FL	
004250	R	JJ	
004253	R	AA	
004251	R	000000	000000

```
PAGE     6

004257 R      BB
004255 R 040500 000000
002570 E    CONTR
002153 R       98
002257 R       20
002225 R       15
004261 R       ID
004262 R 000070
004263 R 000720
004264 R       KK
004114 E     IFIX
004122 E    FLOAT
004265 R     $2 0
004027 E      $QN
004106 E      $QM
004267 R     $2 1
003035 E    RDRCV
004271 R       IS
002556 R       30
004272 R     $1 0
004273 R 000000
004274 R     $1 1
004275 R 000050
004276 R     $1 2
004277 R 000040
004300 R     $1 3
004125 E      $QK
004301 R     $2 3
004103 E      $QL
004303 R     $2 4
002715 R       97
004306 R       II
002766 E      $I3
004305 R     $1 4
004307 R     $1 5
002775 R       96
002752 E      $I1
004162 R      150
004310 R      III
004360 R 001750
```

```
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003013 R       50
004312 R    IREST
004311 R 000040
003034 R       56
003031 R       55
003057 R       58
003057 R       57
003501 R       60
004313 R 000010
004314 R 000030
004315 R 000060
003473 E     SQRT
004316 R 001550
004317 R     $2 5
004321 R     $2 6
003520 R       64
003520 R       63
003534 R       66
003534 R       65
004323 R 040540 000000
003550 R       68
003550 R       67
004325 R 040700 000000
003564 R       70
003564 R       69
003600 R       72
003600 R       71
004327 R 040740 000000
003614 R       74
003614 R       73
004331 R 040760 000000
003630 R       76
003630 R       75
004333 R 041100 000000
003642 R       77
004154 R      140
004335 R     IIII
004341 R       IX
004337 R 042100 000000
004336 R 001654
```

```
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-------------------------------------------------------------------------------

004342 R 000177
003710 R     121
-------------------------------------------------------------------------------
003704 R     120
004343 R 000400
004072 E     $HM
-------------------------------------------------------------------------------
004344 R 001652
004345 R 044100 000000
004007 R     124
-------------------------------------------------------------------------------
003766 R     122
004347 R 043777 077600
004002 R     123
-------------------------------------------------------------------------------
004351 R    IOUT
004012 R     125
004354 R 000200
-------------------------------------------------------------------------------
004352 R    $2 2
004057 R     127
004053 R     126
-------------------------------------------------------------------------------
004355 R 001656
004151 R     130
004133 R     128
-------------------------------------------------------------------------------
004356 R 077777
004144 R     129
004154 R     131
-------------------------------------------------------------------------------
004171 E     $ST
  0 ERRORS COMPILATION COMPLETE
```

```
PAGE    1                    31/03/78

   1  C
   2         SUBROUTINE CONTR (IO,IP,IR,IM)
   3         IA=2+1
   4         IB=32+2+1
   5         IC=IO
   6         ID=IP-1
   7         IE=IP-1
   8         IF=IP-1
   9         IG=IP-1
  10         IH=(IR-1)*4096+512+256+IM-1
  11         IJ=32+2+1
  12         IK=32+1
  13         RETURN
  14         END
ENTRY/COMMON BLOCK NAMES
000131 R  CONTR
EXTERNAL NAMES
000002 E     $SE
000065 E     $HM
SYMBOL TABLE
000111 R 000001
000112 R 000002
100004 R      IO
100005 R      IP
100006 R      IR
100007 R      IM
000002 E     $SE
000113 R      IA
000115 R      IB
000114 R 000040
000116 R      IC
000117 R      ID
000120 R      IE
000121 R      IF
000122 R      IG
000126 R      IH
000123 R 010000
000124 R 001000
000125 R 000400
000065 E     $HM


PAGE    2                    31/03/78

000127 R      IJ
000130 R      IK
   0 ERRORS COMPILATION COMPLETE
```

```
PAGE    1                    31/03/78

   1  C
   2         SUBROUTINE RDRCV (XR,XS,XC,IS,IR)
   3         DIMENSION XR(4),XS(4),XC(4)
   4         DO 80 I=1,IR
   5         XR(I)=32768.*1.+1000.
   6         XS(I)=32768.*1.+2000.
   7         XR(I)=XR(I)+32768.*1.+1000.
   8         XC(I)=32768.*1.+3000.
   9      80 CONTINUE
  10         IS=15
  11         RETURN
  12         END
ENTRY/COMMON BLOCK NAMES
000175 R   RDRCV
EXTERNAL NAMES
000002 E     $SE
000130 E     $QM
000133 E     $QK
000142 E     $DO
SYMBOL TABLE
000156 R 000001
100004 R      XR
100005 R      XS
100006 R      XC
100007 R      IS
100010 R      IR
000002 E     $SE
000141 R      80
000157 R       I
000164 R 044100 000000
000162 R 040300 000000
000166 R 042575 000000
000160 R 177776
000161 R    $1
000130 E     $QM
000133 E     $QK
000170 R 042775 000000
000172 R 043135 060000
000142 E     $DO
000174 R 000017


PAGE    2                    31/03/78

   0 ERRORS COMPILATION COMPLETE
```

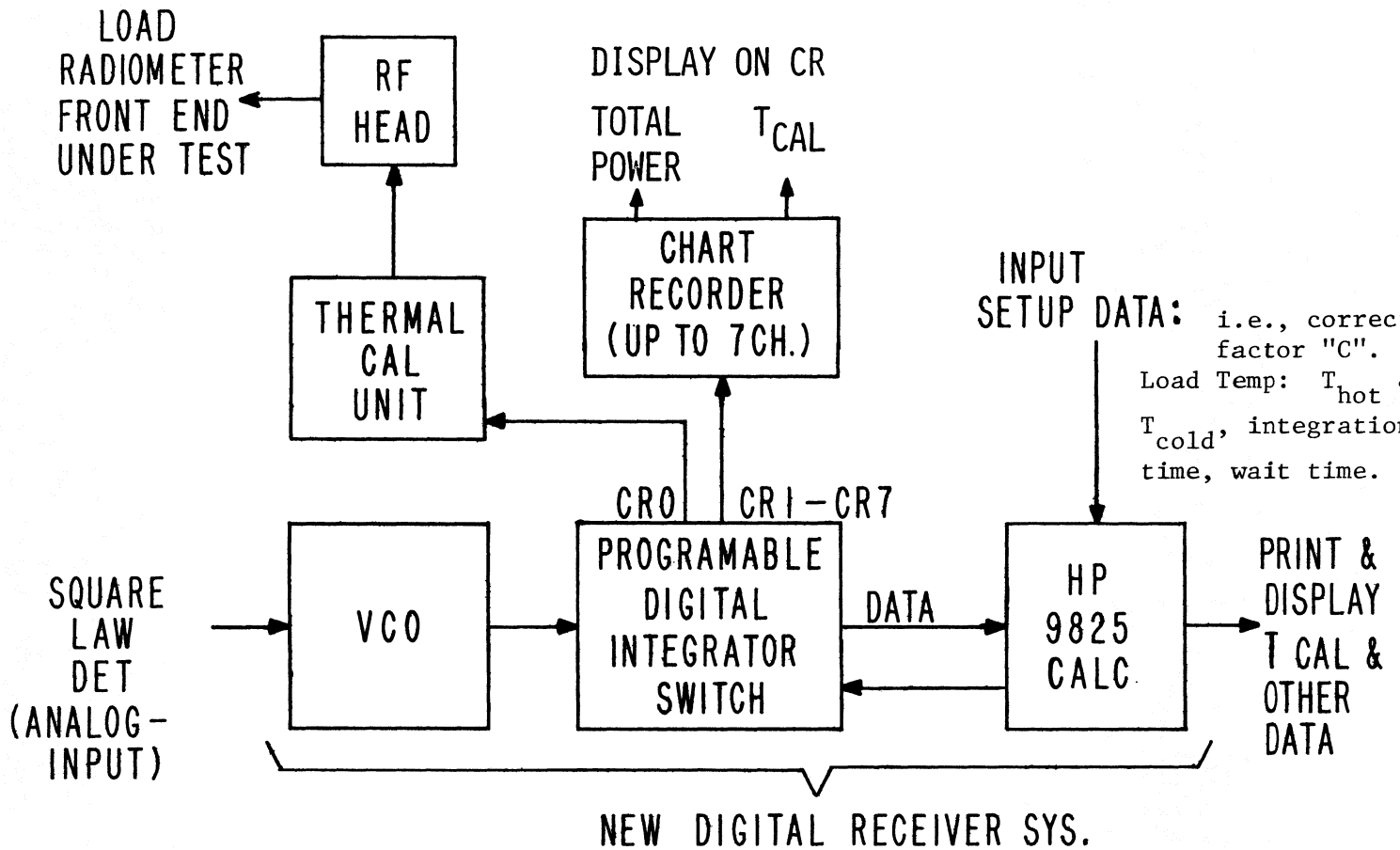
Slave Mode using an External Timing Generator:

The programs will support this "slave mode" with alterations required only to the radiometer data input "program module". Generally, it is only necessary to realign the data from the integrators ϕ_0-ϕ_3 so that the right value is sent to the right input to the calculation routines, i.e., the cal count (ϕ_0) must go to the C[I] input to the computations, etc. If external timing, one other phase may have the cal integration value, for example, depending on the timing relationships and logic conventions of the external timing generator (see p. 74).

Noise Tube Measurement using the Thermal Cal Unit:

The automatic thermal cal unit test set described in EDIR #103 may be connected to the digital receiver system for fully automated measurement of cal values by connecting the T_{hot}/T_{cold} BNC control cable to the "CRO" D/A converter output at the back of the digital receiver. After making ready the "Test Tcal using Thermal Cal Unit" program and executing cold start procedures the system will measure and print out the value of the unknown cal operating with the radiometer system. Follow the set up instructions in EDIR #103. The calculator display shows the program phase in progress. This sequence occurs:

Cold Start:	Rcvr	Bal
	Wait	V_{hot}
	Data	V_{hot}
	Wait	V_{cold}
	Data	V_{cold}
	Wait	V_{cal}
	Data	V_{cal}
	Print Out	T_{cal} Value
	Wait	V_{hot}
	Data	V_{hot}
	↓	
	Data	V_{cal}
	Print Out	T_{cal} Value
	Repeat	



TEST SETUP TO DETERMINE T_{CAL}

Program Phases:

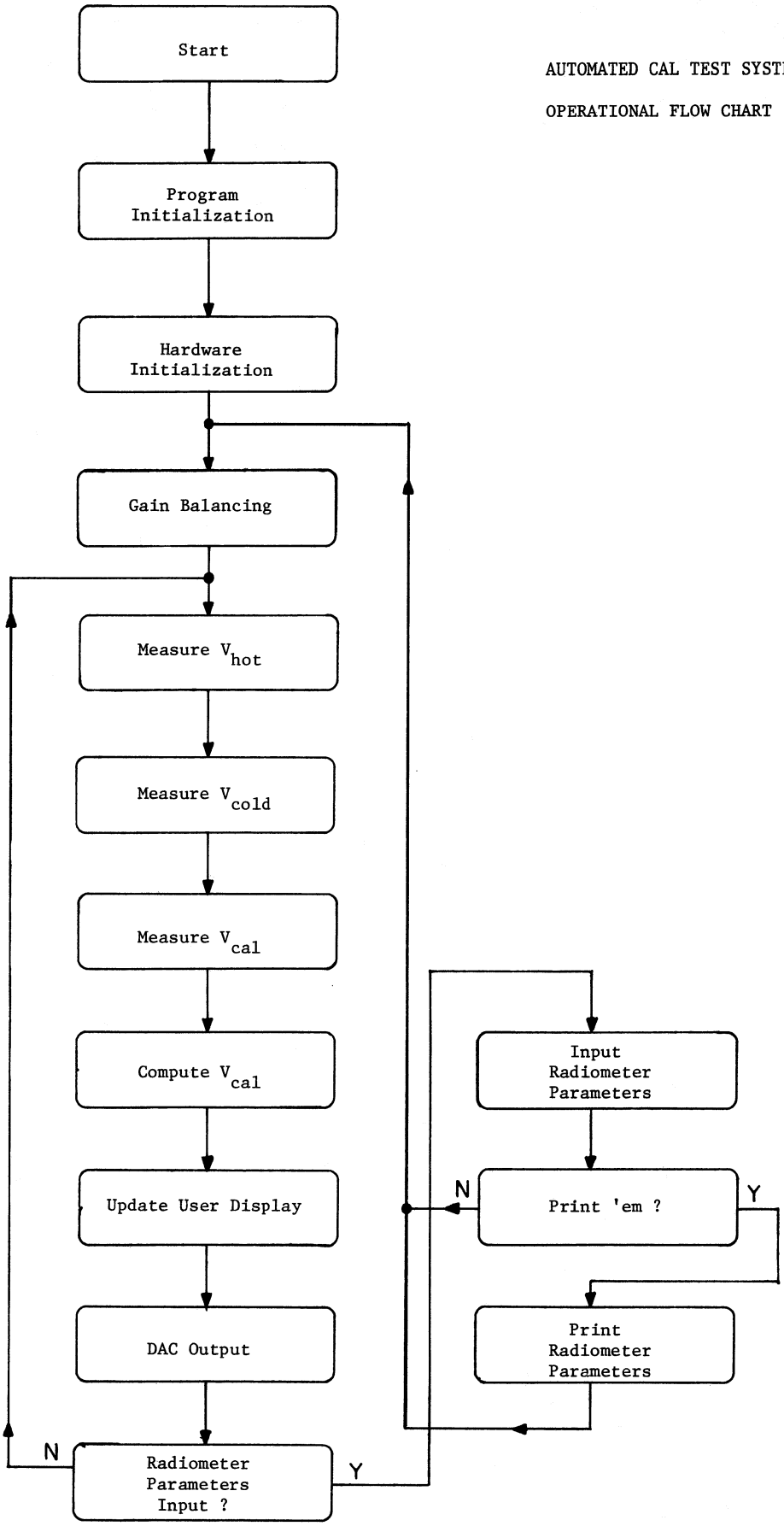
0	Input init parameters*
1	Set T_{hot} mode TCU
2	Wait time
3	Integrate time
4	Set T_{cold} mode TCU
5	Wait time
6	Integrate time
7	Fire cal
8	Integrate time
9	Display T_{cal}
10	Repeat as needed

* Initiate parameters:

1. T_{hot}
2. T_{cold}
3. Wait time
4. Integration time
5. Tot pwr scale factor *K/V
6. T_{cal} scale factor *K/V

AUTOMATED CAL TEST SYSTEM

OPERATIONAL FLOW CHART



Program Lists:

"Test T_{cal} using Thermal Cal Unit"

```
April 21, 1978
  Ray Hallman
```

```
0: dsp "TEST
 Tcal USING THER
 MAL CAL UNIT"
1: sfg 14
2: dim B[4],C[4]
 ,K[4],R[4],S[4]
 ,T[4],V[4],W[4]
 ,X[4],Y[4]
3: dim A[4],C,F,
 K,L,M,N,O,P,Q,
 R,T,U,V,W,Y,Z,
 Z[8]
4: ldf 13,A[*],
 C,F,K,L,M,N,O,
 P,Q,R,T,U,V,W,
 Y,Z,Z[*]
5: ldk 12
6: 1→J;0→A;8→B;
 1→E;0→r0
7: gsb "CONTROL"
8:
*1139
```

Gain Balancing →

← Start

Program Initialization ←

Record Parameters →

Load Parameters ←

Load Function Keys ←

Initialize Hardware ←

```
9: "NEW ALPHA":
10: 0→D;0→W;0→r0
11: wtb 15,0
12: wtc 15,32+r0
13: dsp "
 GAIN BALANCING
 NOW"
14: sfg 1
15: K→G;gsb "GET
  DATA"
16: cfg 1
17: gsb "READ
 RCVR"
18: N→G;gsb "GET
  DATA"
19: for I=1 to R
20: C[I]/B[I]→A[
 I]
21: next I
22: rcf 13,A[*],
 C,F,K,L,M,N,O,
 P,Q,R,T,U,V,W,
 Y,Z,Z[*]
23: if A#2;0→A;
 gto "THOT"
24: spc
25: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
26: spc 2;0→A
27:
*31008
```

```
28: "THOT":-1→D;
 2→W
29: sfg 1
30: K→G;gsb "GET
  DATA"
31: cfg 1
32: L→G;gsb "GET
  DATA"
33: for I=1 to R
34: (C[I]-A[I]B[
 I])/500LM(P-
 Q)→W[I]
35: next I
36:
*13271
```

Measure V_{hot}

```
53: "COMPUTE":
54: for I=1 to R
55: C(Z-Y)/(W[I]
 -V[I])→K[I]
56: K[I](X[I]-
 V[I])→T[I]
57: next I
58: if flg2=0;
 for I=1 to R;
 prt "Tcal=",
 T[R+1-I];next
 I;spc
59:
60: gto "THOT"
61:
*1868
```

Compute T_{cal}

```
37: "TCOLD":0→D;
 1→W
38: sfg 1
39: K→G;gsb "GET
  DATA"
40: cfg 1
41: L→G;gsb "GET
  DATA"
42: for I=1 to R
43: (C[I]-A[I]B[
 I])/500LM(P-
 Q)→V[I]
44: next I
45:
*3839
```

Measure V_{cold}

```
62: "GET DATA":
63: for I=1 to
 R;0→B[I]→C[I];
 next I
64: for H=1 to G
65: wtc 15,32+r0
66: gsb "READ
 RCVR"
67: for I=1 to R
68: B[I]+R[I]→B[
 I];C[I]+S[I]→C[
 I]
69: (S[I]-R[I]A[
 I])/500M(P-Q)→Y
 [I]
70: next I
71: if A=1;0→A;
 gto "NEW ALPHA"
*16542
```

Integrate Input Data

```
46: "TCAL":0→D;
 3→W;1→r0
47: L→G;gsb "GET
  DATA"
48: for I=1 to R
49: (C[I]-A[I]B[
 I])/500LM(P-
 Q)→X[I]
50: next I
51: 0→r0
52:
*21684
```

Measure V_{cal}

```
72: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[R+1-J],J
73: if B=1;fxd
 0;dsp "S=",S[R+
 1-J],"R=",R[R+
 1-J],J
74: if B=2;fxd
 4;dsp "      V
 cold = (volts)"
 ,V[R+1-J],J
75: if B=3;fxd
 4;dsp "      V
 hot = (volts)",
 W[R+1-J],J
76: if B=4;fxd
 4;dsp "      V
 cal = (volts)",
 X[R+1-J],J
77: if B=6;fxd
 4;dsp "      T
 cal =",T[R+1-
 J],"(*K)",J
78: if B=7;8→B;
 gto "INIT"
*23026
```

User

Display

Phase

```
79: if B#8;gto +
 8
80: if W=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",S[R+1-J]/
 R[R+1-J],J
81: if flg1=0;
 if W=1;fxd 4;
 dsp "data V
 cold= (volts)",
 Y[R+1-J],J
82: if flg1=1;
 if W=1;fxd 4;
 dsp "wait V
 cold= (volts)",
 Y[R+1-J],J
83: if flg1=0;
 if W=2;fxd 4;
 dsp "data V
 hot = (volts)",
 Y[R+1-J],J
84: if flg1=1;
 if W=2;fxd 4;
 dsp "wait V
 hot = (volts)",
 Y[R+1-J],J
85: if flg1=0;
 if W=3;fxd 4;
 dsp "data V
 cal = (volts)",
 Y[R+1-J],J
86: if flg1=1;
 if W=3;fxd 4;
 dsp "wait V
 cal = (volts)",
 Y[R+1-J],J
87: wtb 15,0
*11319
```

```
88: 0→X;if R>1;
 int((25.5/Z[3])
 Y[R-1]K[R-1])+
 128→X
89: if X>127;X-
 256→X
90: (25.5/Z[2])Y
 [R]K[R]+128+
 256X→X
91: if X>-32768;
 if X<32767;wtb
 15,X;goto +2
92: wtb 15,0
93: 0→X;if R>3;
 int((25.5/Z[5])
 Y[R-3]K[R-3])+
 128→X
94: if X>127;X-
 256→X
95: if R>2;(25.5
 /Z[4])Y[R-2]K[R
 -2]+128+256X→X
96: if X>-32768;
 if X<32767;wtb
 15,X;goto +2
97: wtb 15,0
98: next H
99: ret
*24251
```

Calculate D/A Converter (Chart Recorder) Outputs ←

Hardware Control →

```
100:
101: "CONTROL":
102: wtc 15,2+r0
103: wtc 15,32+
 2+r0
104: wtb 15,0
105: wtb 15,P-1
106: wtb 15,P-1
107: wtb 15,P-1
108: wtb 15,P-1
109: wtb 15,(R-
 1)4096+2048E+0+
 256+M-1
110: wtc 15,32+
 2+r0
111: wtc 15,32+
 r0
112: ret
113:
*22497
```

```
114: "INIT":1→J
115: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?",R
116: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;gto "R"
117: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;gto "R"
118: "F":ent
 "DICKE SWITCH
 FREQUENCY IN
 Hz?",F;if fl913
 =0;sfg 0
119: int(1000/
 2F)→P
120: if P<1;prt
 "SWITCH FREQ >
 500Hz NOT ALLOW
 ED!";spc 2;gto
 "F"
121: if P>10000;
 prt "WANT SWITC
 H FREQUENCY >
 .0001 Hz";spc
 2;gto "F"
122: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
123: if fl913=0;
 int(4096Q/P)→O;
 cfg 0
124: if fl90=1;
 int(4096Q/P)→O;
 cfg 0
125: if O>4095;
 prt "BLANKING
 TIME MUST BE <
 PHASE PERIOD";
 spc 2;gto "Q"
126: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;gto
 "Q"
*9270
```

```
127: if R=1;int(
 100/2P)→M
128: if R=2;int(
 150/2P)→M
129: if R=3;int(
 200/2P)→M
130: if R=4;int(
 250/2P)→M
131: if M<1;1→M
132: "U":ent
 "RCVR BAL TIME
 (SEC)=",U;int(1
 000U/2PM)2PM/
 1000→X
133: int(1000U/
 2PM)→N
134: if int(500U
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/500;spc 2;
 gto "U"
135: if X#U;X→U;
 fxd 3;prt "ACTU
 AL RCVR BAL
 TIME (SEC)=",U;
 spc 2
136: "T":ent
 "INTEGRATION
 TIME (SEC)=",T;
 int(1000T/2PM)2
 PM/1000→X
137: int(1000T/
 2PM)→L
138: if int(500T
 /P)<1;fxd 3;
 prt "MIN INT
 TIME (SEC)=",P/
 500;spc 2;gto
 "T"
139: "V":ent
 "WAIT TIME (SEC
 )=",V;int(1000V
 /2PM)2PM/1000→X
140: int(1000V/
 2PM)→K
141: if int(500V
 /P)<1;fxd 3;
 prt "MIN WAIT
 TIME (SEC)=",P/
 500;spc 2;gto
 "V"
142: gsb "CONTRO
 L"
*14903
```

```
143: ent "T cold
  = ?",Y
144: ent "T hot
 = ?",Z
145: ent "CORREC
 TION FACTOR=?",
 C
146: ent "CRSF
 2=?  CH1--SW
 POWER (*K/V)",
 Z[2]
147: if R>1;ent
 "CRSF 3=?  CH2-
 -SW POWER (*K/
 V)",Z[3]
148: if R>2;ent
 "CRSF 4=?  CH3-
 -SW POWER (*K/
 V)",Z[4]
149: if R>3;ent
 "CRSF 5=?  CH4-
 -SW POWER (*K/
 V)",Z[5]
150: ent "INIT
 VALUES PRINTED,
  ENT 1, CONT",A
151: if A=1;gsb
 "INIT PRINT"
152: gto "NEW
 ALPHA"
153:
*5492
```

Radiometer

Parameters

Input

Phase

```
154: "READ RCVR"
 :for I=1 to R
155: rdb(15)*
 32768+rdb(15)→R
 [I]
156: rdb(15)*
 32768+rdb(15)→S
 [I]
157: next I
158: rdb(15)→S
159: ret
160:
*31512
```

Radiometer Data Input

Print Out Radiometer Parameters

End

```
161: "INIT PRINT
 ":
162: fxd 0;spc
163: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
164: fxd 3;prt
 "SWITCH FREQUEN
 CY IN Hz=",F;
 spc
165: fxd 3;prt
 "BLANKING TIME
   MS =",P0/4096
 ;spc
166: fxd 0;prt
 "M=",M;spc
167: fxd 3;prt
 "SAMPLE PERIOD
   (SEC)=",2MP/
 1000;spc
168: prt "RCVR
 BAL TIME   (SEC
 )=",(2P/1000)in
 t(1000U/2P);
 spc
169: prt "INTEGR
 ATION TIME
 (SEC)=",(2P/
 1000)int(1000T/
 2P);spc
170: prt "WAIT
 TIME   (SEC)=",
 (2P/1000)int(10
 00V/2P);spc
171: fxd 2;prt
 "T cold =",Y;
 spc
172: prt "T hot
 =",Z;spc
173; prt "CORREC
 TION      FACTO
 R=",C;spc
174: for I=2 to
 R+1
175: fxd 0;prt
 "FOR CR",I;fxd
 5;prt "CRSF=",
 Z[I]
176: spc
177: next I
178: 2→A;spc 2
179: ret
180: end
*4420
```

```
 NUMBER OF RCVR
CHANNELS=       1

SWITCH FREQUENCY
 IN Hz=    50.000

BLANKING TIME
MS =         0.098

M=               5

SAMPLE PERIOD
(SEC)=       0.100

RCVR BAL TIME
(SEC)=      30.000

INTEGRATION TIME
   (SEC)= 60.000

WAIT TIME   (SEC
)=        120.000

T cold =     19.70

T hot =      34.75

CORRECTION
FACTOR=       0.99

FOR CR           2
CRSF=     5.00000



Channel          1
S/R=       1.6292
```

Radiometer Parameters Print Out

Special Functions Key List

```
                    April 21, 1978
                      Ray Hallman

list k

f0: *1→J

f1: *if R>1;2→J

f2: *if R>2;3→J

f3: *if R>3;4→J

f4: *0→B

f5: *8→B

f6: *1→B

f7: *2→B

f8: *3→B

f9: *4→B

f10: *cfg 2

f11: *6→B

f12: *7→B

f15: *prt "P=",P
 ,"Q=",Q,"O=",O

f17: *1→A

f21: *rck12

f22: *sfg 2

f23: *prt" April
  21, 1978    Ra
 y Hallman";spc;
 spc
```

Internal Constants List

Program Title: "Thermal Cal Unit"

Simple Variables		Assignments		
A	If A = 1, rebalance receiver	A	[4]	α (Gain Bal Factor)
B	Display Selector	B	[4]	Σ R[I]
C	Correction Factor	C	[4]	Σ S[I]
D	DAC " " Output T_{hot}/T_{cold} common	D		
E	Cal Control: Continuous = 1 Pulsed = 0	E		
F	Dicke Switch Frequency	F		
G	Integ Const for "Get Data" SRT	G		
H	For I Loops Init Seq	H		
I	For I Loops Init Seq	I		
J	Chron Data Display Slector	J		
K	No. of M's per Data PA (Wait)	K	[4]	Scale Factor °K/Volt = $\frac{T_{hot} - T_{cold}}{V_{hot} - V_{cold}} \times C$
L	No. of M's per Data PA (Data)	L		
M	No. of Samples/Integ Period	M		
N	No. of M's per Data Pt (α)	N		
O	Blanking Time (Parts)	O		
P	Interval in ms ($\phi_0 = \phi_1$)	P		
Q	Blanking Time in ms	Q		
R	No. of Receiver Channels in Use	R	[4]	Ref Rcvr Input (Raw Count)
S	Status	S	[4]	Sig Rcvr Input (Raw Count)
T	Integration Time in Sec	T	[4]	T_{cal}
U	Receiver Bal Time in Sec	U		
V	Wait Time in Sec	V	[4]	V_{cold}
W	Automatic Display Control: 0. Gm const 1. T_{cold} 2. T_{hot} 3. T_{cal}	W	[4]	V_{hot}
X	DAC Out Buffer	X	[4]	V_{cal}
Y	T_{cold} *K	Y	[4]	Switch Power in Volts
Z	T_{hot} *K	Z	[8]	CRSF's

R0 - Cal on/off control: 1 - on.

Automated Cal Test System Equations

The following equation gives the value of T_{cal}, from EDIR #103, which is solved by the automated T_{cal} measurement system: "C" is a correction factor explained in the EDIR.

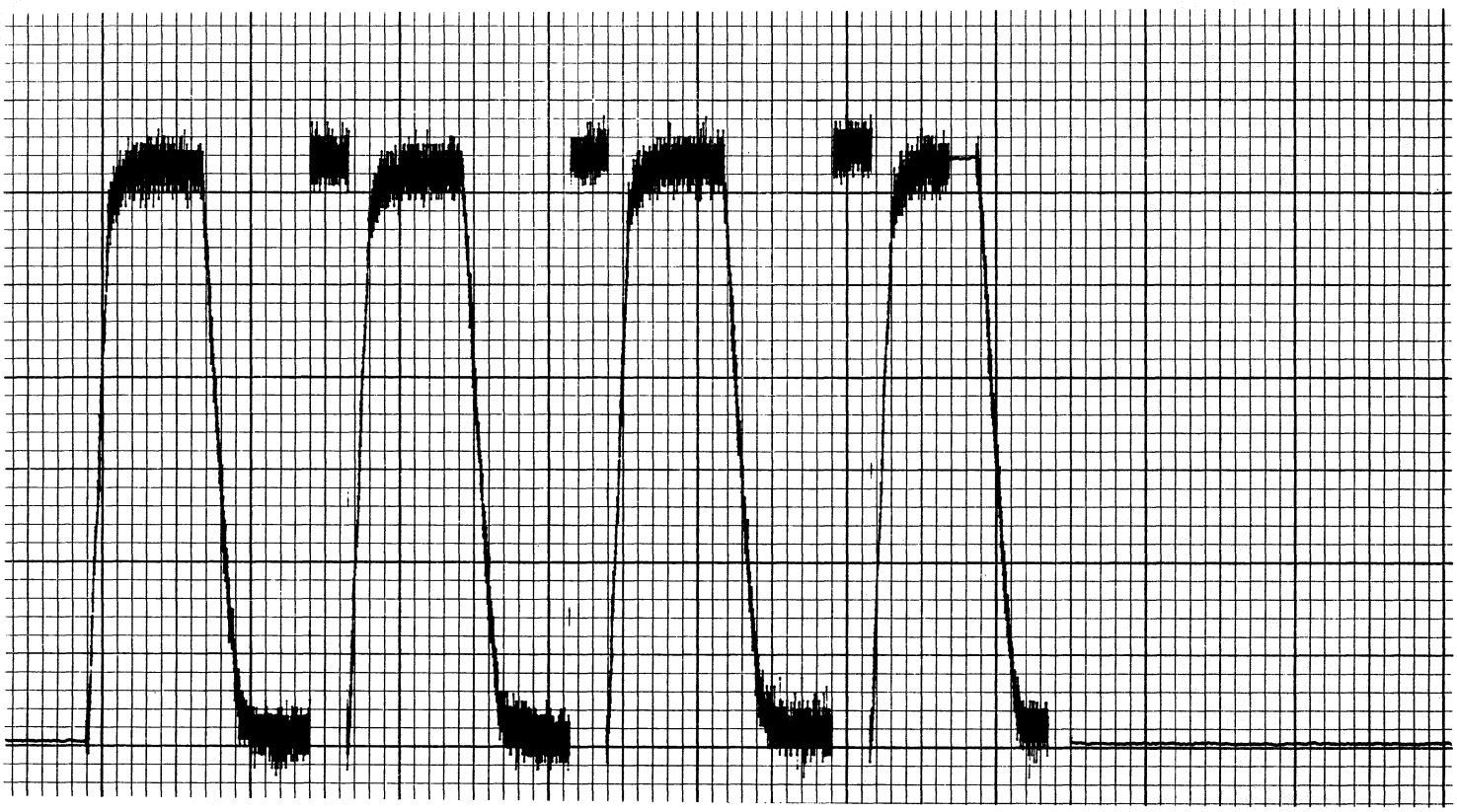
$$T_{cal} = V_{cal}\Big|_{on} - V_{cal}\Big|_{off} \times \frac{T_{hot} - T_{cold}}{V_{hot} - V_{cold}} \times C$$

A chart record of total power can be made from the D/A converter outputs CR2 and CR3 for channels 1 and 2. The output is machine calculated by the following relationship:

$$\text{Tot Power} = \text{Tot Counts} \times \frac{T_{hot} - T_{cold}}{\text{Counts}_{hot} - \text{Counts}_{cold}} \times C$$

(Switch Power)

A typical chart record thus obatained is as shown:



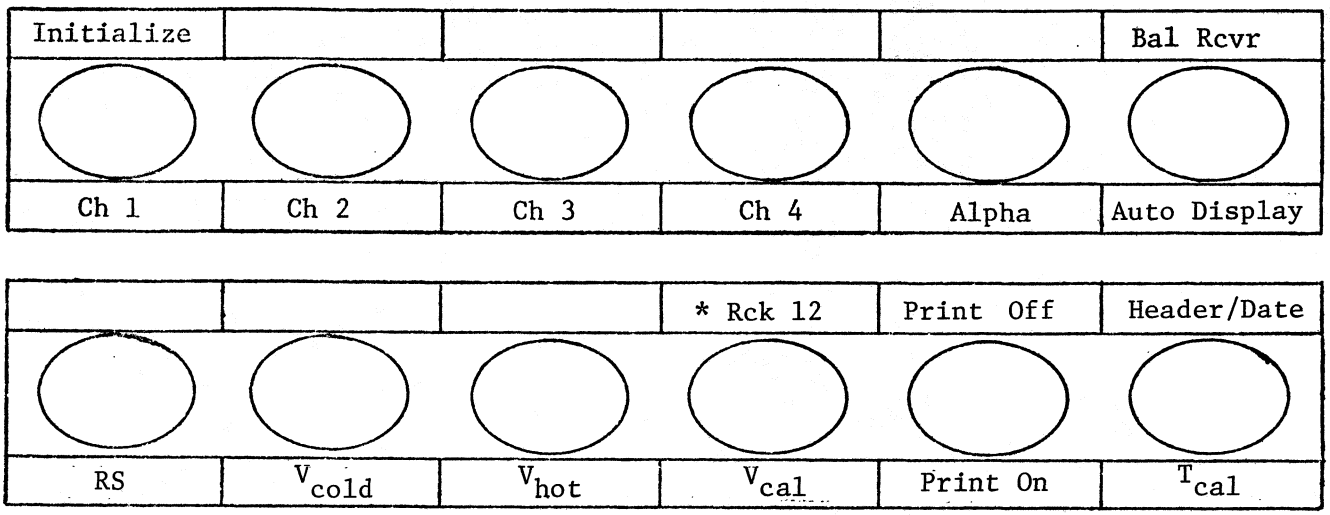
Scale: 5°K/inch
5°K/volt

T_{cold} = 19.70°K

T_{hot} = 34.75°K

Calculated T_{cal} = 15.2°K

Special Function Keys



The special functions key overlay is reproduced above. If it is misplaced, you may pencil a new one onto a blank provided from the supplies drawer. The channel keys Ch 1 - Ch 4 (f_0 - f_3) allow selection of the particular channel for which data is to be displayed. The other upper/lower case keys direct which data is displayed:

Key		Displayed Data
f_4	-	Gain Modulation Constant, Alpha
f_5	-	Auto Display = Current Data of Measurement
f_6	-	RS Raw Count for R&S
f_7	-	V_{cold} - Last integrated value
f_8	-	V_{hot} -- Last integrated value
f_9	-	V_{cal} -- Last integrated value
f_{10}	-	Print On - Enable T_{cal} log
f_{11}	-	T_{cal} - Last Integrated Value
f_{12}	-	Input New Radiometer Parameters
f_{17}	-	RE Balance Radiometer
f_{21}	-	Record Current Function Keys (not used here)
f_{22}	-	Print Off - Inhibit T_{cal} Log
f_{23}	-	Prints Author/Date of Program

Noise Adding Radiometer:

Although this hardware is complete, a program for this mode has not been developed and is left as an exercise for the user.

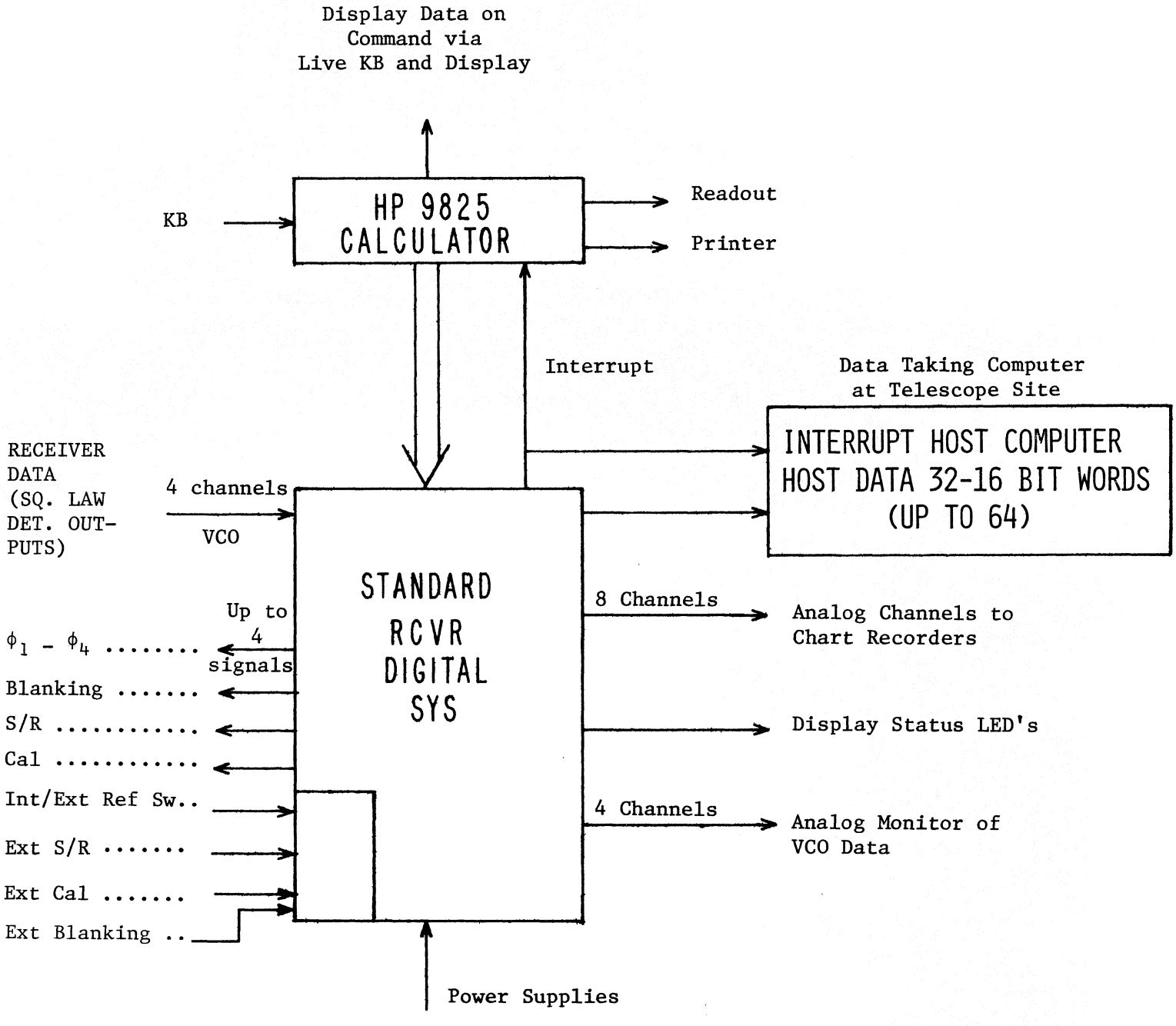


FIGURE II: DIGITAL STANDARD RECEIVER MODEL III

Electronic Circuits Discussion:

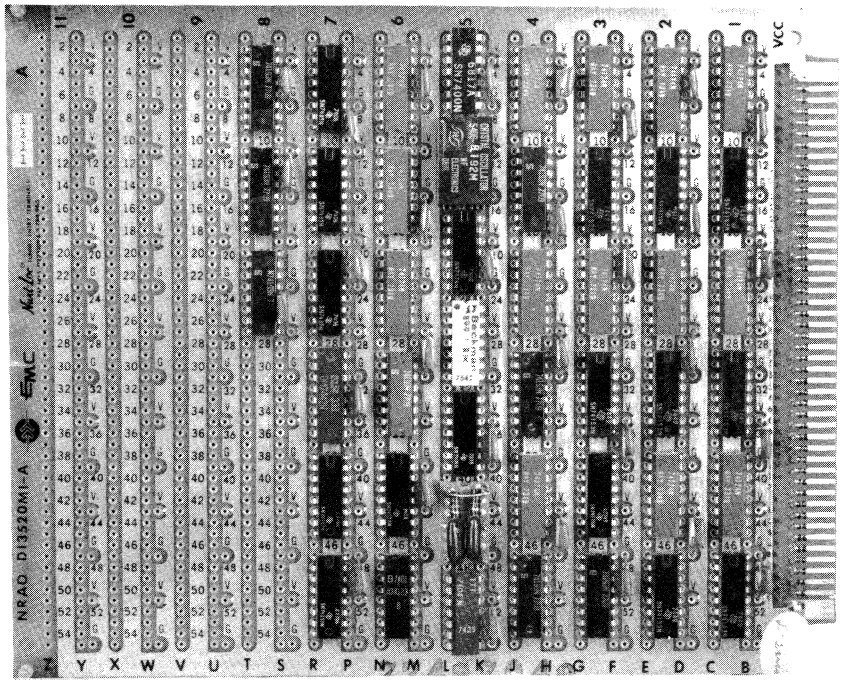
The digital receiver system is constructed of 10 electronic circuit cards, 9 of which are contained in the main hardware module, and one is located in the host computer main frame. The block diagram (Figure II) shows the layout, as integrated into the system.

The front panel is loaded with lights that show the status of (left to right) external timing generator inputs, internal timing generator signals operating by NRAO definitions (S/R, cal, blanking) four phase switch signals ϕ_0 - ϕ_3, the four VCO clipping indicators, and two CPU status indicators showing "CPU Data Dump" failure and "CPU Busy". Also there is a toggle switch for selection on internal or external timing generator inputs, a meter and selector which indicates the analog total power outputs of the four VCO coupled detected inputs and the eight D/A converter outputs designed to drive chart recorder with 250 unit indications.

The rear panel contains connectors that interface any signal indicated by the front panel indicators to any of four logic senses, two for TTL, two for 3C, Elco connector interface with various panels, CPU's and data taking devices.

Of the 9 circuit cards in the box, there are 6 different types as now described.

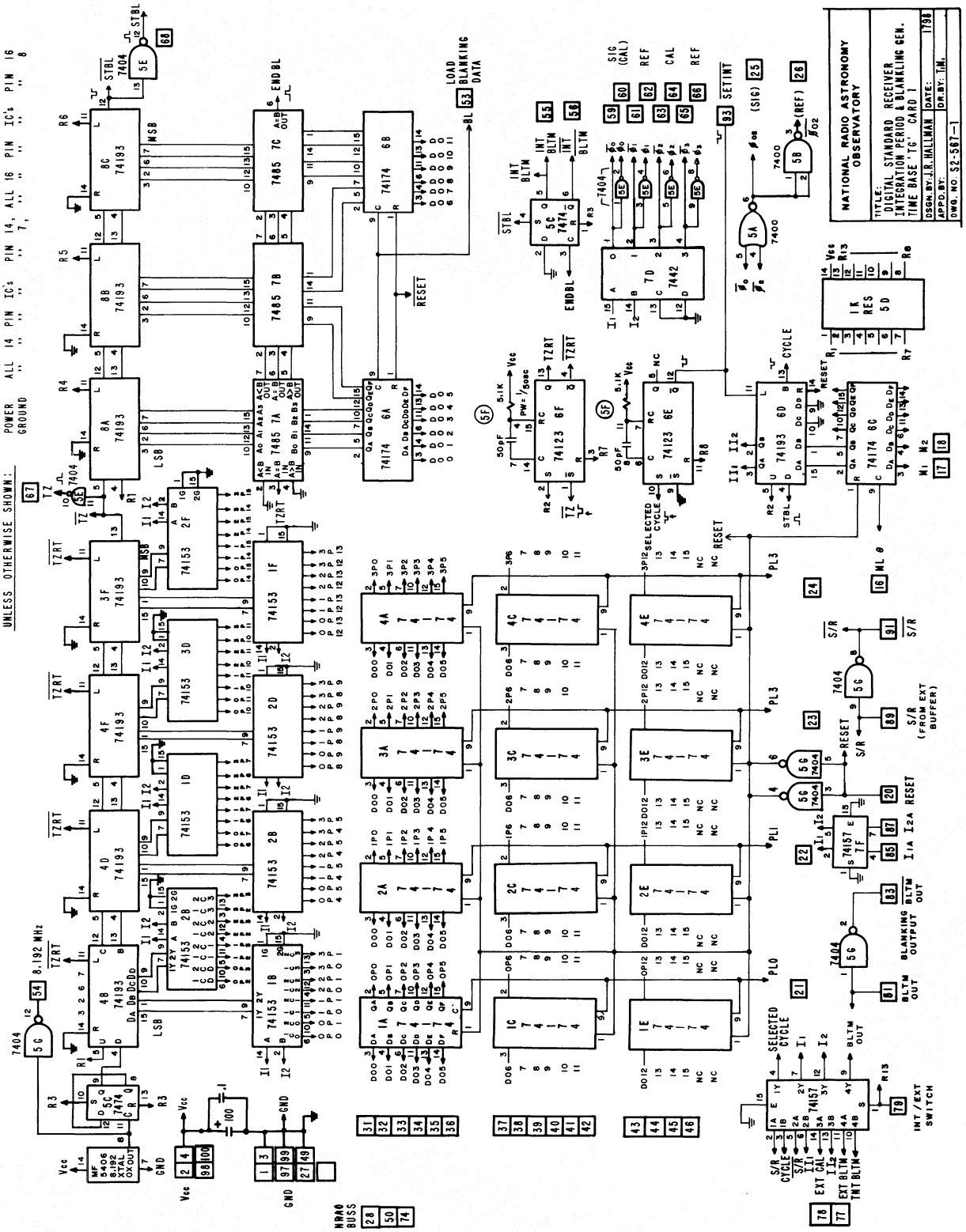
Card 1: "Integration Period and Blanking Generator"



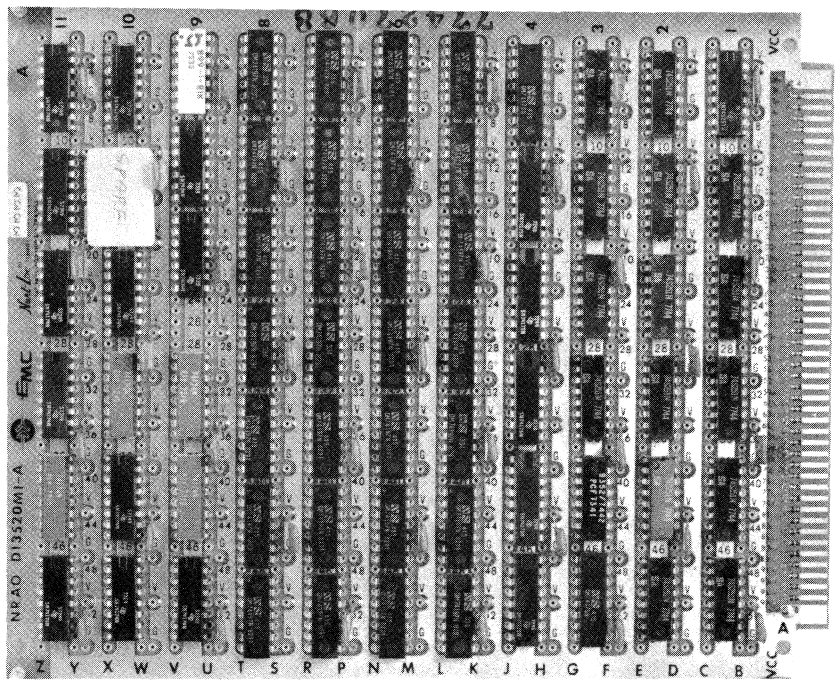
The card #1 schematic shows the timing divider along the top with multiplexed control inputs from the four ranks of latches providing the period definition. The 12-bit blanking generator at the top right drives the miscellaneous formatting logic at the lower right. Part of the int/ext timing generator selector switch logic is at the lower left.

Drawing 2.567-1

The following drawing is a complete timing generator with four separately programmable phase periods in 1 msec steps up to 32 sec and a blanking time generator capable of blanking time resolution of 4096 parts of a phase period.

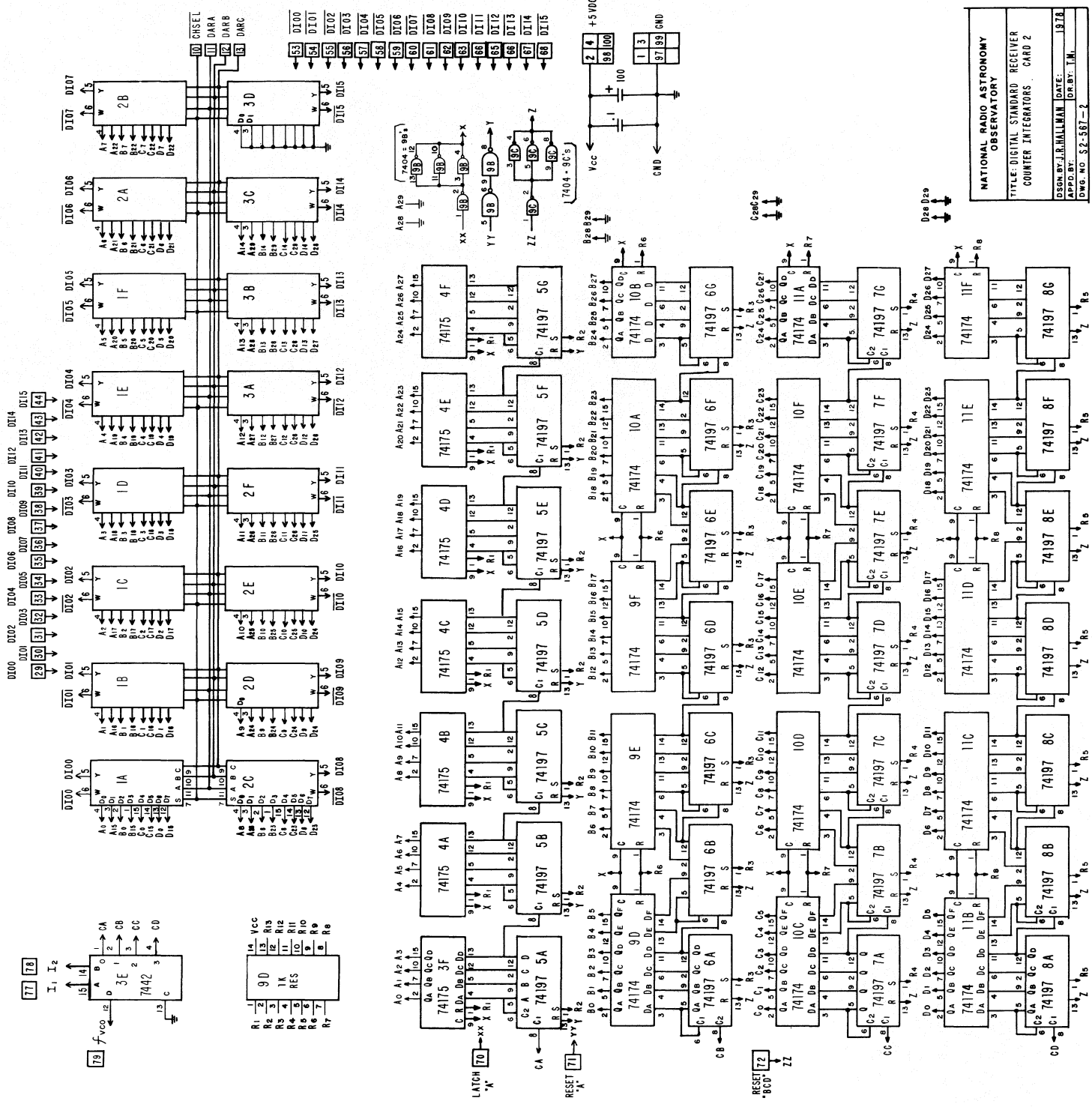


Card 2: "Digital Integrators"

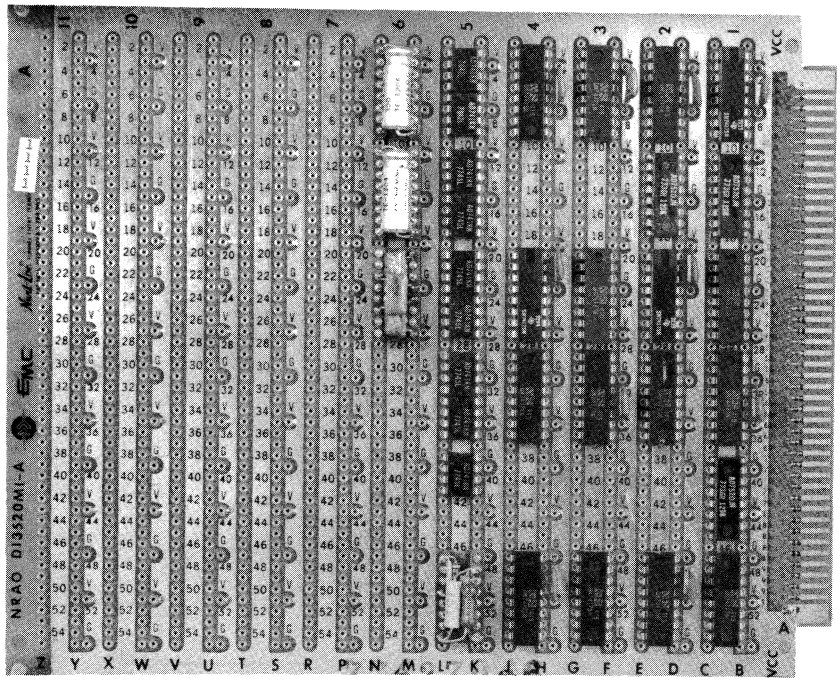


A complete 4-phase integrator system for one channel is constructed on card 1. The counters are 28 bit binary with latch buffers to enable the CPU to take data anytime during an integration period without interrupting counting (integration).

The schematic #2.567-2 shows the integrator card with the 4-phase digital switch (upper left), the Tri-State multiplex gates along the top that connect the counter latch outputs to the CPU input buss according to the address select lines "DARA", "DARB", and "DARC", which connect the four 30-bit counters to the 16-bit buss in 8 words when raw count data is read from the receiver to the CPU. The bottom half of the page shows the latches (74175) and counters (74197) in four groups of alternate rows. The counters are always enabled to count the VCO input which occurs under control of the 7442 decoder (digital switch 3E) in the upper left. When the integration period ends the data is transferred from the counter to the latches after which the counters are reset for a new count sequence. Data may then be read from the latches at anytime during the next integration period.


NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: DIGITAL STANDARD RECEIVER COUNTER INTEGRATORS CARD 2
DSGN. BY: J.R. HALLMAN
DATE: 1978
APPD. BY:
DR. BY: T.M.
DWG. NO. S2-587-2
+5VDC
GND
Vcc
LATCH "X"
RESET "X"
RESET "BCD"
74175 3F
7442
74175 4A
74175 4B
74175 4C
74175 4D
74175 4E
74175 4F
74174 9D
74174 9E
74174 9F
74174 10A
74174 10B
74174 11A
74174 11B
74174 11C
74174 11D
74174 11E
74174 11F
74197 5A
74197 5B
74197 5C
74197 5D
74197 5E
74197 5F
74197 5G
74197 6A
74197 6B
74197 6C
74197 6D
74197 6E
74197 6F
74197 6G
74197 7A
74197 7B
74197 7C
74197 7D
74197 7E
74197 7F
74197 7G
74197 8A
74197 8B
74197 8C
74197 8D
74197 8E
74197 8F
74197 8G
74174 10C
74174 10D
74174 10E
74174 10F
9D 1K RES
7404 = 9BS
7404 - 9CS

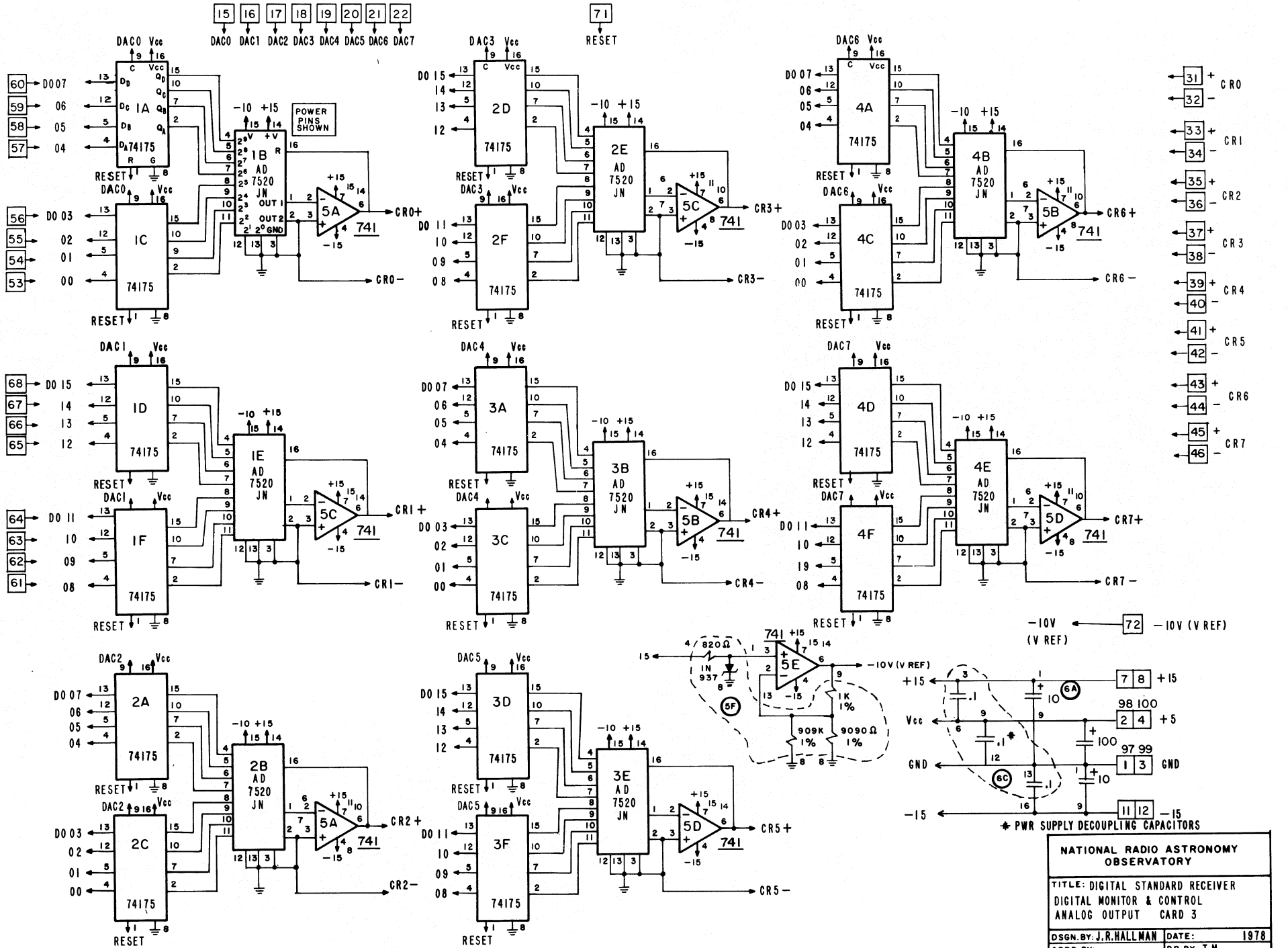
Card 3: "Analog Output"



The analog output card contains the eight D/A converters and latches providing analog outputs (0, 10 V) to chart recorder or to control external devices such as the thermal cal unit of EDIR #103 or noise tube switches (as alternate control facilities).

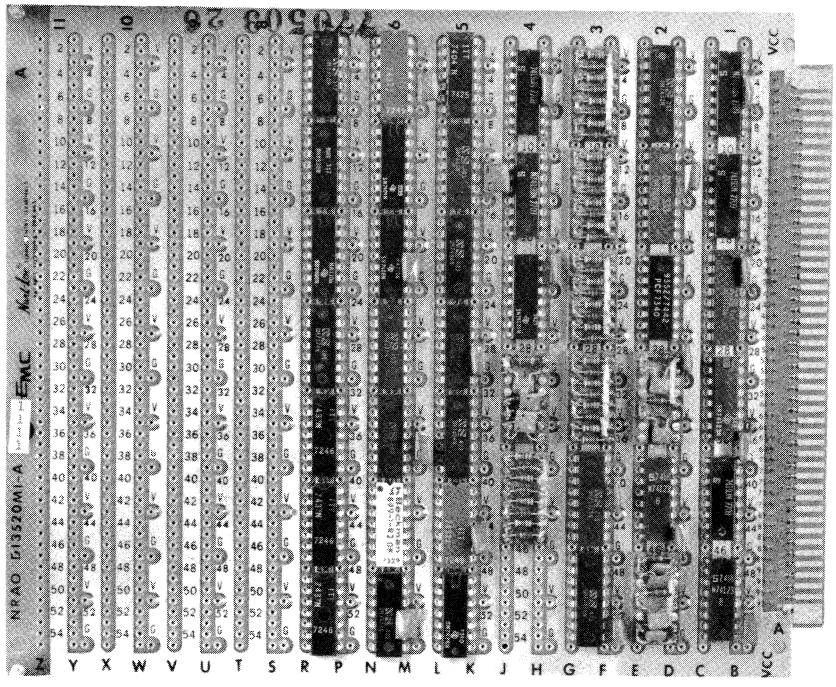
Drawing 2.567-3

The 8-bit D/A converters are connected to the CPU output buss in pairs requiring four 16-bit words to completely define the analog outputs. One -10 V reference is required (lower middle of page) common to all eight DAC's.



NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: DIGITAL STANDARD RECEIVER DIGITAL MONITOR & CONTROL ANALOG OUTPUT CARD 3	
DSGN. BY: J.R.HALLMAN	DATE: 1978
APPD. BY:	DR. BY: T.M.
DWG. NO. S2-567-3	

Card 4: "HP 9825A I/O Control"



The card #4 logic directs the input/output data transfers between the digital receiver and HP 9825A calculator.

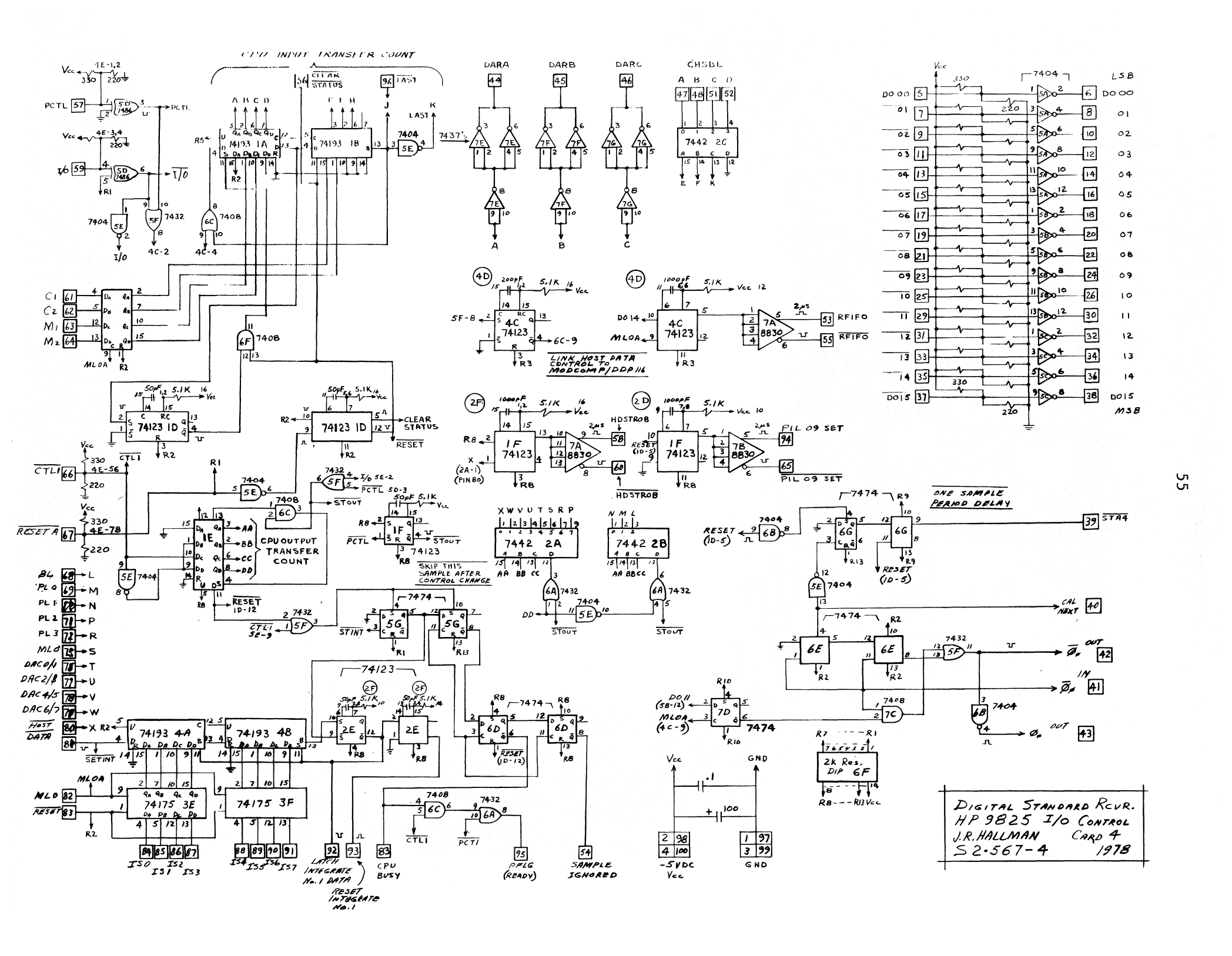
Drawing 2.567-4

Input data transfers are handled under control of counters at the top left of the schematic which directly control the Tri-State multiplex gates on the integrator cards. The CPU output buss is buffered by the logic in the upper right. The buffers in the middle of the page drive the host computer interface card #7 located in the host main frame.

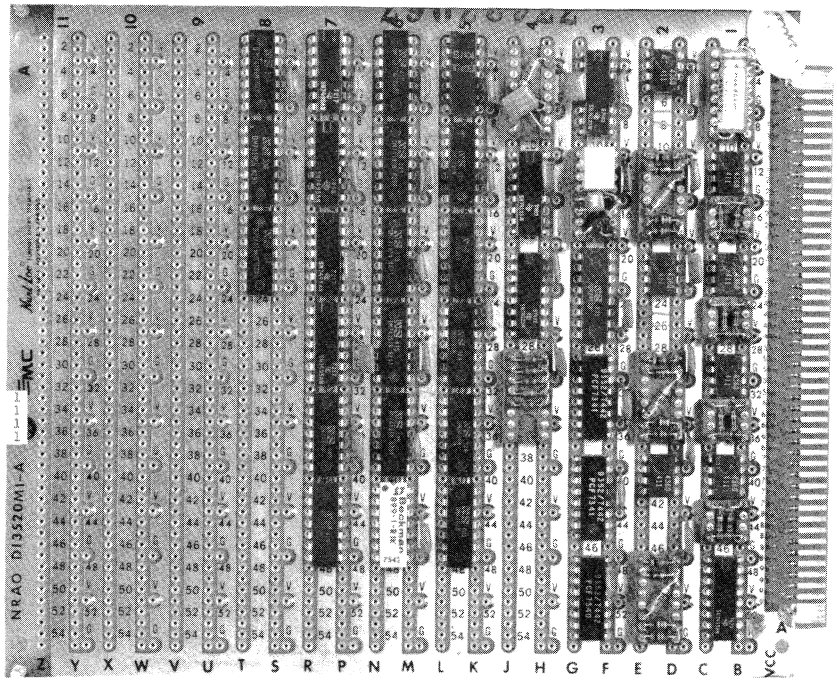
IC-1E is the output data transfer counter which is set to a count of ten (if CTL1 is low) to allow output from the CPU to assign the timing generator period, blanking, and modes for the system. When CTL1 is high, the counter is preset to 4 which skips the above controls, only allowing outputs to the DAC's and host data taking computer.

The lower left shows the samples/integration counter that allows several Dicke switch cycles to occur before flip-flop 6-D indicates data ready, allowing input data to transfer to the 9825 CPU. The number of switch cycles/integration is set by the preset value in the counters 4A and 4B. If 0 is preset, then data is ready after each switch cycle.

The "cal" (noise tube) control logic is at the lower right and may be either pulsed or continuous cal depending on the state of the flip-flop 7D-6. The cal during ϕ_0 when pulsed is selected by bit DO-11 from the mode control word from the calculator.


CPU INPUT TRANSFER COUNT
CLEAR STATUS
LAST
DARA
DARB
DARC
CHSBL
7442 2C
7404
LSB
MSB
DO 00
DO 15
74123 1D
CLEAR STATUS
RESET
CPU OUTPUT TRANSFER COUNT
74123 1A
74123 1B
74123 4A
74123 4B
74175 3E
74175 3F
7442 2A
7442 2B
SKIP THIS SAMPLE AFTER CONTROL CHANGE
ONE SAMPLE PERIOD DELAY
LINK HOST DATA CONTROL TO MODCOMP/DDP 116
2k Res. DIP 6F
-5VDC
GND
CPU BUSY
SAMPLE IGNORED
LATCH INTEGRATE No.1 DATA
RESET INTEGRATE No.1
DIGITAL STANDARD RCVR.
HP 9825 I/O CONTROL
J.R.HALLMAN CARD 4
S2-567-4 1978

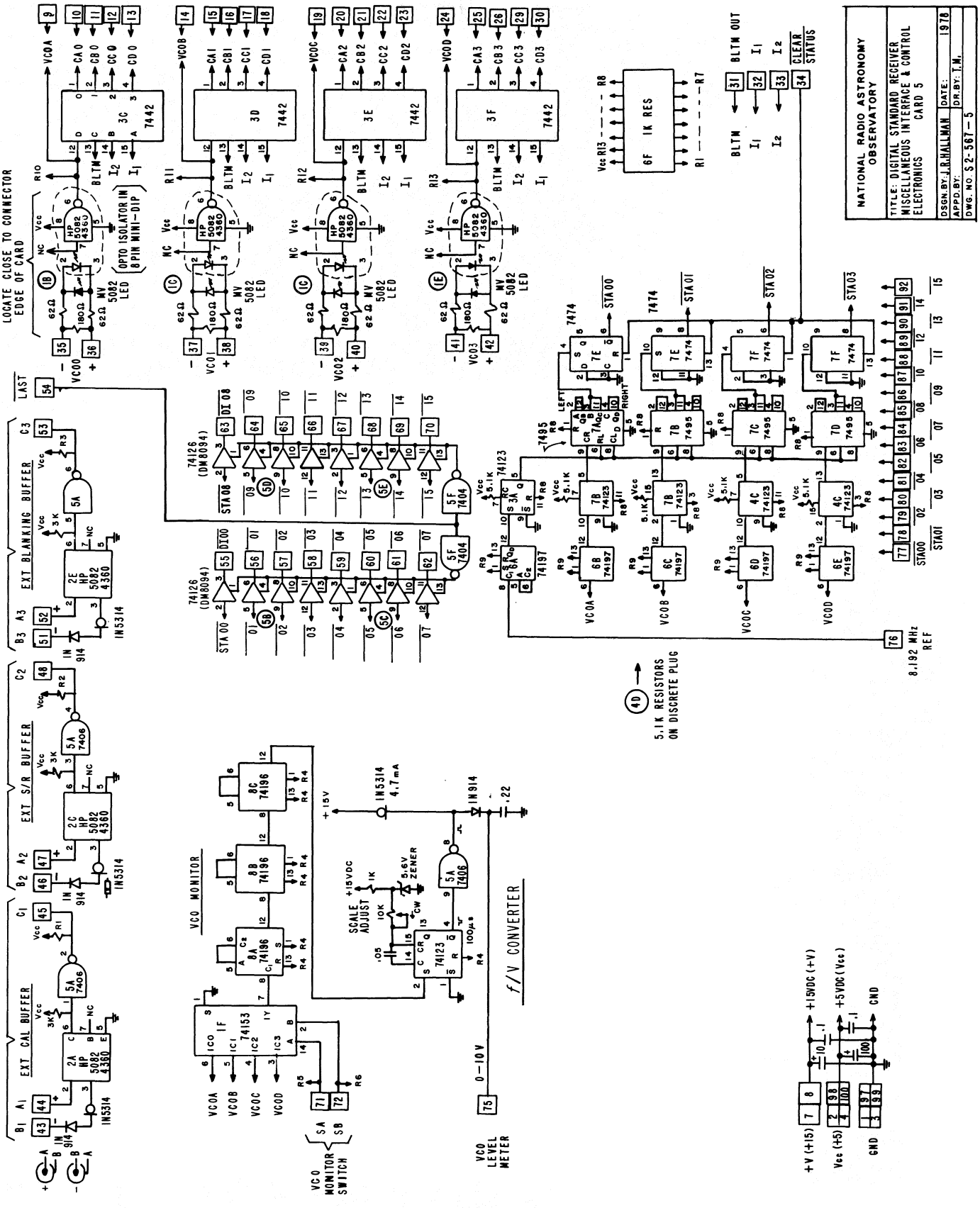
Card 5: "Miscellaneous Interface"



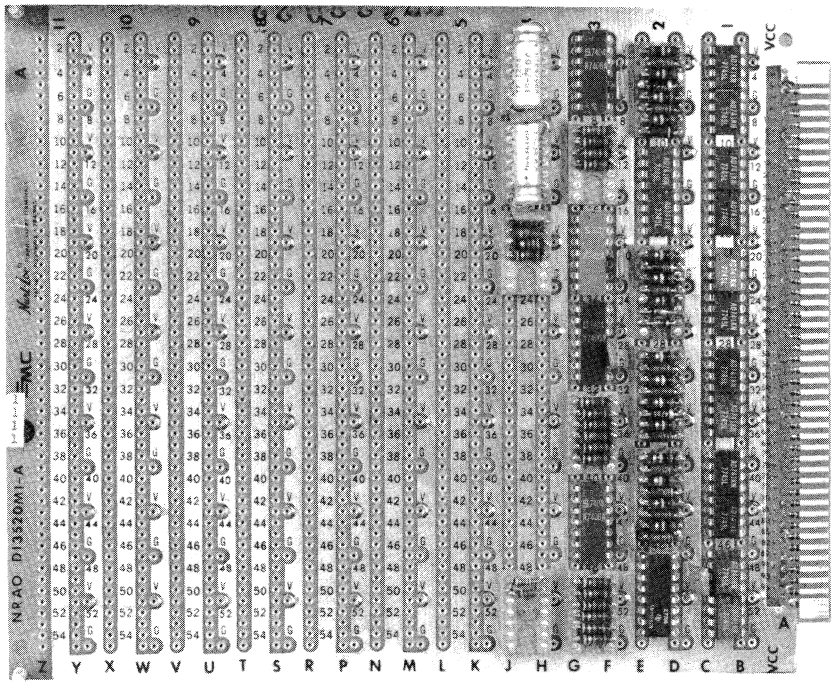
As the name implies, this is the "leftovers" card. It is everything that will not fit on the rest of the system cards. It has the optical isolator circuits, Tri-State input buss buffer for the CPU, VCO clipping indicators (which operate when the frequency exceeds 5 MHz), and the VCO monitor meter driver which uses the frequency to voltage converter made from IC-3A (one shot) and gate 5A. The schematic is on the next page.

Drawing 2.567-5

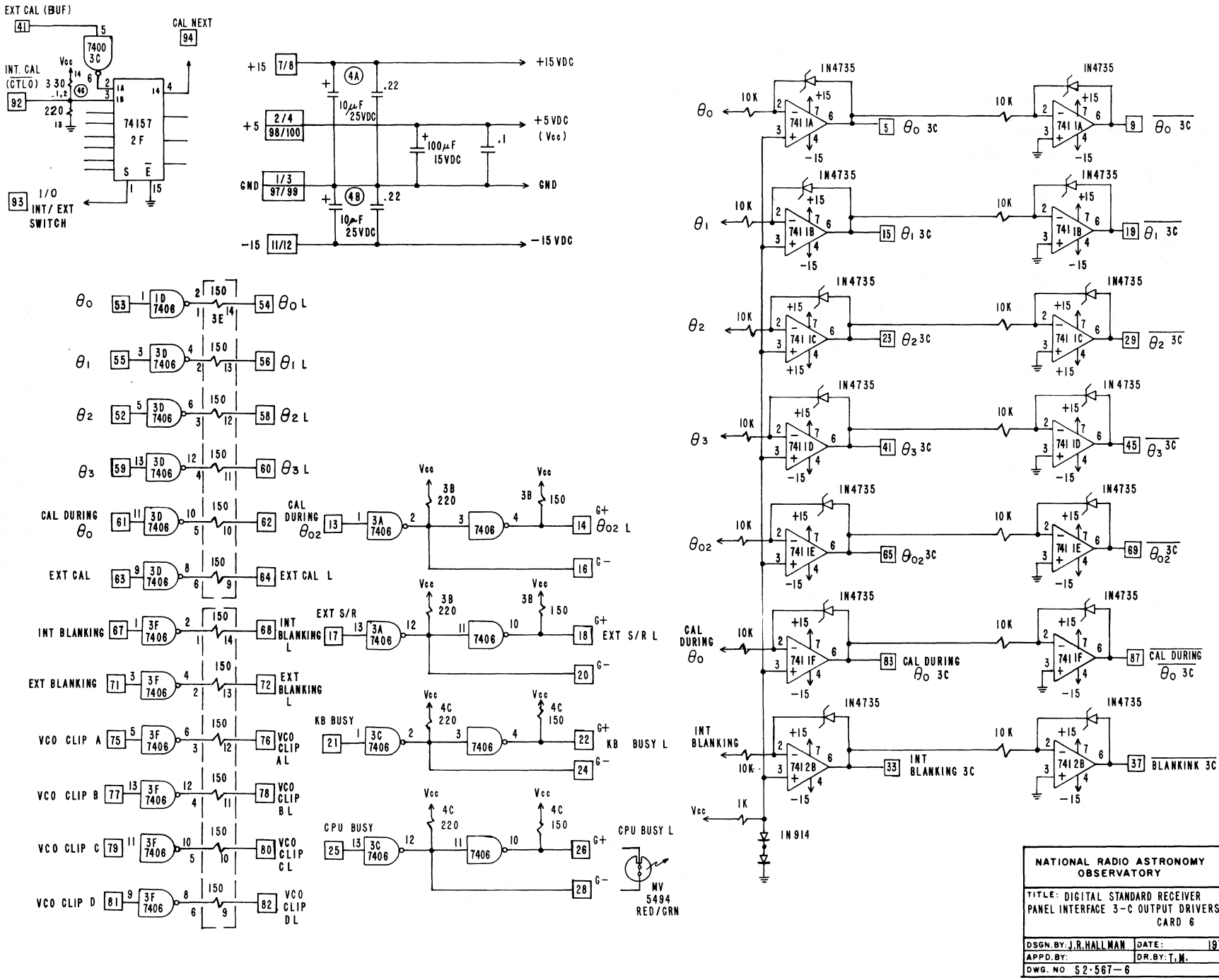
The circuits along the top buffer the external timing generator inputs using optical isolators. The ones along the right buffer the VCO signals using 100 Ω differential and 50 Ω to ground transmission line techniques.


NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE: DIGITAL STANDARD RECEIVER MISCELLANEOUS INTERFACE & CONTROL ELECTRONICS CARD 5
DSGN. BY: J. R. HALLMAN
DATE: 1978
APPD. BY:
DR. BY: T. M.
DWG. NO. S2-567-5
EXT CAL BUFFER
EXT S/R BUFFER
EXT BLANKING BUFFER
LOCATE CLOSE TO CONNECTOR EDGE OF CARD
OPTO ISOLATOR IN 8 PIN MINI-DIP
VCO MONITOR
SCALE ADJUST
f/V CONVERTER
VCO MONITOR SWITCH
VCO LEVEL METER
5.1K RESISTORS ON DISCRETE PLUG
8.192 MHz REF
6F 1K RES
BLTM OUT
CLEAR STATUS
+15VDC (+V)
+5VDC (Vcc)
GND
0-10 V

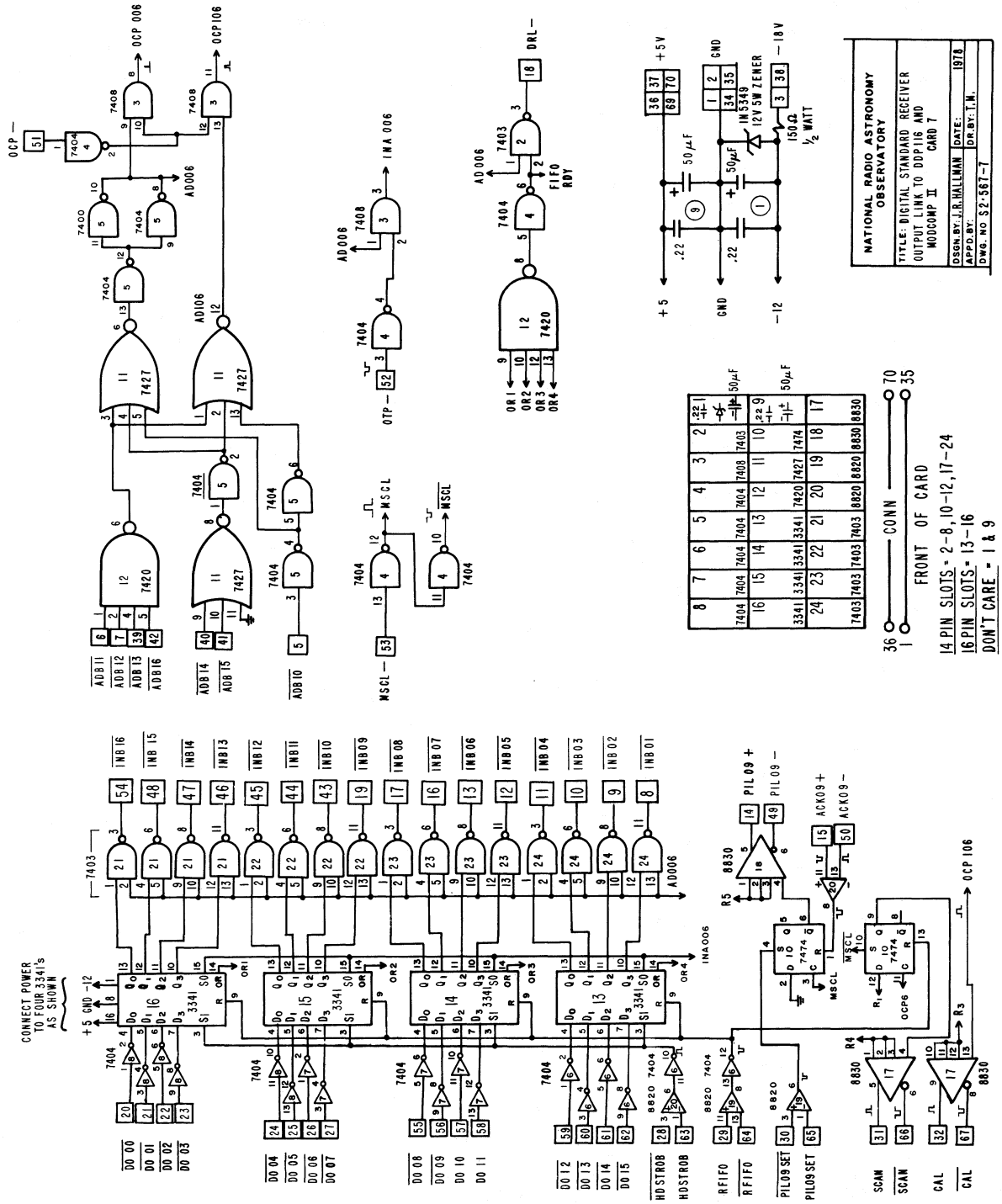
Card 6: "Panel Interface and 3C Output Drivers"



The card #6 is simple interface circuits for the front panel indicators and the TTL to 3C level converters. Also, in the upper left corner is the other part of the int/ext timing generator selector switch logic. The drawing is on the next page.



NATIONAL RADIO ASTRONOMY OBSERVATORY	
TITLE: DIGITAL STANDARD RECEIVER PANEL INTERFACE 3-C OUTPUT DRIVERS CARD 6	
DSGN. BY: J.R. HALLMAN	DATE: 1978
APPD. BY:	DR. BY: T.M.
DWG. NO S2-567-6	



The circuits of card #7 are constructed on a Cambion card. The drawing shows the Fifo memory which is buffered on both its inputs and outputs. Also, an address decoder is shown at the upper right corner. This host interrupt and reset logic is at the lower left.

Wire Lists and Tables:

The system interconnections is listed next where all connections between the circuit cards themselves, the front panel indicators, and rear panel I/O connectors are shown.

Abbreviations:

S	-	Slot
(+)	-	Logic True Sense
(-)	-	Logic False Sense
NC	-	No Connection
BNC	-	Coax Connector on Rear Panel
CRO	-	Chart Recorder Output
H I/O	-	Host I/O Connector (Elco)
C	-	Calculator I/O (Elco)
3C	-	0, -6 Logic Levels
TTL	-	0, +5 Logic Levels
ϕ	-	Phase
INB	-	Input Buss (DDP-116)
ADB	-	Address Buss (DDP-116)
DO	-	Output Buss (HP 9825A)

SLOT 3 NAME: INTEG PERIOD AND BLANKING GENERATOR T.B.

Name	From Pin #	To	From	Name	From Pin #	To	From
	1			+5	2		
	3			+5	4		
	5				6		
	7				8		
	9				10		
	11				12		
	13				14		
	15			MLϕ	16		S9-75
M1	17		S9-22	M2	18		S9-24
	19			Reset	20		S3-28
PLθ	21		S9-69	PL1	22		S9-70
PL2	23		S9-71	PL3	24		S9-72
SIG	25	+ϕ02 BNC	TTL	REF	26	-ϕ02 BNC	TTL
Ground	27	S3-1		Ground	28	S3-3	
	29				30		
DO-θ	31		S9-6	DO-1	32		S9-8
DO-2	33		S9-10	DO-3	34		S9-12
DO-4	35				36		
DO-6	37		S9-18	DO-7	38		S9-20
DO-8	39		S9-22	DO-9	40		S9-24
DO-10	41		S9-26	DO-11	42		S9-28
DO-12	43		S9-30	DO-13	44		S9-32
DO-14	45		S9-34	DO-15	46		S9-36
	47				48		
Ground	49	S3-27		Ground	50	S3-28	
	51				52		
BL	53		S9-68	8.129 MHz REF	54	S10-76	
INT BLTM	55	S11-67		INT $\overline{\text{BLTM}}$	56	NC	
	57				58		
ϕ_0	59	-ϕ_0 BNC	TTL	ϕ_0	60	+ϕ_0 BNC	TTL
ϕ_1	61	-ϕ_1 BNC	TTL	ϕ_1	62	+ϕ_1 BNC	TTL
ϕ_2	63	-ϕ_2 BNC	TTL	ϕ_2	64	+ϕ_2 BNC	TTL
ϕ_3	65	-ϕ_3 BNC	TTL	ϕ_3	66	+ϕ_3 BNC	TTL
TZ	67	NC		STBL	68	NC	
	69				70		
	71				72		
Ground	73	S3-97		Ground	74	S3-99	
	75				76		
EXT BLTM	77		S10-53	EXT CAL	78		S10-45
INT/EXT SWITCH	79	IN/EX SW			80		
BLTM OUT	81	+BL BNC	TTL		82		
$\overline{\text{BLTM OUT}}$	83	-BL BNC	TTL		84		
I_1	85	S4-77			86		
I_2	87	S4-78			88		
S/R	89		S10-48		90		
$\overline{\text{S/R}}$	91	NC			92		
$\overline{\text{SET INT}}$	93		S9-81		94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 4 NAME: DIGITAL BACK END INTEG.

Name	From Pin #	To	From	Name	From Pin #	To	From
	1			+5	2		
	3			+5	4		
	5				6		
	7				8		
	9			$\overline{\text{CHSEL}}$	10		S9-47
DARA	11		S9-44	DARB	12		S9-45
DARC	13		S9-46		14		
	15				16		
	17				18		
	19				20		
	21				22		
	23				24		
	25				26		
Ground	27			Ground	28		
DI-00	29	S5-29		DI-01	30	S5-30	
DI-02	31	S5-31		DI-03	32	S5-32	
DI-04	33	S5-33		DI-05	34	S5-34	
DI-06	35	S5-35		DI-07	36	S5-36	
DI-08	37	S5-37		DI-09	38	S5-38	
DI-10	39	S5-39		DI-11	40	S5-40	
DI-12	41	S5-41		DI-13	42	S5-42	
DI-14	43	S5-43		DI-15	44	S5-44	
	45				46		
	47				48		
Ground	49			Ground	50		
$\overline{\text{DI-00}}$	51	S5-53		$\overline{\text{DI-01}}$	52	S5-54	
$\overline{\text{DI-02}}$	53	S5-55		$\overline{\text{DI-03}}$	54	S5-56	
$\overline{\text{DI-04}}$	55	S5-57		$\overline{\text{DI-05}}$	56	S5-58	
$\overline{\text{DI-06}}$	57	S5-59		$\overline{\text{DI-07}}$	58	S5-60	
$\overline{\text{DI-08}}$	59	S5-61		$\overline{\text{DI-09}}$	60	S5-62	
$\overline{\text{DI-10}}$	61	S5-63		$\overline{\text{DI-11}}$	62	S5-64	
$\overline{\text{DI-12}}$	63	S5-65		$\overline{\text{DI-13}}$	64	S5-66	
$\overline{\text{DI-14}}$	65	S5-67		$\overline{\text{DI-15}}$	66	S5-68	
	67			LATCH 'A'	68	S5-70	
RESET 'A'	69	S5-71		RESET 'BCD'	70	S5-72	
Ground	71			Ground	72		
	73				74		
I_1	75	S5-77		I_2	76	S5-78	
f_{VCO}	77		S10-10		78		
	79				80		
	81				82		
	83				84		
	85				86		
	87				88		
	89				90		
	91				92		
	93				94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 5 NAME: DIGITAL BACK-END INTEG.

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
	5				6		
	7				8		
	9			$\overline{\text{CHSEL}}$	10		S9-48
DARA	11		S9-44	DARB	12		S9-45
DARC	13		S9-46		14		
	15				16		
	17				18		
	19				20		
	21				22		
	23				24		
	25				26		
Ground	27			Ground	28		
DI-00	29	S6-29		DI-01	30	S6-20	
DI-02	31	S6-31		DI-03	32	S6-32	
DI-04	33	S6-33		DI-05	34	S6-34	
DI-06	35	S6-35		DI-07	36	S6-36	
DI-08	37	S6-37		DI-09	38	S6-38	
DI-10	39	S6-39		DI-11	40	S6-40	
DI-12	41	S6-41		DI-13	42	S6-42	
DI-14	43	S6-43		DI-15	44	S6-44	
	45				46		
	47				48		
Ground	49			Ground	50		
	51				52		
$\overline{\text{DI-00}}$	53	S6-53		$\overline{\text{DI-01}}$	54	S6-54	
$\overline{\text{DI-02}}$	55	S6-55		$\overline{\text{DI-03}}$	56	S6-56	
$\overline{\text{DI-04}}$	57	S6-57		$\overline{\text{DI-05}}$	58	S6-58	
$\overline{\text{DI-06}}$	59	S6-59		$\overline{\text{DI-07}}$	60	S6-60	
$\overline{\text{DI-08}}$	61	S6-61		$\overline{\text{DI-09}}$	62	S6-62	
$\overline{\text{DI-10}}$	63	S6-63		$\overline{\text{DI-11}}$	64	S6-64	
$\overline{\text{DI-12}}$	65	S6-65		$\overline{\text{DI-13}}$	66	S6-66	
$\overline{\text{DI-14}}$	67	S6-67		$\overline{\text{DI-15}}$	68	S6-68	
	69			LATCH 'A'	70	S6-70	
RESET 'A'	71	S6-71		RESET 'BCD'	72	S6-72	
Ground	73			Ground	74		
	75				76		
I_1	77	S6-77		I_2	78	S6-78	
f_{VCO}	79		S10-15		80		
	81				82		
	83				84		
	85				86		
	87				88		
	89				90		
	91				92		
	93				94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 6 NAME: DIGITAL BACK-END INTEG.

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
	5				6		
	7				8		
	9			$\overline{\text{CHSEL}}$	10		S9-51
DARA	11		S9-44	DARB	12		S9-45
DARC	13		S9-46		14		
	15				16		
	17				18		
	19				20		
	21				22		
	23				24		
	25				26		
Ground	27			Ground	28		
DI-00	29	S7-29		DI-01	30	S7-30	
DI-02	31	S7-31		DI-03	32	S7-32	
DI-04	33	S7-33		DI-05	34	S7-34	
DI-06	35	S7-35		DI-07	36	S7-36	
DI-08	37	S7-37		DI-09	38	S7-38	
DI-10	39	S7-39		DI-11	40	S7-40	
DI-12	41	S7-41		DI-13	42	S7-42	
DI-14	43	S7-43		DI-15	44	S7-44	
	45				46		
	47				48		
Ground	49			Ground	50		
$\overline{\text{DI-00}}$	51	S7-53		$\overline{\text{DI-01}}$	52	S7-54	
$\overline{\text{DI-02}}$	53	S7-55		$\overline{\text{DI-03}}$	54	S7-56	
$\overline{\text{DI-04}}$	55	S7-57		$\overline{\text{DI-05}}$	56	S7-58	
$\overline{\text{DI-06}}$	57	S7-59		$\overline{\text{DI-07}}$	58	S7-60	
$\overline{\text{DI-08}}$	59	S7-61		$\overline{\text{DI-09}}$	60	S7-62	
$\overline{\text{DI-10}}$	61	S7-63		$\overline{\text{DI-11}}$	62	S7-64	
$\overline{\text{DI-12}}$	63	S7-65		$\overline{\text{DI-13}}$	64	S7-66	
$\overline{\text{DI-14}}$	65	S7-67		$\overline{\text{DI-15}}$	66	S7-68	
	67			LATCH 'A'	68	S7-70	
RESET 'A'	69	S7-71		RESET 'BCD'	70	S7-72	
Ground	71			Ground	72		
	73				74		
	75				76		
I_1	77			I_2	78		
f_{VCO}	79		S10-20		80		
	81				82		
	83				84		
	85				86		
	87				88		
	89				90		
	91				92		
	93				94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 7 NAME: DIGITAL BACK-END INTEG.

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
	5				6		
	7				8		
	9			$\overline{\text{CHSEL}}$	10		S9-52
DARA	11		S9-44	DARB	12		S9-45
DARC	13		S9-46		14		
	15				16		
	17				18		
	19				20		
	21				22		
	23				24		
	25				26		
Ground	27			Ground	28		
DI-00	29	---		DI-01	30	---	
DI-02	31	---		DI-03	32	---	
DI-04	33	---		DI-05	34	---	
DI-06	35	---		DI-07	36	---	
DI-08	37	---		DI-09	38	---	
DI-10	39	---		DI-11	40	---	
DI-12	41	---		DI-13	42	---	
DI-14	43	---		DI-15	44	---	
	45				46		
	47				48		
Ground	49			Ground	50		
	51				52		
DI-00	53	S10-55		DI-01	54	S10-56	
DI-02	55	S10-57		DI-03	56	S10-58	
DI-04	57	S10-59		DI-05	58	S10-60	
DI-06	59	S10-61		DI-07	60	S10-62	
DI-08	61	S10-63		DI-09	62	S10-64	
DI-10	63	S10-65		DI-11	64	S10-66	
DI-12	65	S10-67		DI-13	66	S10-68	
DI-14	67	S10-69		DI-15	68	S10-70	
	69			LATCH 'A'	70	S9-92	
RESET 'A'	71	S9-93		RESET 'BCD'	72	S9-93	
Ground	73			Ground	74		
	75				76		
I_1	77			I_2	78		
f_{VCO}	79		S10-25		80		
	81				82		
	83				84		
	85				86		
	87				88		
	89				90		
	91				92		
	93				94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 8 NAME: ANALOG OUTPUT

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
	5				6		
+15 V DC	7			+15 V DC	8		
	9				10		
-15 V DC	11			-15 V DC	12		
	13				14		
DAC0*	15		S9-76	DAC1*	16		S9-76
DAC2*	17		S9-77	DAC3*	18		S9-77
DAC4*	19		S9-78	DAC5*	20	S9-78	
DAC6*	21		S9-79	DAC7*	22	S9-79	
	23				24		
	25				26		
Ground	27			Ground	28		
	29				30		
CR0+	31	CR0 BNC-P		CR0-	32	CR0 BNC-S	
CR1+	33	CR1 BNC-P		CR1-	34	CR1 BNC-S	
CR2+	35	CR2 BNC-P		CR2-	36	CR2 BNC-S	
CR3+	37	CR3 BNC-P		CR3-	38	CR3 BNC-S	
CR4+	39	CR4 BNC-P		CR4-	40	CR4 BNC-S	
CR5+	41	CR5 BNC-P		CR5-	42	CR5 BNC-S	
CR6+	43	CR6 BNC-P		CR6-	44	CR6 BNC-S	
CR7+	45	CR7 BNC-P		CR7-	46	CR7 BNC-S	
	47				48		
Ground	49			Ground	50		
	51				52		
DO-00	53		S9-6	DO-01	54		S9-8
DO-02	55		S9-10	DO-03	56		S9-12
DO-04	57		S9-14	DO-05	58		S9-16
DO-06	59		S9-18	DO-07	60		S9-20
DO-08	61		S9-22	DO-09	62		S9-24
DO-10	63		S9-26	DO-11	64		S9-30
DO-12	65		S9-32	DO-13	66		S9-34
DO-14	67		S9-36	DO-15	68		S9-38
	69				70		
RESET*	71		NC	-10 V_{REF}	72	NC	
Ground	73			Ground	74		
	75				76		
	77				78		
	79				80		
	81				82		
	83				84		
	85				86		
	87				88		
	89				90		
	91				92		
	93				94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 9 NAME: HP 9825 I/O CONTROL

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
DO-00	5		C-17	DO-00	6	---	
DO-01	7		C-16	DO-01	8	---	
DO-02	9		C-15	DO-02	10	---	
DO-03	11		C-14	DO-03	12	---	
DO-04	13		C-13	DO-04	14	---	
DO-05	15		C-12	DO-05	16	---	
DO-06	17		C-11	DO-06	18	---	
DO-07	19		C-10	DO-07	20	---	
DO-08	21		C-9	DO-08	22	---	
DO-09	23		C-8	DO-09	24	---	
DO-10	25		C-7	DO-10	26	---	
Ground	27			Ground	28	---	
DO-11	29		C-6	DO-11	30	---	
DO-12	31		C-5	DO-12	32	---	
DO-13	33		C-4	DO-13	34	---	
DO-14	35		C-3	DO-14	36	---	
DO-15	37		C-2	DO-15	38	---	
STA 4	39			CAL NEXT	40		S11-94
$\overline{\phi 0}$ in	41		S3-59	$\overline{\phi 0}$ out	42	BNC - ϕ_0	"Cal during ϕ_0"
$\phi 0$ out	43	BNC + ϕ_0	"Cal during ϕ_0"	DARA	44	---	
DARB	45	---		DARC	46	---	
CHSEL A	47	---		CHSEL B	48	---	
Ground	49			Ground	50		
CHSEL C	51	---		CHSEL D	52	---	
R Fifo	53	H I/O - U		Sample Ignored	54	S11-21	
R Fifo	55	H I/O - V		Clear Status	56	S10-34	
PCTL	57		C-19	Hd Strobe	58	H I/O - T	
I/O	59		C-20	Hd Strobe	60	H I/o - S	
C_1	61		S9-32	C_1	62		S9-34
M_1	63		S9-22	M_1	64		S9-24
PIL 09 Set	65	H I/O - W		CTL1	66		C-23
RESET A	67		C-21	BL	68	---	
PL0	69	---		PL1	70	---	
PL2	71	---		PL3	72	---	
Ground	73			Ground	74		
ML0	75	S3-16		DAC0*/DAC1*	76	---	
DAC2*/DAC3*	77	---		DAC4*/DAC5*	78	---	
DAC6*/DAC7*	79	---		HOST DATA	80	NC	
SET INT	81	---		ML0	82		S9-75
CPU Busy	83		S11-25	IS0	84		S9-6
IS1	85		S9-8	IS2	86		S9-10
IS3	87		S9-12	IS4	88		S9-14
IS5	89		S9-16	IS6	90		S9-18
IS7	91		S9-20	LATCH INTEG*/DATA	92	---	
RESET INTEG #1	93	---		PIL 09 SET	94	H I/O - X	
PPLG (Ready)	95		C-44	LAST	96	S10-54	
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

SLOT 10 NAME: MISC. INTERFACE AND CONTROL ELEC.

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
	5				6		
+15 V DC	7			+15 V DC	8		
VCO A	9	NC		CA0	10	---	
CB0	11	NC		CC0	12	NC	
CD0	13	NC		VCO B	14	NC	
CA1	15	---		CB1	16	NC	
CC1	17	NC		CD1	18	NC	
VCO C	19	NC		CA2	20	---	
CB2	21	NC		CC2	22	NC	
CD2	23	NC		VCO D	24	NC	
CA3	25	---		CB3	26	NC	
Ground	27			Ground	28		
CC3	29	NC		CD3	30	NC	
BLTM Out	31		S3-81	I_1	32		S10-3
I_2	33		S10-1	$\overline{\text{CLEAR STATUS}}$	34		
VCO 0 -	35		-CH A BNC	VCO 0 +	36		+CH A BNC
VCO 1 -	37		-CH B BNC	VCO 1 +	38		+CH B BNC
VCO 2 -	39		-CH C BNC	VCO 2 +	40		+CH C BNC
VCO 3 -	41		-CH D BNC	VCO 3 +	42		+CH D BNC
B_1 -	43		Cal Sw BNC Shell	A_1 +	44		Cal Sw BNC Center
C_1 Ext Cal	45	---		B_2	46		S/R Sw BNC Shell
A_2	47		S/R Sw BNC Center	C_2 S/R Ext	48	---	
Ground	49			Ground	50		
B_3	51		Blanking BNC Shell	A_3	52		Blanking BNC Center
C_3 Ext Blanking	53	---		LAST	54		
$\overline{\text{DI-00}}$	55		C-42	$\overline{\text{DI-01}}$	56		C-41
$\overline{\text{DI-02}}$	57		C-40	$\overline{\text{DI-03}}$	58		C-39
$\overline{\text{DI-04}}$	59		C-38	$\overline{\text{DI-05}}$	60		C-37
$\overline{\text{DI-06}}$	61		C-36	$\overline{\text{DI-07}}$	62		C-35
$\overline{\text{DI-08}}$	63		C-34	$\overline{\text{DI-09}}$	64		C-33
$\overline{\text{DI-10}}$	65		C-32	$\overline{\text{DI-11}}$	66		C-31
$\overline{\text{DI-12}}$	67		C-30	$\overline{\text{DI-13}}$	68		C-29
$\overline{\text{DI-14}}$	69		C-28	$\overline{\text{DI-15}}$	70		C-27
VCO SA 2°	71		VCO Monitor Sw 2°	VCO SB 2'	72		VCO Monitor Sw 2'
Ground	73			Ground	74		
VCO LEVEL METER	75	VCO Monitor Switch		8192 MHz REF	76	---	
$\overline{\text{STA-00}}$	77			$\overline{\text{STA-01}}$	78		
$\overline{\text{STA-02}}$	79			$\overline{\text{STA-03}}$	80		
$\overline{\text{STA-04}}$	81			$\overline{\text{STA-05}}$	82		
$\overline{\text{STA-06}}$	83			$\overline{\text{STA-07}}$	84		
$\overline{\text{STA-08}}$	85			$\overline{\text{STA-09}}$	86		
$\overline{\text{STA-10}}$	87			$\overline{\text{STA-11}}$	88		
$\overline{\text{STA-12}}$	89			$\overline{\text{STA-13}}$	90		
$\overline{\text{STA-14}}$	91			$\overline{\text{STA-15}}$	92		
	93				94		
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

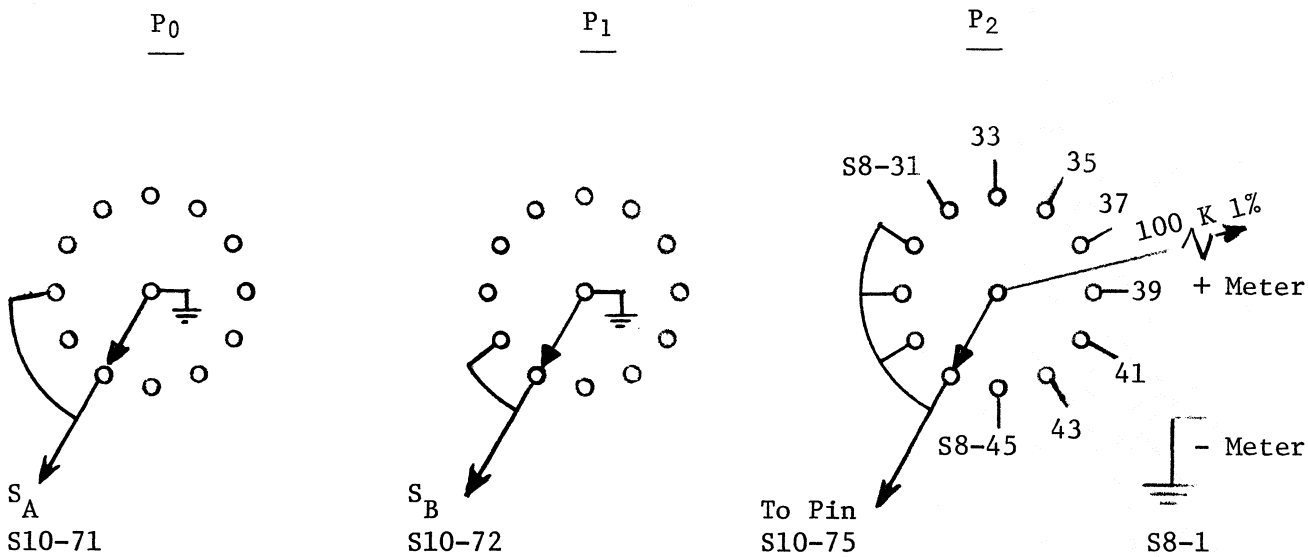
SLOT 11 NAME: PANEL INTERFACE

Name	From Pin #	To	From	Name	From Pin #	To	From
Ground	1			+5	2		
Ground	3			+5	4		
ϕ_0 3C	5	$+\phi_0$ BNC	3C		6		
+15	7			+15	8		
$\overline{\phi_0}$ 36	9	$-\phi_0$ BNC	3C		10		
-15	11			-15	12		
ϕ_{02}	13		S3-25	ϕ_{02} L G+	14	ϕ_{02} LED Notch	
ϕ_1 3C	15	$+\phi_1$ BNC	3C	ϕ_{02} L G-	16	ϕ_{02} LED	
Ext S/R	17		S10-48	Ext S/R L G+	18	Ext S/R LED Notch	
$\overline{\phi_1}$ 3C	19	$-\phi_1$ BNC	3C	Ext S/R L G-	20	Ext S/R LED	
SAMPLE IGNORED	21	S9-54		KB Busy L G+	22	KB LED Notch	
ϕ_2 3C	23	$+\phi_2$ BNC		KB Busy L G-	24	KB LED	
CPU Busy	25	S9-83		CPU Busy L G+	26	CPU LED Notch	
Ground	27			Ground	28		
$\overline{\phi_2}$ 3C	29	$-\phi_2$ BNC	3C	CPP Buxy L G-	30	CPU LED	
	31				32		
INT. BLANKING 3C	33	+ Blanking BNC	3C		34		
	35				36		
$\overline{\text{BLANKING 3C}}$	37	- Blanking BNC	3C		38		
	39				40		
ϕ_3 3C	41	$+\phi_3$ BNC	3C		42		
	43				44		
$\overline{\phi_3}$ 3C	45	$-\phi_3$ BNC	3C		46		
	47				48		
Ground	49			Ground	50		
	51				52		
ϕ_0	53	S3-60		ϕ_0 L	54	ϕ_0 LED	Conn. anode to VCC
ϕ_1	55	S3-62		ϕ_1 L	56	ϕ_1 LED	"
ϕ_2	57	S3-64		ϕ_2 L	58	ϕ_2 LED	"
ϕ_3	59	S3-66		ϕ_3 L	60	ϕ_3	"
Cal during ϕ_0	61	S9-43		Cal during ϕ_0 L	62	Cal during ϕ_0 LED	"
Ext Cal	63	S10-45		Ext cal L	64	Ext cal LED	"
ϕ_{02} 3C	65	$+\phi_{02}$ BNC	3C		66		
INT BLANKING	67	S3-55		INT BLANKING L	68	INT BL LED	"
$\overline{\phi_{02}}$ 3C	69	$-\phi_{02}$ BNC	3C		70		
EXT BLANKING	71	S10-53		EXT BLANKING L	72	EXT BL LED	"
Ground	73			Ground	74		
VCO Clip A	75	S10-77		VCO Clip AL	76	VCO Clip A	"
VCO Clip B	77	S10-78		VCO Clip BL	78	VCO Clip B	"
VCO Clip C	79	S10-79		VCO Clip CL	80	VCO Clip C	"
VCO Clip D	81	S10-80		VCO Clip DL	82	VCO Clip D	"
Cal during ϕ_0 3C	83	Cal during ϕ_0 + BNC	3C		84		
	85				86		
$\overline{\text{Cal during } \phi_0 \text{ 3C}}$	87	Cal during ϕ_0 - BNC	3C		88		
	89				90		
EXT CAL	91		S10-45	INT CAL	92		C-22
INT/EXT SW	93		S3-79	CAL NEXT	94	---	
	95				96		
Ground	97			+5	98		
Ground	99			+5	100		

89 PINS TOTAL

Notes:

1. Use ribbon cable to wire front panel.
2. Use 50 ohm coax to wire Ch A, Ch B, Ch C, and Ch D.
3. Run common ground to red only LED's and BNC's that are not isolated.
4. Run twisted pair to BNC's that are isolated.
5. VCO monitor switch is 2 pole switch wired binary for SA (2°) and SB (2'). A third pole (wafer) is connected to selected analog inputs.



6. For int/ext switch: NC
7. Connect notch side of following LED's to gnd ϕ_0, ϕ_1, ϕ_2, ϕ_3, cal during ϕ_0, ext cal, ext blanking, int blanking, VCO clip A, B, C, and D.

ELCO CONNECTOR LIST FOR BOX/RACK/DRAWER Digital Receiver

CONNECTOR: DESIGNATION Host I/O Data; TYPE _____; 38 PINS

SMALL KEY 1, LARGE KEY 1; PANEL E, CABLE P

Pin	To	Function
A	S9-5	$\overline{\text{DO-00}}$
B	S9-21	$\overline{\text{DO-08}}$
C	S9-7	$\overline{\text{DO-01}}$
D	S9-23	$\overline{\text{DO-09}}$
E	S9-9	$\overline{\text{DO-02}}$
F	S9-25	$\overline{\text{DO-10}}$
H	S9-13	$\overline{\text{DO-04}}$
J	S9-31	$\overline{\text{DO-12}}$
K	S9-15	$\overline{\text{DO-05}}$
L	S9-33	$\overline{\text{DO-13}}$
M	S9-17	$\overline{\text{DO-06}}$
N	S9-35	$\overline{\text{DO-14}}$
P	S9-19	$\overline{\text{DO-07}}$
R	S9-37	$\overline{\text{DO-15}}$
S	S9-60	$\overline{\text{Hd Strob}}$
T	S9-58	Hd Strob
U	S9-53	R Fifo
V	S9-55	$\overline{\text{R Fifo}}$
W	S9-65	$\overline{\text{PIL 09 Set}}$
X	S9-94	PIL 09 Set
Y	NC	Scan
Z	S10-82	$\overline{\text{Scan}}$
a	BNC #1	Cal
b	BNC #2	$\overline{\text{Cal}}$
c	S9-11	$\overline{\text{DO-03}}$
d	S9-29	$\overline{\text{DO-11}}$
e		Spare
f		Spare
h		Spare
j		Spare
k		Spare
l		Spare
m		Spare
n		Spare
p		Spare
r		Spare
s	S9-1	Gnd
t	S9-3	Gnd

End 20 Pin →

End 38 → Pin

Pin	To	Function
u		
v		
w		
x		
y		
z		
AA		
BB		
CC		
DD		
EE		
FF		
HH		
JJ		
KK		
LL		
MM		
NN		

End 56 Pin →

Abbreviations:
Ex: S25-22 Slot 25, Pin 22 | J9-MM Elco J9, Pin MM

Elco Connectors: J1, J2, J3, etc.
Slot Connectors: S1, S2, S3, etc.
Pin No.'s -3, -X, -B,

Digital Receiver Interface to DDP 116

	Name	From	Elco		Name	From	To
1	Ground			36	+5		
2	Ground			37	+5		
3		-18		38	-18		
4				39	ADB 13		
5	ADB 10			40	ADB 14		
6	ADB 11			41	ADB 15		
7	ADB 12			42	ADB 16		
8	INB 01	S6-17		43	INB 10	S6-26	
9	INB 02	18		44	INB 11	27	
10	INB 03	19		45	INB 12	28	
11	INB 04	20		46	INB 13	29	
12	INB 05	21		47	INB 14	30	
13	INB 06	S6-22		48	INB 15	S6-31	
14	PIL09+			49	PIL 09-		
15	ACK09+			50	ACK09-		
16	INB 07	S6-23		51	OCP-		
17	INB 08	S6-24		52	OTP-		
18	DRL-			53	MSCL-		
19	INB 09	S6-25		54	INB 16		
20	DO-00	DO-00	A	55	DO-08	DO-18	B
21	01	01	C	56	09	09	D
22	02	02	E	57	10	10	F
23	03	03	CC	58	11	11	DD
24	04	04	H	59	12	12	J
25	05	05	K	60	13	13	L
26	06	06	M	61	14	14	N
27	DO-07	DO-07	P	62	DO-15	DO-15	R
28	$\overline{\text{Hd Strob}}$		S	63	Hd Strob	HD Strob	T
29	R Fifo		U	64	$\overline{\text{R Fifo}}$	$\overline{\text{R Fifo}}$	V
30	$\overline{\text{PIL 09 Ser}}$		W	65	PIL 09 Ser	PIL 09 Ser	X
31	Scan		Y	66	$\overline{\text{Scan}}$	$\overline{\text{Scan}}$	Z
32	Cal		AA	67	$\overline{\text{Cal}}$	$\overline{\text{Cal}}$	BB
33	-5 V DC		SS	68	GND		TT
34	Ground			69	+5		
35	Ground			70	+5		

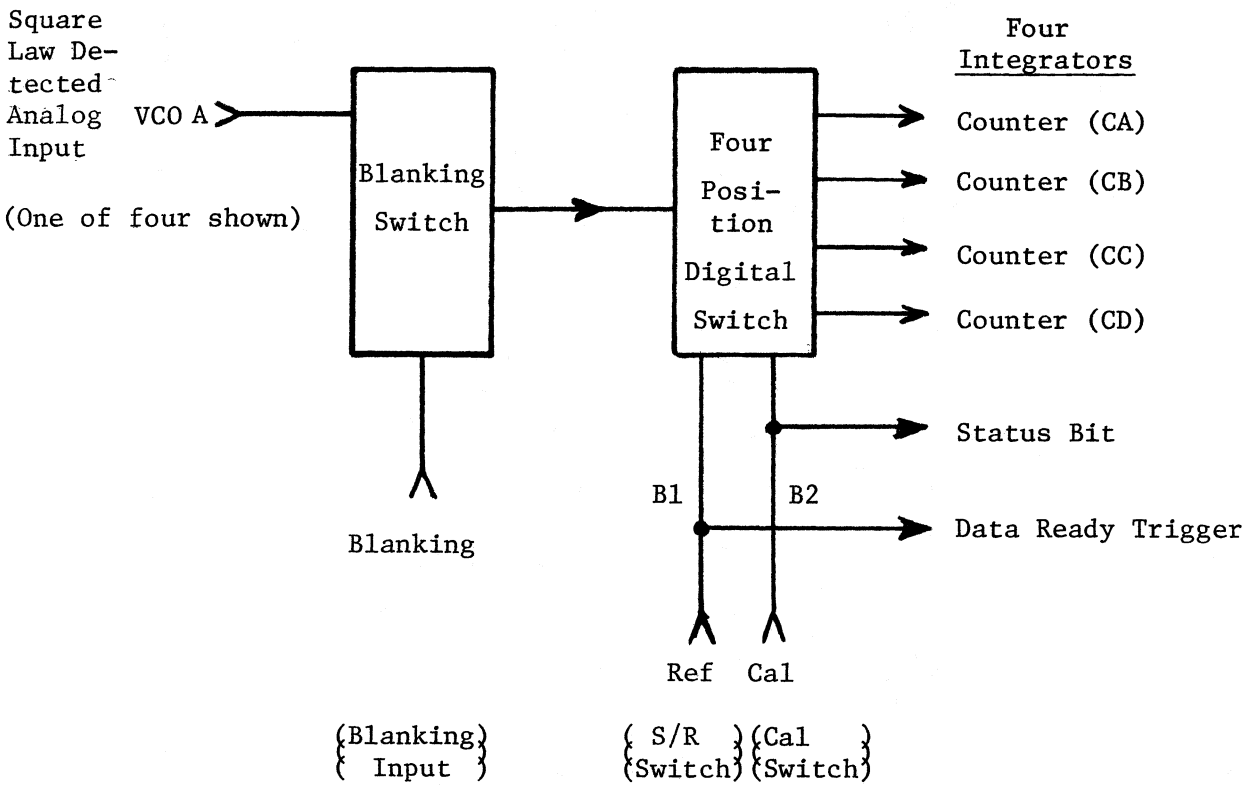
FRONT (Socket Side)

BACK (Wire Wrap Pin Side)

* Single ended signal
  - = Return) on twisted pair
  + = Signal)

External Timing Generator Operational Mode:

Finally, a word should be written about the external timing generator mode of operation where the integrator switch signals are provided from an external source.



Simplified System Functional Diagram

The four integrators are sequenced by a 4-position digital switch which requires a 2-bit control input (B1 and B2) and a blanking control signal to preclude integration during the noise transients that occur after switching in the radiometer. The 2-bit signal is labeled on the back panel BNC's as "S/R Switch" and "Cal Switch". These inputs may be connected to any control signal generator with a blanking interval generator triggered when either B1 or B2 or both change state and lasting the required interval until the transients settle.

The status of the "cal" signal is present as a value of "16" or "0" read in the status word (last word in data input block to CPU).

Programming may have to be done to make the data input ϕ_0, ϕ_1, ϕ_2, and ϕ_3 interface correctly to the "S", "R", and "C" raw counts expected by the

calculation loop. They may be rearranged and/or eliminated as required by the 2-bit input timing. Also, the mode control word setting the number of phases must be dealt with. If you are not sure, set the 4-phase mode (same as the "Gain Balancing Switched with Cal" program). Lastly, toggle the front panel Int/Ext T.G. switch to Ext position.

Conclusion:

It is hoped that the user will recognize the usefulness and potential power that may be contributed to radiometry by a system such as that described in this EDIR. If properly understood and utilized, a significant improvement in reliability and stability should be afforded our present receiving systems as well as the contribution of new and useful modes of operation, noise adding radiometer, for example. The programs may be modified at any time to achieve your custom application, i.e., new calculations may be added or overlayed upon the existing calculation loop. The program can be stripped down with the bells and whistles eliminated, thus allowing much improvement in data throughput. This present system operating with 4 channels in 4-phase mode will update the host data taking system and chart recorders 3 times per second while the 10 times per second data rate may be achieved in only switch power for 4 channels being sent to the host and chart recorders. The operating system may be programmed to automatically inhibit certain features as the integration period is directed below certain minimum values. The "Thermal Cal Unit" program has good improved handling of the integration time versus Dicke frequency and minimum integration time assignments. See the radiometer parameters input phase listed herein for possible incorporation of some of these features into the "Gain Balancing Radiometer" program. These features are more favorable from a human engineering standpoint.

Credit is due many individuals where discussions have occurred regarding this project. There is not space to mention all, but special thanks to Rick Fisher, Ron Weimer, Craig Moore, and Sandy Weinreb.

NATIONAL RADIO ASTRONOMY OBSERVATORY

Supplement to EDIR #188

September 26, 1978

DIGITAL STANDARD RECEIVER TESTS AND PROGRAM MODIFICATIONS

J. Richard Fisher

In August and September 1978 the digital standard receiver was tested for compatability with the DDP-116 on-line computer at the 300-foot telescope, and a number of changes were made to the receiver's HP 9825A calculator program. Most of the tests were performed with the 2 channel, 4 phase load switching program, but 4 channel, 4 phase and 4 channel, 2 phase programs were also tried. The latter included only the calculations necessary to send the synchronously detected data to the DDP 116 to determine the minimum integration period that could be used with this receiver.

A magnetic tape cartridge labeled "DSR Programs 15 Sept. 1978" contains the following program files:

File 0: Contains only one statement to direct calculator to current program in use on power-up. Now it reads "ldp 2".

File 1: Original EDIR #188, page 9 program.

File 2: Two channel, 4 phase load switching program with necessary modifications to File 1.

File 3: Same as File 2 but with some channel indices reversed for better efficiency and a few extraneous special function keys erased.

File 4: Four channel, 4 phase load switching program.

File 5: Four channel, 2 phase load switching program for minimum integration time.

File 6: Same as File 3 except that gain modulator constants (Alpha) are entered through the keyboard and are not changed at the start of each scan.

File 7: Same as File 4 except that gain modulator constants (Alpha) are entered through the keyboard and are not changed at the start of each scan.

File 11: Special function keys for Files 3, 4, 5, and 7.

File 12: Special function keys for Files 2 and 6.

File 13: Stored receiver data from last gain balance.

The minimum integration period usable with the File 2 program is $0^{s}.200$. The shortest integration for the File 5 program depends on the number of channels in use: 1 channel, $0^{s}.042$; 2 channels $0^{s}.054$; 3 channels, $0^{s}.078$; and 4 channels, $0^{s}.100$. There are no chart recorder outputs in this program, but one or more of these might be substituted for the display without much sacrifice in speed.

The following is a list of program and format changes. Page numbers refer to EDIR #188.

Page 17: Internal variables U, V, Y, and Z and array variable E [ ] are now in use.

Page 19: The theoretical sensitivity (ΔT) equation is corrected to read

$$I = \Delta T = \frac{2 \times \text{System Temperature} \times \frac{C+S}{2S}}{\sqrt{\text{Receiver Bandwidth} \times \frac{\text{Samples per Integration} \times \left(\text{Dicke Switch Phase Period} - \text{Blanking Time}\right) \times 4}{1000}}}$$

Page 21: Seven special function keys were added:

f_{13} - Provides for changing gain modulator constants from keyboard. Applies only to Files 6 and 7.

f_{18} - Bypass gain and system temperature calculations if no cal signal is available.

f_{19} - Restores gain and system temperature.

f_{20} - Stops gain and system temperature renormalization at the start of every scan so the functions can be followed over a long period of time. Normalization can be reinstated by pressing f_{19} "w/cal".

Page 21 (continued):

f_{21} - Restores chart recorders to normal operation after setting scale with f_{22} or f_{23}.

f_{22} - Puts zero volts on chart recorder outputs for aligning pens.

f_{23} - Puts ten volts on chart recorder outputs for aligning pens.

Page 23: A word is added to the host data group to tell the DDP 116 how many words (N + 1) are being sent to the DDP 116 with the first one containing the value N (# of channels).

Page 24: The header block sequence was modified to improve the resolution of many of the small numbers which must be transmitted as integers, and to add or modify a couple of words needed by the DDP 116 program. The new header format is as follows:

Value	Description
11 + 9R	Number of words to follow in the header.
E	Host data scale factor (counts/K).
K	Receiver balance time factor (number of switch cycles).
L x 100	Receiver balance time (centiseconds).
4PM	Integration period (milliseconds).
2PM + 185	Delay from the middle of the integration period until the interrupt is sent to the DDP 116 to indicate that the data are in the FIFO register. This value must be determined for each different program since it depends on computation time.
0	Blanking time parts (4096 x Blanking Time/Phase Period).
P	Phase period (milliseconds).
Q	Blanking time (milliseconds).
R	Number of receiver channels in use.
S	Input status word. (Bits 00 through 03 are counter overflow flags, normally "1" with no overflow; bit 05 = "1" indicates start scan pulse received from DDP 116).
T	Summation time for statistics data (sec).

Value	Description
A_1 x 1000	Gain modulation factor for channel 1 times 10^3.
B_1 x 10	System temperature for channel 1 (decikelvins).
G_1 x 1000	Relative gain for channel 1 times 10^3.
H_1 x 1000	Measured output rms fluctuation for channel 1 (millikelvins).
I_1 x 1000	Theoretical output rms for channel 1 (millikelvins).
K_1	V/F counter scale factor for channel 1 (counts/K).
T_1 x 100	Calibration noise source for channel 1 (centikelvins).
U_1 x 10	System temperature for channel 1 (decikelvins)
W_1 x 10	Channel 1 bandwidth (tenths of MHz).
A_2 x 1000	Gain modulation factor for channel 2 times 10^3,
⋮	
⋮	etc., for as many channels as used.

The following changes were made to the program listed in pages 9-15 of EDIR #188. The number on the left is the original number of the line modified or the original line number before any added lines. Note that the new line numbers in File 2 are different from the originals because of additions and deletions.

8: Added 0 → Z and 1 → F to initialize cal/no cal, chart recorder calibrate and FIFO reset parameters.

20: Moved 0 → F to line 21 since, to execute, gsb "CONTROL" must be the last thing on the line.

24: Added Z ≠ 1 and Z ≠ -1 test to bypass gain calculation if cal is disconnected or if renormalization is to be bypassed.

27: Added Z ≠ 1 and Z ≠ -1 test to bypass system temperature calculation if cal is disconnected or if renormalization is to be bypassed.

28: Corrected theoretical rms equation.

32: Changed "if" test to if A > 1 to send header to DDP 116 only on scan start.

46: Added Z ≠ 1 test to bypass system temperature calculation when cal is disconnected.

51: Corrected measured rms equation by adding missing parentheses around (N - 1) term.

53, 54, 55, 56, 57, 58: Added gto "J" to save time doing unnecessary tests.

61: Added "J" label.

61 through 81: Corrected test and write statements to eliminate interference of chart recorder values in the same word under overflow conditions.

63, 68, 74, 79: Added Z > 1 test to write zero or 10 V values to chart recorder channels when called for.

82: Added wtb 15, R to write the number of channels in the DDP 116 data.

84, 85: Changed data overflow response.

105: Added 2 → B as part of line 32 change.

140 through 147: Added units to displays.

148: Changed "digital data scale factor" (in counts per K) to "digital data full scale (°K)" by analogy to old standard receivers.

183: Added wtb 15, 32639, 32639, 32639, 32639, 11+9R to step through chart recorder words and write the number of header words to be transmitted to the DDP 116. This sends all chart recorder pens to center scale when the header is transmitted.

195 through 205: Reversed channel index incrementing to save computation of index for every array variable.

186, 187, 188, 196, 197, 198, 199, 200, 202, 203, 204: Changed header word scale factors to improve accuracy of integer word values.

187, 196, 197, 198, 199, 200, 201, 202, 203, 204: Included tests for out-of-range header values to prevent hangups due to transmission error.

Distribution:

File 2.567	J. Coe	B. Stobie
M. Balister	M. Damashek	B. Vance
W. Brundage	D. Schiebel	R. Weimer

FILE 2

```
0: dsp "GAIN
 BALANCING SWITC
 HED WITH CAL"
1: sfg 14;sfg 5
2: on err "I/O
 ERROR"
3: dim C[4],D[4]
 ,E[4],G[4],R[4]
 ,S[4],U[4]
4: dim M[4],N[4,
 50],P[4],Q[4,
 50],H[4]
5: dim A[4],B[4]
 ,F[4],I[4],K[4]
 ,T[4],W[4],X[8]
 ,P,R,M,O,Q,N,T,
 E,L
6: ldf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
7: ldk 12
8: 1→J→F;0→A;
 2→B;0→D→Z
9: esb "CONTROL"
10:
11: "NEW ALPHA":
12: dsp "
 GAIN BALANCING
 NOW"
13: for I=1 to R
14: for D=1 to N
15: 0→N[I,D]→Q[I
 ,D]
16: next D
17: 0→M[I]→P[I]
18: next I
19: 0→D;1→J
20: 1→F;M→K;int(
 1000L/4P)→M;
 esb "CONTROL"
21: 0→F;esb "REA
 D RCVR"
22: for I=1 to R
23: (C[I]+S[I])/
 R[I]→A[I]
24: if Z#1 [illegible]
 [illegible];(C[I]-S[I]
 )/M→R[illegible]; if Z≠-1;
25: F[I]/T[I]→K[
 I]
26: A[I]R[I]→R[I
 ]
27: if Z#1 and
 Z#-1;S[I]T[I]/
 (C[I]-S[I])→B[I
 ]
28: B[I](C[I]+
 S[I])/S[I]↑(W[I
 ]K4(P-Q)/1000)→
 I[I]
29: next I
30: K→M;rcf 13,
 A[*],B[*],F[*],
 I[*],K[*],T[*],
 W[*],X[*],P,R,
 M,O,Q,N,T,E,L
31: esb "CONTROL
 "
32: if A<1;esb
 "HEADER"
33: if A#2;0→A;
 gto "LOOP"
34: spc ;0→A
35: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
36: spc 2;0→A
37:
38: 0→K
39: "LOOP":wtc
 15,32+1
40: D+1→D;if
 D=N+1;1→D
41: esb "READ
 RCVR"
42: if B=1;fxd
 0;dsp "C=",C[R+
 1-J],"R=",R[R+
 1-J]/2,"S=",
 S[R+1-J],J
43: for I=1 to R
44: A[I]R[I]→R[I
 ]
45: (C[I]+S[I]-
 R[I])/2M→D[I]
46: (C[I]-S[I])/
 MF[I]→G[I]
47: if Z#1;S[I]T
 [I]/(C[I]-S[I])
 →U[I]
48: M[I]-N[I,D]+
 D[I]D[I]→M[I]
49: D[I]D[I]→N[I
 ,D]
50: P[I]-Q[I,D]+
 D[I]→P[I]
51: D[I]→Q[I,D]
52: r((M[I]-P[I]
 P[I]/N)/(N-1))→
 H[I]
53: next I
54: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[R+1-J],J;
 gto "J"
55: if B=2;fxd
 4;dsp "     SWIT
 CH POWER=",D[R+
 1-J]/K[R+1-J],
 "*K",J;gto "J"
56: if B=3;fxd
 4;dsp "
 NORMALIZED GAIN
 =",G[R+1-J],J;
 gto "J"
57: if B=4;fxd
 4;dsp "     SYST
 EM TEMP=",U[R+
 1-J],"*K",J;
 gto "J"
58: if B=5;fxd
 4;dsp " DELTA
 TEMP)meas=",
 H[R+1-J]/K[R+1-
 J],"*K",J;gto
 "J"
59: if B=6;fxd
 4;dsp " DELTA
 TEMP)theo=",
 I[R+1-J],"*K",
 J;gto "J"
60: if B=7;gto
 "INIT"
61: if B=8;fxd
 0;dsp "DIGITAL
 OUTPUT=",ED[R+
 1-J]/K[R+1-J],J
62: "J":int(X[2]
 (G[R]-1))+128→X
 ;if X<0;0→X
63: if X>255;
 255→X
64: X[1](D[R]/
 K[R])+128→Y;if
 Y<0;0→Y
65: if Y>255;
 255→Y
66: if Z>1;wtb
 15,2-Z;gto +2
67: wtb 15,shf(X
 ,-8)+Y
68: int(X[4]H[R]
 /K[R])+128→X;
 if X<0;0→X
69: if X>255;
 255→X
70: X[3](U[R]-
 B[R])+128→Y;if
 Y<0;0→Y
71: if Y>255;
 255→Y
72: if Z>1;wtb
 5,2-Z;gto +2
73: wtb 15,shf(X
 ,-8)+Y
74: if R<2;wtb
 15,0;wtb 15,0;
 gto "NO CH 2"
75: int(X[6](G[R
 -1]-1))+128→X;
 if X<0;0→X
76: if X>255;
 255→X
77: X[5](D[R-1]/
 K[R-1])+128→Y;
 if Y<0;0→Y
78: if Y>255;
 255→Y
79: if Z>1;wtb
 15,2-Z;gto +2
80: wtb 15,shf(X
 ,-8)+Y
81: int(X[8]H[R-
 1]/K[R-1])+128→
 X;if X<0;0→X
82: if X>255;
 255→X
83: X[7](U[R-1]-
 B[R-1])+128→Y;
 if Y<0;0→Y
84: if Y>255;
 255→Y
85: if Z>1;wtb
 15,2-Z;gto +2
86: wtb 15,shf(X
 ,-8)+Y
87: "NO CH 2":wt
 b 15,R
88: for I=1 to R
89: ED[R+1-I]/
 K[R+1-I]→X;if
 X>32767;32767→X
90: if X<-32768;
 -32768→X
91: wtb 15,X
92: next I
93: if S>31;gto
 "NEW ALPHA"
94: if A=1;gto
 "NEW ALPHA"
95: gto "LOOP"
96:
97:
98: "CONTROL":
99: wtc 15,2+1
100: wtc 15,32+
 2+1
101: wtb 15,0
102: wtb 15,P-1
103: wtb 15,P-1
104: wtb 15,P-1
105: wtb 15,P-1
106: wtb 15,1638
 4F+(R-1)4096+
 512+256+M-1
107: wtc 15,32+
 2+1
108: wtc 15,32+1
109: ret
110:
```

```
111: "INIT":dsp
 "INITIALIZE
 SEQ--2CH,CRSR
 MODE";2→B
112: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?",R
113: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;gto "R"
114: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;gto "R"
115: "P":ent
 "DICKE SWITCH
 PHASE PERIOD
 IN MS?",P;if
 flg13=0;gsb 0
116: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;gto
 "P"
117: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;gto "P"
118: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
119: if flg13=0;
 int(4096Q/P)→O;
 cfg 0
120: if flg0=1;
 int(4096Q/P)→O;
 cfg 0
121: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 gto "Q"
122: if O<0;prt
  BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;gto
 "Q"
123: "M":ent
 "HOW MANY SAMPL
 ES/INTEGRATION?
 ",M
124: if M<1;prt
 "MUST BE AT
 LEAST 1 SAMPLES
 /INTEGRATION";
 spc 2;gto "M"
125: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
126: "L":ent
 "RCVR BAL TIME
 (SEC)=",L;int(1
 000L/4P)4P/1000
 →K
127: if int(250L
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/250;spc 2;
 gto "L"
128: if int(250L
 /P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;gto
 "L"
129: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
130: "N":ent
 "DELTA T)meas
 SUMATION TIME?
 SEC",T
131: int(1000T/
 4MP)→N
132: if N<2;fxd
 3;beep;prt "REQ
  MIN SUMMATION
 TIME=",4MP2/
 1000,"SEC";gto
 "N"
133: if N>50;
 beep;prt "MAX
 SUMATION TIME="
 ,4MP50/1000,
 "SECONDS";gto
 "N"
134: if T#4MPN/
 1000;4MPN/1000→
 T;beep;fxd 3;
 prt "ACTUAL
 SUMATION TIME="
 ,T;spc
135: ent "WHAT
 IS CAL *K FOR
 CHANNEL 1?",
 T[R]
136: if R-1>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 2?",T[R-1]
137: if R-2>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 3?",T[R-2]
138: if R-3>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 4?",T[R-3]
139: ent "BANDWI
 DTH (MHz) FOR
 CHANNEL 1?",
 W[R];if flg13=0
 ;W[R]1e6→W[R]
140: if R-1>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 2?",W[R-1]
141: if R-1>0;
 if flg13=0;W[R-
 1]1e6→W[R-1]
142: if R-2>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 3?",W[R-2]
143: if R-2>0;
 if flg13=0;W[R-
 2]1e6→W[R-2]
144: if R-3>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 4?",W[R-3]
145: if R-3>0;
 if flg13=0;W[R-
 3]1e6→W[R-3]
146: ent "CRSF
 0=?  CH1--SWITC
 H POWER (*K/
 V)",X[1];if
 flg13=0;25.5/
 X[1]→X[1]
147: ent "CRSF
 1=?  CH1--GAIN
 (Parts/V)",X[2]
 ;if flg13=0;
 25.5/X[2]→X[2]
148: ent "CRSF
 2=?  CH1--T
 SYS (*K/V)",
 X[3];if flg13=0
 ;25.5/X[3]→X[3]
149: ent "CRSF
 3=?  CH1--DELTA
  T (*K/V)",X[4]
 ;if flg13=0;
 25.5/X[4]→X[4]
150: ent "CRSF
 4=?  CH2--SWITC
 H POWER (*K/
 V)",X[5];if
 flg13=0;25.5/
 X[5]→X[5]
151: ent "CRSF
 5=?  CH2--GAIN
 (Parts/V)",X[6]
 ;if flg13=0;
 25.5/X[6]→X[6]
152: ent "CRSF
 6=?  CH2--T
 SYS (*K/V)",
 X[7];if flg13=0
 ;25.5/X[7]→X[7]
153: ent "CRSF
 7=?  CH2--DELTA
  T (*K/V)",X[8]
 ;if flg13=0;
 25.5/X[8]→X[8]
154: ent "DIGITA
 L OUTPUT FULL
 SCALE (*K)",E;
 if flg13=0;3276
 8/E→E
155: if E>32767;
 32767→E;dsp
 "SCALE MUST BE
 >= 1K (Set=1)";
 wait 3000
156: ent "INIT
 VALUES PRINTED?
 , ENT 1, CONT",
 A
157: if A=1;gsb
 "INIT PRINT"
158: gto "NEW
 ALPHA"
159:
160: "READ RCVR"
 :for I=1 to R
161: rdb(15)*
 32768+rdb(15)→R
 [I]
162: rdb(15)*
 32768+rdb(15)→S
 [I]
163: R[I]+rdb(15
 )*32768+rdb(15)
 →R[I]
164: rdb(15)*
 32768+rdb(15)→C
 [I]
165: next I
166: rdb(15)→S
167: ret
168:
169: "I/O ERROR"
 :
170: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line",
 erl;beep;9→B;
 gto "LOOP"
171:
172: "INIT PRINT
 ":
173: fxd 0;spc
174: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
175: prt "SWITCH
  PERIOD INMS
 =",P;spc
176: fxd 4;prt
 "BLANKING TIME
   MS =",PO/4096
 ;spc
177: fxd 0;prt
 "SAMPLES/INTEGR
 ATION=",M;spc
178: fxd 3;prt
 "INTEG. PERIOD
   (SEC)=",4MP/
 1000;spc
179: fxd 3;prt
 "RCVR BAL TIME
   (SEC)=",(4P/
 1000)int(1000L/
 4P);spc
180: fxd 3;prt
 "DELTA T)meas
 SUMATION TIME
 (SEC)=",4MPN/
 1000;spc
181: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "CAL=
 ",T[R+1-I];next
  I
182: spc 2
183: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "BW="
 ,W[R+1-I]/1e6;
 next I
184: spc 2
185: for I=1 to
 8;fxd 0;prt
 "FOR CR",I-1;
 fxd 5;prt "CRSF
 =",25.5/X[I];
 next I
186: spc ;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=",E
187: 2→A;spc
188: ret
```

```
189: "HEADER":if
  fla5=1;cfa 5;
 ret
190: wtb 15,3263
 9,32639,32639,
 32639,11+9R
191: wtb 15,E
192: wtb 15,K
193: wtb 15,100L
194: 4PM→V;if
 V>32767;32767→V
195: wtb 15,V
196: wtb 15,185+
 2PM
197: wtb 15,O
198: wtb 15,P
199: wtb 15,Q
200: wtb 15,R
201: wtb 15,S
202: wtb 15,T
203: for I=R to
 1 by -1
204: 1000A[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
205: wtb 15,V
206: 10B[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
207: wtb 15,V
208: 1000G[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
209: wtb 15,V
210: 1000H[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
211: wtb 15,V
212: 1000I[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
213: wtb 15,V
214: K[I]→V;if
 V>32767 or V<-
 32768;32767→V
215: wtb 15,V
```

```
216: 100T[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
217: wtb 15,V
218: 10U[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
219: wtb 15,V
220: W[I]/1e5→V;
 if V>32767 or
 V<-32768;32767→
 V
221: wtb 15,V
222: next I
223: ret
224:
225: end
*3189
```

FILE 3

```
0: dsp "GAIN
 BALANCING SWITC
 HED WITH CAL"
1: sfg 14;sfg 5
2: on err "I/O
 ERROR"
3: dim C[4],D[4]
 ,E[4],G[4],R[4]
 ,S[4],U[4]
4: dim M[4],N[4,
 50],P[4],Q[4,
 50],H[4]
5: dim A[4],B[4]
 ,F[4],I[4],K[4]
 ,T[4],W[4],X[8]
 ,P,R,M,O,Q,N,T,
 E,L
6: ldf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
7: ldk 11
8: 1→J→F→U;0→A;
 2→B;0→D→Z
9: gsb "CONTROL"
10:
```

```
11: "NEW ALPHA":
12: dsp "
 GAIN BALANCING
 NOW"
13: for I=1 to R
14: for D=1 to N
15: 0→N[I,D]→Q[I
 ,D]
16: next D
17: 0→M[I]→P[I]
18: next I
19: 0→D;1→J
20: 1→F;M→K;int(
 1000L/4P)→M;
 gsb "CONTROL"
21: 0→F;gsb "REA
 D RCVR"
22: for I=1 to R
23: (C[I]+S[I])/
 R[I]→A[I]
24: if Z≠0;(C[I]
 -S[I])/M→X;
25: X/T[I]→K[
 I]
26: A[I]R[I]→R[I
 ]
27: if Z=0;S[I]T
 [I]/(C[I]-S[I])
 →B[I]
28: B[I](C[I]+
 S[I])/S[I]r(W[I
 ]K4(P-Q)/1000)→
 I[I]
29: next I
30: K→M;rcf 13,
 A[*],B[*],F[*],
 I[*],K[*],T[*],
 W[*],X[*],P,R,
 M,O,Q,N,T,E,L
31: gsb "CONTROL
 "
32: if A<1;gsb
 "HEADER"
33: if A#2;0→A;
 gto "LOOP"
34: spc ;0→A
35: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
36: spc 2;0→A
37:
```

```
38: "LOOP":wtc
 15,32+1
39: D+1→D;if
 D=N+1;1→D
40: gsb "READ
 RCVR"
41: if B=1;fxd
 0;dsp "C=",C[J]
 ,"R=",R[J]/2,
 "S=",S[J],R+1-J
42: for I=1 to R
43: A[I]R[I]→R[I
 ]
44: (C[I]+S[I]-
 R[I])/2M→D[I]
45: (C[I]-S[I])/
 MF[I]→G[I]
46: if Z#1;S[I]T
 [I]/(C[I]-S[I])
 →U[I]
47: M[I]-N[I,D]+
 D[I]D[I]→M[I]
48: D[I]D[I]→N[I
 ,D]
49: P[I]-Q[I,D]+
 D[I]→P[I]
50: D[I]→Q[I,D]
51: r((M[I]-P[I]
 P[I]/N)/(N-1))→
 H[I]
52: next I
```

```
53: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[J],R+1-J;
 gto "J"
54: if B=2;fxd
 4;dsp "    SWIT
 CH POWER=",D[J]
 /K[J],"*K",R+1-
 J;gto "J"
55: if B=3;fxd
 4;dsp "
 NORMALIZED GAIN
 =",G[J],R+1-J;
 gto "J"
56: if B=4;fxd
 4;dsp "    SYST
 EM TEMP=",U[J],
 "*K",R+1-J;gto
 "J"
57: if B=5;fxd
 4;dsp " DELTA
 TEMP)meas=",
 H[J]/K[J],"*K",
 R+1-J;gto "J"
58: if B=6;fxd
 4;dsp " DELTA
 TEMP)theo=",
 I[J],"*K",R+1-
 J;gto "J"
59: if B=7;gto
 "INIT"
60: if B=8;fxd
 0;dsp "DIGITAL
 OUTPUT=",ED[J]/
 K[J],R+1-J
```

```
61: "J":int(X[2]
 (G[R]-1))+128→X
 ;if X<0;0→X
62: if X>255;
 255→X
63: X[1](D[R]/
 K[R])+128→Y;if
 Y<0;0→Y
64: if Y>255;
 255→Y
65: if U>1;wtb
 15,2-U;gto +2
66: wtb 15,shf(X
 ,-8)+Y
67: int(X[4]H[R]
 /K[R])+128→X;
 if X<0;0→X
68: if X>255;
 255→X
69: X[3](U[R]-
 B[R])+128→Y;if
 Y<0;0→Y
70: if Y>255;
 255→Y
71: if U>1;wtb
 15,2-U;gto +2
72: wtb 15,shf(X
 ,-8)+Y
73: if R<2;wtb
 15,0;wtb 15,0;
 gto "NO CH 2"
74: int(X[6](G[R
 -1]-1))+128→X;
 if X<0;0→X
75: if X>255;
 255→X
76: X[5](D[R-1]/
 K[R-1])+128→Y;
 if Y<0;0→Y
77: if Y>255;
 255→Y
78: if U>1;wtb
 15,2-U;gto +2
79: wtb 15,shf(X
 ,-8)+Y
80: int(X[8]H[R-
 1]/K[R-1])+128→
 X;if X<0;0→X
81: if X>255;
 255→X
82: X[7](U[R-1]-
 B[R-1])+128→Y;
 if Y<0;0→Y
83: if Y>255;
 255→Y
84: if U>1;wtb
 15,2-U;gto +2
85: wtb 15,shf(X
 ,-8)+Y
```

```
86: "NO CH 2":wt
 b 15,R
87: for I=R to
 1 by -1
88: ED[I]/K[I]→X
 ;if X>32767;
 32767→X
89: if X<-32768;
 -32768→X
90: wtb 15,X
91: next I
92: if S>31;gto
 "NEW ALPHA"
93: if A=1;gto
 "NEW ALPHA"
94: gto "LOOP"
95:
96:
97: "CONTROL":
98: wtc 15,2+1
99: wtc 15,32+2+
 1
100: wtb 15,0
101: wtb 15,P-1
102: wtb 15,P-1
103: wtb 15,P-1
104: wtb 15,P-1
105: wtb 15,1638
 4F+(R-1)4096+
 512+256+M-1
106: wtc 15,32+
 2+1
107: wtc 15,32+1
108: ret
109:
```

```
110: "INIT":dsp
 "INITIALIZE
 SEQ--2CH,CRSR
 MODE";2→B
111: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?",R
112: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;gto "R"
113: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;gto "R"
114: "P":ent
 "DICKE SWITCH
 PHASE PERIOD
 IN MS?",P;if
 fl≠13=0;sfg 0
115: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;gto
 "P"
116: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;gto "P"
117: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
118: if fl≠13=0;
 int(4096Q/P)→O;
 cfg 0
119: if fl≠0=1;
 int(4096Q/P)→O;
 cfg 0
120: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 gto "Q"
121: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;gto
 "Q"
```

```
122: "M":ent
 "HOW MANY SWITC
 H CYCLES/INTEGR
 ATION?",M
123: if M<1;prt
 "MUST BE AT
 LEAST 1 CYCLE/
 INTEGRATION";
 spc 2;gto "M"
124: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
125: "L":ent
 "RCVR BAL TIME
 (SEC)=",L;int(1
 000L/4P)4P/1000
 →K
126: if int(250L
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/250;spc 2;
 gto "L"
127: if int(250L
 /P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;gto
 "L"
128: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
129: "N":ent
 "DELTA T)meas
 SUMATION TIME?
 SEC",T
130: int(1000T/
 4MP)→N
131: if N<2;fxd
 3;beep;prt "REQ
  MIN SUMMATION
 TIME=",4MP2/
 1000,"SEC";gto
 "N"
132: if N>50;
 beep;prt "MAX
 SUMATION TIME="
 ,4MP50/1000,
 "SECONDS";gto
 "N"
133: if T#4MPN/
 1000;4MPN/1000→
 T;beep;fxd 3;
 prt "ACTUAL
 SUMATION TIME="
 ,T;spc
```

```
134: ent "WHAT
 IS CAL *K FOR
 CHANNEL 1?",
 T[R]
135: if R-1>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 2?",T[R-1]
136: if R-2>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 3?",T[R-2]
137: if R-3>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 4?",T[R-3]
138: ent "BANDWI
 DTH (MHz) FOR
 CHANNEL 1?",
 W[R];if fl≠13=0
 ;W[R]1e6→W[R]
139: if R-1>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 2?",W[R-1]
140: if R-1>0;
 if fl≠13=0;W[R-
 1]1e6→W[R-1]
141: if R-2>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 3?",W[R-2]
142: if R-2>0;
 if fl≠13=0;W[R-
 2]1e6→W[R-2]
143: if R-3>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 4?",W[R-3]
144: if R-3>0;
 if fl≠13=0;W[R-
 3]1e6→W[R-3]
```

```
145: ent "CRSF
 0=?  CH1--SWITC
 H POWER (*K/
 V)",X[1];if
 flg13=0;25.5/
 X[1]→X[1]
146: ent "CRSF
 1=?  CH1--GAIN
 (Parts/V)",X[2]
 ;if flg13=0;
 25.5/X[2]→X[2]
147: ent "CRSF
 2=?  CH1--T
 SYS (*K/V)",
 X[3];if flg13=0
 ;25.5/X[3]→X[3]
148: ent "CRSF
 3=?  CH1--DELTA
  T (*K/V)",X[4]
 ;if flg13=0;
 25.5/X[4]→X[4]
149: ent "CRSF
 4=?  CH2--SWITC
 H POWER (*K/
 V)",X[5];if
 flg13=0;25.5/
 X[5]→X[5]
150: ent "CRSF
 5=?  CH2--GAIN
 (Parts/V)",X[6]
 ;if flg13=0;
 25.5/X[6]→X[6]
151: ent "CRSF
 6=?  CH2--T
 SYS (*K/V)",
 X[7];if flg13=0
 ;25.5/X[7]→X[7]
152: ent "CRSF
 7=?  CH2--DELTA
  T (*K/V)",X[8]
 ;if flg13=0;
 25.5/X[8]→X[8]
153: ent "DIGITA
 L OUTPUT FULL
 SCALE (*K)",E;
 if flg13=0;3276
 8/E→E
154: if E>32767;
 32767→E;dsp
 "SCALE MUST BE
 => 1K (Set=1)";
 wait 3000
155: ent "INIT
 VALUES PRINTED?
 , ENT 1, CONT",
 A
156: if A=1;gsb
 "INIT PRINT"
157: gto "NEW
 ALPHA"
158:

159: "READ RCVR"
 :for I=1 to R
160: rdb(15)*
 32768+rdb(15)→R
 [I]
161: rdb(15)*
 32768+rdb(15)→S
 [I]
162: R[I]+rdb(15
 )*32768+rdb(15)
 →R[I]
163: rdb(15)*
 32768+rdb(15)→C
 [I]
164: next I
165: rdb(15)→S
166: ret
167:
168: "I/O ERROR"
 :
169: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line",
 erl;beep;9→B;
 gto "LOOP"
170:

171: "INIT PRINT
 ":
172: fxd 0;spc
173: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
174: prt "SWITCH
  PERIOD INMS
 =",P;spc
175: fxd 4;prt
 "BLANKING TIME
   MS =",P0/4096
 ;spc
176: fxd 0;prt
 " CYCLES/INTEGR
 ATION=",M;spc
177: fxd 3;prt
 "INTEG. PERIOD
   (SEC)=",4MP/
 1000;spc
178: fxd 3;prt
 "RCVR BAL TIME
   (SEC)=",(4P/
 1000)int(1000L/
 4P);spc
179: fxd 3;prt
 "DELTA T)meas
 SUMATION TIME
 (SEC)=",4MPN/
 1000;spc
180: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "CAL=
 ",T[R+1-I];next
  I
181: spc 2
182: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "BW="
 ,W[R+1-I]/1e6;
 next I
183: spc 2
184: for I=1 to
 8;fxd 0;prt
 "FOR CR",I-1;
 fxd 5;prt "CRSF
 =",25.5/X[I];
 next I
185: spc ;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=",E
186: 2→A;spc
187: ret

188: "HEADER":if
  flg5=1;cfg 5;
 ret
189: wtb 15,3263
 9,32639,32639,
 32639,11+9R
190: wtb 15,E
191: wtb 15,K
192: wtb 15,100L
193: 4PM→V;if
 V>32767;32767→V
194: wtb 15,V
195: wtb 15,2PM+
 0
196: wtb 15,O
197: wtb 15,P
198: wtb 15,Q
199: wtb 15,R
200: wtb 15,S
201: wtb 15,T
202: for I=R to
 1 by -1
203: 1000A[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
204: wtb 15,V
205: 10B[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
206: wtb 15,V
207: 1000G[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
208: wtb 15,V
209: 1000H[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
210: wtb 15,V
211: 1000I[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
212: wtb 15,V

213: K[I]→V;if
 V>32767 or V<-
 32768;32767→V
214: wtb 15,V
215: 100T[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
216: wtb 15,V
217: 10U[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
218: wtb 15,V
219: W[I]/1e5→V;
 if V>32767 or
 V<-32768;32767→
 V
220: wtb 15,V
221: next I
222: ret
223:
224: end
*13217
```

FILE 4

```
0: dsp "GAIN
 BALANCING SWIT
 HED WITH CAL'
1: sfg 14;sfg 5
2: on err "I/O
 ERROR"
3: dim C[4],D[4]
 ,E[4],G[4],R[4]
 ,S[4],U[4]
4: dim M[4],N[4,
 50],P[4],Q[4,
 50],H[4]
5: dim A[4],B[4]
 ,F[4],I[4],K[4]
 ,T[4],W[4],X[8]
 ,P,R,M,O,Q,N,T,
 E,L
6: 1→r1→r5;2→r2→
 r6;3→r3→r7;4→r4
 →r8
7: 1→r9→r10→r11→
 r12;2→r13→r14→r
 15→r16
8: ldf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
9: ldk 11
10: 1→J→F→U;0→A;
 2→B;0→D→Z
11: gsb "CONTROL
 "
12:
13: "NEW ALPHA":
14: dsp "
 GAIN BALANCING
 NOW"
15: for I=1 to R
16: for D=1 to N
17: 0→N[I,D]→Q[I
 ,D]
18: next D
19: 0→M[I]→P[I]
20: next I
21: 0→D;1→J
22: 1→F;M→K;int(
 1000L/4P)→M;
 gsb "CONTROL"
23: 0→F;gsb "REA
 D RCVR"
24: for I=1 to R
25: (C[I]+S[I])/
 R[I]→A[I]
26: if Z#0;(C[I]
 -S[I])/M→X;ﾌﾟﾛｸﾞﾗﾑ
27: X/T[I]→K[
 I]
28: A[I]R[I]→R[I
 ]
29: if Z=0;S[I]T
 [I]/(C[I]-S[I])
 →B[I]
30: B[I](C[I]+
 S[I])/S[I]r(W[I
 ]K4(P-Q)/1000)→
 I[I]
31: next I
32: K→M;rcf 13,
 A[*],B[*],F[*],
 I[*],K[*],T[*],
 W[*],X[*],P,R,
 M,O,Q,N,T,E,L
33: gsb "CONTROL
 "
34: if A<1;gsb
 "HEADER"
35: if A#2;0→A;
 gto "LOOP"
36: spc ;0→A
37: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
38: spc 2;0→A
39:
40: "LOOP":wtc
 15,32+1
41: D+1→D;if
 D=N+1;1→D
42: gsb "READ
 RCVR"
43: if B=1;fxd
 0;dsp "C=",C[J]
 ,"R=",R[J]/2,
 "S=",S[J],R+1-J
44: for I=1 to R
45: A[I]R[I]→R[I
 ]
46: (C[I]+S[I]-
 R[I])/2M→D[I]
47: (C[I]-S[I])/
 MF[I]→G[I]
48: if Z#1;S[I]T
 [I]/(C[I]-S[I])
 →U[I]
49: M[I]-N[I,D]+
 D[I]D[I]→M[I]
50: D[I]D[I]→N[I
 ,D]
51: P[I]-Q[I,D]+
 D[I]→P[I]
52: D[I]→Q[I,D]
53: r((M[I]-P[I]
 P[I]/N)/(N-1))→
 H[I]
54: next I
55: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[J],R+1-J;
 gto "J"
56: if B=2;fxd
 4;dsp "    SWIT
 CH POWER=",D[J]
 /K[J],"*K",R+1-
 J;gto "J"
57: if B=3;fxd
 4;dsp "
 NORMALIZED GAIN
 =",G[J],R+1-J;
 gto "J"
58: if B=4;fxd
 4;dsp "    SYST
 EM TEMP=",U[J],
 "*K",R+1-J;gto
 "J"
59: if B=5;fxd
 4;dsp " DELTA
 TEMP)meas=",
 H[J]/K[J],"*K",
 R+1-J;gto "J"
60: if B=6;fxd
 4;dsp " DELTA
 TEMP)theo=",
 I[J],"*K",R+1-
 J;gto "J"
61: if B=7;gto
 "INIT"
62: if B=8;fxd
 0;dsp "DIGITAL
 OUTPUT=",ED[J]/
 K[J],R+1-J
63: "J":for I=1
 to 7 by 2
64: I+8→H;jmp rI
65: int(X[I]D[rH
 ]/K[rH])+128→X;
 gto +5
66: int(X[I](G[r
 H]-1))+128→X;
 gto +4
67: int(X[I](U[r
 H]-B[rH]))+128→
 X;gto +3
68: int(X[I]H[rH
 ]/K[rH])→X;gto
 +2
69: 0→X
70: if X>255;
 255→X
71: if X<0;0→X
72: 1+H→H;jmp
 r(I+1)
73: int(X[I+1]D[
 rH]/K[rH])+128→
 Y;gto +5
74: int(X[I+1](G
 [rH]-1))+128→Y;
 gto +4
75: int(X[I+1](U
 [rH]-B[rH]))+
 128→Y;gto +3
76: int(X[I+1]H[
 rH]/K[rH])→Y;
 gto +2
77: 0→Y
78: if Y>255;
 255→Y
79: if Y<0;0→Y
80: if U>1;wtb
 15,2-U;gto +2
81: wtb 15,shf(X
 ,-8)+Y
82: next I
83: "CALIB":wtb
 15,R
84: for I=R to
 1 by -1
85: ED[I]/K[I]→X
 ;if X>32767;
 32767→X
86: if X<-32768;
 -32768→X
87: wtb 15,X
88: next I
89: if S>31;gto
 "NEW ALPHA"
90: if A=1;gto
 "NEW ALPHA"
91: gto "LOOP"
92:
93:
94: "CONTROL": !
95: wtc 15,2+1
96: wtc 15,32+2+
 1
97: wtb 15,0
98: wtb 15,P-1
99: wtb 15,P-1
100: wtb 15,P-1
101: wtb 15,P-1
102: wtb 15,1638
 4F+(R-1)4096+
 512+256+M-1
103: wtc 15,32+
 2+1
104: wtc 15,32+1
105: ret
106:
```

```
107: "INIT":dsp
 "INITIALIZE
 SEQ--2CH,CRSR
 MODE";2→B
108: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?";R
109: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;gto "R"
110: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;gto "R"
111: "P":ent
 "DICKE SWITCH
 PHASE PERIOD
 IN MS?";P;if
 flg13=0;sfg 0
112: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;gto
 "P"
113: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;gto "P"
114: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
115: if flg13=0;
 int(40960/P)→O;
 cfg 0
116: if flg0=1;
 int(40960/P)→O;
 cfg 0
117: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 gto "Q"
118: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;gto
 "Q"
119: "M":ent
 "HOW MANY SWITC
 H CYCLES/INTEGR
 ATION?",M
120: if M<1;prt
 "MUST BE AT
 LEAST 1 CYCLE/
 INTEGRATION";
 spc 2;gto "M"
121: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
122: "L":ent
 "RCVR BAL TIME
 (SEC)=",L;int(1
 000L/4P)4P/1000
 →K
123: if int(250L
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/250;spc 2;
 gto "L"
124: if int(250L
 /P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;gto
 "L"
125: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
126: "N":ent
 "DELTA T)meas
 SUMATION TIME?
 SEC",T
127: int(1000T/
 4MP)→N
128: if N<2;fxd
 3;beep;prt "REQ
  MIN SUMMATION
 TIME=",4MP2/
 1000,"SEC";gto
 "N"
129: if N>50;
 beep;prt "MAX
 SUMATION TIME="
 ,4MP50/1000,
 "SECONDS";gto
 "N"
130: if T#4MPN/
 1000;4MPN/1000→
 T;beep;fxd 3;
 prt "ACTUAL
 SUMATION TIME="
 ,T;spc
131: ent "WHAT
 IS CAL *K FOR
 CHANNEL 1?",
 T[R]
132: if R-1>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 2?",T[R-1]
133: if R-2>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 3?",T[R-2]
134: if R-3>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 4?",T[R-3]
135: ent "BANDWI
 DTH (MHz) FOR
 CHANNEL 1?",
 W[R];if flg13=0
 ;W[R]1e6→W[R]
136: if R-1>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 2?",W[R-1]
137: if R-1>0;
 if flg13=0;W[R-
 1]1e6→W[R-1]
138: if R-2>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 3?",W[R-2]
139: if R-2>0;
 if flg13=0;W[R-
 2]1e6→W[R-2]
140: if R-3>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 4?",W[R-3]
141: if R-3>0;
 if flg13=0;W[R-
 3]1e6→W[R-3]
142: fxd 0
143: for I=1 to
 8
144: "FNSEL":dsp
  "CR",I-1,"SwP=
 1,G=2,Ts=3,DT=4
 ,NoCh=0";ent
 "",rI
145: if rI<0 or
 rI>4;dsp "Bad
 selection!";
 wait 2000;gto
 "FNSEL"
146: if rI=0;
 5→rI;gto "NOCH"
147: "CS":dsp
 "Chan. to CR",
 I-1,"?";ent "",
 r(I+8);if flg13
 =0;R+1-r(I+8)→r
 (I+8)
148: if r(I+8)>4
  or r(I+8)<1;
 dsp "Bad select
 ion!";gto "CS"
149: dsp "CR",I-
 1,"scale in
 units/volt?";
 ent "",X[I];if
 flg13=0;25.5/
 X[I]→X[I]
150: "NOCH":next
  I
151: ent "DIGITA
 L OUTPUT FULL
 SCALE (*K)",E;
 if flg13=0;3276
 8/E→E
152: if E>32767;
 32767→E;dsp
 "SCALE MUST BE
 >= 1K (Set=1)";
 wait 3000
153: ent "INIT
 VALUES PRINTED?
 ; ENT 1; CONT",
 A
154: if A=1;gsb
 "INIT PRINT"
155: gto "NEW
 ALPHA"
156:
157: "READ RCVR"
 :for I=1 to R
158: rdb(15)*
 32768+rdb(15)→R
 [I]
159: rdb(15)*
 32768+rdb(15)→S
 [I]
160: R[I]+rdb(15
 )*32768+rdb(15)
 →R[I]
161: rdb(15)*
 32768+rdb(15)→C
 [I]
162: next I
163: rdb(15)→S
164: ret
165:
166: "I/O ERROR"
 :
167: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line",
 erl;beep;9→B;
 gto "LOOP"
168:
169: "INIT PRINT
 ":
170: fxd 0;spc
171: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
172: prt "SWITCH
  PERIOD INMS
 =",P;spc
173: fxd 4;prt
 "BLANKING TIME
  MS =",P0/4096
 ;spc
174: fxd 0;prt
 " CYCLES/INTEGR
 ATION=",M;spc
175: fxd 3;prt
 "INTEG. PERIOD
  (SEC)=",4MP/
 1000;spc
176: fxd 3;prt
 "RCVR BAL TIME
  (SEC)=",(4P/
 1000)int(1000L/
 4P);spc
177: fxd 3;prt
 "DELTA T)meas
 SUMATION TIME
 (SEC)=",4MPN/
 1000;spc
178: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "CAL=
 ",T[R+1-I];next
  I
179: spc 2
180: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "BW="
 ,W[R+1-I]/1e6;
 next I
181: spc 2
182: for I=1 to
 8;fxd 0;prt
 "FOR CR",I-1;
 fxd 5;prt "CRSF
 =",25.5/X[I];
 next I
183: spc 1;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=",E
184: 2→A;spc
185: ret
```

```
186: "HEADER":if
  flg5=1;cfg 5;
  ret
187: wtb 15,3263
  9,32639,32639,
  32639,11+9R
188: wtb 15,E
189: wtb 15,K
190: wtb 15,100L
191: 4PM→V;if
  V>32767;32767→V
192: wtb 15,V
193: wtb 15,2PM+
  0
194: wtb 15,O
195: wtb 15,P
196: wtb 15,Q
197: wtb 15,R
198: wtb 15,S
199: wtb 15,T
200: for I=R to
  1 by -1
201: 1000A[I]→V;
  if V>32767 or
  V<-32768;32767→
  V
202: wtb 15,V
203: 10B[I]→V;
  if V>32767 or
  V<-32768;32767→
  V
204: wtb 15,V
205: 1000G[I]→V;
  if V>32767 or
  V-32768;32767→V
206: wtb 15,V
207: 1000H[I]→V;
  if V>32767 or
  V<-32768;32767→
  V
208: wtb 15,V
209: 1000I[I]→V;
  if V>32767 or
  V<-32768;32767→
  V
210: wtb 15,V
```

```
211: K[I]→V;if
  V>32767 or V<-
  32768;32767→V
212: wtb 15,V
213: 100T[I]→V;
  if V>32767 or
  V<-32768;32767→
  V
214: wtb 15,V
215: 10U[I]→V;
  if V>32767 or
  V<-32768;32767→
  V
216: wtb 15,V
217: W[I]/1e5→V;
  if V>32767 or
  V<-32768;32767→
  V
218: wtb 15,V
219: next I
220: ret
221:
222: end
*27044
```

FILE 5

```
0: dsp "GAIN
  BALANCING SWITC
  HED"
1: sfg 14;sfg 5
2: on err "I/O
  ERROR"
3: dim C[4],D[4]
  ,E[4],G[4],R[4]
  ,S[4],U[4]
4: dim M[4],N[4,
  50],P[4],Q[4,
  50],H[4]
5: dim A[4],B[4]
  ,F[4],I[4],K[4]
  ,T[4],W[4],X[8]
  ,P,R,M,O,Q,N,T,
  E,L
6: ldf 13,A[*],
  B[*],F[*],I[*],
  K[*],T[*],W[*],
  X[*],P,R,M,O,Q,
  N,T,E,L
7: ldk 11
8: 1→J→F;0→A;
  2→B;0→D→Z
9: gsb "CONTROL"
```

```
10: "NEW ALPHA":
11: dsp "
  GAIN BALANCING
  NOW"
12: for I=1 to R
13: for D=1 to N
14: 0→N[I,D]→Q[I
  ,D]
15: next D
16: 0→M[I]→P[I]
17: next I
18: 0→D;1→J
19: 1→F;M→K;int(
  1000L/4P)→M;
  gsb "CONTROL"
20: 0→F;gsb "REA
  D RCVR"
21: for I=1 to R
22: S[I]/R[I]→A[
  I]
23: S[I]/MU[I]→K
  [I]
24: next I
25: K→M
26: gsb "CONTROL
  "
27: if A<1;gsb
  "HEADER"
28: if A#2;0→A;
  gto "LOOP"
29: spc
30: for I=1 to
  R;fxd 0;prt
  "Channel",I;
  fxd 4;prt "S/
  R=",A[R+1-I];
  next I
31: spc 2;0→A
32:
33: "LOOP":wtc
  15,32+1
34: gsb "READ
  RCVR"
35: for I=1 to R
36: (S[I]-A[I]R[
  I])/M→D[I]
37: next I
38: fxd 4;dsp
  "Switched Power
  =",D[J]/K[J],"*
  K"
39: if B=7;gto
  "INIT"
```

```
40: wtb 15,0,0,
  0,0
41: wtb 15,R
42: for I=R to
  1 by -1
43: ED[I]/K[I]→X
  ;if X>32767;
  32767→X
44: if X<-32768;
  -32768→X
45: wtb 15,X
46: next I
47: if S>31;gto
  "NEW ALPHA"
48: if A=1;gto
  "NEW ALPHA"
49: gto "LOOP"
50:
51:
52: "CONTROL":
53: wtc 15,2+1
54: wtc 15,32+2+
  1
55: wtb 15,0
56: wtb 15,P-1
57: wtb 15,P-1
58: wtb 15,P-1
59: wtb 15,P-1
60: wtb 15,16384
  F+(R-1)4096+
  256+M-1
61: wtc 15,32+2+
  1
62: wtc 15,32+1
63: ret
```

```
64: "INIT":dsp
 "INITIALIZE
 SEQ--2CH,CRSR
 MODE";2→B
65: "R":ent "HOW
  MANY RCVR CHAN
 NELS IN USE?";R
66: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;gto "R"
67: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;gto "R"
68: "P":ent "DIC
 KE SWITCH PHASE
  PERIOD IN MS?"
 ,P;if flg13=0;
 sfg 0
69: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;gto
 "P"
70: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;gto "P"
71: "Q":ent "BLA
 NKING TIME IN
 MS? ",Q
72: if flg13=0;
 int(4096Q/P)→O;
 cfg 0
73: if flg0=1;
 int(4096Q/P)→O;
 cfg 0
74: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 gto "Q"
75: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;gto
 "Q"
76: "M":ent "HOW
  MANY SAMPLES/
 INTEGRATION?",M
77: if M<1;prt
 "MUST BE AT
 LEAST 1 SAMPLES
 /INTEGRATION";
 spc 2;gto "M"
78: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
79: "L":ent "RCV
 R BAL TIME (SEC
 )=",L;int(1000L
 /4P)4P/1000→K
80: if int(250L/
 P)<1;fxd 3;prt
 "MIN Rx BAL
 TIME (SEC)=",P/
 250;spc 2;gto
 "L"
81: if int(250L/
 P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;gto
 "L"
82: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
83: fxd 0;for
 I=1 to R
84: dsp "T(sys),
  Channel",I,"?"
85: ent "",U[I]
86: next I
87: ent "DIGITAL
  OUTPUT FULL
 SCALE (*K)",E;
 if flg13=0;3276
 8/E→E
88: if E>32767;
 32767→E;dsp
 "SCALE MUST BE
 >= 1K (Set=1)";
 wait 3000
89: ent "INIT
 VALUES PRINTED?
 , ENT 1, CONT",
 A
90: if A=1;gsb
 "INIT PRINT"
91: gto "NEW
 ALPHA"
92:
93: "READ RCVR":
 for I=1 to R
94: rdb(15)*3276
 8+rdb(15)→R[I]
95: rdb(15)*3276
 8+rdb(15)→S[I]
96: next I
97: rdb(15)→S
98: ret
99: "I/O ERROR":
100: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line",
 erl;beep;9→B;
 gto "LOOP"
101: "INIT PRINT
 ":
102: fxd 0;spc
103: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
104: prt "SWITCH
  PERIOD INMS
 =",P;spc
105: fxd 4;prt
 "BLANKING TIME
  MS =",PO/4096
 ;spc
106: fxd 0;prt
 "SAMPLES/INTEGR
 ATION=",M;spc
107: fxd 3;prt
 "INTEG. PERIOD
  (SEC)=",2MP/
 1000;spc
108: fxd 3;prt
 "RCVR BAL TIME
  (SEC)=",(4P/
 1000)int(1000L/
 4P);spc
109: spc ;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=",E
110: 2→A;spc
111: ret
112: "HEADER":if
  flg5=1;cfg 5;
 ret
113: wtb 15,3263
 9,32639,32639,
 32639,11+9R
114: wtb 15,E
115: wtb 15,K
116: wtb 15,100L
117: 2PM→V;if
 V>32767;32767→V
118: wtb 15,V
119: wtb 15,PM+0
120: wtb 15,O
121: wtb 15,P
122: wtb 15,Q
123: wtb 15,R
124: wtb 15,S
125: wtb 15,T
126: for I=R to
 1 by -1
127: 1000A[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
128: wtb 15,V
129: 10B[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
130: wtb 15,V
131: 1000G[I]→V;
 if V>32767 or
 V-32768;32767→V
132: wtb 15,V
133: 1000H[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
134: wtb 15,V
135: 1000I[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
136: wtb 15,V
137: K[I]→V;if
 V>32767 or V<-
 32768;32767→V
138: wtb 15,V
139: 100T[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
140: wtb 15,V
141: 10U[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
142: wtb 15,V
143: W[I]/1e5→V;
 if V>32767 or
 V<-32768;32767→
 V
144: wtb 15,V
145: next I
146: ret
147:
148: end
*3702
```

FILE 6

```
0: dsp "MANUAL
 GAIN BALANCING
 WITH CAL"
1: sfg 14;sfg 5
2: on err "I/O
 ERROR"
3: dim C[4],D[4]
 ,E[4],G[4],R[4]
 ,S[4],U[4]
4: dim M[4],N[4,
 50],P[4],Q[4,
 50],H[4]
5: dim A[4],B[4]
 ,F[4],I[4],K[4]
 ,T[4],W[4],X[8]
 ,P,R,M,O,Q,N,T,
 E,L
6: ldf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
7: ldk 11
8: 1→J→F→U;0→A;
 2→B;0→D→Z→C
9: gsb "CONTROL"
10:
11: "NEW ALPHA":
12: for I=1 to R
13: for D=1 to N
14: 0→N[I,D]→Q[I
 ,D]
15: next D
16: 0→M[I]→P[I]
17: next I
18: 0→D;1→J;fxd
 0
19: 1→F;M→K;int(
 1000L/4P)→M;
 gsb "CONTROL"
20: if C=0;1→C;
 for I=R to 1
 by -1;dsp "Alph
 a",R+1-I,"?";
 ent "",A[I];
 next I
21: 0→F;gsb "REA
 D RCVR"
22: for I=1 to R
23: if Z≠0;(C[I]
 -S[I])/M→X ≡≡; (Z≠1)^X → F[I]
24: F[I]/T[I]→K[
 I]
25: A[I]R[I]→R[I
 ]
26: if Z=0;S[I]T
 [I]/(C[I]-S[I])
 →B[I]
27: B[I](C[I]+
 S[I])/S[I]r(W[I
 ]K4(P-Q)/1000)→
 I[I]
28: next I
29: K→M;rcf 13,
 A[*],B[*],F[*],
 I[*],K[*],T[*],
 W[*],X[*],P,R,
 M,O,Q,N,T,E,L
30: gsb "CONTROL
 "
31: if A<1;gsb
 "HEADER"
32: if A#2;0→A;
 gto "LOOP"
33: spc ;0→A
34: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
35: spc 2;0→A
36:
37: "LOOP":wtc
 15,32+1
38: D+1→D;if
 D=N+1;1→D
39: gsb "READ
 RCVR"
40: if B=1;fxd
 0;dsp "C=",C[J]
 ,"R=",R[J]/2,
 "S=",S[J],R+1-J
41: for I=1 to R
42: A[I]R[I]→R[I
 ]
43: (C[I]+S[I]-
 R[I])/2M→D[I]
44: (C[I]-S[I])/
 MF[I]→G[I]
45: if Z#1;S[I]T
 [I]/(C[I]-S[I])
 →U[I]
46: M[I]-N[I,D]+
 D[I]D[I]→M[I]
47: D[I]D[I]→N[I
 ,D]
48: P[I]-Q[I,D]+
 D[I]→P[I]
49: D[I]→Q[I,D]
50: r((M[I]-P[I]
 P[I]/N)/(N-1))→
 H[I]
51: next I
52: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[J],R+1-J;
 gto "J"
53: if B=2;fxd
 4;dsp "    SWIT
 CH POWER=",D[J]
 /K[J],"*K",R+1-
 J;gto "J"
54: if B=3;fxd
 4;dsp "
 NORMALIZED GAIN
 =",G[J],R+1-J;
 gto "J"
55: if B=4;fxd
 4;dsp "    SYST
 EM TEMP=",U[J],
 "*K",R+1-J;gto
 "J"
56: if B=5;fxd
 4;dsp " DELTA
 TEMP)meas=",
 H[J]/K[J],"*K",
 R+1-J;gto "J"
57: if B=6;fxd
 4;dsp " DELTA
 TEMP)theo=",
 I[J],"*K",R+1-
 J;gto "J"
58: if B=7;gto
 "INIT"
59: if B=8;fxd
 0;dsp "DIGITAL
 OUTPUT=";ED[J]/
 K[J],R+1-J
60: "J":int(X[2]
 (G[R]-1))+128→X
 ;if X<0;0→X
61: if X>255;
 255→X
62: X[1](D[R]/
 K[R])+128→Y;if
 Y<0;0→Y
63: if Y>255;
 255→Y
64: if U>1;wtb
 15,2-U;gto +2
65: wtb 15,shf(X
 ,-8)+Y
66: int(X[4]H[R]
 /K[R])+128→X;
 if X<0;0→X
67: if X>255;
 255→X
68: X[3](U[R]-
 B[R])+128→Y;if
 Y<0;0→Y
69: if Y>255;
 255→Y
70: if U>1;wtb
 15,2-U;gto +2
71: wtb 15,shf(X
 ,-8)+Y
72: if R<2;wtb
 15,0;wtb 15,0;
 gto "NO CH 2"
73: int(X[6](G[R
 -1]-1))+128→X;
 if X<0;0→X
74: if X>255;
 255→X
75: X[5](D[R-1]/
 K[R-1])+128→Y;
 if Y<0;0→Y
76: if Y>255;
 255→Y
77: if U>1;wtb
 15,2-U;gto +2
78: wtb 15,shf(X
 ,-8)+Y
79: int(X[8]H[R-
 1]/K[R-1])+128→
 X;if X<0;0→X
80: if X>255;
 255→X
81: X[7](U[R-1]-
 B[R-1])+128→Y;
 if Y<0;0→Y
82: if Y>255;
 255→Y
83: if U>1;wtb
 15,2-U;gto +2
84: wtb 15,shf(X
 ,-8)+Y
85: "NO CH 2":wt
 b 15,R
86: for I=R to
 1 by -1
87: ED[I]/K[I]→X
 ;if X>32767;
 32767→X
88: if X<-32768;
 -32768→X
89: wtb 15,X
90: next I
91: if S>31;gto
 "NEW ALPHA"
92: if A=1;gto
 "NEW ALPHA"
93: gto "LOOP"
94:
95:
96: "CONTROL":
97: wtc 15,2+1
98: wtc 15,32+2+
 1
99: wtb 15,0
100: wtb 15,P-1
101: wtb 15,P-1
102: wtb 15,P-1
103: wtb 15,P-1
104: wtb 15,1638
 4F+(R-1)4096+
 512+256+M-1
105: wtc 15,32+
 2+1
106: wtc 15,32+1
107: ret
108:
```

```
109: "INIT":dsp
 "INITIALIZE
 SEQ--2CH;CRSR
 MODE";2→B
110: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?";R
111: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;gto "R"
112: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;gto "R"
113: "P":ent
 "DICKE SWITCH
 PHASE PERIOD
 IN MS?",P;if
 flg13=0;sfg 0
114: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;gto
 "P"
115: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;gto "P"
116: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
117: if flg13=0;
 int(4096Q/P)→O;
 cfg 0
118: if flg0=1;
 int(4096Q/P)→O;
 cfg 0
119: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 gto "Q"
120: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;gto
 "Q"
121: "M":ent
 "HOW MANY SWITC
 H CYCLES/INTEGR
 ATION?",M
122: if M<1;prt
 "MUST BE AT
 LEAST 1 CYCLE/
 INTEGRATION";
 spc 2;gto "M"
123: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
124: "L":ent
 "RCVR BAL TIME
 (SEC)=",L;int(1
 000L/4P)4P/1000
 →K
125: if int(250L
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/250;spc 2;
 gto "L"
126: if int(250L
 /P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;gto
 "L"
127: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
128: "N":ent
 "DELTA T)meas
 SUMATION TIME?
 SEC",T
129: int(1000T/
 4MP)→N
130: if N<2;fxd
 3;beep;prt "REQ
  MIN SUMMATION
 TIME=",4MP2/
 1000,"SEC";gto
 "N"
131: if N>50;
 beep;prt "MAX
 SUMATION TIME="
 ,4MP50/1000,
 "SECONDS";gto
 "N"
132: if T#4MPN/
 1000;4MPN/1000→
 T;beep;fxd 3;
 prt "ACTUAL
 SUMATION TIME="
 ,T;spc
133: ent "WHAT
 IS CAL *K FOR
 CHANNEL 1?",
 T[R]
134: if R-1>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 2?",T[R-1]
135: if R-2>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 3?",T[R-2]
136: if R-3>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 4?",T[R-3]
137: ent "BANDWI
 DTH (MHz) FOR
 CHANNEL 1?",
 W[R];if flg13=0
 ;W[R]1e6→W[R]
138: if R-1>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 2?",W[R-1]
139: if R-1>0;
 if flg13=0;W[R-
 1]1e6→W[R-1]
140: if R-2>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 3?",W[R-2]
141: if R-2>0;
 if flg13=0;W[R-
 2]1e6→W[R-2]
142: if R-3>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 4?",W[R-3]
143: if R-3>0;
 if flg13=0;W[R-
 3]1e6→W[R-3]
144: ent "CRSF
 0=?  CH1--SWITC
 H POWER (*K/
 V)",X[1];if
 flg13=0;25.5/
 X[1]→X[1]
145: ent "CRSF
 1=?  CH1--GAIN
 (Parts/V)",X[2]
 ;if flg13=0;
 25.5/X[2]→X[2]
146: ent "CRSF
 2=?  CH1--T
 SYS (*K/V)",
 X[3];if flg13=0
 ;25.5/X[3]→X[3]
147: ent "CRSF
 3=?  CH1--DELTA
  T (*K/V)",X[4]
 ;if flg13=0;
 25.5/X[4]→X[4]
148: ent "CRSF
 4=?  CH2--SWITC
 H POWER (*K/
 V)",X[5];if
 flg13=0;25.5/
 X[5]→X[5]
149: ent "CRSF
 5=?  CH2--GAIN
 (Parts/V)",X[6]
 ;if flg13=0;
 25.5/X[6]→X[6]
150: ent "CRSF
 6=?  CH2--T
 SYS (*K/V)",
 X[7];if flg13=0
 ;25.5/X[7]→X[7]
151: ent "CRSF
 7=?  CH2--DELTA
  T (*K/V)",X[8]
 ;if flg13=0;
 25.5/X[8]→X[8]
152: ent "DIGITA
 L OUTPUT FULL
 SCALE (*K)",E;
 if flg13=0;3276
 8/E→E
153: if E>32767;
 32767→E;dsp
 "SCALE MUST BE
 >= 1K (Set=1)";
 wait 3000
154: ent "INIT
 VALUES PRINTED?
 , ENT 1, CONT",
 A
155: if A=1;gsb
 "INIT PRINT"
156: gto "NEW
 ALPHA"
157:
158: "READ RCVR"
 :for I=1 to R
159: rdb(15)*
 32768+rdb(15)→R
 [I]
160: rdb(15)*
 32768+rdb(15)→S
 [I]
161: R[I]+rdb(15
 )*32768+rdb(15)
 →R[I]
162: rdb(15)*
 32768+rdb(15)→C
 [I]
163: next I
164: rdb(15)→S
165: ret
166:
167: "I/O ERROR"
 :
168: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line",
 erl;beep;9→B;
 gto "LOOP"
169:
170: "INIT PRINT
 ":
171: fxd 0;spc
172: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
173: prt "SWITCH
  PERIOD INMS
 =",P;spc
174: fxd 4;prt
 "BLANKING TIME
  MS =",PO/4096
 ;spc
175: fxd 0;prt
 " CYCLES/INTEGR
 ATION=",M;spc
176: fxd 3;prt
 "INTEG. PERIOD
  (SEC)=",4MP/
 1000;spc
177: fxd 3;prt
 "RCVR BAL TIME
  (SEC)=",(4P/
 1000)int(1000L/
 4P);spc
178: fxd 3;prt
 "DELTA T)meas
 SUMATION TIME
 (SEC)=",4MPN/
 1000;spc
179: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "CAL=
 ",T[R+1-I];next
  I
180: spc 2
181: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "BW="
 ,W[R+1-I]/1e6;
 next I
182: spc 2
183: for I=1 to
 8;fxd 0;prt
 "FOR CR",I-1;
 fxd 5;prt "CRSF
 =",25.5/X[I];
 next I
184: spc ;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=",E
185: 2→A;spc
186: ret
```

```
187: "HEADER":if
  fls5=1;cfs 5;
 ret
188: wtb 15,3263
 9,32639,32639,
 32639,11+9R
189: wtb 15,E
190: wtb 15,K
191: wtb 15,100L
192: 4PM→V;if
 V>32767;32767→V
193: wtb 15,V
194: wtb 15,2PM+
 0
195: wtb 15,O
196: wtb 15,P
197: wtb 15,Q
198: wtb 15,R
199: wtb 15,S
200: wtb 15,T
201: for I=R to
 1 by -1
202: 1000A[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
203: wtb 15,V
204: 10B[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
205: wtb 15,V
206: 1000G[I]→V;
 if V>32767 or
 V-32768;32767→V
207: wtb 15,V
208: 1000H[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
209: wtb 15,V
210: 1000I[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
211: wtb 15,V
212: K[I]→V;if
 V>32767 or V<-
 32768;32767→V
213: wtb 15,V
214: 100T[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
215: wtb 15,V
216: 10U[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
217: wtb 15,V
218: W[I]/1e5→V;
 if V>32767 or
 V<-32768;32767→
 V
219: wtb 15,V
220: next I
221: ret
222:
223: end
*32740
```

FILE 7

```
0: dsp "MANUAL
 GAIN BALANCING
 WITH CAL"
1: sfg 14;sfg 5
2: on err "I/O
 ERROR"
3: dim C[4],D[4]
 ,E[4],G[4],R[4]
 ,S[4],U[4]
4: dim M[4],N[4,
 50],P[4],Q[4,
 50],H[4]
5: dim A[4],B[4]
 ,F[4],I[4],K[4]
 ,T[4],W[4],X[8]
 ,P,R,M,O,Q,N,T,
 E,L
6: 1→r1→r5;2→r2→
 r6;3→r3→r7;4→r4
 →r8
7: 1→r9→r10→r11→
 r12;2→r13→r14→r
 15→r16
8: ldf 13,A[*],
 B[*],F[*],I[*],
 K[*],T[*],W[*],
 X[*],P,R,M,O,Q,
 N,T,E,L
9: ldk 11
10: 1→J→F→U;0→A;
 2→B;0→D→Z→C
11: gsb "CONTROL
 "
12:
13: "NEW ALPHA":
14: for I=1 to R
15: for D=1 to N
16: 0→N[I,D]→Q[I
 ,D]
17: next D
18: 0→M[I]→P[I]
19: next I
20: 0→D;1→J;fxd
 0
21: 1→F;M→K;int(
 1000L/4P)→M;
 gsb "CONTROL"
22: if C=0;1→C;
 for I=R to 1
 by -1;dsp "Alph
 a",R+1-I,"?";
 ent "",A[I];
 next I
23: 0→F;gsb "REA
 D RCVR"
24: for I=1 to R
25: if Z≠1;(C[I]
 -S[I])/M→X;
26: X/T[I]→K[
 I]
27: A[I]R[I]→R[I
 ]
28: if Z=0;S[I]T
 [I]/(C[I]-S[I])
 →B[I]
29: B[I](C[I]+
 S[I])/S[I]r(W[I
 ]K4(P-Q)/1000)→
 I[I]
30: next I
31: K→M;rcf 13,
 A[*],B[*],F[*],
 I[*],K[*],T[*],
 W[*],X[*],P,R,
 M,O,Q,N,T,E,L
32: gsb "CONTROL
 "
33: if A<1;gsb
 "HEADER"
34: if A#2;0→A;
 gto "LOOP"
35: spc ;0→A
36: for I=1 to
 R;fxd 0;prt
 "Channel";I;
 fxd 4;prt "S/
 R=",A[R+1-I];
 next I
37: spc 2;0→A
38:
39: "LOOP":wtc
 15,32+1
40: D+1→D;if
 D=N+1;1→D
41: gsb "READ
 RCVR"
42: if B=1;fxd
 0;dsp "C=",C[J]
 ,"R=",R[J]/2,
 "S=",S[J],R+1-J
43: for I=1 to R
44: A[I]R[I]→R[I
 ]
45: (C[I]+S[I]-
 R[I])/2M→D[I]
46: (C[I]-S[I])/
 MF[I]→G[I]
47: if Z#1;S[I]T
 [I]/(C[I]-S[I])
 →U[I]
48: M[I]-N[I,D]+
 D[I]D[I]→M[I]
49: D[I]D[I]→N[I
 ,D]
50: P[I]-Q[I,D]+
 D[I]→P[I]
51: D[I]→Q[I,D]
52: r((M[I]-P[I]
 P[I]/N)/(N-1))→
 H[I]
53: next I
```

17

```
54: if B=0;fxd
 4;dsp "GAIN
 MODULATOR CONST
 =",A[J],R+1-J;
 sto "J"
55: if B=2;fxd
 4;dsp "    SWIT
 CH POWER=",D[J]
 /K[J],"*K",R+1-
 J;sto "J"
56: if B=3;fxd
 4;dsp "
 NORMALIZED GAIN
 =",G[J],R+1-J;
 sto "J"
57: if B=4;fxd
 4;dsp "    SYST
 EM TEMP=",U[J],
 "*K",R+1-J;sto
 "J"
58: if B=5;fxd
 4;dsp " DELTA
 TEMP)meas=",
 H[J]/K[J],"*K",
 R+1-J;sto "J"
59: if B=6;fxd
 4;dsp " DELTA
 TEMP)theo=",
 I[J],"*K",R+1-
 J;sto "J"
60: if B=7;sto
 "INIT"
61: if B=8;fxd
 0;dsp "DIGITAL
 OUTPUT=",ED[J]/
 K[J],R+1-J
```

```
62: "J":for I=1
 to 7 by 2
63: I+8→H;jmp rI
64: int(X[I]D[rH
 ]/K[rH])+128→X;
 sto +5
65: int(X[I](G[r
 H]-1))+128→X;
 sto +4
66: int(X[I](U[r
 H]-B[rH]))+128→
 X;sto +3
67: int(X[I]H[rH
 ]/K[rH])→X;sto
 +2
68: 0→X
69: if X>255;
 255→X
70: if X<0;0→X
71: 1+H→H;jmp
 r(I+1)
72: int(X[I+1]D[
 rH]/K[rH])+128→
 Y;sto +5
73: int(X[I+1](G
 [rH]-1))+128→Y;
 sto +4
74: int(X[I+1](U
 [rH]-B[rH]))+
 128→Y;sto +3
75: int(X[I+1]H[
 rH]/K[rH])→Y;
 sto +2
76: 0→Y
77: if Y>255;
 255→Y
78: if Y<0;0→Y
79: if U>1;wtb
 15,2-U;sto +2
80: wtb 15,shf(X
 ,-8)+Y
81: next I
```

```
82: "CALIB":wtb
 15,R
83: for I=R to
 1 by -1
84: ED[I]/K[I]→X
 ;if X>32767;
 32767→X
85: if X<-32768;
 -32768→X
86: wtb 15,X
87: next I
88: if S>31;sto
 "NEW ALPHA"
89: if A=1;sto
 "NEW ALPHA"
90: sto "LOOP"
91:
92:
93: "CONTROL":
94: wtc 15,2+1
95: wtc 15,32+2+
 1
96: wtb 15,0
97: wtb 15,P-1
98: wtb 15,P-1
99: wtb 15,P-1
100: wtb 15,P-1
101: wtb 15,1638
 4F+(R-1)4096+
 512+256+M-1
102: wtc 15,32+
 2+1
103: wtc 15,32+1
104: ret
105:
```

```
106: "INIT":dsp
 "INITIALIZE
 SEQ--2CH,CRSR
 MODE";2→B
107: "R":ent
 "HOW MANY RCVR
 CHANNELS IN
 USE?",R
108: if R<1;prt
 "MUST HAVE AT
 LEAST 1 RCVR
 CHANNEL!";spc
 2;sto "R"
109: if R>4;prt
 "MORE THAN 4
 RCVR CHANNELS
 NOT ALLOWED!";
 spc 2;sto "R"
110: "P":ent
 "DICKE SWITCH
 PHASE PERIOD
 IN MS?",P;if
 flg13=0;sfg 0
111: if P<1;prt
 "WANT AT LEAST
 1 MS PHASE PERI
 OD";spc 2;sto
 "P"
112: if P>32768;
 prt "PHASE PERI
 OD > 32768 MS
 NOT ALLOWED!";
 spc 2;sto "P"
113: "Q":ent
 "BLANKING TIME
 IN MS? ",Q
114: if flg13=0;
 int(40960/P)→O;
 cfg 0
115: if flg0=1;
 int(40960/P)→O;
 cfg 0
116: if O>4095;
 prt "BLANKING
 MUST BE < PHASE
  PERIOD";spc 2;
 sto "Q"
117: if O<0;prt
 "BLANKING TIME
 < 0 NOT ALLOWED
 !";spc 2;sto
 "Q"
```

```
118: "M":ent
 "HOW MANY SWITC
 H CYCLES/INTEGR
 ATION?",M
119: if M<1;prt
 "MUST BE AT
 LEAST 1 CYCLE/
 INTEGRATION";
 spc 2;sto "M"
120: if M>256;
 256→M;fxd 0;
 prt "MAX VALUE=
 256";spc 2
121: "L":ent
 "RCVR BAL TIME
 (SEC)=",L;int(1
 000L/4P)4P/1000
 →K
122: if int(250L
 /P)<1;fxd 3;
 prt "MIN Rx
 BAL TIME (SEC)=
 ",P/250;spc 2;
 sto "L"
123: if int(250L
 /P)>256;fxd 3;
 prt "MAX Rx
 BAL TIME=",1.02
 4P;spc 2;sto
 "L"
124: if K#L;K→L;
 fxd 3;prt "ACTU
 AL BAL TIME=",
 L;spc 2
125: "N":ent
 "DELTA T)meas
 SUMATION TIME?
 SEC",T
126: int(1000T/
 4MP)→N
127: if N<2;fxd
 3;beep;prt "REQ
  MIN SUMMATION
 TIME=",4MP2/
 1000,"SEC";sto
 "N"
128: if N>50;
 beep;prt "MAX
 SUMATION TIME="
 ,4MP50/1000,
 "SECONDS";sto
 "N"
129: if T#4MPN/
 1000;4MPN/1000→
 T;beep;fxd 3;
 prt "ACTUAL
 SUMATION TIME="
 ,T;spc
```

```
130: ent "WHAT
 IS CAL *K FOR
 CHANNEL 1?",
 T[R]
131: if R-1>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 2?",T[R-1]
132: if R-2>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 3?",T[R-2]
133: if R-3>0;
 ent "WHAT IS
 CAL *K FOR CHAN
 NEL 4?",T[R-3]
134: ent "BANDWI
 DTH (MHz) FOR
 CHANNEL 1?",
 W[R];if flg13=0
 ;W[R]1e6→W[R]
135: if R-1>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 2?",W[R-1]
136: if R-1>0;
 if flg13=0;W[R-
 1]1e6→W[R-1]
137: if R-2>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 3?",W[R-2]
138: if R-2>0;
 if flg13=0;W[R-
 2]1e6→W[R-2]
139: if R-3>0;
 ent "BANDWIDTH
 (MHz) FOR CHANN
 EL 4?",W[R-3]
140: if R-3>0;
 if flg13=0;W[R-
 3]1e6→W[R-3]
```

```
141: fxd 0
142: for I=1 to
 8
143: "FNSEL":dsp
  "CR",I-1,"SwP=
 1,G=2,Ts=3,DT=4
 ,NoCh=0";ent
 "",rI
144: if rI<0 or
 rI>4;dsp "Bad
 selection!";
 wait 2000;gto
 "FNSEL"
145: if rI=0;
 5→rI;gto "NOCH"
146: "CS":dsp
 "Chan. to CR",
 I-1,"?";ent "",
 r(I+8);if flg13
 =0;R+1-r(I+8)→r
 (I+8)
147: if r(I+8)>4
  or r(I+8)<1;
 dsp "Bad select
 ion!";gto "CS"
148: dsp "CR";I-
 1,"scale in
 units/volt?";
 ent "",X[I];if
 flg13=0;25.5/
 X[I]→X[I]
149: "NOCH":next
  I
150: ent "DIGITA
 L OUTPUT FULL
 SCALE (*K)",E;
 if flg13=0;3276
 8/E→E
151: if E>32767;
 32767→E;dsp
 "SCALE MUST BE
 >= 1K (Set=1)";
 wait 3000
152: ent "INIT
 VALUES PRINTED?
 , ENT 1, CONT",
 A
153: if A=1;gsb
 "INIT PRINT"
154: gto "NEW
 ALPHA"
155:
156: "READ RCVR"
 :for I=1 to R
157: rdb(15)*
 32768+rdb(15)→R
 [I]
158: rdb(15)*
 32768+rdb(15)→S
 [I]
159: R[I]+rdb(15
 )*32768+rdb(15)
 →R[I]
160: rdb(15)*
 32768+rdb(15)→C
 [I]
161: next I
162: rdb(15)→S
163: ret
164:
165: "I/O ERROR"
 :
166: fxd 0;dsp
 "INPUT/OUTPUT
 ERROR---line",
 erl;beep;9→B;
 gto "LOOP"
167:
168: "INIT PRINT
 ":
169: fxd 0;spc
170: prt " NUMBE
 R OF RCVR CHANN
 ELS=",R;spc
171: prt "SWITCH
  PERIOD INMS
 =",P;spc
172: fxd 4;prt
 "BLANKING TIME
  MS =",P0/4096
 ;spc
173: fxd 0;prt
 " CYCLES/INTEGR
 ATION=",M;spc
174: fxd 3;prt
 "INTEG. PERIOD
  (SEC)=",4MP/
 1000;spc
175: fxd 3;prt
 "RCVR BAL TIME
  (SEC)=",(4P/
 1000)int(1000L/
 4P);spc
176: fxd 3;prt
 "DELTA T)meas
 SUMATION TIME
 (SEC)=",4MPN/
 1000;spc
177: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "CAL=
 ",T[R+1-I];next
  I
178: spc 2
179: for I=1 to
 R;fxd 0;prt
 "Channel",I;
 fxd 4;prt "BW="
 ,W[R+1-I]/1e6;
 next I
180: spc 2
181: for I=1 to
 8;fxd 0;prt
 "FOR CR",I-1;
 fxd 5;prt "CRSF
 =",25.5/X[I];
 next I
182: spc ;fxd 4;
 prt "DIGITAL
 OUTPUT  SCALE
 FACTOR=",E
183: 2→A;spc
184: ret
185: "HEADER":if
  flg5=1;cfg 5;
 ret
186: wtb 15,3263
 9,32639,32639,
 32639,11+9R
187: wtb 15,E
188: wtb 15,K
189: wtb 15,100L
190: 4PM→V;if
 V>32767;32767→V
191: wtb 15,V
192: wtb 15,2PM+
 0
193: wtb 15,O
194: wtb 15,P
195: wtb 15,Q
196: wtb 15,R
197: wtb 15,S
198: wtb 15,T
199: for I=R to
 1 by -1
200: 1000A[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
201: wtb 15,V
202: 10B[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
203: wtb 15,V
204: 1000G[I]→V;
 if V>32767 or
 V-32768;32767→V
205: wtb 15,V
206: 1000H[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
207: wtb 15,V
208: 1000I[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
209: wtb 15,V
210: K[I]→V;if
 V>32767 or V<-
 32768;32767→V
211: wtb 15,V
212: 100T[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
213: wtb 15,V
214: 10U[I]→V;
 if V>32767 or
 V<-32768;32767→
 V
215: wtb 15,V
216: W[I]/1e5→V;
 if V>32767 or
 V<-32768;32767→
 V
217: wtb 15,V
218: next I
219: ret
220:
221: end
```