APPLICATION FOR
FCC TYPE ACCEPTANCE
TCAS II COMPUTER UNIT

5140-0750
REV. A

HONEYWELL INC.
SPERRY COMMERCIAL
FLIGHT SYSTEMS GROUP
PHOENIX, ARIZONA

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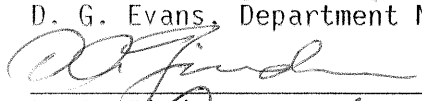
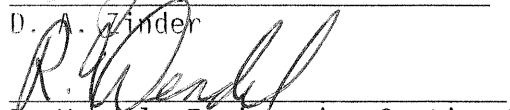
APPROVALS

Issue	Date	Approved By
Original		D. A. Zinder R. Wendel, Engineering Section Head D. G. Evans, Department Manager
A	29 May 90	



D. A. Zinder



R. Wendel, Engineering Section Head

D. G. Evans, Department Manager

RECORD OF REVISIONS

Rev Level	Paragraph	Page No.	Description
-			Initial issue.
A			Add pages 24a-24e

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 SCOPE

This report consists of data establishing the conformance of the Honeywell, Inc. TCAS II Computer Unit, Model 4066010-901, to the requirements established by the Federal Communications Commission in its rules and regulations (as referenced in Section 2 of this document).

1.2 CERTIFICATION

The TCAS II Computer Unit as described herein has been shown to have completely met the cited requirements.

David A Zinder, PE

Test Engineer Certification

David A. Zinder
BSEE University of Arizona, 1958
12 years experience in military and commercial avionics
Holder of First Class Radiotelephone Operator License (now General Class) since 1953.

2.0 REFERENCED DOCUMENTS

2.1 Federal Communications Commission

Latest Issue	Rules and Regulations Volume II, Part 2, Subpart J Volume V, Part 87, Subpart A

2.2 Radio Technical Commission on Aeronautics (RTCA)

DO-160 Rev. B July 1984	Environmental Conditions and Test Procedures for Airborne Equipment
DO-185 Change 6 Sept 1989	Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment

2.3 Honeywell, Inc. (These documents are attached to this report and are identified in the List of Exhibits.)

3.0 GENERAL REQUIREMENTS

3.1 Type Designation. The equipment has been designated by Honeywell, Inc., Sperry Commercial Flight Systems Group as TCAS II Computer Unit, 4066010-901.

3.2 Service and Rule for Intended Operation. Air Traffic Control, Part 87, Subpart A.

3.3 Description of Equipment.

3.3.1 Type of Emission: 18M0P1D

3.3.2 Frequency Range: 1030± 0.01 MHz

3.3.3 Power Rating: 0.4 to 500 watts peak pulse effective radiated power

3.3.4 Final Power Amplifier: Solid State Balanced Amplifier (Class C) using four MSC 1011-400 silicon bipolar transistors.

3.3.5 Active Device Functions:

Function	Device Type	Manufacturer
Oscillator		
Crystal controlled	5044-1052	TRAK Microwave
Transmitter		
Microwave Pulse Power Transistor--Amplifier, 1 watt	MSC1000 (2 ea)	Microwave Semiconductor
Microwave Pulse Power Transistor--Amplifier, 4 watt	MSC1004MP	Microwave Semiconductor
Microwave Pulse Power Transistor--Amplifier, 20 watt	81020	Microwave Semiconductor
Microwave Pulse Power Transistor--Amplifier, 70 watt	1011-70	Microwave Semiconductor
Microwave Pulse Power Transistor--Amplifier, 400 watt	1011-400 (4 ea)	Microwave Semiconductor
Pulse Modulator		
N Channel FET Modulator	IRF110	Generic
DPSK Modulators		
NPN Transistor (3) Modulator	BSV52	Generic
PNP Transistor (2) Modulator	BSR16	Generic

3.3.6 Circuit Diagram. See attached drawings.

3.3.7 Instruction Book. The total instruction package is contained in two documents attached to this report. The document names are self explanatory:

Honeywell Document Number	Title
C-28-3841-01	TCAS II Pilot's Manual for Northwest Airlines
34-43-00	TCAS System Description and Installation Manual

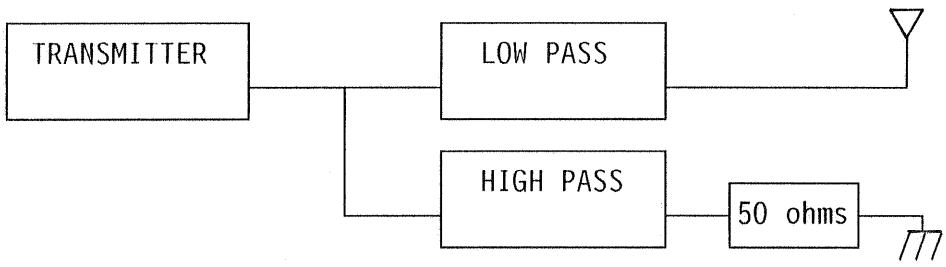
3.3.8 Tune-up Procedure. No field tuning is required.

3.3.9 Oscillator Circuit. The oscillator consists of a purchased assembly utilizing an aged quartz crystal resonator in a heated, temperature controlled environment. Isolation and bias stabilization is provided internally in the oscillator container. Final frequency adjustment is performed during the acceptance test of the I/O module using a calibrated frequency counter. The frequency is adjusted at room temperature to 1030 MHz ± 250 Hz. Figure A-14 from the test document IT7514216 is included here as item 5 of the Appendix.

3.3.10 Frequency Stabilization. Crystal controlled.

3.3.11 Modulation Limiting. Not Applicable.

3.3.12 Radiated Interference Suppression. Low pass/ high pass filter consisting of microstrip printed circuit elements (see drawing below).



Harmonic Filter

The filter provides essentially zero attenuation at the transmitted frequency (1030 MHz) and maximum attenuation of the second and third harmonics.The lowpass section is a five pole combline filter with a cutoff at approximately 1800 MHz. The high pass element is also a five pole combline filter with the same cutoff frequency.

The high pass section provides a termination for the higher order harmonics which will be reflected back and forth from the transmitter output to the low pass filter. To prevent the high pass filter from loading the transmitter output, the filter impedance at 1030 MHz is matched by a microstrip transformer to appear as an open circuit at that frequency.

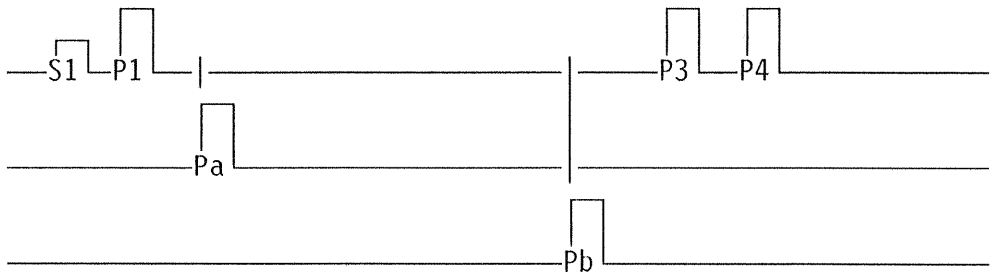
The spectral output of the 1030 MHz transmitter will be limited to the following schedule:

Frequency difference (MHz from carrier)	Relative power (dB below maximum)
≥4, <6	6
≥6, <8	11
≥8, <10	15
≥10, <20	19
≥20, <30	31
≥30, <40	38
≥40, <50	43
≥50, <60	47
≥60	50

3.3.13 Modulation Details.

3.3.13.1 ATCRBS Interrogations. Interrogations are sent out on an intentionally jittered 1±0.2 second interval in increasing power levels according to the schedules shown in Figures 1 through 3 which are at the end of this document. By transmitting the weakest signals first only the closest aircraft will reply. The interrogations progress in a roughly circular pattern weighted toward the front of the aircraft since that is the area from which the greatest closing speeds originate. In areas of high density the sequence is halted when the computer has reached a limit defined by a complex set of three inequalities. In this manner interference to other TCAS equipped aircraft in the area is minimized since the strongest interrogations are the first to be dropped. The priority of elimination of steps for interference limiting is also shown in Figures 1 through 3. This priority is inversely related to the order of the step sequence.

Pulse Widths: 0.8±0.05 usec.
Rise Times (10% to 90%): ≥0.05 usec., ≤0.1 usec.
Fall Times (90% to 10%): ≥0.05 usec., ≤0.2 usec.



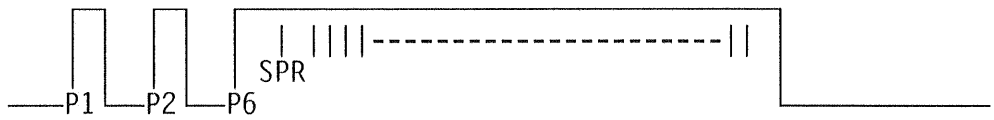
Pulses P1, P3, and P4 will appear in all interrogation steps of the whisper/shout sequence and will be at the same power level. Pulse S1 will appear in all steps except the initial step on each antenna direction and at a level two or three dB below the level of P1, etc. according to the schedules shown in Figures 1 through 3. The steps occur at intervals of two milliseconds until the entire program is complete. The program length depends upon the

individual aircraft installation. Options are available for using either an omni-directional bottom antenna or a directional bottom antenna. The top antenna is always directional. Pulses Pa and Pb are transmitted on the antenna lobes -90° and +90° respectively to the primary beam, that of P1, P3, and P4. They are used for suppression of sensitivity of the receiving aircraft to the side lobes of the transmitted beam.
Timing of the pulses is as follows, always referenced to the leading edge of the indicated pulses:

S1 = -2 microseconds
P1 = 0 microseconds
Pa = 2 microseconds
Pb = 19 microseconds
P3 = 21 microseconds
P4 = 23 microseconds

3.3.13.2 Mode S Interrogations. Details of the Mode S interrogations are shown in the figure below. The preamble and the synchronizing phase reversal (SPR) will appear the same in all interrogations. The data block will be either 56 or 112 chips of 0.25 microseconds, depending upon the type of reply desired. The data chips will be of reversed phase from their previous chips if their data bits are 1, they will remain the same phase as the previous chips if their data bits are 0. The allowable transition time of the phase reversals is a maximum of 80 nanoseconds. The Mode S interrogations are transmitted after the whisper/shout sequence of ATCRBS interrogations. When no Mode S equipped aircraft are replying, the TCAS CU sends out Mode S broadcast interrogations based upon a 10 second pattern with 2 or 3 seconds between transmissions on the four lobes of the antenna. The time remaining after the Mode S transmeissions are completed is used as a listening period for other unacquired aircraft.

Preamble pulse Widths: 0.8 ± 0.05 usec.
Rise Times (10% to 90%): ≤ 0.1 usec.
Fall Times (90% to 10%): ≤ 0.2 usec.



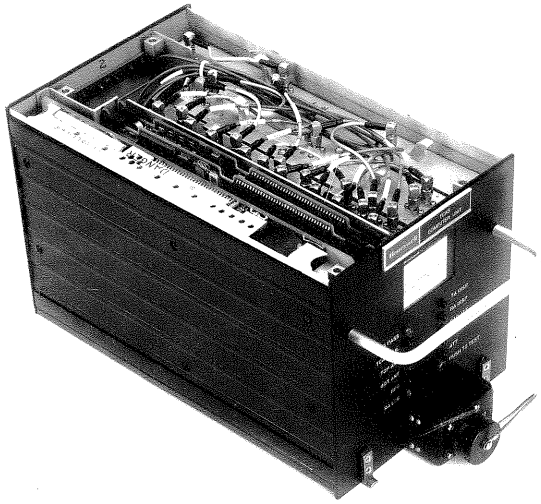
Timing of the events is as follows, referenced to the leading edge of the P1 pulse:

P1	0.0 microseconds
P2	2.0 microseconds
P6	3.5 microseconds
SPR	4.75 microseconds
Bit 1	5.25 microseconds
End P6	19.75 microseconds (56 bits)
	33.75 microseconds (112 bits)

4.0 DRAWINGS AND PHOTOGRAPHS

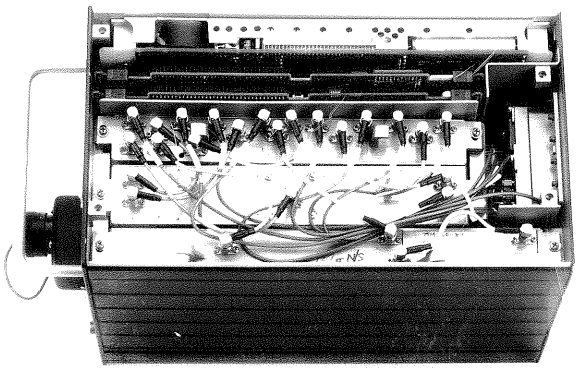
4.1 The drawings listed in section 2.3 of this document are furnished as separate items with this appliction.

4.2 Photographs of the TCAS Computer Unit illustrating the assembly drawings are presented here and on the next page. Photographs showing the overall appearance including placement of the nameplates and views showing the details of the nameplates are shown in 8 x 10 prints in the attachments.

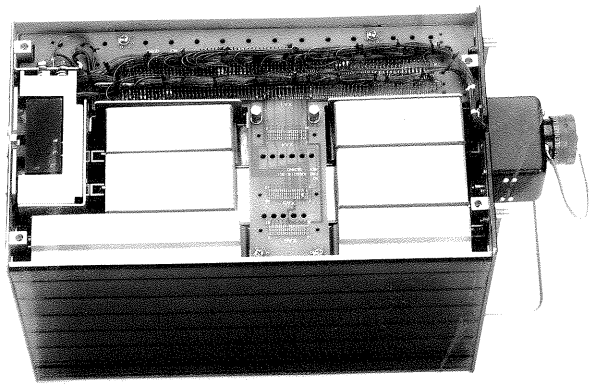


Oblique front view
Top cover removed

Oblique rear view
Shows ARINC 600 connector



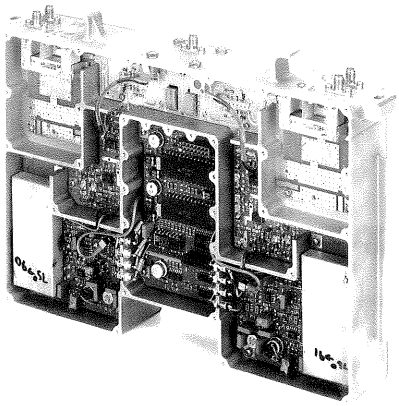
Inside top view



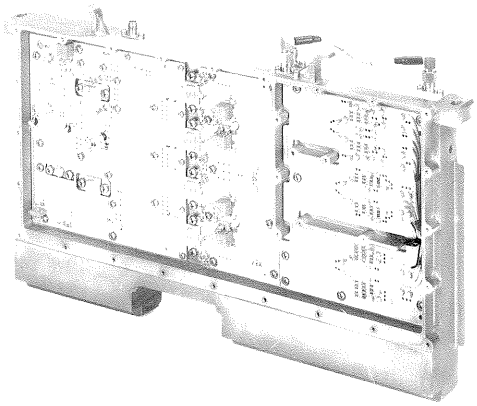
Inside bottom view

4.2 Photographs of the TCAS Computer Unit (cont'd)

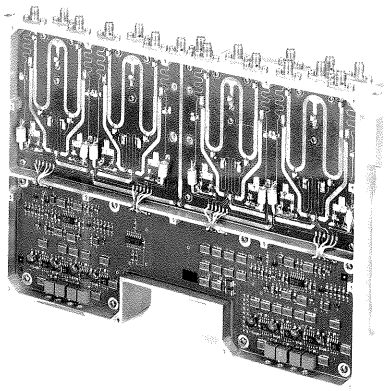
RF Modules with the covers removed.



Receiver Assembly



Transmitter Assembly



I/O Assembly

Note: All original photographs are available for inspection.

5.0 TEST DATA

Data from the required tests is appended to this report per the following list. Paragraphs referenced are from FCC Rules and Regulations, Part 2, Subpart J.

5.1 Modulation Characteristics, para 2.987

MOPS test data sheets showing ATCRBS and Mode S interrogation transmission characteristic measurements. Oscilloscope photographs of TCAS CU interrogations showing typical patterns and rise and fall times.

5.2 Occupied Bandwidth, para 2.989

Data sheet from spectrum analyzer showing spectral data at 5 MHz per division. All spectra were taken while the TCAS CU was in its normal mode of operation, transmitting one whisper/shout sequence of mode C interrogations each second, jittered at a random rate between 0.8 and 1.2 seconds. The unit also transmits four mode S interrogations every ten seconds at two and three second intervals, once on each directional lobe of the antenna.

The measured occupied bandwidth as shown on the spectrum is from 1024 to 1035 MHz.

5.3 Spurious Emissions, para. 2.991, 2.993

Data sheets from EMI testing, radiated emissions from 150 kHz to 10 GHz. Additionally, spectra were taken directly from the antenna terminals through 10.9 GHz, the 10th harmonic of the fundamental frequency.

5.4 Frequency Stability with Temperature, para 2.995b
RF Power Output, para. 2.985

Data sheet taken during temperature performance testing of the computer unit. Both frequency and maximum power output were recorded.

5.6 Frequency Stability under Voltage Fluctuations, para 2.995d
RF Power Output, para. 2.985

Data taken during power variations testing on the transponder. Both frequency and maximum power output were recorded.

Omni-Directional Antenna

Nominal Power Levels (dB relative to full power)

Level	P_1, P_3, P_4 Pulses	S_1 Pulse
00	-13	-16
01	-15	-18
02	-17	-20
03	-19	-22
04	-21	-24
05	-23	-26
06	-25	none

Directional Antenna

Nominal Power Levels (dB relative to full power)

Level	P_1, P_3, P_4 Pulses	S_1 Pulse	P_A, P_B Pulses
D0	0	-3	-2
D1	-1	-3	-3
D2	-2	-5	-4
D3	-3	-5	-5
D4	-4	-7	-6
D5	-5	-7	-7
D6	-6	-9	-8
D7	-7	-9	-9
D8	-8	-11	-10
D9	-9	-11	-11
D10	-10	-13	-12
D11	-11	-13	-13
D12	-12	-15	-14
D13	-13	-15	-15
D14	-14	-17	-16
D15	-15	-17	-17
D16	-16	-19	-18
D17	-17	-19	-19
D18	-18	-21	-20
D19	-19	-21	-21
D20	-20	-23	-22
D21	-21	-23	-23
D22	-22	-25	-24
D23	-23	-25	-25
D24	-24	-27	-26
D25	-25	-27	-27
D26	-26	--	-16 (P_A only)

Figure 1

INTERROGATION TRANSMISSION LEVELS

Bottom Omni-Directional Antenna

Interference Limiting Priority/Interrogation Level

98 / 06
97 / 05
96 / 04
95 / 03
94 / 02
93 / 01
92 / 00

Top Directional Antenna

Interference Limiting Priority/Interrogation Level

0°	180°	90°	270°
91 / D26	-	-	-
90 / D25	-	-	-
89 / D24	-	-	-
88 / D23	-	87 / D26	86 / D26
85 / D22	-	84 / D25	83 / D25
82 / D21	-	81 / D24	80 / D24
79 / D20	-	78 / D23	77 / D23
76 / D19	-	75 / D22	74 / D22
73 / D18	72 / D26	71 / D21	70 / D21
69 / D17	68 / D25	67 / D20	66 / D20
65 / D16	64 / D24	63 / D19	62 / D19
61 / D15	60 / D23	59 / D18	58 / D18
57 / D14	56 / D22	55 / D17	54 / D17
53 / D13	52 / D21	51 / D16	50 / D16
49 / D12	48 / D20	47 / D15	46 / D15
45 / D11	44 / D19	43 / D14	42 / D14
41 / D10	40 / D18	39 / D13	38 / D13
37 / D9	36 / D17	35 / D12	34 / D12
33 / D8	32 / D16	31 / D11	30 / D11
29 / D7	28 / D15	27 / D10	26 / D10
25 / D6	24 / D14	23 / D9	22 / D9
21 / D5	20 / D13	19 / D8	18 / D8
17 / D4	16 / D12	15 / D7	14 / D7
13 / D3	12 / D11	11 / D6	10 / D6
9 / D2	8 / D10	7 / D5	6 / D5
5 / D1	4 / D9	3 / D4	2 / D4
1 / D0	-	-	-

Figure 2

TOP DIRECTIONAL/BOTTOM OMNI-DIRECTIONAL INTERROGATION SEQUENCE
Interrogation sequence is right to left, top to bottom.

Interference Limiting Priority/Interrogation Level

Top Directional Antenna

0°	180°	90°	270°
113 / D26	-	-	-
111 / D25	-	-	-
109 / D24	-	-	-
107 / D23	-	-	-
-	-	105 / D26	104 / D26
101 / D22	-	-	-
-	-	99 / D25	98 / D25
95 / D21	-	-	-
-	-	92 / D24	91 / D24
88 / D20	-	-	-
-	-	85 / D23	84 / D23
81 / D19	-	-	-
-	-	78 / D22	77 / D22
74 / D18	-	-	-
-	72 / D26	71 / D21	70 / D21
69 / D17	68 / D25	67 / D20	66 / D20
65 / D16	64 / D24	63 / D19	62 / D19
61 / D15	60 / D23	59 / D18	58 / D18
57 / D14	56 / D22	55 / D17	54 / D17
53 / D13	52 / D21	51 / D16	50 / D16
49 / D12	48 / D20	47 / D15	46 / D15
45 / D11	44 / D19	43 / D14	42 / D14
41 / D10	40 / D18	39 / D13	38 / D13
37 / D9	36 / D17	35 / D12	34 / D12
33 / D8	32 / D16	31 / D11	30 / D11
29 / D7	28 / D15	27 / D10	26 / D10
25 / D6	24 / D14	23 / D9	22 / D9
21 / D5	20 / D13	19 / D8	18 / D8
17 / D4	16 / D12	15 / D7	14 / D7
13 / D3	12 / D11	11 / D6	10 / D6
9 / D2	8 / D10	7 / D5	6 / D5
5 / D1	4 / D9	3 / D4	2 / D4
1 / D0	-	-	-

Bottom Directional Antenna

0°	180°	90°	270°
112 / D26	-	-	-
110 / D25	-	-	-
108 / D24	-	-	-
106 / D23	-	-	-
-	-	103 / D26	102 / D26
100 / D22	-	-	-
-	-	97 / D25	96 / D25
94 / D21	93 / D26	-	-
-	-	90 / D24	89 / D24
87 / D20	86 / D25	-	-
-	-	83 / D23	82 / D23
80 / D19	79 / D24	-	-
-	-	76 / D22	75 / D22
73 / D18	-	-	-

Interrogations for each sector that has a TA or RA present.

1 / D17	1 / D23	1 / D21	1 / D21
1 / D16	1 / D22	1 / D20	1 / D20
1 / D15	1 / D21	1 / D19	1 / D19
1 / D14	1 / D20	1 / D18	1 / D18
1 / D13	1 / D19	1 / D17	1 / D17
	1 / D18	1 / D16	1 / D16
	1 / D17	1 / D15	1 / D15
	1 / D16	1 / D14	1 / D14
	1 / D15	1 / D13	1 / D13
	1 / D14		
	1 / D13		

Figure 3

TOP DIRECTIONAL/BOTTOM DIRECTIONAL INTERROGATION SEQUENCE
Interrogation sequence is right to left, top to bottom.

APPENDIX

DATA SHEETS AND OTHER MATERIAL

All items are separated by identifying cover sheets.

1. Modulation Characteristics, para 2.987

2. Occupied Bandwidth, para 2.989

3. Spurious Emissions, para. 2.991, 2.993

4. RF Power Output, para. 2.985
   Frequency Stability with Temperature, para 2.995b
   Frequency Stability under Voltage Fluctuations, para 2.995d

5. 1030 MHz Oscillator Detail Diagram, from Integrated Test Procedure IT7514216

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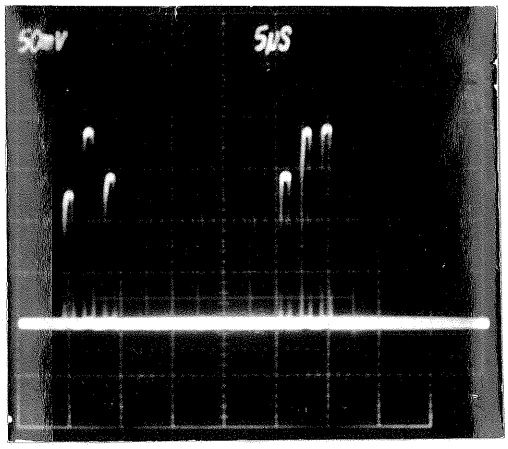
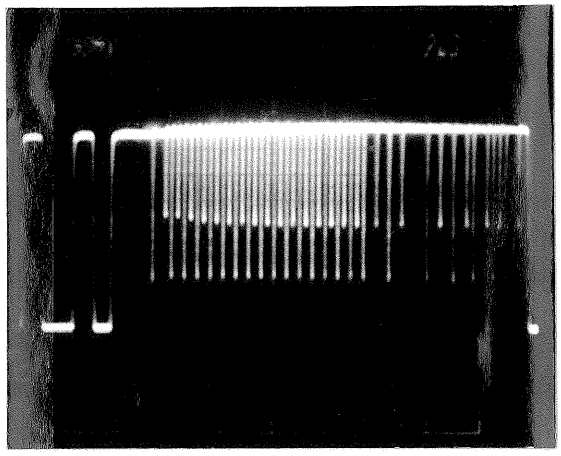
   Frequency Stability with Temperature, para 2.995b
   Frequency Stability under Voltage Fluctuations, para 2.995d

MODULATION CHARACTERISTICS

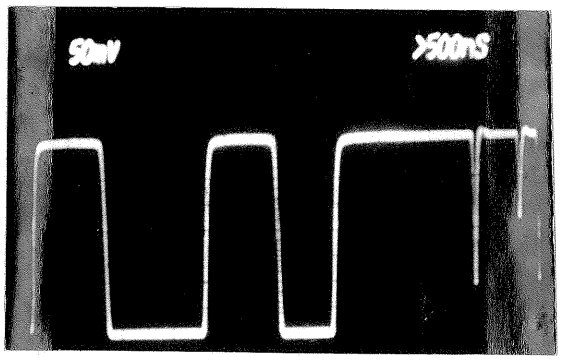
Oscilloscope photographs of typical modulation patterns.



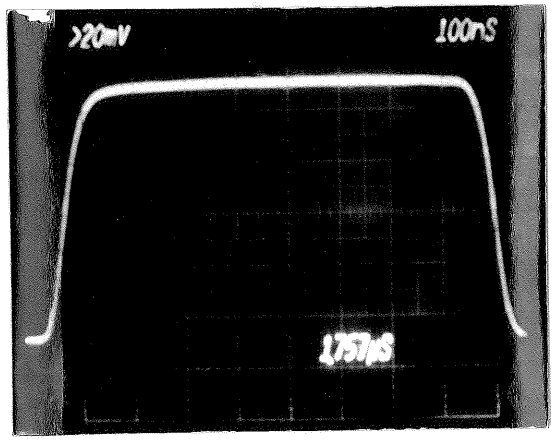
ATCRBS Mode C Interrogation



Mode S Interrogation



Close up of Mode S Interrogation Preamble and Sync Phase Reversal



Typical ATCRBS or Mode S Interrogation Pulse Showing Rise and Fall Times