ENGINEERING SPECIFICATION

SECURITY NOTATION	SPEC NO.	EB7516219	B
	CAGE CODE	55939	REV LTR

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DOCUMENT TYPE	CLASS	INITIAL RELEASE DATE
ENGINEERING BULLETIN	A	13 FEB 01

DIVISION	DEPARTMENT NO.	PRODUCT LINE NO.	CONTRACT NO.
AES – BELL RD.		5111	

TITLE

FCC TYPE ACCEPTANCE REPORT FOR THE SD-700 SATELLITE DATA UNIT, HONEYWELL PART NUMBER 7516118.

PREPARED BY:	DATE	APPROVED BY TECHNICAL MANAGER	DATE	APPROVED BY PRODUCT LINE DIRECTOR	DATE
P. Bailey	02/13/01	C. Dosdall	02/13/01	M. McGowan	02/13/01
APPROVED FOR SCM	DATE	APPROVED FOR SQA	DATE	APPROVED BY:	DATE

REF AWAEB/PSAEB NO.	CHECKER	PRODUCT DESIGN CHECKER (FOR REF, SPCL CONT PER EPM 1-A-40)	COGNIZANCE OF QE SUPVR (FOR REF, SPCL CONT PER EPM 1-A-40)
7516081			

FOR PAGE INDEX, SEE PAGE CR-2. REVISION RECORD FOLLOWS PAGE INDEX.

THIS IS AN ELECTRONIC FACSIMILE OF THE CR-1 ON FILE WITH DOCUMENT CONTROL.

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B	SEE PAGE INDEX SHEET CR-2	C.O. 200200088A (NA)	P. Bailey 22 JAN 02

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TITLE: SD-700 HONEYWELL/RACAL MULTI-CHANNEL SATCOM SYSTEM SATELLITE DATA UNIT

1. INTRODUCTION

This report consists of data establishing the conformance of the Honeywell/Racal SD-700 Satellite Data Unit (SDU) to the requirements established by the Federal Communications Commission in its rules and regulations as referenced in Section 2 of this paper. Transmit tests were performed in the two cases where the SD-700 is transmitting with either a 20W High Power Amplifier (HPA) or a 40W HPA as indicated in the report.

The SD-700 Satellite Data Unit supports four different equipment configurations or variants:

- 7-channel SDU with a 115V AC supply
- 4-channel SDU with a 115V AC supply
- 7-channel SDU with a 28V DC supply
- 4-channel SDU with a 28V DC supply

The transmit characteristics of all four versions are identical since the RF Module (RFM), which contains the entire transmit chain, is the same for all four variants. The AC or DC variants are realized by changing the Power Supply in the SD-700. Both Power Supplies have been previously tested and qualified with the SD-600, an earlier model currently in production. The 4-channel variant is realized by simply removing one of the Triple Transcoder Modem cards (TTCM). The 7-channel AC version is the baseline configuration and has been chosen as the test SDU reflected in this report.

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The Honeywell/Racal Multichannel Satcom system (MCS-7000) baseline configuration is a seven channel system comprised of two Line Replaceable Units (LRUs): the SDU, Honeywell part number 7516118-XXXXX and the 20 W or 40W HPA, Honeywell part number 7516251-XXXXX or 7516250-XXXXX respectively. It is a full duplex communication system capable of transmitting and receiving simultaneously any number of modulated carriers up to the channel capabilities of the system. The reference oscillator is located in the SDU. The multichannel power output is rated at 40 watts when a 40W HPA is used and at 20 watts when a 20W HPA is used. The SD700 output by itself is 31.6 mW.

This report contains the performance parameters with both HPAs and the Diplexer/LNA (Phase Atlantic Model WGE-0090-00), except as noted in the various test sections of this report. The HPAs were included to demonstrate the overall transmit characteristics of the SDU/HPA transmit line-up. The Diplexer/LNA was used in the testing to include its transmit passband and reject band characteristics.

Honeywell has assigned the following model numbers to its system LRUs:

SDU – SD700

40W HPA – HP600

20W HPA – HP700

LIST OF ACRONYMS AND ABBREVIATIONS

A/D	Analog to Digital Converter
AGC	Automatic Gain Control
BER	Bit Error Rate
BW	Bandwidth
CCA	Circuit Card Assembly
CCS	Cabin Communication System
CF	Center Frequency
CODEC	Coder/Decoder
CS	Channel Synthesizer
D/A	Digital to Analog Converter
DTMF	Dual Tone Multi-Frequency
FL	Filter
GES	Ground Earth Station
HPA	High Power Amplifier
IF	Intermediate Frequency
LNA	Low Noise Amplifier
LO	Local Oscillator
LRU	Line Replacement Unit
MCS	Multichannel Satcom
OCXO	Oven Controlled Crystal Oscillator
PLO	Phase Locked Oscillator
PSM	Power Supply Module
RFM	Radio Frequency Module
SDU	Satellite Data Unit
SIOM	SDU Input Output Module
SMPM	SDU Main Processor Module
TTCM	Triple Transcoder Modem
VHF	Very High Frequency
VIM	Voice Interface Module

2. REFERENCES AND ATTACHMENTS

2.1 References

Code of Federal Regulations, Title 47

Part 2, Subpart J

Part 87, Subpart D

FCC Type Acceptance Report for the HP-700 HPA Honeywell P/N 7516251, EB7516254

FCC Type Acceptance Report for the Multi-Channel Satcom System, A72-5111-122

2.2 Attachments

2.2.1 Satellite Data Unit (SDU)

Radio Frequency Module (RFM)	7516113-904
Receiver Card (Rx Assembly)	7516114-906
Transmitter Card (Tx Assembly)	7516116-905
Power Supply Module	7516359-910
Power Supply Power Card	7516410-903
Power Supply Control Card	7516420-902
Main Processor Module (MMPM) Assembly	81771-DEB
Main Processor Module Schematic	81771-WDEB
Input/Output Module (SIOM) Assembly	81771-DFA
Input/Output Module Schematic	81771-WDFA
Triple Transcoder Modem Assembly	81771-DLC
Triple Transcoder Modem Schematic	81771-WDLC
Voice Interface Module Assembly	81771-DYB
Voice Interface Module Schematic	81771-WDYB
Front Panel Display Assembly	81771-DHA
Front Panel Display Schematic	81771-WDHA
Interface Module Card (IFM) Assembly	81771-DTA
Interface Module Card Schematic	81771-WDTA
Mother Board Assembly	81771-DVC
Mother Board Schematic	81771-WDVC
Frequency Reference Oscillator (OCXO) Assembly	81771-MBE
Frequency Reference Oscillator Schematic	81771-WDME
Plate, Identification, Hardware, Software	7021570-40
Integrated Test Specification for Satellite Data Unit (IT)	IT7516118
Internal and External Photographs	
System Definition and Installation Manual (SDIM)	A15-5111-001-00

NOTE: Alignment and calibration procedures are in the IT.

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2.2.2 System Description and Installation Manual

A15-5111-001-00

3. TEST CERTIFICATION

I do hereby certify that to the best of my knowledge the technical test data contained in this report are true and correct and that the SD-700 has been shown to have completely met the cited requirements.

SIGNED: Peter D. Bailey

Test Engineer Certification

Peter D. Bailey

BS Arizona State University, 1969

15 Years Experience in Commercial Avionics

4. GENERAL INFORMATION

4.1 Type Designation

The equipment has been designated by Honeywell, Inc., Commercial Electronic Systems, as an SD-700 Satellite Data Unit for use in a Multichannel SATCOM System, MCS-7000.

4.2 Service and Rule for Intended Operation

Aeronautical Mobile Satellite Service
Part 87, Subpart A

4.3 Description of Equipment

4.3.1 Type of Emission

B

G7W

4.3.2 Frequency Range [MHz]

1626.5 - 1660.5

4.3.3 Power Rating

40 Watts Maximum for MCS-7000 with 40 W HPA.

20 Watts Maximum for MCS-7000 with 20 W HPA.

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31.6 mW Maximum for the SD700 alone.

4.3.4 Final Power Amplifier

The SDU final stage is a solid state class A Gallium Arsenide Heterojunction Bipolar Transistor amplifier, RF2125 (RF Micro Devices). The 20W HPA final stage is a solid state class AB balanced amplifier using two LYE16350X (PHILIPS) silicon bipolar transistors. The 40W HPA final stage is a solid state class AB balanced amplifier using four LYE16350X (PHILIPS) silicon bipolar transistors.

4.3.5 Reference Oscillator

SC cut crystal ovenized oscillator manufactured by CQE.

4.3.6 SDU Transmit Component Functions

4.3.6.1 Radio Frequency Module (RFM) in SDU

Function	Component	Manufacturer
Quadrature Modulator (Channel 1)	U63	TEMIC TELEFUNKEN
MMIC Amplifier (Channel 1)	U67	MINICIRCUITS
Mixer	U5	MINICIRCUITS
Filter	FL1	K&L
MMIC Amplifier	U24	MINICIRCUITS
MMIC Amplifier	U26	MINICIRCUITS
Mixer	U28	PULSAR
MMIC Amplifier	U32	MINICIRCUITS
MMIC Amplifier	U37	MINICIRCUITS
Amplifier	U42	RF MICRO DEVICES
Filter	FL2	TOKO

All amplifiers in SDU are Class A.

Channels 1 - 8 are functionally identical.

4.3.7 Circuit Diagram

See attached schematics.

4.3.8 Instruction Book

To be supplied as soon as possible.

4.3.9 Tune-up Procedures

No field tuning is required. Tuning is done during manufacturing using subassembly test. See Integrated Test Specifications.

4.3.10 Reference Oscillator

An oven controlled high stability reference oscillator (Racal part number 81771-MBE located in the Satellite Data Unit) is used as the primary frequency reference for:

- Radio Frequency Module Local Oscillators and Synthesized Channel Local Oscillators
- Modem Sample Rate Clocks
- Voice Codec Bit Rate Clock

The crystal oscillator provides good stability versus temperature, power supply voltage and load variations. The output frequency is 10.08 MHz and has sufficient mechanical adjustment range to compensate for ten years of aging. The reference oscillator frequency is sent to the Radio Frequency Module (RFM) where it is buffered and routed to each Modem. The oscillator also outputs a logic signal directly coupled to the SDUs Main Processor Module to indicate the oven temperature stabilization.

4.3.11 Frequency Stabilization

The channel phase-locked-loop synthesizers and other phase-locked-loop oscillators are all referenced to the single reference oscillator.

4.3.12 Modulation Limiting

Not applicable.

4.3.13 Radiated Interference Suppression

The output of the High Power Amplifier in an operating system is fed into the transmit port of an LNA/Diplexer. This device provides greater than 80 dB rejection for out of band signals between 0 MHz to 1585 MHz and greater than 50 dB rejection between 1735 MHz and 12000 MHz. The transmitter chain in the SDU and in the HPA is also bandpass limited.

4.3.14 Modulation Method

Aviation Binary Phase Shift Keying (A-BPSK) Aviation Quaternary Phase Shift Keying (A-QPSK) (A-BPSK up to 2400 bps, A-QPSK up to 21 kbps).

4.3.14.1 Modulation Method - Modulation Carrier

The generation of a modulated carrier is achieved using digital signal processing techniques and is converted to an analog RF signal employing Digital-to-Analog conversion techniques. The SDU utilizes two kinds of signals as inputs for transmission. Analog audio or digital data. The analog audio is digitized in the CODEC (Coder/ Decoder) assemblies. The digitized audio or the digital data is then scrambled, interleaved and Forward-Error-Corrected (FEC) before being inputted to the data “modulator”.

4.3.15 Theory of Operation

The MCS is able to transmit data and voice information simultaneously in full duplex mode. The power management and frequency selection in this system is controlled by the GES without user assistance.

The digital packet data to be transmitted is routed to the SDU main processor assembly, the analog voice to the six codec assemblies of the SDU and the digitized cabin voice is routed to the transcoder circuits of the SDU.

The codec performs A/D and D/A conversion coding/decoding on the analog voice, while the transcoder executes coding/decoding functions. The coded data is passed to the processor module of the SDU. After processing each channel of data or voice the information is forwarded to a modem assembly.

There are seven modems in the SDU and eight available channels in the SDU's RFM. Modems one through four can be connected to any of the RFM channels one through four. Modems five through seven can be connected to any of the RFM channels five through eight. There is one modem located on the main processor card and three modems on each of two Triple Transcoder Modem (TTCM) cards. The generation of the modulated RF signal begins in the modem assembly in the form of a fully digital complex baseband signal. This signal is then passed to the RFM where it is processed and converted into an analog IF signal. The RFM produces final frequency conversion to the operational L-band frequency region.

The Honeywell Multichannel Satcom System is compliant to AERONAUTICAL RADIO INC. (ARINC) CHARACTERISTIC 741 PART 2 paragraph 3.1.4 and 4.1.3. The digital modulator fulfills the functions of the modulator model presented on Figures 8b and 8c of Attachment 2x of ARINC 741 part 2.

ARINC 741 Part 2 Figure 8b - Modulator Model

ARINC 741 Part 2 Figure 8c - Data Encoder Model

4.3.15.1 Major Functions of the CODEC:

Digitize and encode the incoming cockpit or cabin audio, the Cabin Communication System (CCS), or PCM data using the voice coding algorithm specified by the British Telecom 9.6 kbit/sec Speech Codec for Aeronautical Mobile Satellite Communication.

Receive encoded audio data arriving from the GES and convert it back to analog audio for routing to the cockpit, or to PCM data.

Generate various call progress messages and tones.

Decode Dual Tone Multi-Frequency (DTMF) tones as specified in CCITT Recommendations Q.11, Q.16 and Q.23, which have been generated by the telephone handset or a PBX and provide the information to the SDU Main Processor.

Monitor and control the state of various interfaces.

4.3.15.2 Major Functions of the Modem

There are seven modems within the SDU. Each modem receives and transmits Signaling Units and Circuit Mode Data Primary Fields to and from the Main Processor Module. Complex baseband I and Q signals are passed to and from the RFM. The receive channel of the Modem performs demodulation and decoding of complex baseband signals received and passed by the RFM. The transmit stages of the modem perform encoding and scrambling operations to provide a complex bandpass signal for the transmit section of the RFM. All inputs and outputs of the modem are in the digital domain.

4.3.15.3 Major functions for the Radio Frequency Module:

Downconversion, filtering, and A/D conversion of received signals.
AGC functions as commanded by the main processor.
Passes baseband signals to the modem.
Converts baseband complex signals into RF signals.
Performs QAM modulation and Doppler correction.
D/A conversion to produce analog IF signals.

The SDU contains one RFM. The RFM has one L-band block up/down converter and 8 identical UHF/VHF up/down converters (one per transmit/receive channel). Both the Rx assembly (7516114) and the Tx assembly (7516116) have identical circuitry for four transmit and four receive channels.

Block Downconverter (on the 7516114 Rx assembly):

The L-band (1525-1559 MHz) signals from the Diplexer/LNA are applied to the receive port of the RFM. The signal passes through a bandpass filter (FL1, center frequency 1542 MHz, 34 MHz bandwidth) which rejects the out of band signals. The signal then passes to a two stage low noise amplifier (LNA, U25, U23) which increases the signal by 35 dB. Included in the LNA section are the block AGC attenuator diodes (CR9 and CR10). If the input signal is large, these diodes will be activated and will reduce the signal by as much as 28 dB. If the signal is small, the diodes have no effect on the signal. The LNA is followed by a 7 dB gain RF amplifier (U24) and mixer (U27) which mixes the 1159.2 MHz PLO with the receive signal to produce a UHF (382.8 MHz mid band) IF. The IF signal goes through a Tx reject low pass filter and is amplified 12 dB by U39 and 20 dB by U40, and sent through an image reject high pass filter. The signal is then split eight ways in the UHF divider. Four channels (5-8) are routed to circuitry on the Rx assembly (7516114). The remaining four channels (1-4) are routed to the Tx assembly (7516116) which contains circuitry for four receive channels.

The eight UHF/VHF downconverters are identical, therefore, the following description applies to each of the eight channels generically.

The UHF signal goes through a 15 dB pad and a 12 dB gain amplifier stage to provide additional isolation between signals at the splitter outputs. The signal is then mixed with the channel synthesizer frequency (209.575 MHz mid band) to produce a 173.225 MHz IF signal. This signal passes through a SAW filter of 140 kHz bandwidth before going to the channel AGC amplifier which has a gain range of 5-35 dB. The signal is then applied to the quadrature demodulator which downconverts the signal to 168.4 kHz by mixing it with the 173.0566 MHz PLO LO signal as well as producing the I and Q components. Each I and Q product goes through an op amp stage to a switch-cap filter of 26 kHz bandwidth and then a second op amp stage before being applied to the A to D converter.

AGC

The AGC signal for each RFM channel AGC amplifier is provided by the Main Processor card to the RFM. The digital AGC signal goes through the CPLDs (U18 on the Rx assembly, 7516114, and U22 on the Tx assembly, 7516116) to the DACs (U11 on the Rx assembly and U35 on the Tx assembly) which in turn provide the proper control to each of the eight RFM receive channels. The block AGC signal is similarly produced at the output of the DAC (U11) where it is scaled and temperature compensated before being applied to the block AGC attenuator diodes in the LNA of the block downconverter.

VHF Upconversion (on the Tx assembly, 7516116, and Rx assembly, 7516114):

The eight VHF upconversions are identical, therefore, the following description applies to each of the eight channels generically. Channels 1-4 originate on the Tx assembly; channels 5-8 on the Rx assembly.

The I & Q baseband signals arrive at the quadrature modulator from the main processor card via the CPLD (U72 on the Rx assembly, 7516114, and U77 on the Tx assembly, 7516116) and the DACs (U56 or U73 on the Rx assembly, and U58 or U79 on the Tx assembly). The LO signal to the modulator from the channel synthesizer produces a modulator output in the range of 192.575 MHz to 226.575 MHz, depending on the channel frequency selected, which passes through a low pass filter and a 12 dB MMIC amplifier. The signal then combines with the other seven channels and travels to the Block Upconverter for further up-conversion.

Block Upconverter (on the Tx assembly, 7516116):

The VHF input to the block upconverter passes through a 4.5 dB attenuator and into a mixer (U5) whose LO power comes from the Doppler synthesizer centered at 163.845 MHz. The mixer output is in the range of 356.42 MHz to 390.42 MHz depending on the channel frequency selected.. Following the mixer is an 8-pole bandpass filter (FL1) centered at 373.42 MHz with a bandwidth of 34 MHz, a 12 dB gain amplifier (U24), a temperature compensation circuit, and an 18 dB gain amplifier (U26). The amplifier feeds the final mixer (U28) where the signal is mixed with an LO frequency of 1270.08 MHz from the Tx PLO to produce the transmit frequency in the range of 1626.5 MHz to 1660.5 MHz. The upconverted signal goes through a preliminary diplexed filter and then through successive RF gain stages of 15 dB (U32), 18dB (U37), and 15 dB (U42), and finally through a bandpass filter (FL2) to the RFM transmit port.

Synthesizers:

There are basically five synthesizers used in the SDU all of which reside in the RFM.

- Channel synthesizer: One per channel, nested dual loop design capable of tuning in 2.5 kHz increments over a 34 MHz range centered at 209.575 MHz. There are four channel synthesizers on each of the Rx and Tx assemblies, 7516114 and 7616116 respectively. Each synthesizer is dedicated simultaneously to both a Tx and Rx channel.
- Doppler synthesizer: Cascaded dual loop design capable of tuning in 10 Hz increments over a range of +/- 2180 Hz centered at 163.845 MHz. It is located on the Tx assembly, 7516116.
- 1270.08 MHz PLO: Fixed frequency, located on the Tx assembly, 7516116.
- 1159.2 MHz PLO: Fixed frequency, located on the Rx assembly, 7516114.
- 173.0566 MHz PLO: Fixed frequency, located on the Rx assembly, 7516114.

4.3.15.3.1 The Honeywell MCS system does employ Doppler correction techniques as required by ARINC 741 Part 2 Paragraph 4.1.2.

4.3.15.4 RF Signal Path through HPA

20W HPA:

INPUT: 1626.5 MHz to 1660.5 MHz

Gain 57 dB ± 1 dB with 0 dB back-off attenuation

OUTPUT: 1626.5 MHz to 1660.5 MHz
20 Watts operational (continuous)
40 Watts maximum

40W HPA:

INPUT: 1626.5 MHz to 1660.5 MHz

Gain 60 dB ± 1 dB with 0 dB back-off attenuation

OUTPUT: 1626.5 MHz to 1660.5 MHz
40 Watts operational (continuous)
60 Watts maximum

For both the 20 watt and 40 watt HPA, the RF signals in the HPA pass through five stages of class A amplification followed by two stages of class AB amplification. The signals then are routed through an output power detector after which they exit the HPA. The HPA output is connected to the diplexer and antenna subsystem.

A description of the 20W HPA circuitry can be found in the previously submitted FCC report, EB7516254.

A description of the 40W HPA circuitry can be found in the previously submitted FCC report, A72-5111-122.

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5. PHOTOGRAPHS

The following photographs can be found in PDF files submitted separately from this report.

Number	View
01	SD-700 Front showing label
02	SD-700 Rear
03	SD-700 Front-Right/PSU partially removed
04	SD-700 Front-Left/RFM partially removed
05	SD-700 Front/Front Plate partially removed
06	SD-700 Front/Front Plate removed
07	SD-700 Right showing IFM & Motherboard
08	SD-700 Left showing IFM & Motherboard
09	SD-700 Right showing OCXO
10	Front Plate inside
11	Triple Transcoder Modem Assembly Side 1
12	Triple Transcoder Modem Assembly Side 2
13	Main Processor Module Side 1
14	Main Processor Module Side 2
15	Voice Interface Module
16	Input/Output Module
17	Power Supply Power Card
18	Power Supply Control Card
19	RF Module Transmit Card/Side 1
20	RF Module Transmit Card/Side 2
21	RF Module Receive Card/Side 1
22	RF Module Receive Card/SIde 2