EXHIBIT D

THOMSON-CSF
DETEXIS

2, avenue Gay-Lussac - 78851 Elancourt Cedex - Tel +33 (0) 1 34 81 60 00

SATCOM AERO-I

JETSAT PRODUCT

FCC RULES COMPLIANCE REPORT

(Part 87 Subpart D & Part 2 Subpart J)

♦ **This document includes : 28 pages**

NE 935 427 AN Issue 0

Elancourt, March 15, 2000

DOCUMENT FOLLOWUP

PROJECT :	TITRE : SATCOM AERO-I - JETSAT PRODUCT FCC RULES COMPLIANCE REPORT	REFERENCE : NE 935 427 AN Issue 0

ACTION	NAME	DATE	SIGNATURE
DRAFTED BY	M. JURQUET G.	March 2000	
APPROVED BY	M. FERRE G.		
CONTROLLED BY	M. PABOEUF P.		

RECORD OF REVISIONS

INDEX	DATE	REVISIONS	NAME
0	15 March 2000	Creation	G. JURQUET

CONTENT

1. APPLICANT

THOMSON-CSF DETEXIS
2, avenue Gay-Lussac
78851 ELANCOURT Cedex
FRANCE

Tel: 33 1 34 81 60 00
Fax: 33 1 30 66 79 66
E-Mail: gilles.jurquet@detexis.thomson-csf.com

2. PURPOSE

This technical report is a part of the application for certification of the THOMSON-CSF DETEXIS equipment JETSAT satellite receiver-transmitter operating under FCC rules 47 CFR Part 87, Subpart D and Part 2, Subpart J.

This document provides data showing that the JETSAT satellite receiver-transmitter complies with the corresponding FCC Rules and Regulations.

3. APPLICABLE AND REFERENCE DOCUMENTS

3.1 APPLICABLE DOCUMENTS

[A1] ARINC characteristic n° 761 " Second Generation Aviation Satellite Communication System, Part 1 Aircraft Installation Provisions" published September 22, 1998.

[A2] INMARSAT System Definition Manual Modules, version 1.46, September 1996.

[A3] RTCA paper DO160D "Environmental Conditions and Test Procedures", and its equivalent document :

[A4] EUROCAE ED14D "Environmental Conditions and Test Procedures for Airborne Equipment".

3.2 REFERENCE DOCUMENTS

[R1]	THOMSON-CSF DETEXIS	HLD QUALIFICATION TEST REPORT	NE878419
[R2]	THOMSON-CSF DETEXIS	SDU QUALIFICATION TEST REPORT	NE929157
[R3]	Technical Reports for INMARST Access Approval of a class 3 AERO-I AES		

4. DESCRIPTION

The JETSAT AES is a complete communication system for satellite communication in the AERO-I INMARSAT 3 satellite network, intended to provide voice and data communication services to and from aircraft. JETSAT is a small, light, and low cost system, but offering 4 voice channels and one data channel simultaneously . The radio link between the aircraft and the satellite operates in L-band (1.5 / 1.7 GHz). Voice services and high speed data services (4800 bps) operate under spot beam satellite, while Packet Mode Data Services (600 and 1200 bps) operate under spot and global beam.

The JETSAT equipment meets the RTCA DO-210C Minimum Operational Performance Standards requirements and the ARINC 761 Characteristics.

JETSAT comprises the following basic units: a mechanically steered Intermediate Gain Antenna (IGA),the High power amplifier-Low noise amplifier-Diplexer unit (HLD) and the Satellite Data Unit (SDU).

Only the HLD and SDU subsystems are concerned with the FCC equipment certification. These subsystems are available with two different main power voltage (115Vac/400Hz and 28Vdc) and with different options. Detailed description will be found in the attached Design and Performance report or in Installation and User manuals.

The Part Numbers of the JETSAT subsystems are listed in table 1. The equipment is available with two different power supplies: 115Vac/400Hz or 28Vdc.

Component	P/N (115V ac)	P/N (28V dc)	Notes
SDU	3433-500-00X	3433-500-01X	Several avionics interfaces available.
SDU / MCTU	3433-500-10X	3433-500-11X	Up to 32 digital handset capacity. Several avionics interfaces available
HLD	3433-300-000	3433-300-010	

Table 1: JETSAT AES Subsystems Part-Numbers

Note: The listed Part Numbers are hardware references, final P/N includes a software related suffix (XNN)

5. TESTS REQUIREMENT

The JETSAT equipment shall comply with FCC rules Part 87 Subpart D and Part 2 Subpart J. The following sections provide measurements or calculations proving the compliance with these FCC rules.

5.1 FCC RULES PART 87 SUBPART D COMPLIANCE

Technical requirements are as follow:

Technical Requirement	Section	Tolerance
Power and Emissions	§87.131	60 W max.
Frequency Stability	§87.133	320 Hz
Bandwidth of Emission	§87.135	25 kHz
Type of Emission	§87.137	21K0G1W
Emissions Limitations	§87.139	• Composite spurious and noise output Frequency — Attenuation .005 – 1559 MHz — 83dB 1559 – 18000 MHz — 55dB • Inter-modulation IMn rejection > 24dB • Spectrum Frequency Offset — Attenuation +/- 0.75xSR — 0 dB +/- 1.40xSR — 20 dB +/- 2.80xSR — 40 dB +/- 35 kHz — 55 dB
Modulation Requirements	§87.141	• 600 – 2400 bps — A-BPSK • 4800 bps — A-QPSK
Doppler Compensation	§87.145	The equipment provides adequate Doppler effect compensation.

5.2 FCC RULES PART 2 SUBPART J COMPLIANCE

Technical requirements are as follow:

Technical Requirement	Section	Tolerance
RF Power Output	§2.1046	60 W max.
Modulation Characteristics	§2.1047	• 600 – 2400 bps A-BPSK • 4800 bps A-QPSK
Occupied Bandwidth	§2.1049	25 kHz
Spurious Emissions at Antenna Terminals	§2.1051	Composite spurious and noise output: Frequency Attenuation .005 – 1559 MHz 83dB 1559 – 18000 MHz 55dB
Field Strength of Spurious Radiation	§2.1053	DO160D Section 21 Cat. L
Frequency Stability	§2.1055	± 320 Hz

6. MEASUREMENTS

6.1 FCC PART 87 SUBPART D

6.1.1 Power and Emissions [§87.131]

INMARSAT Access Approval Tests: PL7_02 and PL7_03.

The linear output power of the JETSAT (output of the HLD subsystem) is, by design, limited to less than 11 Watts. The maximum EIRP will not exceed 17.5 dBW per carrier.

Furthermore, the AES monitors the output power of the high power RF amplifier (HPA). An HPA output power sharing algorithm is implemented to ensure that the maximum linear operating output power is not exceeded.

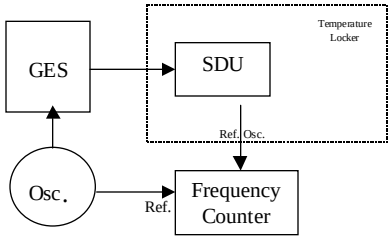
The tolerance for an Aircraft Earth Station is pY < 60 Watts.

CONCLUSION: JETSAT is compliant with the requirement.

6.1.2 Frequency Stability [§87.133]

INMARSAT Access Approval Tests: PL7_07.

Test Set-up:



Procedure:

The GES transmit a P-channel. The SDU is set to receive and lock on to the channel. The frequency counter shows the frequency of the reference oscillator on the SDU. The test temperature is ranging from –25°C to +70°C.

The reference oscillator frequency has to lead to a max. error on the transmitted frequency of ±320 Hz. This frequency is generated from the reference oscillator in the SDU. The max. error on this reference frequency can be derived:

Error on Ref. Osc. = (Tolerance/Transmit Freq.)x Ref.Osc.Freq.

Error on Ref. Osc. = (±320 Hz / 1643.5MHz)x16.8MHz = ±3.3 Hz

Results:

Temperature (°C)	**-25**	**25**	**70**
Frequency Error (Hz)	0.9	1	~0

Moreover, the measured frequency from the Tx output of the SDU is within ±120Hz, whatever the temperature and the selected output channel.

Conclusion:

The frequency error is about a third of the allowed error. A 120 hour stability test is not necessary as the SDU corrects the reference frequency every time a frame lock is obtained on a received P-Channel.

The equipment is compliant.

6.1.3 Bandwidth of Emission [§87.135]

The authorized bandwidth for the AES type of emission is ± 12.5kHz. The occupied bandwidth is the width of frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are equal to 0.5% of the total mean power of a given emission.

From figure 5 to 7, we can derive the following results:

Emission	**Occupied bandwidth**
BPSK, 600 bps	± 0.7 kHz
BPSK, 1200 bps	± 1.4 kHz
QPSK, 8400 bps	± 7.1 kHz

Conclusion: Equipment is compliant with the requirement.

6.1.4 Type of Emission [§87.137]

The AES transmit telephony, facsimile, PC-modem and packet-mode data information.

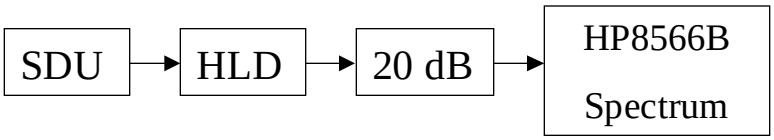
Therefore, the Emission Designator of the AES is **21K0G1W**.

6.1.5 Emissions Limitations [§87.139]

INMARSAT Access Approval Tests: PL7_05, PL7_06 and PL7_09.

- **Composite Spurious and Noise Output**

Test Set-up:



Procedure:

The spurious measurement in the frequency range 0 to 17 GHz, are carried out in the following sub-bands:

- 100 kHz – 1000 MHz
- 1000 MHz – 2900 MHz
- fc ± 100 kHz
- 2.9 GHz – 16.9 GHz

The output power is set-up at the maximum available linear output power.

Results:

For convenience, plots are provided at ambient temperature, with the carrier frequency in the middle of the band.

No harmonics, spurious or noise is above line specifications: see figures 1 to 4.

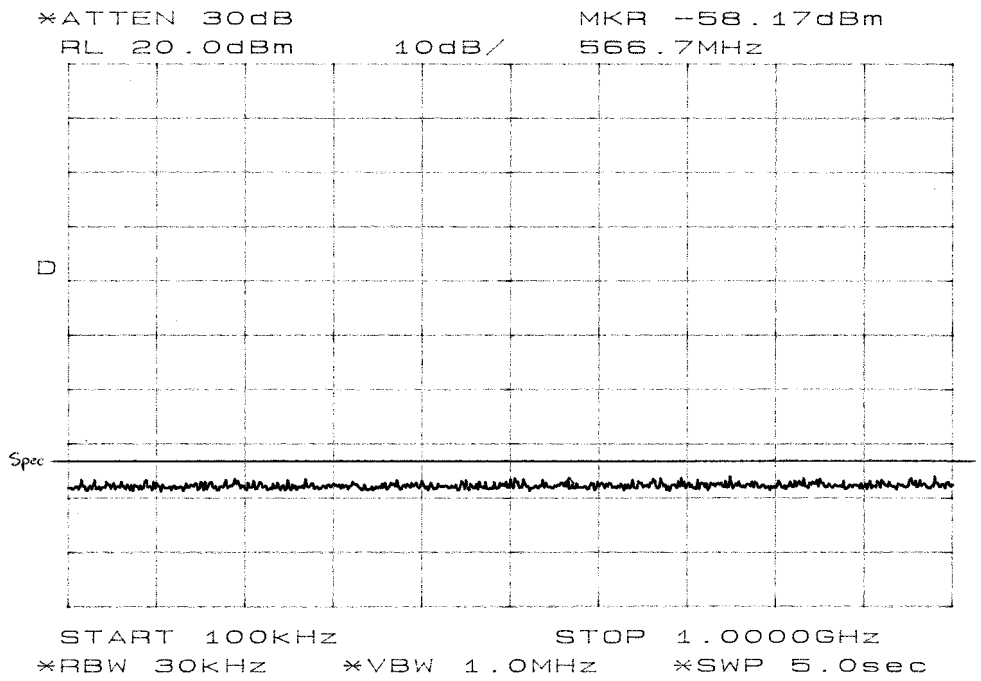


Figure 1: Spurious Emissions at Antenna Terminal (100 kHz to 1 GHz)

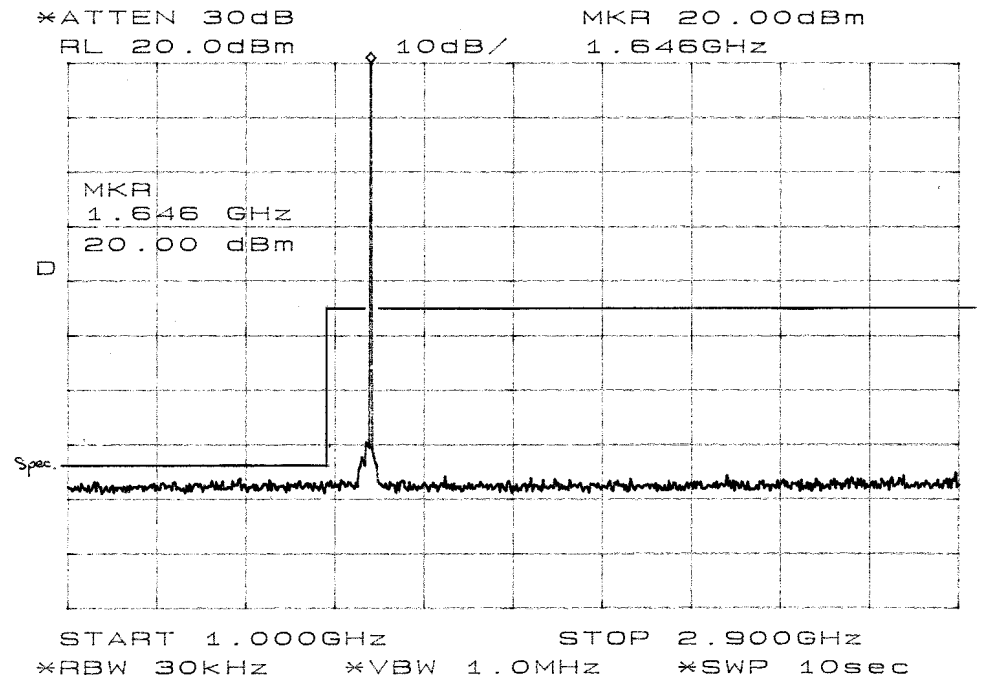


Figure 2: Spurious Emissions at Antenna Terminal (1 GHz to 2.9 GHz)

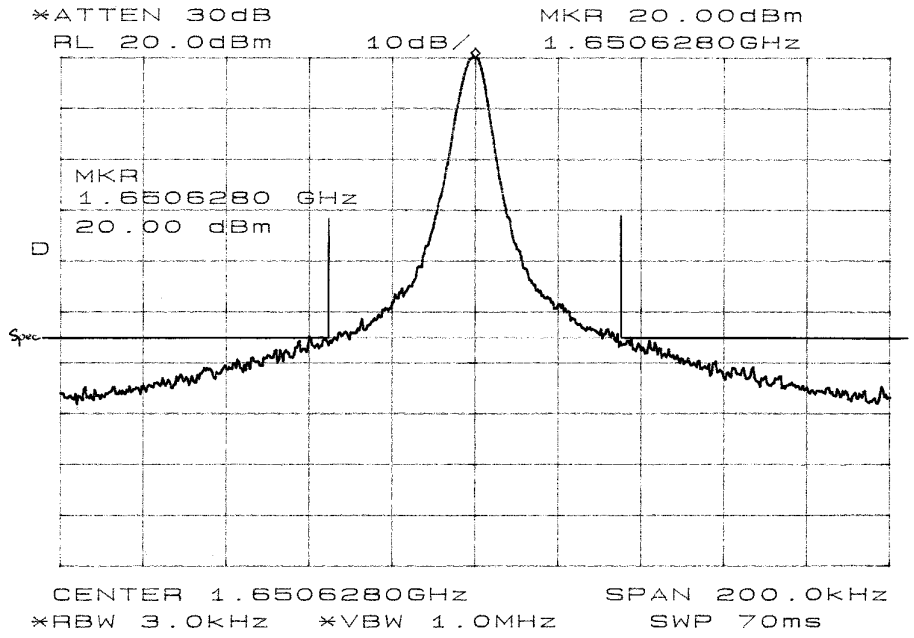


Figure 3: Spurious Emissions at Antenna Terminal (Fc ± 100 kHz)

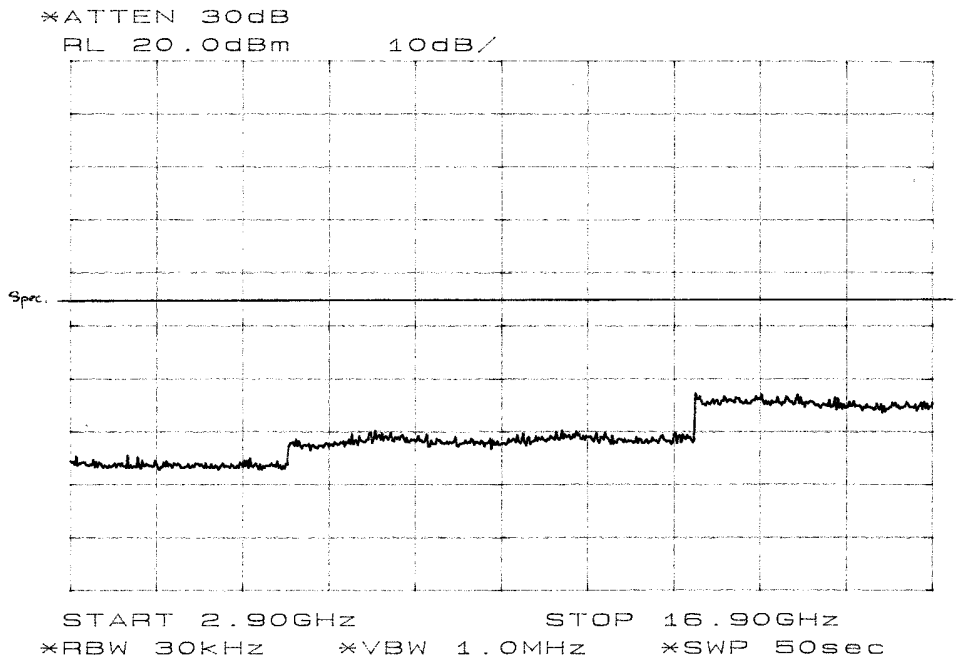


Figure 4: Spurious Emissions at Antenna Terminal (2.9 GHz to 16.9 GHz)

Conclusion:

The equipment is compliant with the requirement.

- **Inter-Modulation**

Procedure:

Two unmodulated carriers are transmitted with three different spacing (10, 100 and 1000 kHz) and with a total EIRP equal to the AES maximum allowable operating EIRP. The EIRP of each IM3 product shall be at least 24 dB below the EIRP of each carrier.

Equipment used:

- Spectrum Analyzer: HP8566B
- Power Meter: HP436A
- Synthesizer: HP8625A and Marconi 2041
- Thermal Chamber: SAPRATIN

Results:

HLD P/N 3433-300-000

S/N 5

			IM3 level (dBc)		
F1(MHz)	**F2(MHz)**	**Delta F(kHz)**	**-15°C**	**25°C**	**55°C**
1626.50	1626.51	10	27.8	25	25
1626.50	1626.60	100	26.1	25	25
1626.50	1627.50	1000	28	25	25
1660.49	1660.50	10	26.8	25	24.8
1660.40	1660.50	100	26	25	28
1659.50	1660.50	1000	27	25	24.5

Max. IM 3 level: 24.5 dBc

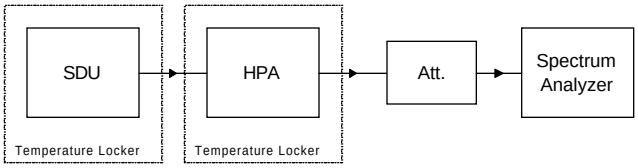
Requirement: <24 dBc

Conclusion:

The AES is compliant with the HPA linearity specification.

- **Per-Carrier Transmit Spectrum**

Test Set-up:



Procedure:

Control the IQ balance to be correct. The resolution band wide of the spectrum analyzer is set lower or equal 0.1 symbol rate. Set up an R/T channel to transmit random signal at 600 bps. Control the spectrum to be within the in table A given limit. Repeat the test with an R/T data rate of 1200 bps.

Repeat the test with the C channel and control the spectrum to be within the in table B given limit.

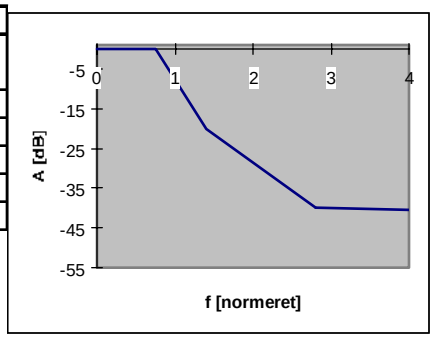
The transmitted spectrums are controlled with both the SDU and the HPA over temperature.

The test is done with a hard limit made to the data signal. This hard limit makes sure there is no amplitude modulation on the data signal, which could be converted into phase modulation and disturb the transmitted data.

(INMARSAT SDM module 2, section 3.6.5)

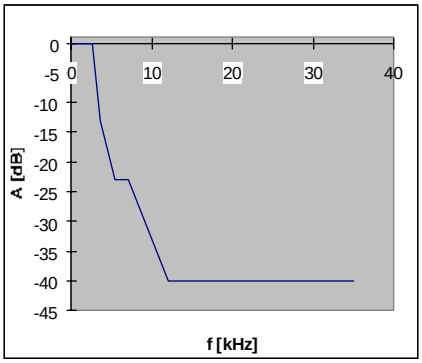
A-BPSK og A-Opsk med 100 % roll off filter	
freq.normalized to channel symbolrate	Attenuation relativ to max envelope level
0	0
0.75	0
1.405	-20
2.8	-40
35 kHz	-55

Table A



8.4 kbit A-QPSK med 60 % roll off filter	
freq.normalized to channel symbolrate	Attenuation relativ to max envelope level
0	0
2.6	0
3.5	-13
5.3	-23
7.1	-23
12	-40
35	-40

Table B



Results:

The print of these tests shows that the modulated spectrum is within the limits specified for the transmitter. It could be also shown that the transmitted spectrum does not change according to the temperature of the SDU or the HPA. Because of this, there can be no worst case combination of temperature of the SDU and HPA, which can lead to an unacceptable transmitted spectrum.

For convenience, we report hereafter the plots of channels modulated with three different data rate (600, 1200 and 8400 bps) at 25°C ambient temperature: see figures 5 to 7.

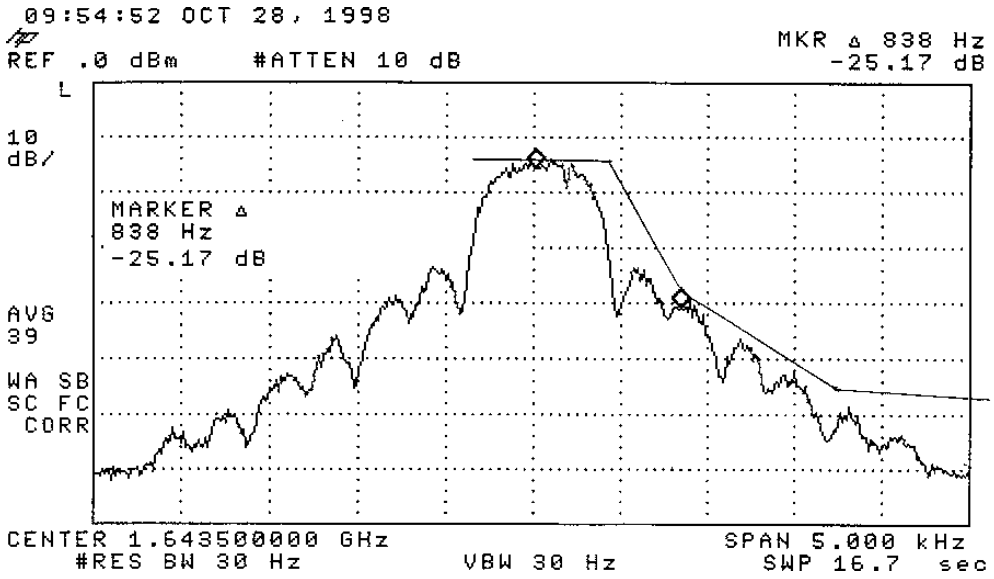


Figure 5: Transmit Spectrum - Channel R/T - 600 bps

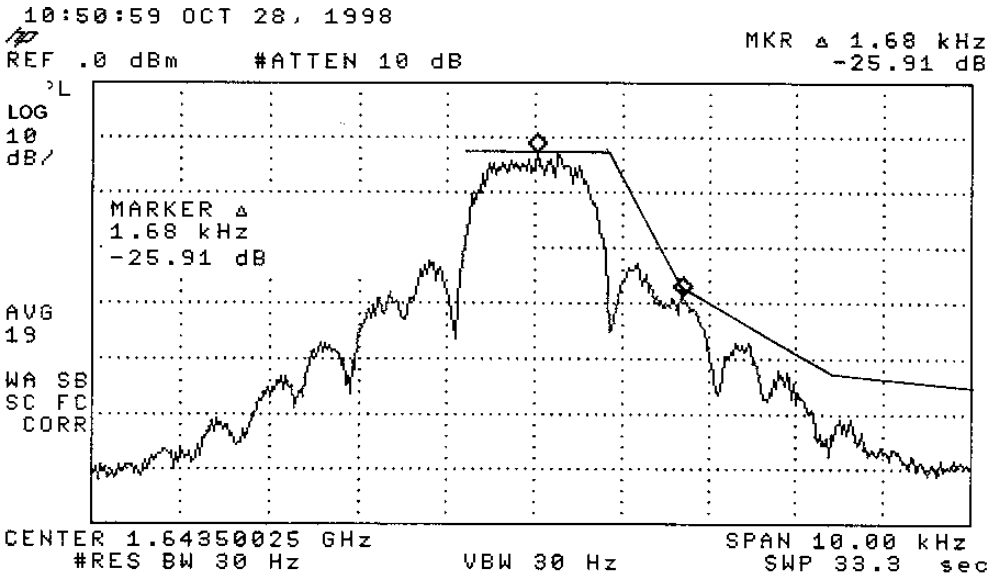


Figure 6: Transmit Spectrum - Channel R/T - 1200 bps

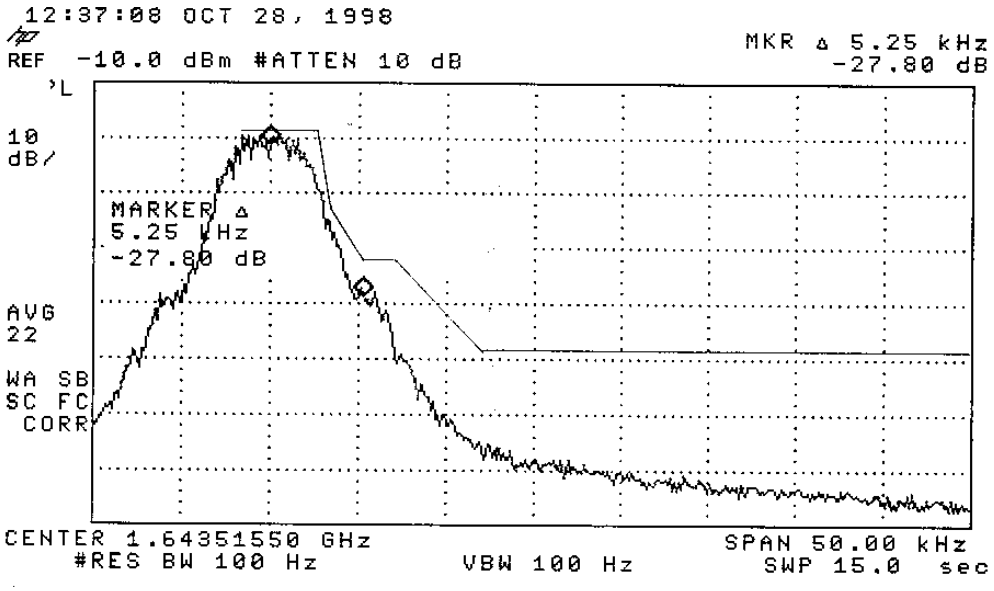


Figure 7: Transmit Spectrum - Channel C - 8400 bps

Conclusion:

The transmitter complies with the requirements to the transmitted spectrum for all data rates and over temperature.

6.1.6 Modulation Requirements [§87.141]

A-BPSK and A-QPSK modulation are implemented in the AES.

Test Set-up:

A spectrum Analyzer (HP 8566B) is used to verify that the phase definition of the modulated signal is as required.

Procedure:

- A-QPSK: a C-Channel board is set to transmit a sine signal. The IQ balance is measured directly on the output of the IQ mixer.
- A-BPSK: a R/T Channel is set to transmit a 600 Hz signal. The IQ balance is measured directly on the output of the IQ mixer.

The attenuation of the lower side band is controlled. The unbalance on the I and Q amplitudes have to be within $\pm$ 0.2dB. This could alone lead to a mirror product level of –38.7 dB refereed to the intended signal. The phase balance between the I and Q signals have to be correct within $\pm$3°. This could alone lead to a mirror product level of –31.5 dB refereed to the intended signal.

The toughest requirements is then set by the amplitude error. If the mirror product is below –38.7 dB of the intended signal, it is sure that both the amplitude error and the phase error is below the limit. It is then not necessary to measure the part coming from the phase error and the part coming from the amplitude error.

Results:

Temperature (°C)	**-25**	**25**	**70**
Rejection (dB) A-BPSK	45.7	42.3	56.9
Rejection (dB) A-QPSK	44.6	43.2	54.9

Conclusion:

The attenuation of the lower side band is within the specified limits. The I/Q implementation complies with the requirements.

6.1.7 Doppler Compensation [§87.145 (d)]

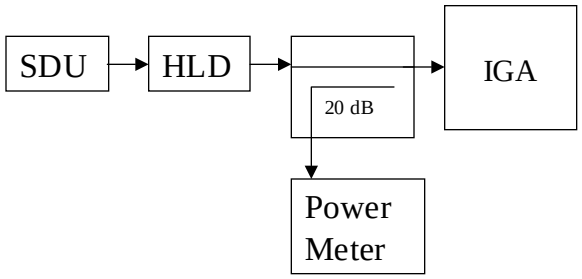
The frequency of all transmitted signals are corrected for Doppler frequency shifts caused by the relative motions of the aircraft and the satellite (for subsonic aircraft, the maximum adjustment due to aircraft velocity alone is approximately ± 2kHz).

Due to all causes, the total error of the transmitted frequency received at the satellite does not exceed 383 Hz (root-sum-square contribution of the various AES frequency error terms).

6.2 FCC PART 2 SUBPART J

6.2.1 RF Power Output [§2.1046]

Test Set-up:



Procedure:

The system is set to output a theoretical EIRP of 13.5 dBW. The output power is measured at the antenna port of the HLD, for different antenna steering commands and at the highest, lowest and central frequencies. The equivalent measured EIRP is calculated with corresponding antenna gain and cable losses.

Results:

Antenna Elevation (°)	**5**	**15**	**30**
EIRP (dBW) at 1626.5 MHz	13.24	13.3	13.1
EIRP (dBW) at 1643 MHz	13.62	13.55	13.4
EIRP (dBW) at 1660.5 MHz	13.4	13.5	13.25

The maximum variation compared to the expected EIRP of 13.5 dBW is –0.4 / +0.12 dB.

Conclusion:

The AES is able to adjust its output power at the requirement of the GES with an accuracy better than 0.5dB.

6.2.2 Modulation Characteristics [§2.1047]

See § 6.1.6

6.2.3 Occupied Bandwidth [§2.1049]

See § 6.1.3

6.2.4 Spurious Emissions at Antenna Terminal [§2.1051]

See § 6.1.5

6.2.5 Field Strength of Spurious Radiation [§2.1053]

The following results are extracted from the JETSAT SDU and HLD Qualification Test Reports (R1 and R2) and according to section 21 " Emission of Non-Essential Energy at RadioElectric Frequencies " – Category L of RTCA DO-160D.

Test Set-up:

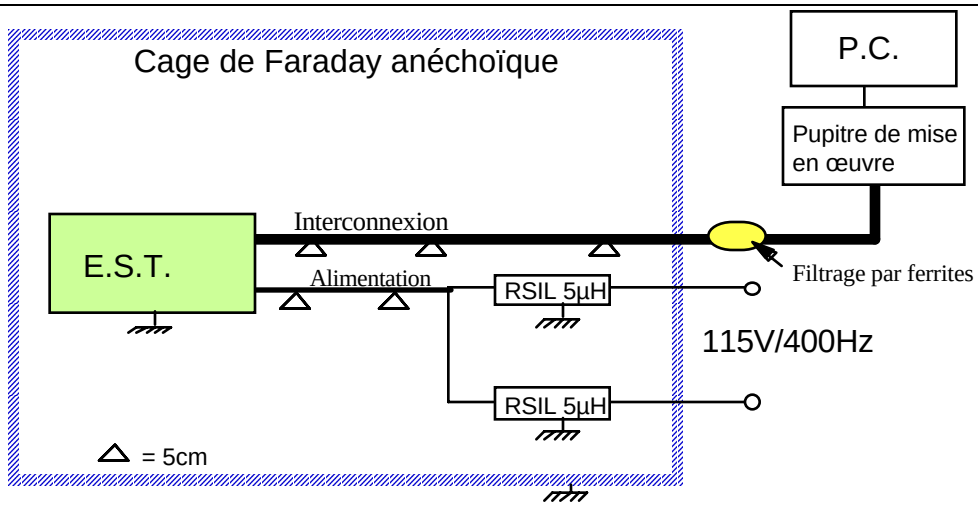


Figure 8: Facility block diagram

List of test equipment:

The measurements are taken in a SIEMENS anechoic Faraday cage under the conditions detailed in the test report.

The attenuation performance of the Faraday cage and its filters are as follows:

- 70 dB at 10 kHz,
- >100 dB from 200 kHz to 35 GHz.

The attenuation performance levels of the EMERSON and CUMING materials are as follows:

- 10 dB at 45 MHz,
- 20 dB at 100 MHz,
- 33 dB at 200 MHz,
- 53 dB at 1000 MHz,
- 73 dB at 10000 MHz.

The measuring instruments used in Thomson CSF Detexis EMC laboratory, for performing the test covered in this document, are listed in the following table:

EQUIPMENT	MANUFACTURER	MODEL	Frequencies
Active whip antenna	R & S	HFH2-Z6	9 kHz 30 MHz
Biconical antenna	EMCO	3109	20 MHz 300 MHz
Computer	HEWLETT PACKARD	9000s.300	N/A
EMI software 85869A Opt 830	HEWLETT PACKARD	Rev.A.02.01	N/A
Faradized anechoic chamber	SIEMENS	N/A	35 GHz
LISN - 5 µH	Dassault Électronique	804556000-1	N/A
LISN - 5 µH	Dassault Électronique	804556000-2	N/A
Log-spiral conical antenna	EMCO	3102	1 GHz 10 GHz
Log-spiral conical antenna	EATON	93490-1	200 MHz 1 GHz
Power supply for active antenna	R & S	HZ-9	N/A
Preselector	HEWLETT PACKARD	85685A	20 Hz 2 GHz
Spectrum analyzer	HEWLETT PACKARD	8566B	100 Hz 22 GHz

Procedure:

The tests were carried out under the conditions specified in standard **DO160D Section 21**: "**Emission of Non-Essential Energy at RadioElectric Frequencies** "

Results:

- **SDU**

The recorded values are shown in figures 9, 10 and 11.

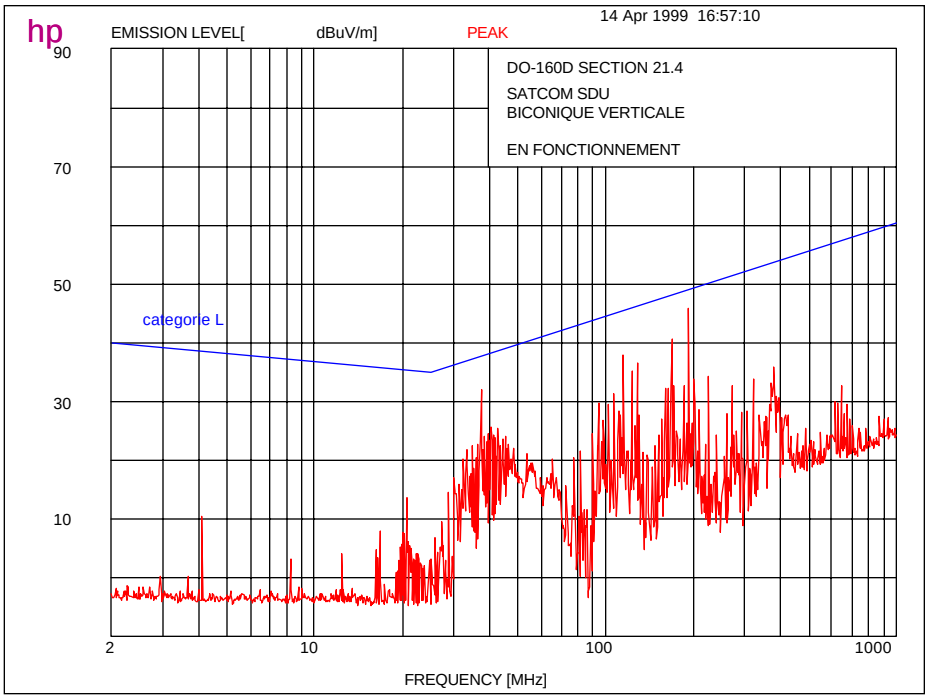


Figure 9: Radiated interference (vertical polarization: 30 MHz to 200 MHz).

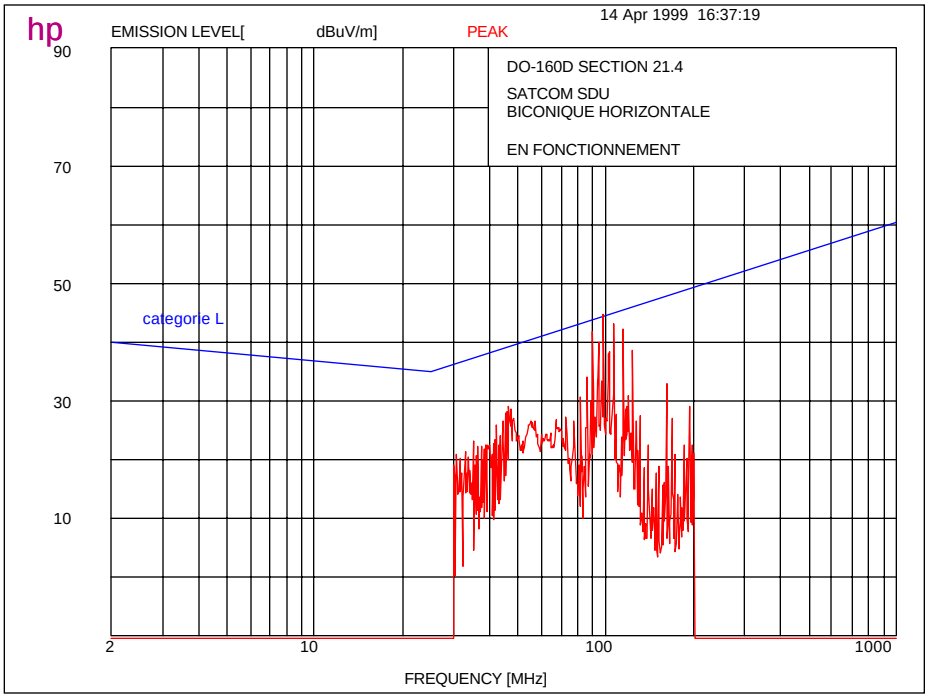


Figure 10: Radiated interference (horizontal polarization: 30 MHz to 200 MHz).

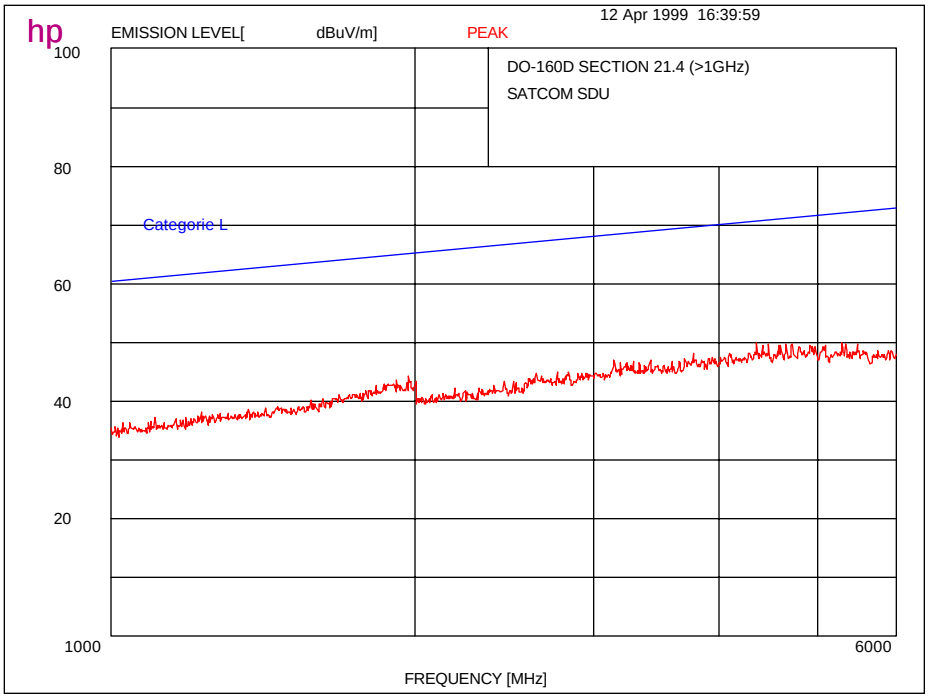


Figure 11: Radiated RF Interference.

- **HLD**

The recorded values are shown in figures 12 to 17. Worst polarization is shown.

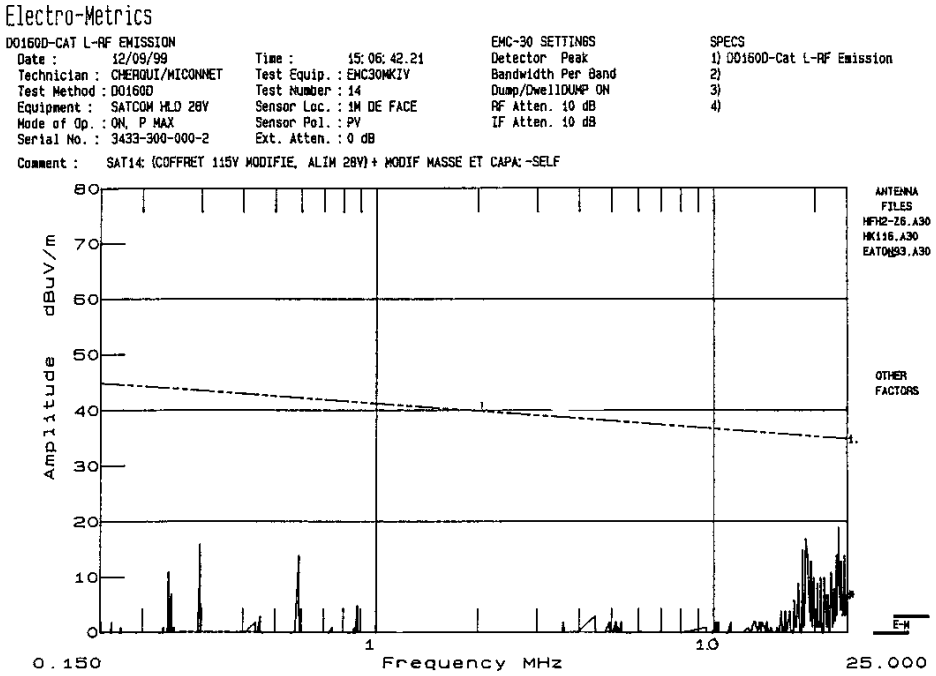


Figure 12: Radiated interference (150 kHz to 25 MHz).

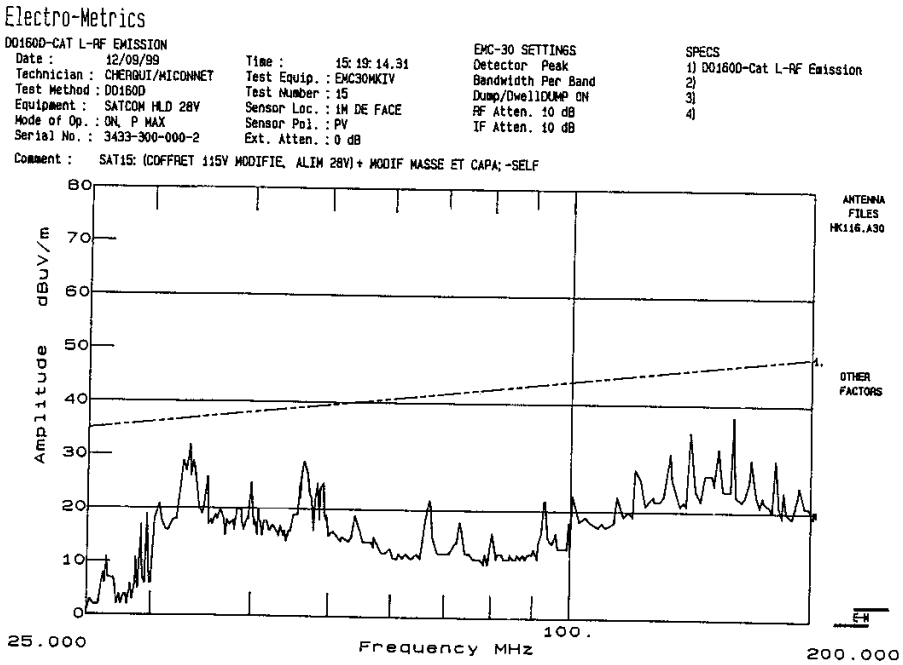


Figure 13: Radiated interference (vertical polarization: 25 MHz to 200 MHz).

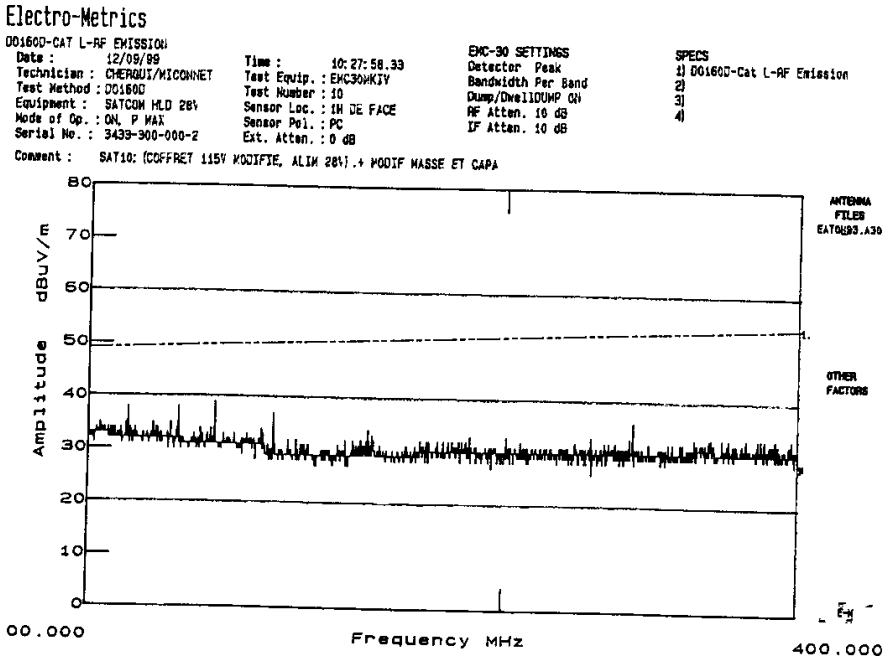


Figure 14: Radiated interference (200 MHz to 400 MHz).

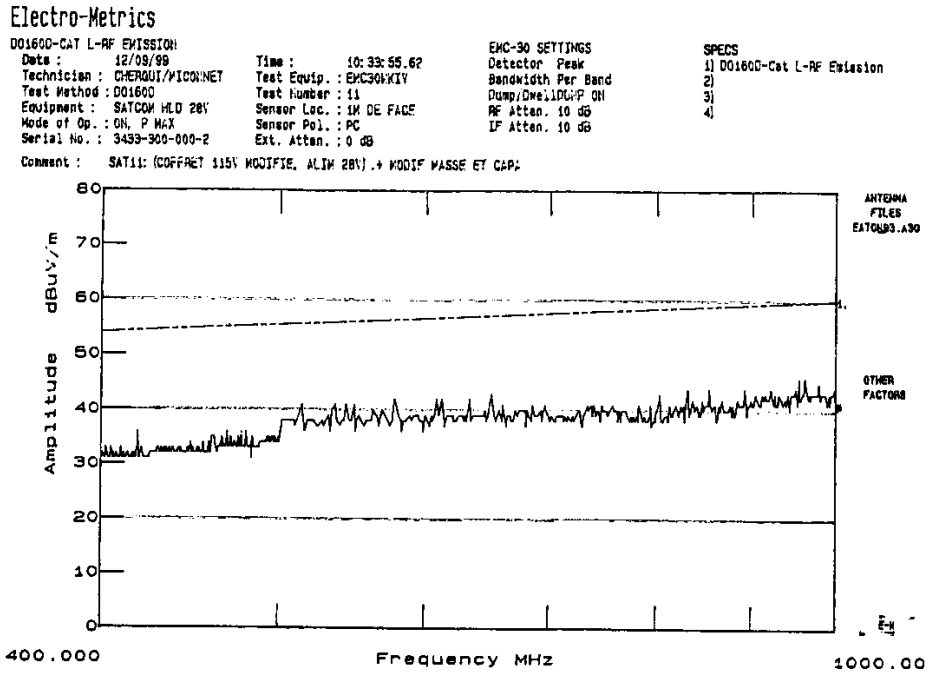


Figure 15: Radiated interference (400 MHz to 1000 MHz).

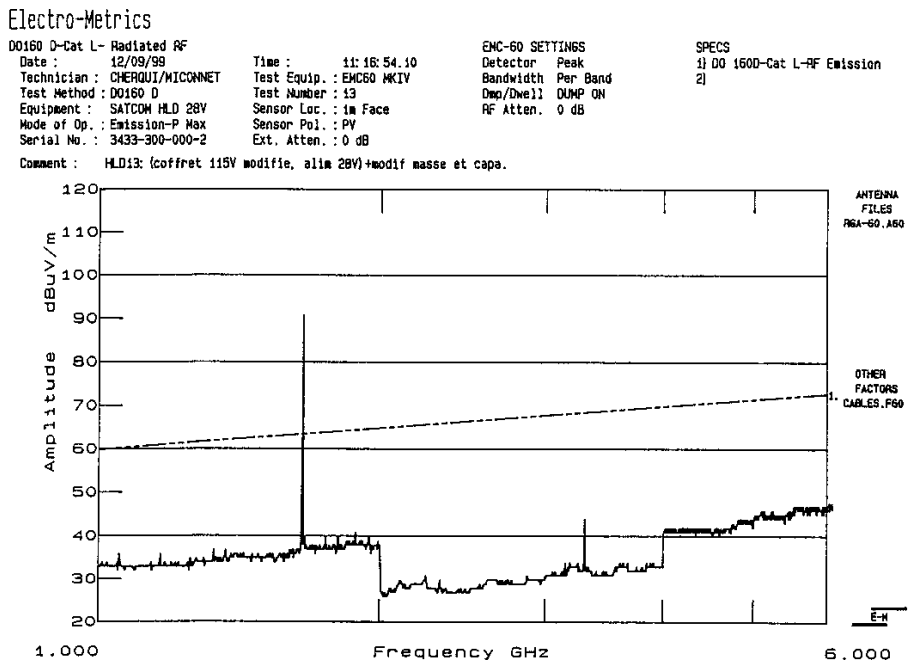


Figure 16: Radiated interference (vertical polarization: 1 GHz to 6 GHz).

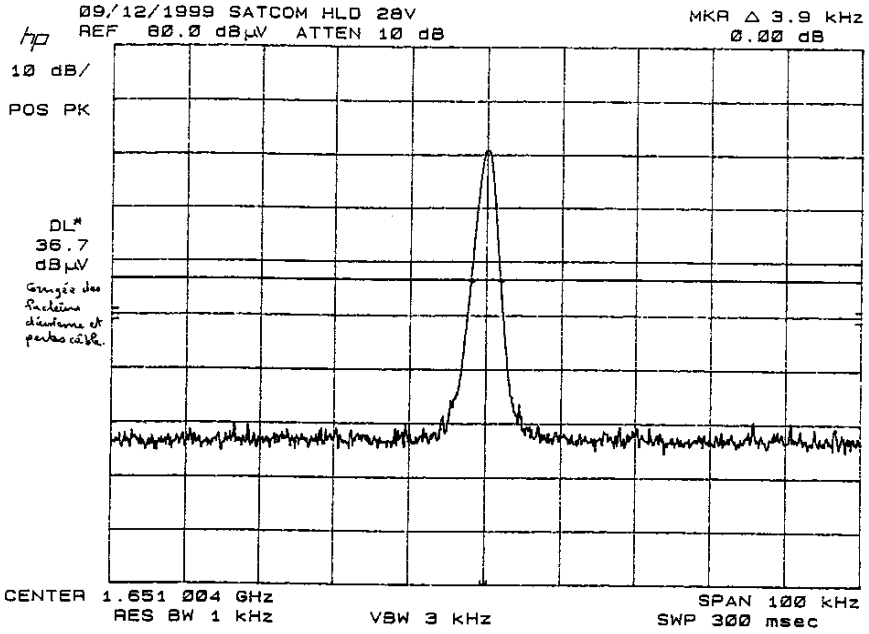


Figure 17: Radiated interference (spectrum around the carrier).

Conclusion:

The levels of the radiated emissions of the SDU and HLD comply with the limits set forth in standard DO160D (section 21.4, category L).

The equipment is compliant with the requirement.

6.2.6 Frequency Stability [§2.1055]

See § 6.1.2

7. CONCLUSION

LIST OF COMPLIANCY

FCC Rule	Characteristics	See §	Comment
Part 87 Subpart D	Power and Emissions	6.1.1	Compliant
Part 2 Subpart J	RF Power Output	6.2.1	Compliant
Part 87 Subpart D / Part 2 Subpart J	Frequency Stability	6.1.2 / 6.2.6	Compliant
Part 87 Subpart D / Part 2 Subpart J	Bandwidth of Emission	6.1.3 / 6.2.3	Compliant
Part 87 Subpart D	Type of Emission	6.1.4	No Comment
Part 87 Subpart D / Part 2 Subpart J	Emissions Limitations	6.1.5 / 6.2.4	Compliant
Part 87 Subpart D / Part 2 Subpart J	Modulation Requirements	6.1.6 / 6.2.2	Compliant
Part 87 Subpart D	Doppler Compensation	6.1.7	Compliant
Part 2 Subpart J	Field Strength of Spurious Radiation	6.2.5	Compliant

All the results obtained with the JETSAT system are compliant with the requirements.

CONCLUSION: The JETSAT satellite receiver-transmitter is compliant with FCC Rules.