TEST REPORT

Evaluation of the

THALES ULTIMATE FLO DIGITAL TRANSMITTER:
TDU2 1K00 LC
TDU2 1K50 LC
TDU2 2K10 LC
TDU2 3K10 LC
TDU2 4K20 LC
TDU2 4K70 LC
TDU2 5K20 LC
TDU2 6K30 LC
TDU2 7K20 LC
TDU2 8K20 LC
TDU2 9K20 LC
TDU2 10K20 LC

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1.0 INTRODUCTION

FCC Section 2.901 (a) (b), 2.902 (a) (b), 2.907 (a) (b), 2.908, 2.911, 2.913 (c), 2.924

This report contains all the required data for certification of Thales ULTIMATE FLO digital transmitter. In accordance with section 2.924 "Marketing of electrically identical equipment having multiple trade names and models or type numbers under the same FCC Identifier", Thales wishes to certify its ULTIMATE FLO transmitter family comprised of several models of identical construction. The models vary in number of identical parallel amplifiers dependent on the RF output power of the particular model, also in redundancy schemes for power supplies. The equipment's operating power range is scalable between 1000-10200W average RMS power. The RF output filter is designed for compliance of a 5200W transmitter. The 10200W transmitter is constituted of two 5200W cabinets. The data presented was taken from tests performed on a production transmitter system model TDU2 5K20 LC having a 5200W maximum rated output power, tuned to operate on a fixed 719MHz (6MHz BW) channel. All products perform identical to the DUT herein, within section 2.908 limits. Other information required for certification, such as circuit diagrams and descriptions, photographs, tune-up and maintenance procedures, and the technical manual are separately enclosed.

2.0 TEST EQUIPMENT

FCC Section 2.947 (d)

The following is a list of major test equipment, which was used in testing the transmitter for this report:

1.	Spectrum Analyzer(s)	Agilent E4411B Agilent 77405Au
2.	Power Meter	Agilent E4418B
3.	Network Analyzer	Hewlett Packard HP 8720 C / MAURY 8850C25
4.	Frequency Counter	RACAL DANA 1992

3.0 MEASUREMENTS

FCC Section 2.947(b) (c), 2.1033 (c)(14)

3.1 RF POWER OUTPUT

FCC Section 2.1046 (a) (c)

Average Output Power (before RF output filter): **5200 watts**

Method of Measurement: Per FCC 2.1046 (a) (c)

The transmitter was operated into a dummy load of substantially zero reactance with a resistance equal to the transmission line characteristic impedance. Average power was indirectly measured using an Agilent E4418B rms power meter by means of a directional coupler which coupling factor was previously determined.

Figure 1 shows the test setup

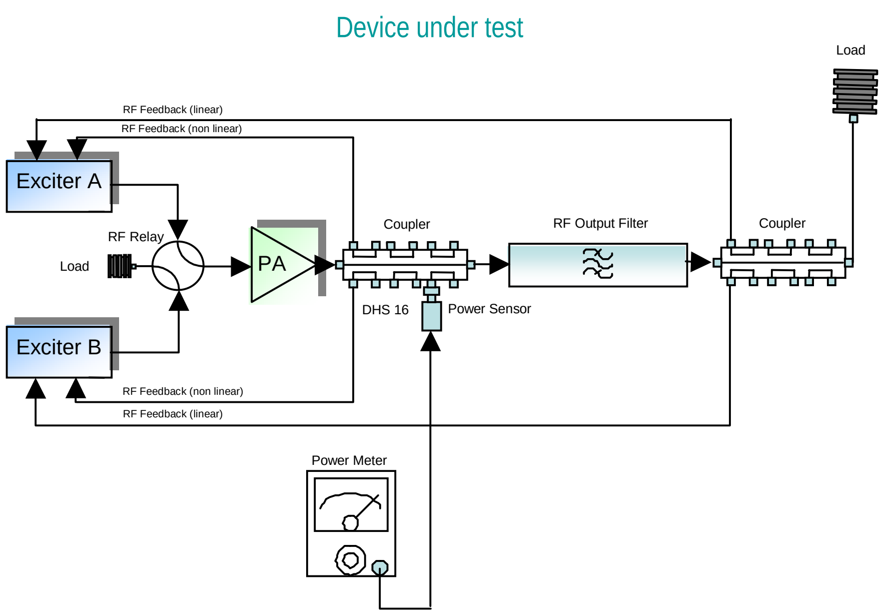


Figure 1: Test setup for RF power output measurement.

Result: :

Table 1 shows the test result.

Power level (dBm) @ DHS 16 =	13,94
Coupling value (dB) @ DHS 16 =	53,22
RF output power (dBm) =	67,16
RF output power (W) =	5200

Table 1: RF power output measurement.

3.2 OCCUPIED BANDWIDTH / EMISSIONS

FCC Section 2.1049 (h), 2.202 (a), 2.1047, 27.53 (f)

Occupied bandwidth:

Method of Measurement:

The transmitter is operated at maximum output power, while connected to the spectrum analyzer as shown in Figure 2 below.

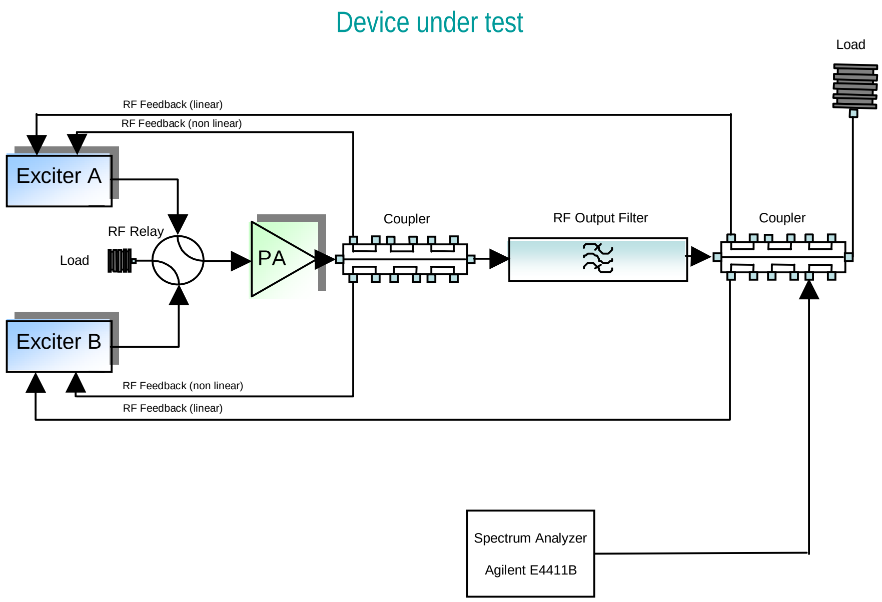
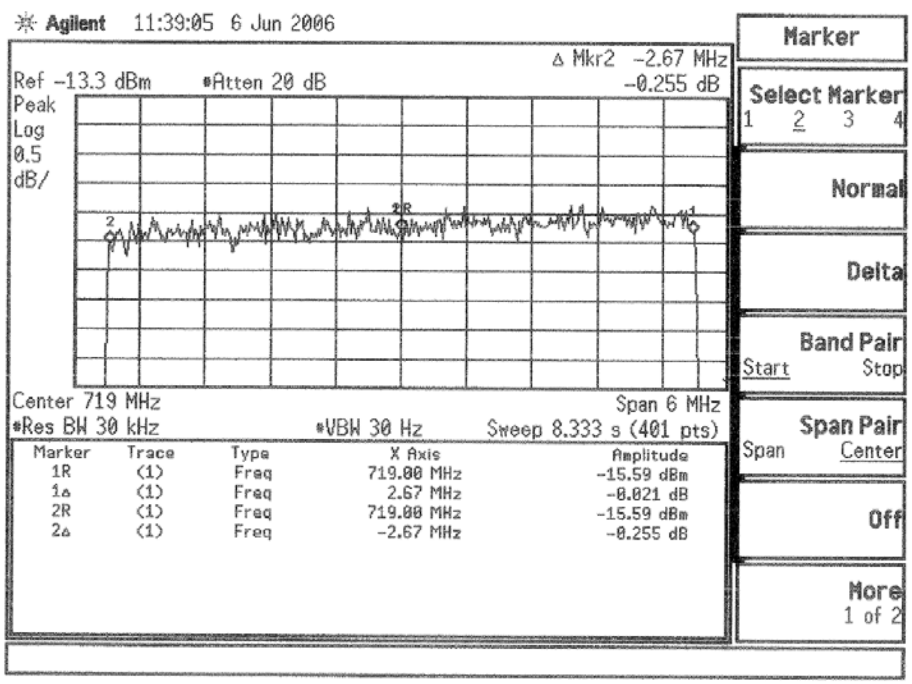


Figure 2: Test setup for occupied bandwidth analysis

Average Output Power:	5200 watts
Type Modulation:	FLO modulation
Spectrum Analyzer setting:	
Frequency Span:	0.6 MHz per division
Center Frequency:	719MHz
Resolution Bandwidth:	30 KHz
Video Bandwidth:	30Hz
Scale:	0,5 dB per division

The in-band occupied bandwidth is recorded in the following spectral Plot 1, which shows a 5.34MHz BW effective for the FLO channel.



Plot 1 Channel occupied bandwidth of the FLO transmitter.

Emissions:

Method of Measurement:

The following measurement demonstrates the occupied bandwidth as related to the emissions of the FLO signal at the RF output filter at the maximum rated average power. Emissions compliance is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or less, but at least one percent of the emission bandwidth of the fundamental emission of the transmitter, provided the measured energy is integrated over a 1 MHz bandwidth. The signal meets the requirements wherein the power of any emission outside the 716-722MHz band of operation shall be attenuated below the transmitter power (P) by at least 43+ 10 log (P) dB in accordance to section 27.53 of the FCC rules.

The measurement method presented, evaluates the out-of-band emissions by comparing the power spectral density (PSD) of the channel with the PSD of the two most adjacent 1MHz slots. Note that the two immediate adjacent 1MHz slots are the most critical and present the most difficulty for compliance with commission regulations in section 27.53. Therefore these are the focus of the plots that show out of band emissions.

- First step is to determine the power of the channel [716-722MHz] and of the adjacent 1MHz slots [715-716MHz and 722-723MHz] before the RF output filter. This step uses the spectrum analyzer and its channel power feature.
- Second step is to capture punctual attenuation data of the filter in 10KHz increments throughout the same frequency interval [715-723MHz], using a Network Analyzer. The instrument will generate a table of attenuation values automatically. The attenuation data is then mathematically processed in order to achieve integrated values, both for the 6MHz channel and adjacent 1MHz slots.
- Third step is to apply integrated attenuation numbers of step two to respective PSD numbers of step one.
- Fourth and last step is to compose two relations: one with the resulting PSD’s of the 6MHz channel against the lower frequency 1MHz slot, and the other with the same 6MHz channel frequency against the higher 1MHz slot.

The setup for conducting emissions limits tests is shown in Figure 3:

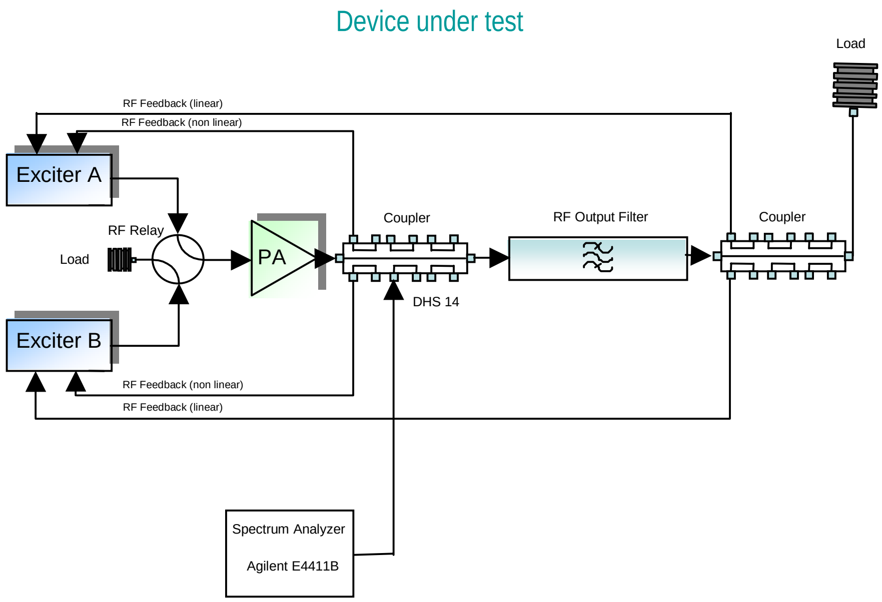
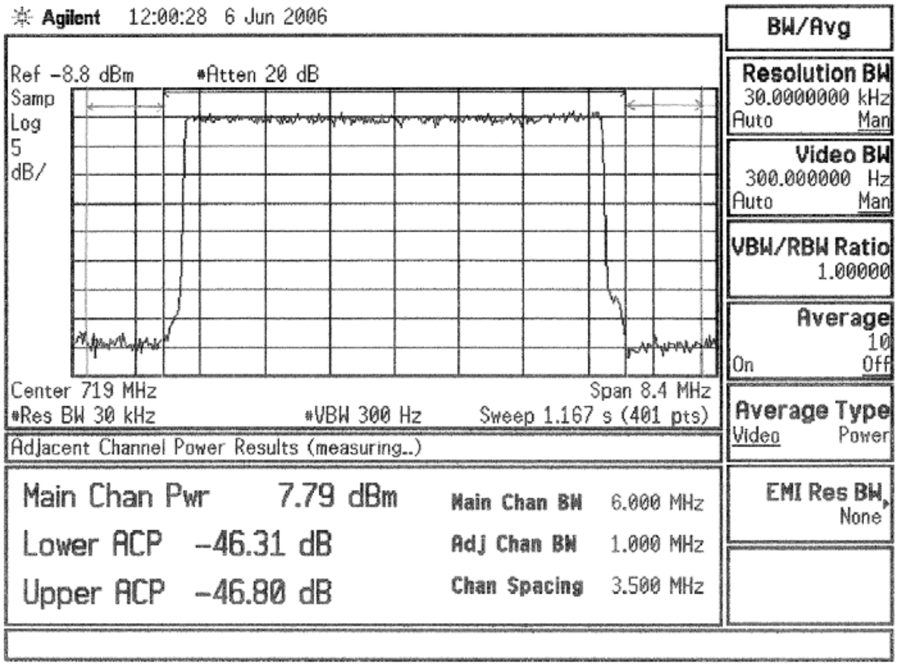


Figure 3: Test setup for out-of-band emissions measurement

<u>First step:</u>

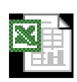
1) Spectrum Analyzer measurements
   a) Proper input attenuation to accept 719MHz signal from directional coupler before the channel filter.
   b) Record of CHANNEL POWER at 719MHz center frequency and 6MHz bandwidth
   c) Record of CHANNEL POWER at 715.5MHz center frequency and 1MHz bandwidth
   d) Record of CHANNEL POWER at 722.5MHz center frequency and 1MHz bandwidth

Refer to Plot 2 below, which shows the direct measurement of the signal in each case.



Plot 2 Occupied bandwidth of the FLO transmitter.

<u>Second step:</u>
2) Using a network analyzer the filter response data is recorded. The data is taken in 10kHz intervals, which is directly logged in a file from the network analyzer output. This file is attached as ANNEX A.



Data_Filter_719_MHz_Part27.xls

ANNEX A

The recorded data is then transferred to the EXCEL WORKSHEET below, where the following numerical integration process is applied:

$$\frac{1}{f_2 - f_1} \sum_{i=1}^{n-1} (f_{i+1} - f_i) \left(\frac{\left(10^{\frac{Att_{i+1}}{10}} + 10^{\frac{Att_i}{10}}\right)}{2} \right)$$

Where:

f_1 = Low frequency limit of integration
f_2 = High frequency limit of integration
n = $(f_2 - f_1)$ /10kHz
f_i = f_1 +10kHz, f_1+20kHz, f_1+30kHz … $f2$,
Att_i = Attenuation relative to f_i

Mask_Filter_719MHz
_Part27.xls

EXCEL WORKSHEET

Note: Example of worksheet is shown below, to access actual spreadsheet data see link to excel file above.

See notes in cells

B1 or B3

Do Not Change this Column Frequency (MHz)	**Paste Filter Characteri** Filter Transfer Function (dB)	Do Not Change this	Do Not Change this	Do Not Change this	Do Not Change this Filter Integrated Rejection at Lower 1MHz adjacent Slots (dB).	Do Not Change this Filter Integrated Rejection at Higher 1MHz adjacent Slots (dB).	Do Not Change this Filter Integrated In-Band Insertion Loss (dB).
715	-59.15	1.215E-06			56.4	59.9	0.7374009
715.01	-59.17	1.211E-06	1.213E-08	2.274E-06			
715.02	-59.22	1.198E-06	1.204E-08				

The resulting outputs from the spreadsheet provide the integrated rejection of the RF output filter for the high and low 1MHz adjacent slots 59,9dB and 56,4dB respectively, as well as, the integrated in-band insertion loss of 0.737dB. These values will be used in our final calculations for out of band emissions.

Figure 4 illustrates the filter response reproduced from the network analyzers data file. It is shown as a reference only.

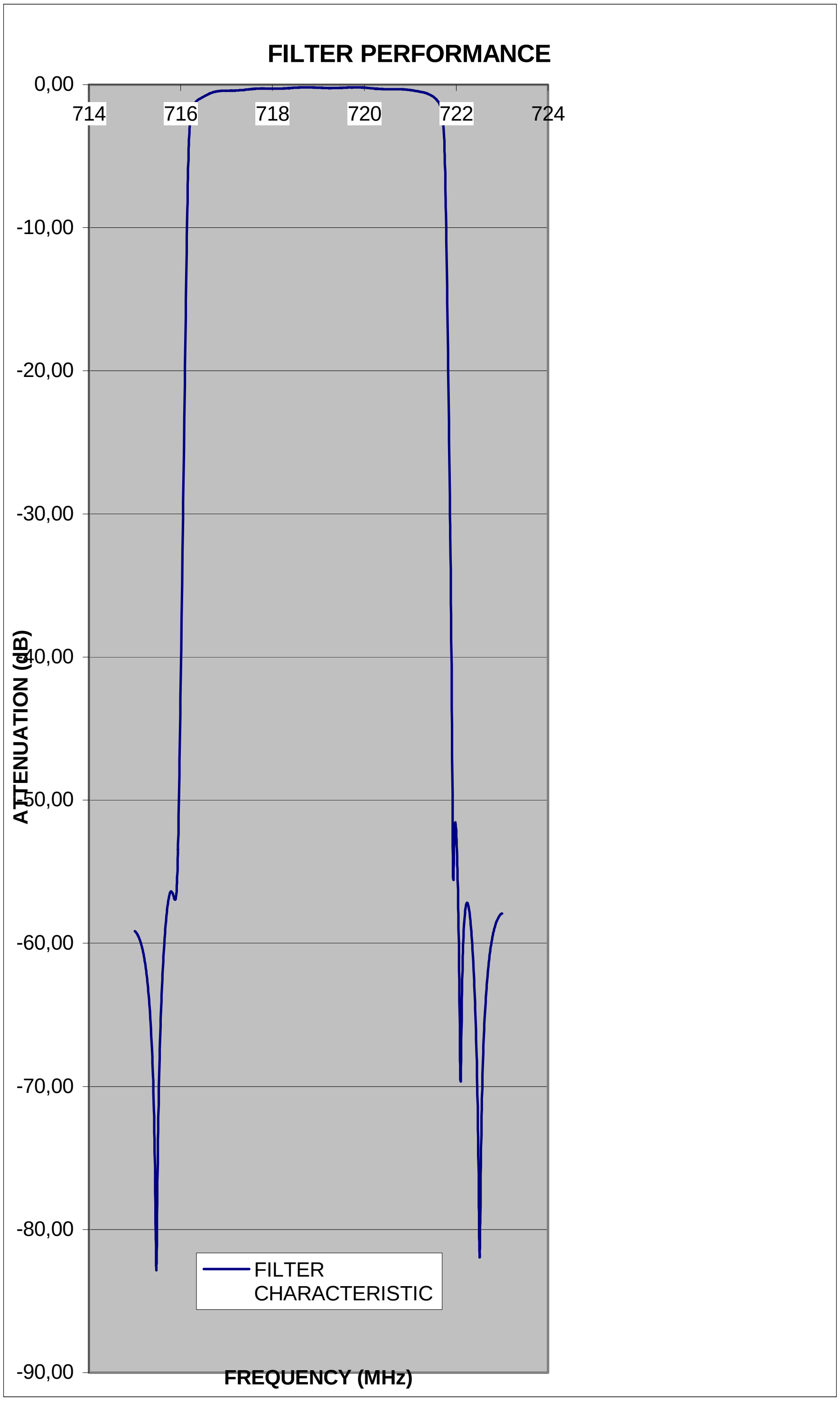


Figure 4 Filter response plot derived from worksheet data

Third step:
3) The filter's integrated rejection or loss from the previous step is applied to the transmitter's output signal shown in Plot 2.

a) The 716-722MHz channel PSD, recorded as 7,79 dBm is attenuated by the integrated in-band filter loss of 0.74 dB; yielding: 7,79 dBm – 0.74 dB = 7,05 dBm ***(Channel power)***

b) The lower adjacent 1MHz slot, recorded as –46,31 dBm is attenuated by the integrated rejection of the filter 56.4 dB; yielding: –46,31 dBm – 56,4 dB = -102,71 dBm ***(Power in 1MHz lower adjacent)***

c) The upper adjacent 1MHz slot, recorded as –46,80 dBm is attenuated by the integrated rejection of the filter dB; yielding: –46,80 dBm – 59,9 dB = -106,70 dBm ***(Power in 1MHz upper adjacent)***

Fourth step:
4) To extract the final result for the upper and lower 1MHz slot rejection the following method is applied.

a) Channel power – power in 1MHz lower adjacent = lower side rejection ratio
7,05 dBm – (-102,71 dBm) = 109,76 dB

b) Channel power – power in 1MHz upper adjacent = upper side rejection ratio
7,05 dBm – (-106,70 dBm) = 113,75 dB

Applying the method as described in section 27.53 of the FCC rules for a 5200W transmitter, which represents the device under test we obtain:

5200W transmitter:
43 + 10 log (5200) = 80.160 dB

Comparing this result.

Lower side rejection ratio – FCC limit = low side margin
109,76 dB - 80.16 dB = 29,60 dB

Upper side rejection ratio – FCC limit = high side margin
113,75 dB - 80.16 dB = 33,59 dB

The method described above is employed because of dynamic range limitation of current analyzers (most of them will not have more than 60dB dynamic range, not including the noise floor effect), a direct comparison between the channel power and the 1MHz adjacent slots is not always feasible. The method presented here evaluates the out-of-band emissions using a numerical integration process coupled with a direct measurement of the channel power and adjacent slots.

This method of measurement also minimizes the spill over caused by the resolution bandwidth filter within the instrument, which can cause the adjacent power measured to be greater then the real power due to this effect, and consequently introduce error into the actual out of band rejection measurement.

In conclusion, the results show compliance with out of band emissions limits set forth by the commission with enough margins to ensure long term stability.

3.3 SPURIOUS EMISSIONS AT ANTENNA TERMINALS

FCC Section 2.1051/2.1057 (a)(1) (b) (c)

Method of Measurement:

The setup for conducting the spurious emissions test is shown in Figure 5.

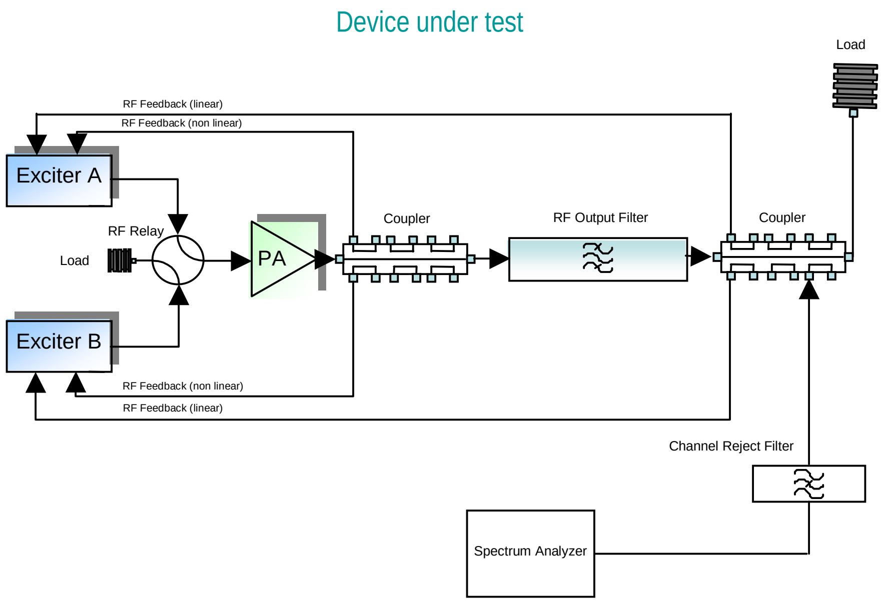


Figure 5: Test setup for spurious emissions measurement

Average Output Power:	5200 watts
Type Modulation:	FLO
Spectrum Analyzer Setting:	
Frequency Span:	10 MHz per Division
Center Frequency:	Adjusted continuously for 10 MHz to 3 GHz
Resolution Bandwidth:	100 KHz
Video Bandwidth:	30kHz
Video Filter:	Out
Input Attenuator Setting:	Input level was set for a full-scale calibration of the average digital power. All other frequencies were referenced to this point.
Spurious Emissions:	See chart; measured values account for coupler curve.

The results of this measurement can be seen in Table 2.

Frequency (MHz)		Measured Level (dBm)	Note	Losses (dB) (Channel Band Reject + Measurement Cables + Coupler)	True Level (dBm)	Amplitude (dBc)
719,00	Carrier Reference	-8	Without channel band reject	56	48,00	Reference
746,50	Local oscillator	-91 (Noise floor)		56	-35,00	83,00
1438,00	2nd Harmonic	-91 (Noise floor)	With channel band reject	52,1	-38,90	86,90
2157,00	3rd Harmonic	-91 (Noise floor)		54,5	-36,50	84,50
2876,00	4th Harmonic	-91 (Noise floor)		53,8	-37,20	85,20
3595,00	5th Harmonic	-91 (Noise floor)		48,5	-42,50	90,50
4314,00	6th Harmonic	-91 (Noise floor)		55,1	-35,90	83,90
5033,00	7th Harmonic	-91 (Noise floor)		56,4	-34,60	82,60
5752,00	8th Harmonic	-91 (Noise floor)		57	-34,00	82,00
6471,00	9th Harmonic	-91 (Noise floor)		58	-33,00	81,00
7190,00	10th Harmonic	-91 (Noise floor)		58,4	-32,60	80,60

Table 2 Spurious emissions.

No other spurious emissions detected.

3.4 FIELD STRENGTH OF SPURIOUS RADIATION

FCC Section 2.1053, 2.1057 (a)(1) (b) (c)

Method of Measurement:

The setup for conducting radiated emissions test is shown in Figure 6. The transmitter is operated at full rated power into a 50-ohm terminating load, while an antenna connected to the spectrum analyzer is used to measure radiated emissions at a distance of 3-meters away from the transmitter on all sides. The receiving antenna is a set to measure each of the following internally generated frequencies: intermediate frequency(s), local oscillator(s), carrier frequency, and 2nd and 3rd harmonics of the FLO transmitter.

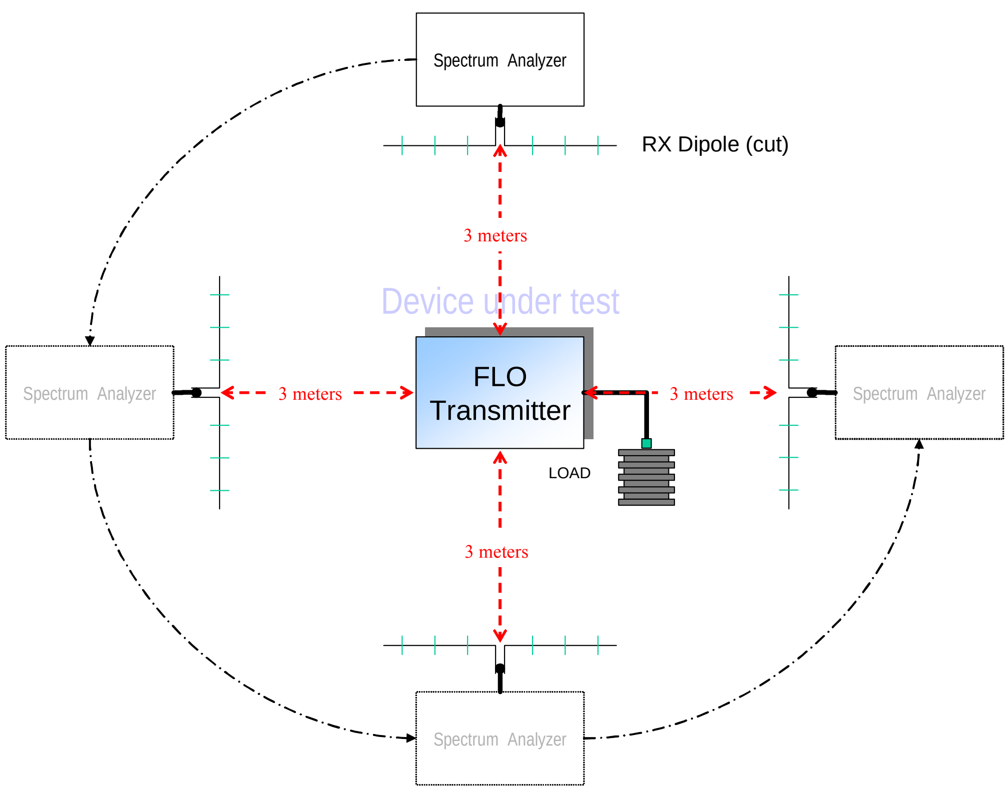


Figure 6: Test setup for radiated emissions measurement

Average Output Power: 5200 Watts

Type Modulation: FLO

Spectrum Analyzer Settings: A spectrum analyzer used to measure the spurious emissions at a distance of 3 meters from the transmitter was set as follows:

Reference Level:	AUTO
Attenuation:	10 dB
Frequency Span:	AUTO
Center Frequency:	AUTO
Resolution Bandwidth:	100 kHz
Video Bandwidth:	300 kHz
Video Average:	AUTO

Absolute power of the spurious radiation was measured on a spectrum analyzer at a distance of 3 meters from the transmitter. The radiation was received with a log periodic antenna for frequency < 1 GHz and a horn antenna for frequency > 1 GHz and measured as an absolute power level; therefore, all measurements include the antennas gains. The relative levels of the received spurious signals were calculated with respect to the absolute power level of the transmitter's output received with a log periodic antenna and a horn antenna at 3 meters. The received power level was calculated as shown:

	Parameter	Value	Units
Data Input			
System Parameters	Antenna feed loss	0	dB
	Operating Frequency	719	MHz
	Transmit Antenna Gain	0	dBi
	Transmitter Output Power	67.16	dBm
	Receive Antenna Gain	0	dBi
Link Parameters	Link Distance	0.003	Km
Constants	Speed of light	3.00E+08	m/s
Link Calculation			
Transmitted ERP Calculation	Transmitted Signal Power	67.16	dBm
	Antenna Feed Loss	0	dB
	TX Antenna Gain	0	dB
	Effective Radiated Power(ERP)	67.16	dBm
Path Loss Calculation	Link Frequency	719	MHz
	Link Distance	0.003	Km
	Path Loss *(for line of sight with no fade)*	-39.12	dB
Received Power Calculation	Receiver Antenna Gain	0	dBi
	Antenna Feed Loss	0	dB
	Received Signal Power	28.04	dBm
	Received Signal Electric Field	160.24	dBµV/m

The measurement results are depicted in Table 3.

Spurious Radiation:
The following measurements of radiation were taken and are given in terms of absolute and relative dBµV/m to the average digital signal power.

	Absolute Received (dBµV/m)	Relative to Level (dB)
719 MHz	160.24	Reference
1438 MHz	53.24	107
2157 MHz	45	115.24
2876 MHz	52	108.24
3595 MHz	42.5	117.7
4314 MHz	42	118.24
5033 MHz	40	120.24
5752 MHz	41	119.24
6471 MHz	41.5	118.74
7190 MHz	42.5	117.7

Table 3 Spurious Products/Harmonics Field Measurements.

5200W transmitter:

Max Spurious Radiation relative to level is 107 dB

10200W transmitter:
Regarding this result.

For 10200W transmitter , two 5200W transmitters are used.
With the resulting spurious both 5200 W transmitters in phase, the relative to level is reduced to 101 dB.

3.5 FREQUENCY STABILITY

FCC Section 2.1055 (a) (3) (b)(c)(d), 27.54

Method of Measurement:

Frequency Stability over Temperature:

The unit was place inside a temperature chamber to control the ambient temperature; each measurement was recorded after approx 1 hour at each temperature interval.
The unit was phase-locked to a GPS receiver source (10MHz and 1PPS) like in normal operation mode.

The measured results are recorded in Table 4

Temperature (C)	Modulator I.F.		Local Oscillator		Total channel Error (Hz)
	Frequency (Hz)	Error (Hz)	Frequency (Hz)	Error (Hz)	
+25	27 500 000	0	746 500 000	0	0
0	27 500 000	0	746 500 000	0	0
+10	27 500 000	0	746 500 000	0	0
+20	27 500 000	0	746 500 000	0	0
+30	27 500 000	0	746 500 000	0	0
+40	27 500 000	0	746 500 000	0	0
+50	27 500 000	0	746 500 000	0	0

Table 4 Frequency stability measured over temperature -30° to +50°C.

Frequency Stability over AC Input Voltage:

The error due to AC line variation was measured while the unit is place inside a temperature chamber at 25°C. The unit was phase-locked to a GPS receiver source (10MHz and 1PPS) like in normal operation mode.

Table 5 shows the measured results.

AC Line (V)	Modulator I.F.		Local Oscillator		Total channel Error (Hz)
	Frequency (Hz)	Error (Hz)	Frequency (Hz)	Error (Hz)	
90	27 500 000	0	746 500 000	0	0
95	27 500 000	0	746 500 000	0	0
100	27 500 000	0	746 500 000	0	0
105	27 500 000	0	746 500 000	0	0
110	27 500 000	0	746 500 000	0	0
115	27 500 000	0	746 500 000	0	0
120	27 500 000	0	746 500 000	0	0
125	27 500 000	0	746 500 000	0	0
130	27 500 000	0	746 500 000	0	0
135	27 500 000	0	746 500 000	0	0
140	27 500 000	0	746 500 000	0	0
145	27 500 000	0	746 500 000	0	0
150	27 500 000	0	746 500 000	0	0
155	27 500 000	0	746 500 000	0	0
160	27 500 000	0	746 500 000	0	0
165	27 500 000	0	746 500 000	0	0
170	27 500 000	0	746 500 000	0	0
175	27 500 000	0	746 500 000	0	0
180	27 500 000	0	746 500 000	0	0
185	27 500 000	0	746 500 000	0	0
190	27 500 000	0	746 500 000	0	0
195	27 500 000	0	746 500 000	0	0
200	27 500 000	0	746 500 000	0	0
205	27 500 000	0	746 500 000	0	0
210	27 500 000	0	746 500 000	0	0
215	27 500 000	0	746 500 000	0	0
220	27 500 000	0	746 500 000	0	0
225	27 500 000	0	746 500 000	0	0
230	27 500 000	0	746 500 000	0	0
235	27 500 000	0	746 500 000	0	0
240	27 500 000	0	746 500 000	0	0
245	27 500 000	0	746 500 000	0	0
250	27 500 000	0	746 500 000	0	0
255	27 500 000	0	746 500 000	0	0
260	27 500 000	0	746 500 000	0	0
265	27 500 000	0	746 500 000	0	0
270	27 500 000	0	746 500 000	0	0
275	27 500 000	0	746 500 000	0	0
280	27 500 000	0	746 500 000	0	0

Table 5 Frequency stability measured over AC input voltage 90 to 280VAC

4.0 SUMMARY

This report demonstrates that the ULTIMATE FLO digital television transmitter meets or exceeds the FCC certification criteria.

- The occupied bandwidth conforms to the required emissions limits of 27.53 wherein the power of any emission outside the 719MHz band of operation shall be attenuated below the transmitter power (P) by at least 43+ 10 log (P) dB.
- Measurement of spurious emissions at the RF output revealed no emissions above –80,16 dBc.
- Frequency stability tests of the synthesizer and modulator over variations in temperature or input AC line voltage showed no frequency shit.