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# Amplification Chain Used On UHF Transmitter

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*Abstract :* - In this paper, we describe the UHF transmitter amplification chain of the satellite engineering model communication subsystem, part of Alsat-1 project. To be able to deliver a power of 10W to the transmit antenna, with an input signal of 5dBm delivered by the UHF VCO, an amplification chain is required. The chain is constituted by the driver, intermediate and high power amplifiers. For a good efficiency, the last stage should work in class C, therefore the CPFSK modulated signal is not affected by the amplifier non linearities. The first and the second stages work in class A and AB respectively. Laboratory test results are given mentioning the performance of the amplifiers.

*Key-Words*: - UHF, Transmitter, CPFSK, Modulator, Amplification chain, performance.

## 1 Introduction

The UHF transmitter is constituted by the FSK modulator, synthesiser, VCO, power supply unit, band pass filter and the amplification chain (figure N°1) [1]-[4]. The FSK modulator is used to deliver several data rate to be used for data transmission in FSK format (9K6, 38K4, and 76K8). The FSK data is then transmitted to the VCO to be modulated by the frequency synthesiser. The transmitter frequency is delivered from a UHF synthesiser. A separate low level output of the VCO is compared in phase with the crystal reference, and produces en error voltage. This is filtered using two-pole low pass filter, before it is applied to the control input VCO.

The VCO provides a voltage controlled UHF frequency source, which can be frequency modulated. It is phase locked using the synthesiser module, and drives the amplification chain. The power supply unit provides a redundant, linear, regulated +5V and +9V supply from the nominal 14V satellite bus, delivered to the synthesiser and VCO units respectively.

The band Pass Filter is designed to provide harmonic rejection for the transmitter, as well as good rejection in the receiver frequency band (VHF band).

## 2 Amplification chain

### 2.1 Driver Amplifier

The Driver Amplifier is a small signal amplifier used on the Microsatellite UHF transmitter modules at Surrey Satellite Technology Limited (UK). It is used to raise the output signal from the synthesiser to a nominal 200 mW level. The output of the amplifier is used to feed an intermediate amplifier [7].

The driver amplifier produces an output of up to 0.4 Watt from the output of the attenuator. The output of this PCB is used to feed an intermediate amplifier. The amplifier can accommodate frequencies of 400 - 435 MHz with suitable matching components fitted to the RF path.

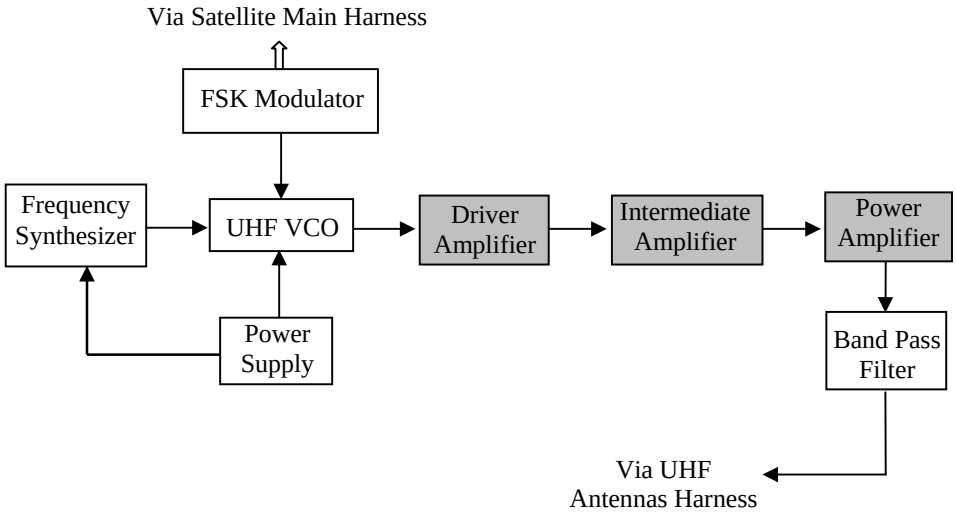


Fig.1 UHF Transmitter Block Diagramm

### 2.2 UHF Intermediate Amplifier

The intermediate amplifier circuit provides a nominal 2W output form the driver amplifier. The circuit is built on a double sided PCB with a cut provided to allow the RF transistor to be mounted directly to the Tx box chassis., to ensures a good thermal path. The intermediate amplifier is a class AB. Ferrite beads are used to ensure low frequency stability. The output of this PCB is used to feed a high power amplifier [5].

### 2.3 UHF High Power Amplifier

The high power amplifier (HPA) is used to raise the nominal 2W from the intermediate amplifier output to 10W. This signal is fed via transmit filter and switch to the antenna matching harness.

The HPA is operating in the range of 400-435 MHz. The circuit uses standard microstrip design techniques and was built on a low dielectric constant fiberglass board. Microstrip techniques were chosen as they offer a lower loss solution to matching sections than the use of the alternative equivalent lumped elements. This amplifier is biased into class C operation by grounding the base via an RF choke with a ferrite bead for stability at lower frequencies [6].

## 3 Amplifiers Test And Alignment

The process of setting the return loss and gain for the amplifiers is an iterative process requiring patience.

Adjustments made on the output circuit will feed back to the input and vice versa, improvement in one parameter will often be made at the expense of another. It is important therefore, to check that the performance of both gain and return loss at regular intervals. The input power should then be reduced to the lowest drive level and results recorded between this level and full power and the results plotted with the aid of the spreadsheet program.

The output signal must be inspected with a spectrum analyser to ensure that there is no signs of instability or parasitic oscillation.

The results should then be repeated for power supply settings of +12.5 Volts and +11 Volts, once again ensuring that their is no sign of instability.

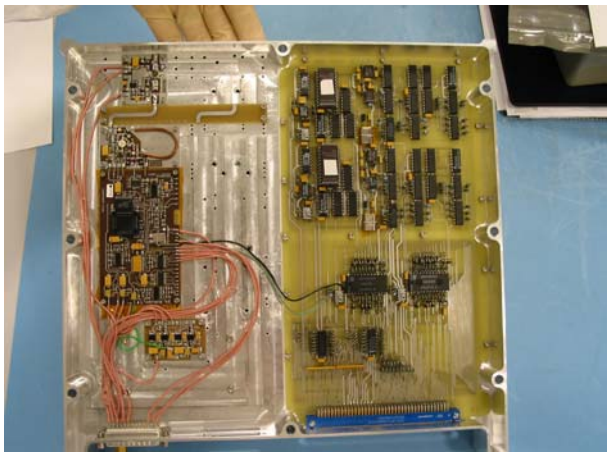

Fig.2 UHF transmitter assembly module engineering model

# 4 Test Results

## 4.1 Initial Power Supply Check and Setting of DC Bias

The conclusion of the bias currents for the initial power supply check (on the 14V line) are :

- 5mA for the driver amplifier
- 25mA for the intermediate amplifier
- 970mA for the high power amplifier.

## 4.2 Amplifiers Test and Alignment

### 4.2.1 Driver Amplifier

- Nominal input power : 4 mW (6.02dBm)
- Nominal output power: 172 mW (22.37dBm)
- Gain: 16
- Input cable loss: 1dB
- Output cable loss: 0.3dB.

Depending on the voltage supply, the gain is nearly constant over output power range (0-0.2 W)
The power efficiency is little bit constant versus voltage supply. It is equal to 24% at 0.2W output power at 14V power supply.

### 4.2.2 Intermediate Amplifier

- Power supply current is limited to 500 mA.
- Nominal input level 80 mW.
- Nominal output power: 2.5W
- Gain: 15
- Input cable loss: 1dB
- Output cable loss: 0.3dB.

Same results is recorded, the gain is nearly constant over output power range (0-0.3Watts)
The power efficiency is little bit constant versus voltage supply. Power efficiency is equal to 50% for 2W output power at 14V supply.

### 4.2.3 High Power Amplifier

- Nominal input power : 2W
- Nominal output power: 10W
- Gain: 7
- The amplifier (in house) is used to drive the HPA has a gain about 45.
- Losses due of equipment : 0.32dB RF cables, 0.74dB Coupler cable, 0.42 dB coupler loss, 29.7dB Coupler line.

For input power = 1.8W, the output power is 9.6 W, the gain is then 7.1, Ic= 960mA. The DC voltage is 14V.
Efficiency = 68.94%, Power add efficiency = 55%, Return loss = 32.35-14.33=18.22dB.

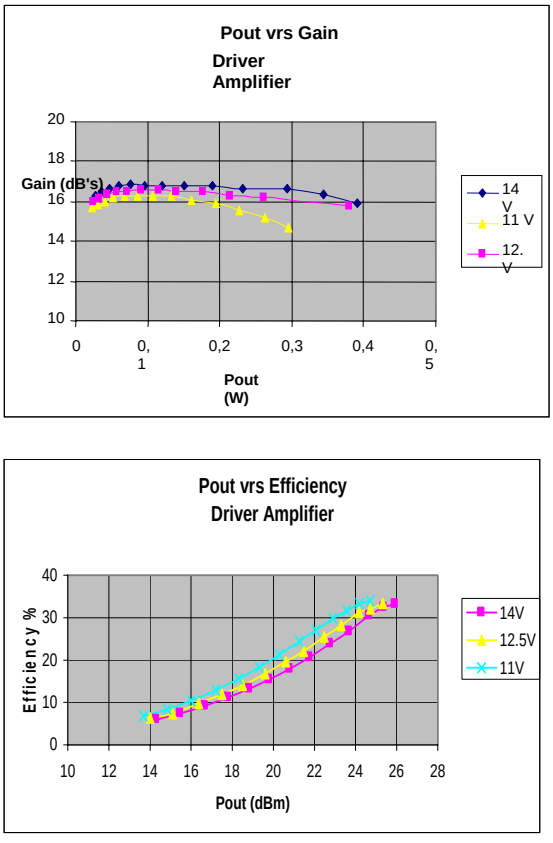


Fig.3 Driver amplifier test results.

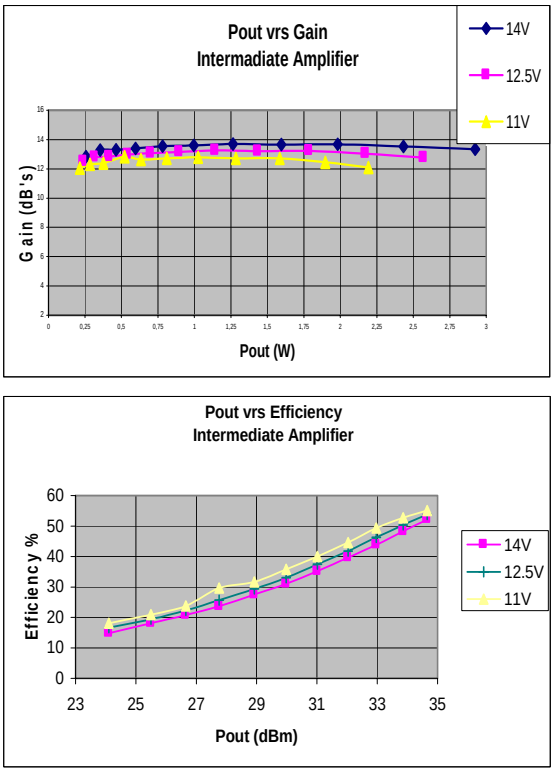


Fig.4 Intermediate amplifier test results

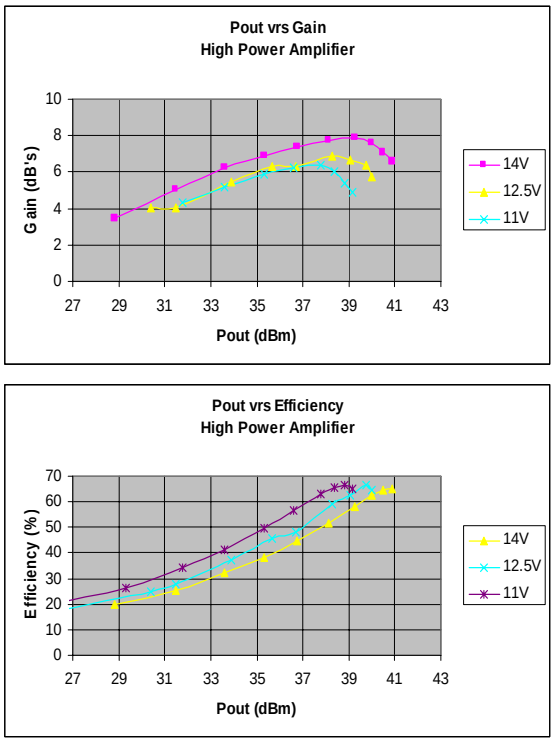


Fig.5 Intermediate amplifier test results

# 5 Conclusions

To allow a satellite UHF transmitter signal to be transmitted via a downlink, it is necessary to amplifier it. The operation is done in several stages. Because one amplifier can't deliver an output power of 10W from an input power of 5 dBm, three amplifiers are suggested to support high gain. The efficiency of the amplifiers depend on the class that amplifiers are operating.

Because the modulation used is CPFSK, the delivered signal is not perturbed by the amplifier non linearities, the high power amplifier (HPA) should work in class C to improve amplification chain performance. An efficiency of 55% is recorded, allowing an DC current consumption of 2A at 14V voltage supply.

The suggested amplification chain was implemented on the UHF transmitter of an earth observation Microsatellite at Surrey Satellite Technology Limited (UK).

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