MULTI FUNCTION RF MODULE

Y. ASHOK KUMAR, T.J. APREM, M. NADAR
Electronics Group, VSSC, ISRO
Trivandrum.
INDIA

ABSTRACT

Generally, to meet the Telemetry and Tracking functions in space probes, RF packages are realised using dedicated circuit configurations and different building blocks. While this approach is warranted for certain Space missions, for some Space programmes, which are basically Technology demonstrators and where the main emphasis is on higher flexibility with minimal complexity - usage of multifunction RF modules (MFRM), would be highly avantageous.

The MFRM, which can be considered as a RF package, has a flexible configuration and is built around Common basic building blocks like broadband MMIC, wide band amplifiers, switches, Dielectric Resonant Oscillators (DRO), Numerically Controlled Oscillators (NCO), etc. It also has a Microcontroller, whose function is to select the required configuration and make necessary interconnections between the building blocks, so as to achieve a specific end function, based on the pre set commands from system designer. The commands can either be preprogrammed or they can be through uplink Telecommand signals from the ground stations.

A brief outline of the results of the proto unit of a MFRM which can be configured for different end RF functions, through a microcontroller is presented in the paper.

It is expected that in Space missions like LEO programmes, Microsats, Reentry, Microgravity experiments etc, the MFRM approach would offer greater flexibility to the system designer at reduced-cost, complexity and production turn around time.

KEYWORDS: Multifunction, MFRM, NCO, DRO, Microsat.

INTRODUCTION:

The advent of Cellular Communication has given a tremendous boost to the components industry and the main focus now is to develop and deliver highly integrated device designs to the user. The present trend is to incorporate more RF functions on to the same piece of semiconductor, silicon or Gallium Arsenide. Already, integrated power amplifiers/switches and transreceiver multifunction MMICs available.

With such a backing from the component Industry, it is all but natural for the present system designer, to concentrate his efforts on achieving maximum benefits with minimum complexity. Exploitation of the Programmable features of the state-of-the art devices available in the market today is one way to achieve this objective.

Instead of having dedicated circuit configurations and different building blocks for the RF packages as in earlier days, the present technology provides an opportunity to have a flexible, general configuration, centered around common wideband building blocks and then select the required configuration to achieve a specific end function of the RF package.

The potential advantages offered by this aproach are-enhancement of system flexibility, standardization, adaptability to suit/meet various mission requirements (both in off line and in real time), repeatability, reproducibility. At the same time it would result in the reduction of-complexity, inventory, production turn around time, cost etc.

One typical area, where MFRM packages score over conventional packages, is in the Microsat missions in LEO, which are used for scientific purposes and other Technology demonstrators. The very nature of the Microsat precludes the luxary of the different, dedicated RF package usage. Instead a package with multifunciton capabilities would allow the end user to achieve his mission objectives at reduced complexities and in a shorter time.

MFRM:

The merits of the MFRM approach can better be understood by comparing it with the conventional schemes followed for the realization of Telemetry Transmitter and a CW beacon used for tracking purpose.

Conventional:

Fig(l) shows the simplified block diagram of a Microwave telemetry transmitter. Here the final carrier frequency is generated from a VHF crystal oscillator, with successive multiplications and filtering. The carrier frequency is modulated by the base band in a

modulator, and then amplified by a power amplifier and routed to the antenna through an isolator/circulator.

For a CW beacon, the circuit configuration is similar to that of the Telemetry transmitter, except that no base band modulation is employed.

MFRM:
The MFRM scheme adopted in the proto unit is shown in a simplified manner in fig(2). It's main building blocks are as follows.
.DRO: The Dielectric Resonator Oscillator, which operates in the fundamental mode at Microwave frequency with the required stability.
.Broad Band switches: They direct the signal routings between the selected input/output blocks, depending upon the commands from the controller. Also they function as modulators.
.Power Amplifiers: They provide the required power output levels. Also they are capable of being operated in either CW mode or pulsed mode, through appropriate control logic interface.
.Controller:
All the flexibility/multifunction capability needed for the package is provided by the Controller, whose requirements are:
.End Function selection
.Activation of the appropriate blocks needed for the selected end function.
.Routing of the signals in the required fashion.
.Operation in a preset programmed mode or through uplink Telecommand signals from the ground stations in real time.
.Self check capability
.Abort mode in case of any abnormality in the package behaviour.
.Other requirements as desired by the mission.
In the Proto unit, 8031 Microcontroller has been used and the software is written in assembly language. The following are the multifunctions realized by the Proto unit.
1. Transponder mode(pulse)
2. CW beacon.
3. Telemetry Transmitter.
The activated elements for the specific function are shown by the shaded blocks and the results are given in table 1.

(a) Transponder mode:
In this mode, the incoming pulsed signal is detected by the receiver section and after required pulse shaping, is applied to the Pulse modulator through a switch. The Rf signal, which acts as the downlink carrier from the transponder, is generated by the DRO and is

applied to the RF input of the pulse modulator. The output pulse modulated signal is amplified by the power amplifier and then routed to the antenna through the Circulator.

The input detected pulse shaping, pulse modulator ON/OFF timings are controlled by the controller through appropriate logic interfaces. The activated blocks for transponder mode are shown in fig(3).

(b) CW beacon mode:
In this mode, the controller deenergises the receiver section, and only the transmitting section is activated. The pulse modulator is commanded to operate in a continuous ON condition and the DRO output through the modulator is amplified by the power amplifier and routed to the circulator. The activated blocks for this mode are shown fig(4)

© Telemetry transmitter mode:
In this mode, the receiver section is deenergised and only the transmitting section, base band circuitry and modulator are activated by the controller as shown in fig (5).

SUMMARY

With the satisfactory performance of the MFRM proto, modifications are being planned, to incorporate a Direct Digital Synthesizer (DDS) module in the unit, to act as the basic frequency generating source, with its attendant advantages.
It should be mentioned here that, the significant progress made in the field of miniaturization of devices (like chip form), also should favour the MFRM users, in keeping the size and weight of the packages to smaller levels.

CONCLUSIONS

As is evident, the availability of Programmable devices like multifunction MMICs, Single Chip Digital Down Converters, RF ICs, Direct Digital Synthesizers etc, is opening up new strategies to realize software intensive RF packages, with multifunction capabilities, with their associated advantages having far behind the conventional schemes.

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REFERENCES

(1) Ron Schrieiderman; Silicon or Ga As'? Who is winning the wireless war?; Microwaves &R-F, Vol 33, No10, October 1994.
(2) David B. chester, Single chip Digital Down Converter Simplifies RF DSP applications; RF design, November 1992.
(3) J. Feustel - Buechl; Flight Opportunities for small payloads, ESA Bulletin, No 60, November 1989.

Telemetry Transmitter (Conventional)

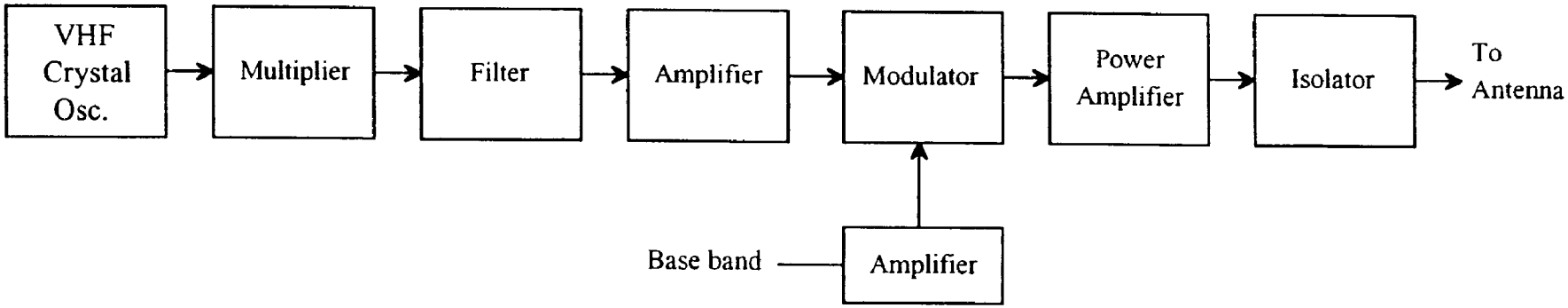


Fig.(1)

MFRM Simplified Configuration

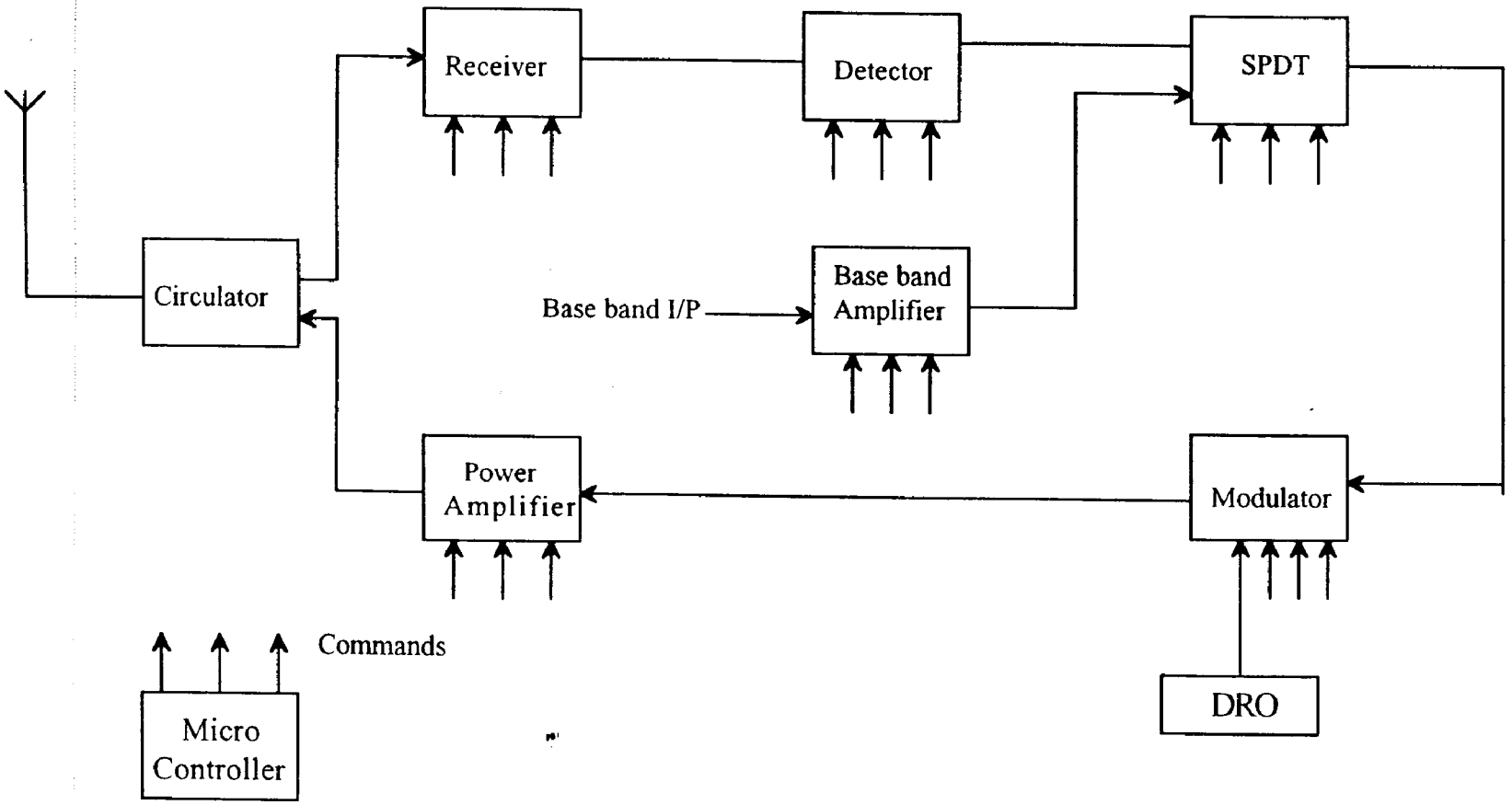
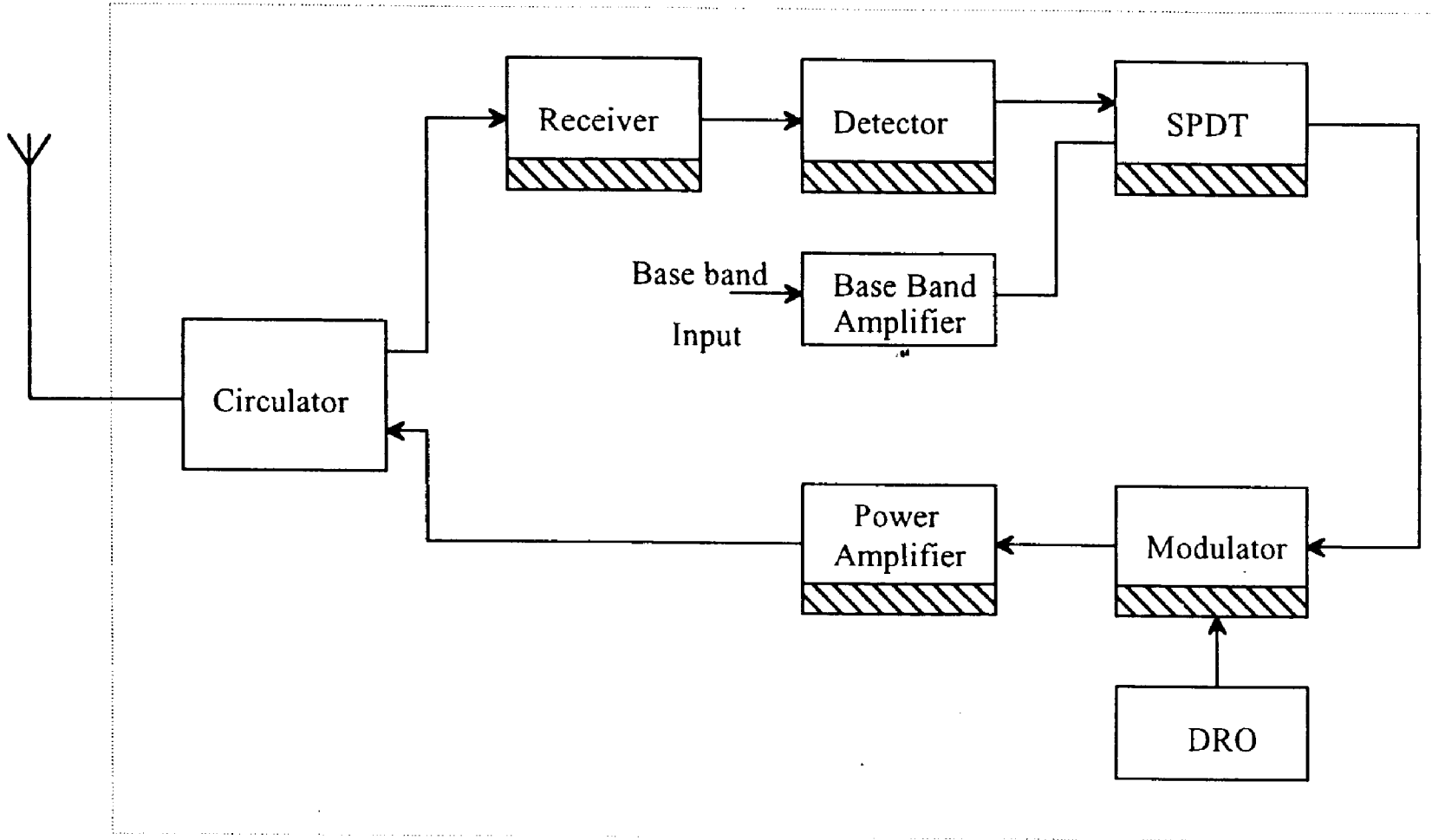


Fig (2)

MFRM Transponder Mode



Fig(3)

MFRM CW Beacon mode

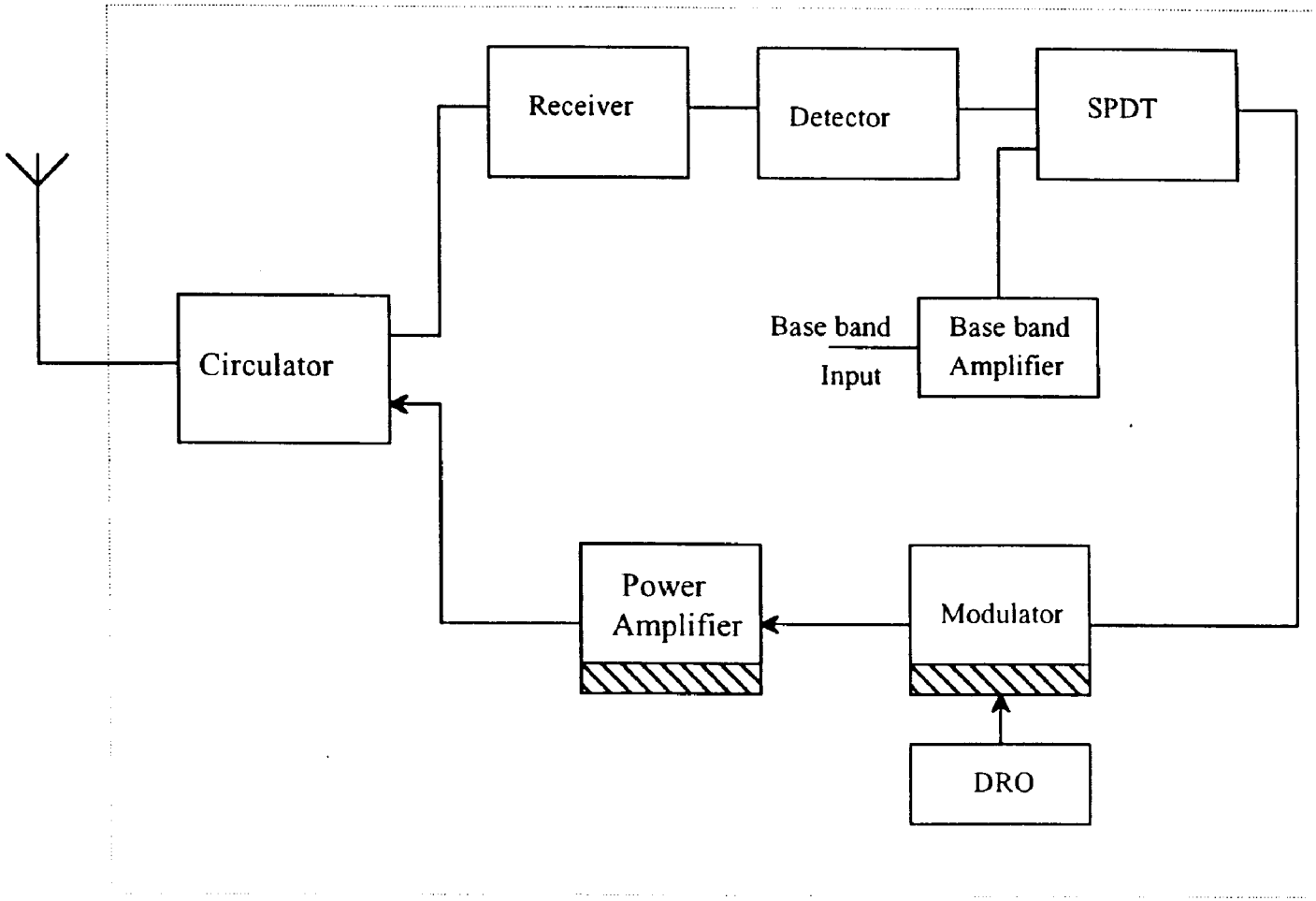
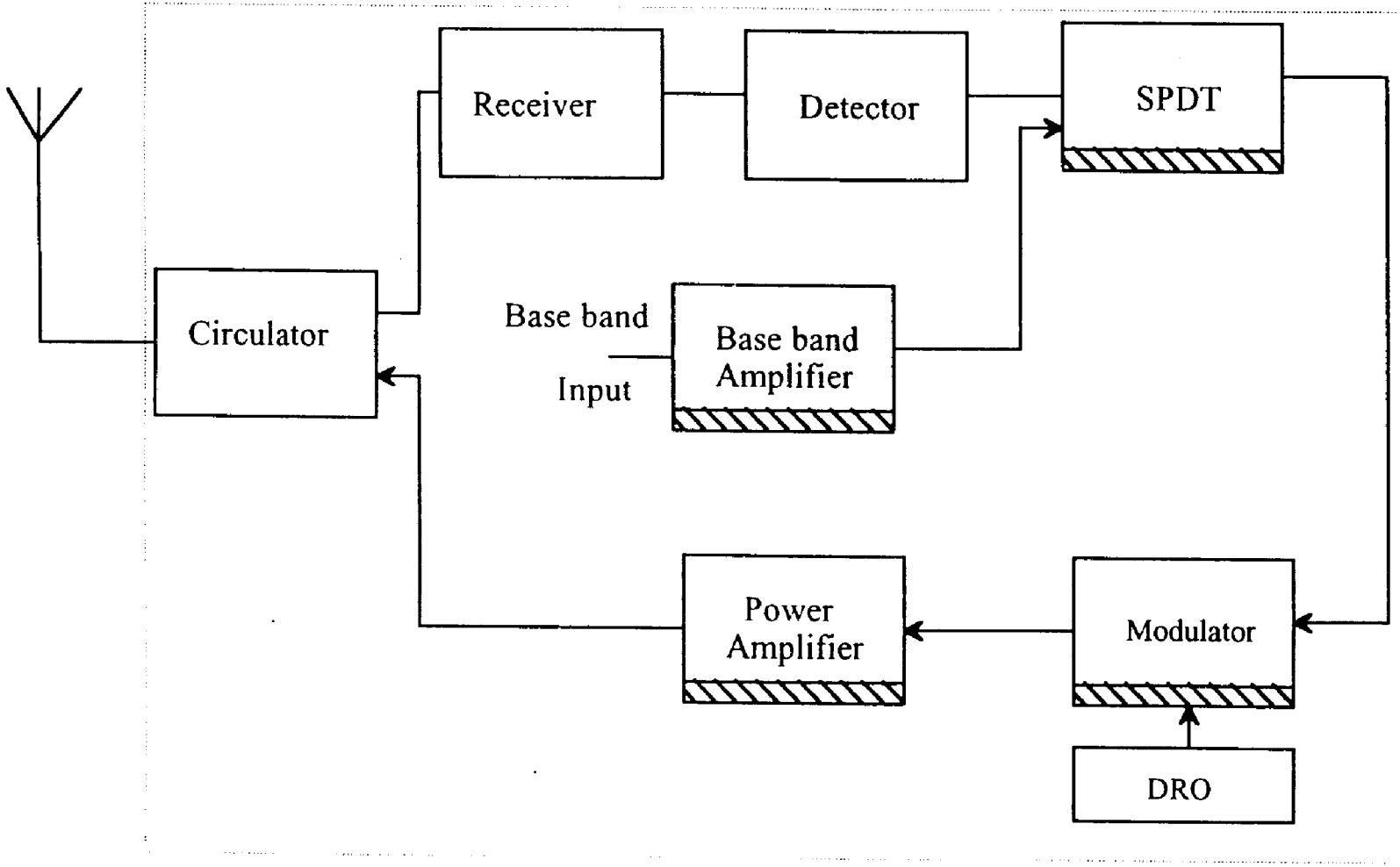


Fig (4)

MFRM Telemetry Transmitter Mode



Fig(5)

Table 1

Proto Unit Results

For the proto unit, the following are the main results under various modes

1.CW Beacon

Output frequency	5.80	GHz
Output Level	+ 33	dbm

2.Transponder Mode

Receive Frequency	5.51	GHz
Sensitivity	- 70	dbm
Pulse Width	1	Micro Sec.
Prf	1171	Hz
Output Power	+ 33	dbm

3.Telemetry Transmitter

Transmit Frequency	5.80	GHz
Power	+ 33	dbm
Modulation	PCM	
Base band signal	1	KHz