DIGITAL TELECOMMUNICATIONS RADIO SYSTEMS

Paul R. Hartmann
Joseph A. Crossett

Collins Radio Group - Rockwell International
Dallas, Texas

Abstract

The increasing need for digital transmission facilities has generated requirements for microwave digital transmission systems that are reliable, have high performance and are spectrally efficient. Application considerations, including interference, frequency planning and growth, of such a system are discussed.

Introduction

Increased cost pressures on wire facilities and the establishment of a regulatory framework have made the digital microwave system attractive. This system has two distinct advantages over conventional FDM-FM systems, cost and performance. Sampling and encoding of voice signals is a less expensive process than generating a single sideband FDM signal. Digital system noise is not related to the sum of thermal and intermodulation noise, as is the case for FDM-FM, but rather to the sum of the Bit Error Rates (BER) of each radio path. Digital systems are also more tolerant than analog systems to interference. Ease of interfacing with digital switching and provisions for bulk encryption are important by-products.

System Design Considerations and Trade-Offs

The basic design constraints for digital microwave system are FCC Docket 19311[1], and FCC Docket 18920[2] which were released in the last half of 1974 and the first quarter of 1975. AT&T's "11 GHz Digital Radio Engineering Considerations"[3] recommends the use of the DSX-3 interface as the standard interface between the radio and multiplex systems. Thus, the necessary channel capacity for each assigned radio frequency is 1344 channels.

Conventional microwave features must be included in the new digital communications systems including party line orderwire and fault reporting. These functions are best realized by multiplexing a sufficient number of synchronous data channels into the system bit stream at the rate converters. This method of overhead transmission minimizes the performance impact on the user traffic. Protection systems must also be incorporated into the design in order to meet system availability requirements.

Modulation and spectrum efficiency are the two major areas in the development of a system design. The required data capacity for the two DS-3 inputs and the FCC limitations on channel bandwidth make 8 PSK a logical modulation choice. The effects of AM-PM conversion and amplitude non-linearities in saturating solid-state RF amplifiers becomes relatively unimportant if the modulation is done at RF where the transition time can be made a small fraction of the band interval. The transmit spectrum shaping is accomplished at RF using a 5 cell cylindrical cavity Tchebychev design.

System Description and Performance

The MDR-11 microwave digital radio system has been developed with the major system characteristics shown in Table I. Block diagrams of the transmitter and receiver are shown in Figures 1 and 2. Tests on the MDR-11 prototype have demonstrated system performance. Spectrum occupancy is shown in Figure 3 and the Bit Error Rate curve is shown in Figure 4.

System Application Considerations

Areas which should be considered in the application of a digital microwave radio system include interference, frequency planning and growth. A practical interference design value for 8 PSK is 25 dB below the desired signal to avoid degrading the BER threshold more than 1 dB. The frequency plan in the 11 GHz band for digital radios is the same as the FM radio plan except the 30 MHz bandwidth channels are excluded. A predetermined growth plan is needed for systems with large cross sections to avoid self-interference and $2f_A-f_B$ problems.

Conclusion

The microwave digital radio system has been proven to be a practical means of achieving high quality communications. The utilization of state-of-the-art technology provides a system with high performance and meets standard high level multiplex interfaces.

Acknowledgements

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References

1. "Policies and Procedures for the Use of Digital Modulation Techniques in Microwave Radio", Federal Communications Commission Docket 19311, September 27, 1974.
2. "Policies and Procedures for Consideration of Applications to Provide Specialized Common Carrier Services in the Domestic Public Point-to-Point Microwave Radio Service", Federal Communications Commission Docket 18920, March 18, 1975.
3. "11 GHz Digital Radio - Engineering Considerations", American Telephone & Telegraph GL: 75-02-001, February 7, 1975.

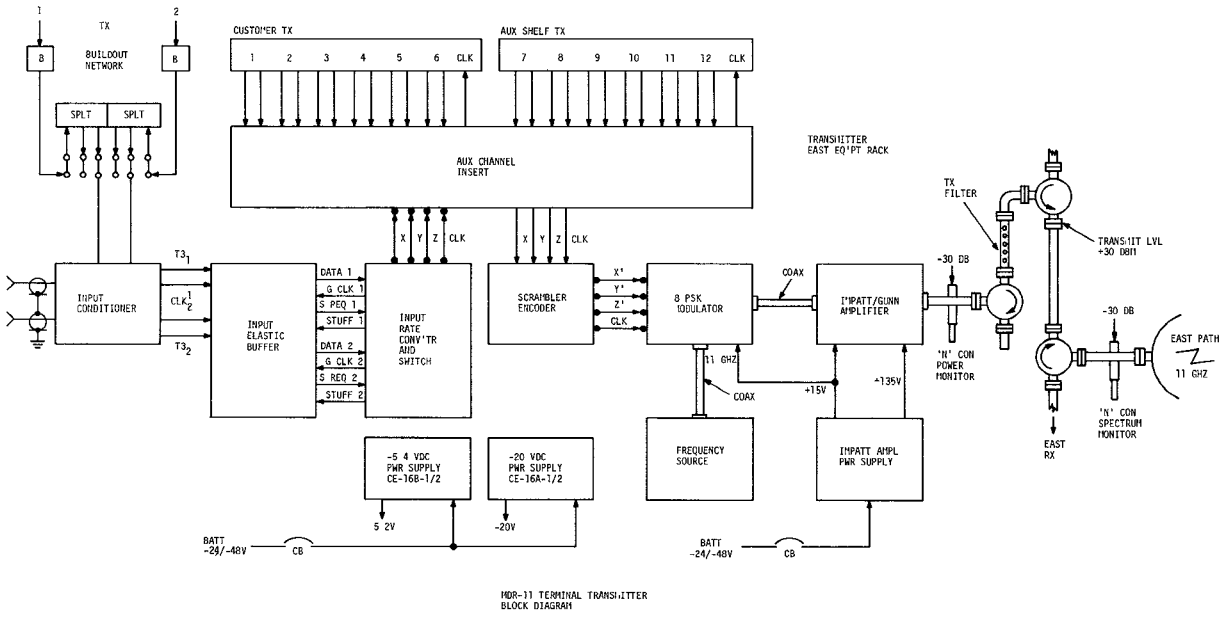

FIGURE 1
MDR-11 TERMINAL TRANSMITTER

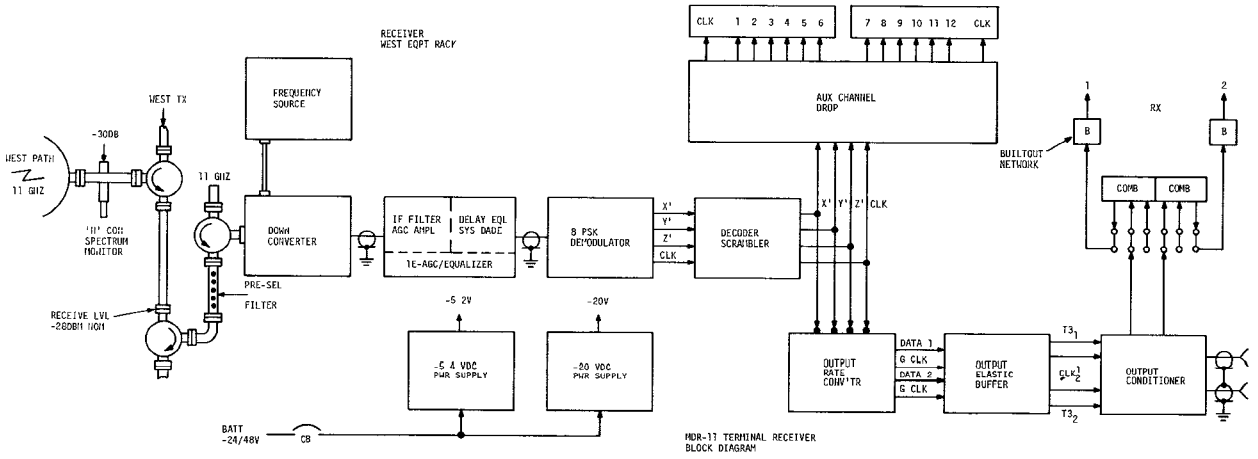

FIGURE 2
MDR-11 TERMINAL RECEIVER

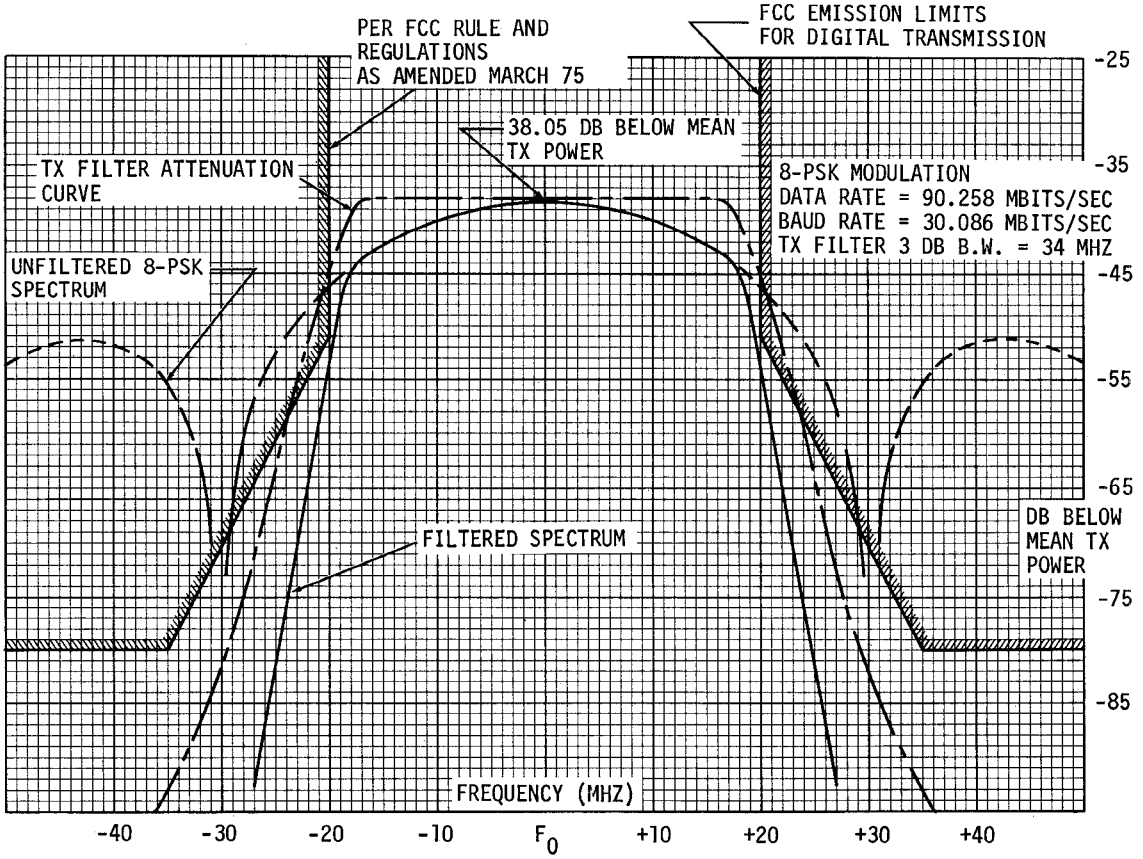

FIGURE 3 - MDR-11 SPECTRUM OCCUPANCY

TABLE I

SYSTEM CHARACTERISTICS

Frequency Range:	10.7 to 11.7 GHz
Transmitter Frequency Stability:	±0.0005%
Power Output (At Branching Circulator Output):	+30 dBm minimum
Emission Designator:	40,000 F9Y
Modulation Type:	8 PSK
Occupied Spectrum:	Per FCC Rules & Regulations See Figure 4
Data Capacity:	90.258 MBS ±10 PPM
Receiver Noise Figure (At Branching Circulator Input):	8 dB maximum
IF Frequency:	70 MHz
IF Noise Bandwidth:	55 MHz
IF Dynamic Range:	66 dB minimum
Maximum Receive Carrier Level:	-18 dBm nominal
Receiver Threshold for 1 X 10^{-6} BER (At Branching Circulator Input):	-68 dBm maximum
Data Input/Output (Terminals and Drop and Insert Repeaters):	2 DXS-3 lines

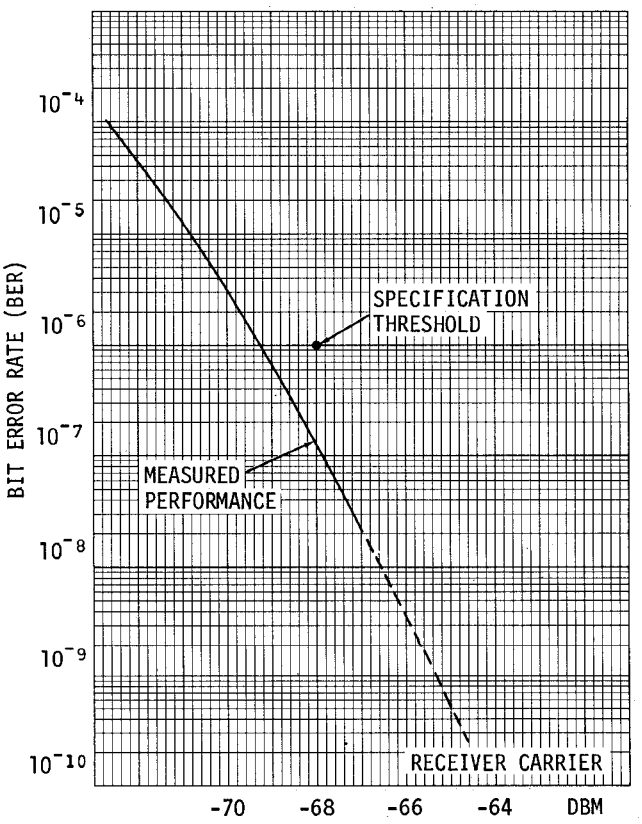

FIGURE 4 - MDR-11 BIT ERROR RATE PERFORMANCE