Digital Modulator

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Utilization of the increased capability of the DSS 14 transmitter and antenna for planetary radar transmission has been made possible by the design, construction, and installation of a digital modulator at DSS 14. This device reshapes the digital modulating waveform generated at DSS 13 and received over the microwave link at DSS 14. The digital modulator output is an accurately adjustable 2-level waveform used to biphase-modulate the transmitter frequency. During precalibration setup, the digital modulator provides selectable frequency square waves used in correctly adjusting the waveform amplitude to obtain carrier suppression greater than 40 dB. The capability that this technique provides has been demonstrated in planetary radar experiments. By this method, one station's processor can be used to generate commands to be sent to a spacecraft from another station at the same complex, thus increasing the reliability of the DSN command system.

I. Introduction

A digital modulator was constructed and installed in the pedestal room at DSS 14. Its function is to reshape a partially degraded digital waveform received over the microwave link. The modulator output is an accurately controlled 2-level digital waveform used to biphase modulate the transmitter frequency. Thus it is now possible to modulate the Mars Deep Space Station transmitter (DSS 14) from digital coders being operated at the Venus Deep Space Station (DSS 13).

II. System Operation

Since the transmitter phase modulator has a linear phase modulation characteristic versus input voltage, it is necessary to accurately set the amplitude of the digital modulating signal in order to obtain the required 180-deg biphase modulation of the transmitter output frequency. To assist in this precalibration adjustment, the digital modulator can be switched to produce precise square waves at selected frequencies between 0.5 and 100 kHz.

Figure 1, the transmitter modulation block diagram, illustrates the calibration technique. A front panel mode switch on the digital modulator disconnects the normal microwave link signal and introduces a DC signal into the transmitter phase modulator. During this procedure the transmitter power amplifier is not energized. The receiver input is connected to the ambient load and the 455-kHz IF frequency output is connected to the wave analyzer. The

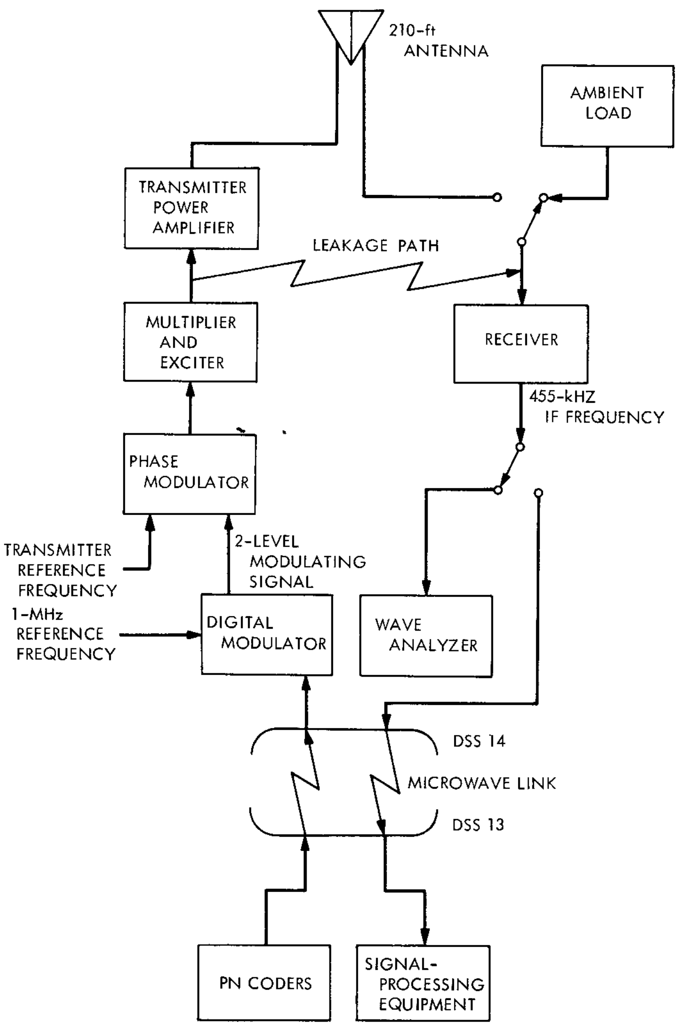

Fig. 1. Transmitter modulation block diagram

wave analyzer is tuned to the 455-kHz signal obtained from the leakage path between the transmitter exciter output and the receiver input. After noting the wave analyzer reading, the operator selects a frequency on the digital modulator close to half the scheduled clock frequency of the pseudonoise (PN) coders. He then switches the digital modulator mode switch to the square wave position, which is the output of a digital circuit counting down the 1-MHz reference frequency. A 10-turn output level control potentiometer on the digital modulator panel is then adjusted for a minimum reading on the wave analyzer. This denotes 180-deg biphase modulation and the resultant high degree of carrier suppression.

The mode switch is then turned to the microwave position, the receiver connected to the antenna and microwave link, and the system is ready for operation.

III. Digital Modulator Block Diagram

Figure 2 shows a block diagram of the digital modulator. The 1-V peak-to-peak microwave input signal is amplified to 2 V peak-to-peak and then passed to a capacitance-diode clamping circuit. This stabilizes the trigger point of the Schmitt trigger on the PN waveform with minimum sensitivity to the changing PN code duty cycle. The reshaped PN code is then available to the output circuit when the mode switch is in the microwave position.

Also available to the output circuit is a square wave counted down from an external 1-MHz reference frequency. The multi-frequency countdown circuit is controlled by a front panel frequency selector switch which can select one of the following 8 frequencies: 0.5, 1, 2, 5, 10, 20, 50, or 100 kHz.

The output circuit produces a stable, accurate 2-level waveform at 50 Ω internal impedance for both the microwave and square wave mode switch positions. Figure 3 shows some details of the output circuit. Q_1 provides a constant current whose value is adjusted by means of the resistance programmed power supply. This current is steered into either Q_2 when Q_2 is in the conducting state, or into the 50-Ω source resistor and output load when Q_2

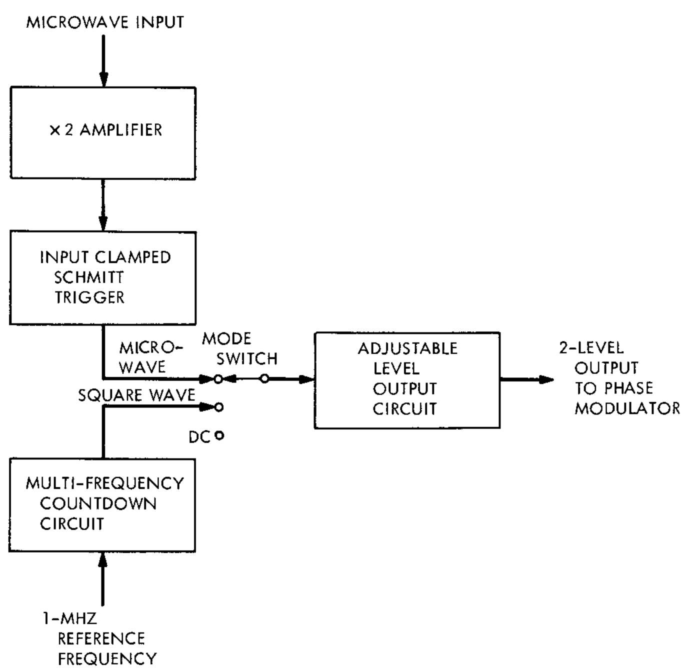

Fig. 2. Digital modulator block diagram

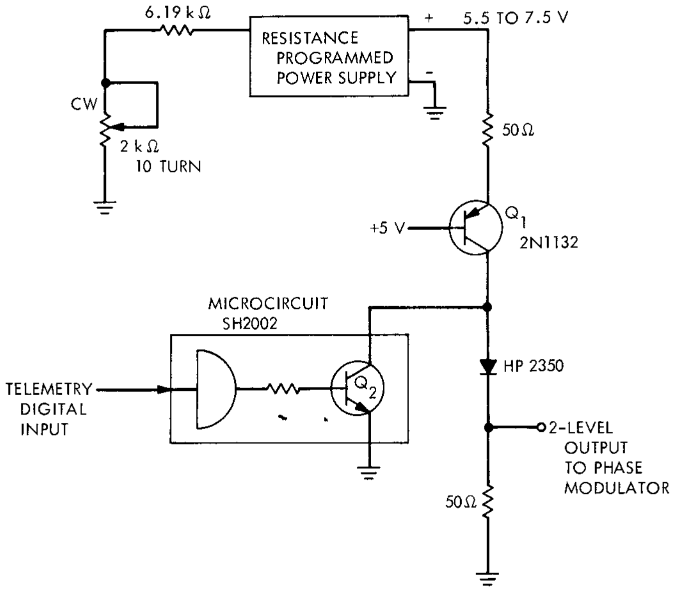

Fig. 3. Output circuit

is not conducting. Thus one level of the output is at ground potential, and the other level is adjustable from 0 V to +1 V when the output is loaded with 50 Ω. Current steering results in an extremely flat stable waveform with transition times less than 100 ns.

IV. Conclusion

The described digital modulator has been successfully utilized in the planetary radar program. The DSS 14 antenna has been used in the monostatic radar mode while the controlling waveforms have been generated and data processing carried out at DSS 13. Thus advantage has been taken of the high transmitter power capability and high antenna gain at DSS 14 during the radar transmission cycle. In the precalibration setup, the stability and purity of the digital modulator output waveform has permitted carrier suppression adjustments typically greater than 40 dB for square-wave modulation.