# The Use of an Interplex Modulation Technique for the Mariner Venus-Mercury 1973 Mission

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*The use of interplex modulation for the Mariner Venus–Mercury 1973 mission necessitates modification of the station ground equipment to effect compatibility. The Simulation Conversion Assembly (SCA) is to be modified to provide a source for generation of simulated telemetry data, using interplex, for system testing, training and software development. Implementation of the SCA hardware modifications, together with a discussion of the simulation test modes, is presented.*

## I. Introduction

The use of an interplex modulation technique for the *Mariner* Venus–Mercury 1973 (MVM 73) mission, rather than the conventional two-channel telemetry system, necessitates modifications in the station ground equipment to effect compatibility. As such, the Simulation Conversion Assembly (SCA) is to be modified to provide an interplex capability for system and subsystem testing, training of station personnel, and software development for the DSIF.

The interplex-modulated signal is generated in the Simulation Conversion Assembly and typically is routed to the Subcarrier Demodulator Assembly which, in turn, processes and demodulates the signal. The signal is subsequently routed through the Symbol Synchronizer Assembly (SSA), Block Decoder Assembly/Data Decoder Assembly (BDA/DDA), and the Telemetry and Command Processor (TCP). The block diagram in Fig. 1 illustrates the configuration for processing simulated telemetry data in the DSIF.

## II. SCA Implementation

The existing SCA hardware does not now have the interplexing feature. As such, additional hardware will be required. Further, supporting software must also be developed for MVM 73 system testing, training, and DSIF software development.

An overall SCA interplex block diagram is shown in Fig. 2. A modulo two adder is used to modulate two previously modulated subcarriers. A typical timing diagram is shown in Fig. 3. The timing is drawn on a noncoherent basis. However, the two subcarriers are coherent for MVM 73. An EXCLUSIVE OR gate ($\oplus$) is added in the Video Conditioner of the SCA to provide this function. The high-rate data channel remains as is (D1$\oplus$SC1); while the low-rate data channel (engineering) is modulated again with the high-rate channel subcarrier. Thus, the expression is

$$(D1 \oplus SC1) \oplus (D2 \oplus SC2)$$

The two modulated signals are fed into two separate attenuators for a proper signal mix ratio. Thus, the attenuator will set a modulation index. Typically, a science channel is set to 70 deg ($\theta_1 = 65$ deg for MM 69) and an engineering channel to 30 deg. The attenuators can be programmed to 100 dB (resolution 0.2 dB) manually or by a computer, thus providing various modulation indices.

After setting the modulation index, the two attenuated signals are mixed together by a summing operational amplifier (mixer). The signal from the mixer now contains a simulated spacecraft signal, which is fed into the test transmitter for carrier modulation.

## III. Simulation Support for MVM 73

DSIF Simulation Support for MVM 73 is scheduled to commence in April 1973. The simulation function has two basic modes of operation, a local (DSIF) mode and a long loop mode. In the local mode, the SCA provides signals for several subsystems. These various signals will provide capabilities for subsystem checkout, subsystem software development, and the DSIF integration effort.

The long loop simulation involves SFOF and DSIF via High-Speed Data (HSD) Line. The dynamically changing spacecraft data are generated in the Simulation Center by the 6050 computer. This signal is sent to the DSIF (sometimes simultaneously to two stations) by the Ground Communications Facility (GCF). The SCA will receive the simulated data via HSD and supply the signal to the DSIF. The simulated data will be routed to the TEST TRANSMITTER, RECEIVER, SDA, SSA, BDA/DDA and the TCP. The TCP will format an HSD data block and return it to the SFOF. The SFOF will examine the returned data for verification. Unfortunately, the 117.6-kbps telemetry (uncoded video) for MVM 73 cannot utilize the long loop simulation due to hardware limitations on communication facilities and some DSIF subsystems. However, 2.45-kbps (block coded 32,6) telemetry is able to use both modes.

The SCA provides four independent telemetry channels. Each channel has basically the same hardware with respect to the interplex implementation. This feature will provide flexibility for readily interchanging science and engineering channels. Also, the SCA delivers a high-level signal (bit error rate, word error rate, convolution error rate) for verification of correct decoding in addition to a low-level analog signal.

## Reference


1. Butman, S., and Timor, U., "Coding and Synchronization: Interplex—An Efficient Two-Channel Telemetry System for Space Exploration," in *Supporting Research and Advanced Development*, Space Programs Summary 37-62, Vol. III, pp. 57–60. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 30, 1970.

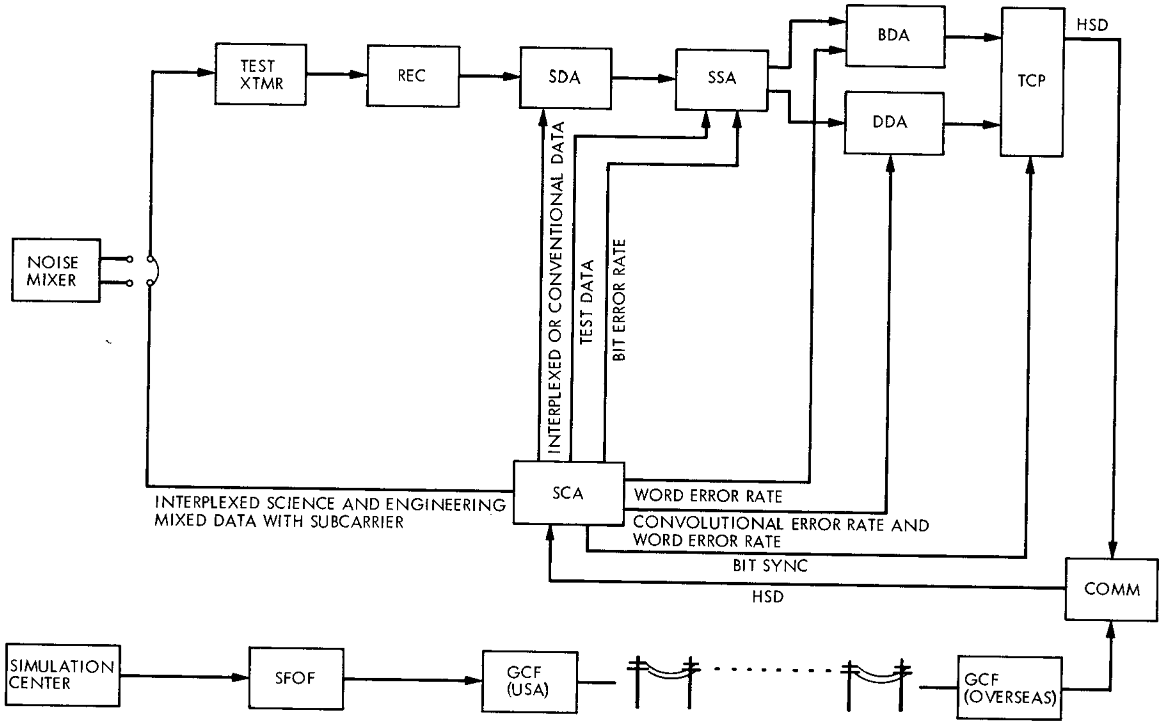


**Fig. 1. SCA configuration**

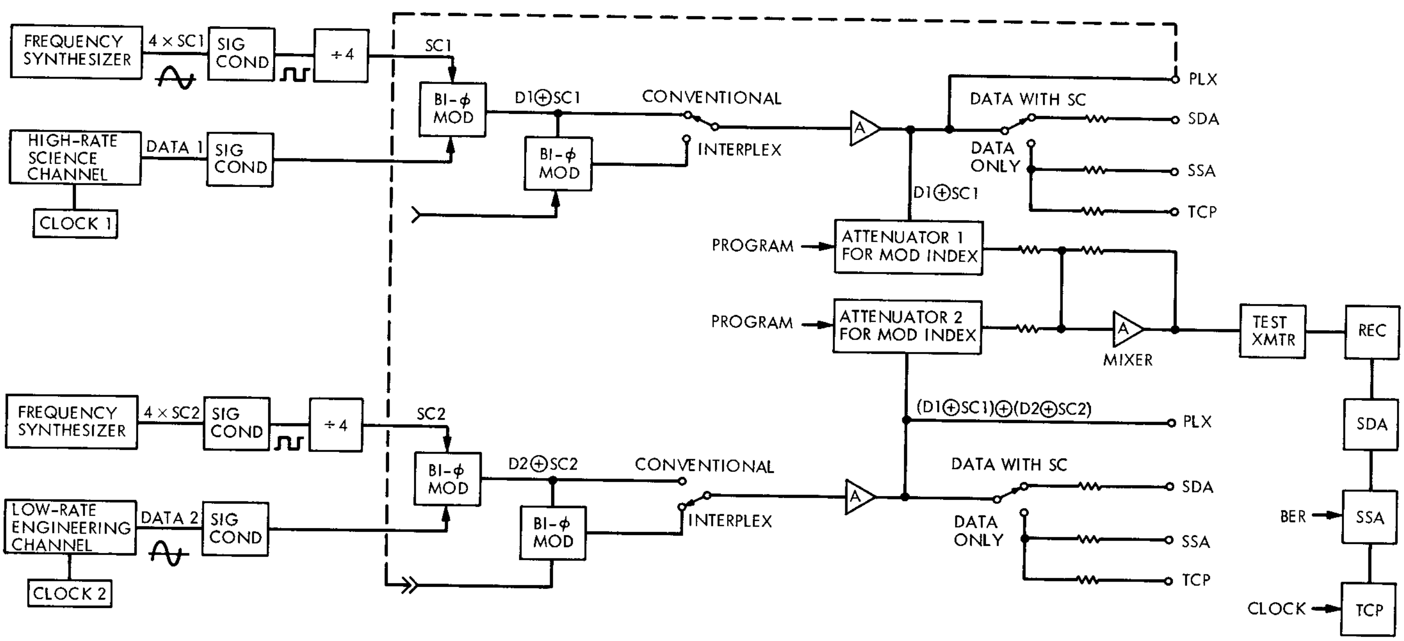


**Fig. 2. SCA interplex implementation**

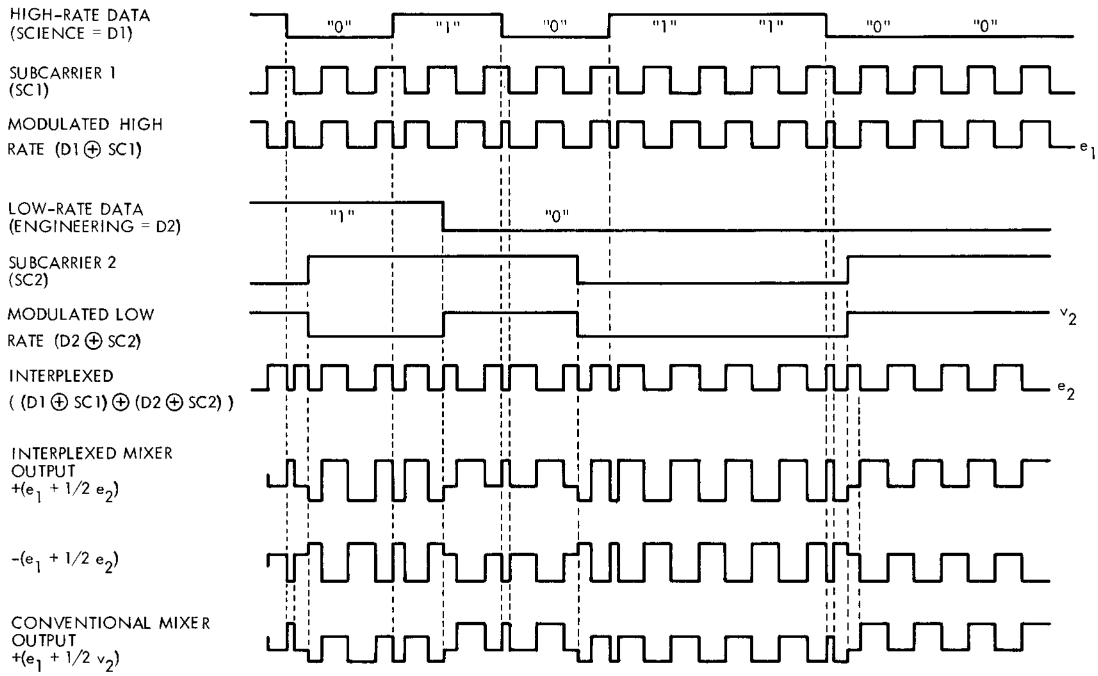


**Fig. 3. Simulated non-coherent interplexed data**