MULTI-PURPOSE SIGNAL CHASSIS SGLS

RECEIVER/PROCESSOR

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INTRODUCTION

Space-Ground-Link-System (SGLS) is a specific capability of an earth terminal which, in conjunction with a space vehicle (SV) transponder, provides Tracking, Telemetry and Commanding (TT&C) services for space vehicles. This paper describes a multi-purpose, single chassis earth terminal receiver/ processor (R/P) which provides and supports those services. The R/P utilizes digital design techniques and microprocessor executed algorithims that provides a design that is physically small (12 inch high chassis), reliable (MTBF > 4000 hours) and parameters/performance that exceed most present and future TT&C requirements.

SGLS SERVICES PROVIDED BY THE R/P

A typical SGLS system is shown in Figure 1. In this system the uplink and downlink are both S-Band spectra signals but separated in frequency. The uplink carrier is normally selected to be in the range of 1.76 to 1.84 GHz while the downlink carrier (or carriers) is normally selected to be in the range of 2.2 to 2.3 GHz. For coherent carrier mode operations the downlink carrier is derived from the uplink carrier by the SV transponder. The ratio between the uplink and downlink carriers for this mode of operation is 256/205.

UPLINK SERVICES (CARRIER I)

The R/P can input serial data streams for either or both SV commands or SV payload data. The command data rate can be either 1,2 or 10 Kbps and is frequency shift keyed (FSK) onto a ternary tone system (1, 0, S tones) compatible with the SV command tone detector. The payload data rate can be up to 512 Kbps and is Bi-phase modulated on a subcarrier selectable in the range of 1.024 to 1.75 MHz. The R/P linearly combines these two signals with a internally generated psuedo random (PRN) ranging code. The composite baseband

signal is provided to a modulator which phase modulates the uplink carrier. As part of the versatility of the R/P the modulation index for each of the three signal components can be controlled by control data provided to the R/P.

DOWNLINK TELEMETRY SERVICES (CARRIER I AND II)

The R/P can simultaneously receive, demodulate and detect up to 2 PCM data streams bi-phase modulated on subcarriers in the frequency range of 1.024 to 1.7 MHz. In addition, the R/P can receive, demodulate and detect a PCM bit streams directly bi-phase modulated on S-bands carriers. Direct carrier modulation can either be on a carrier to which the R/P is nominally tuned to or on a carrier 5 MHz below that value (Carrier I). The data rates can be selected anywhere in the range of 250 BPS to 512 Kbps for subcarrier modulated data or 250 BPS to 5 MBPS for direct carrier modulated data.

RANGING SERVICES

SV range is measured by transmitting a PRN range code from the R/P to the SV transponder where it is remodulated and transmitted back to the R/P. Utilizing this method SV ranges up to 507471 miles can be measured.

RANGE RATE SERVICES

SV range rate is measured in the coherent mode in which the downlink carrier is derived from the uplink carrier by the SV transponder. The measurement is based on comparing the frequency and phase difference between the transmitted and received carriers.

ANTENNA TRACKING SERVICES

The R/P also supports rapid downlink mainbeam acquisition by performing a Fast Fourier Transform (FFT) frequency search of the downlink RF signal to determine the presence of the signal in the aperture of the antenna. The R/P can thereafter support track ng of the mainbeam by demodulating an amplitude-modulated monoscan error signal modulated on the downlink signal by the station antenna controller.

SUMMARY PARAMETER/CONTROL/STATUS CAPABILITIES OF THE R/P

The R/P can be completely controlled from a remote controller via a serial interface. Controllable parameters are:

- Uplink Mod Index Control - 0 to 1.85 radians
- Uplink Subcarrier Frequency - 1.024 to 1.75 MHz
- Payload Data Rate - 250 BPS to 512 Kbps
- Command Rate - 1, 2 or 10 Kbps
- Downlink Telemetry Subcarrier No. 1 - 1.024 to 1.7 MHz
- Downlink PCM No. 1 Bit Rate - 250 BPS to 5 Kbps
- Downlink Telemetry Subcarrier No. 2 - 1.024 to 1.7 MHz
- Downlink PCM No. 2 Bit Rate - 250 BPS to 5 Kbps
- Direct Carrier Modulated Bit Rate - 250 BPS to 5 MBPS
- Telemetry Code Modulation - Any of 8 different formats
- Estimated range (0 to 507471 miles)
- Test Range (0 to 507471 miles)
- Self Test Modes
  - Telemetry Demodulation and Detection
  - Ranging

RECEIVER PERFORMANCE

Important receiver performance parameters of the R/P are:

- Nosie Figure - < 10 dB
- Range RMS error < 5 feet RMS for PRN Ranging Signal SNR of 33 dB -Hz.
- Range rate error < 0.010 feet RMS for carrier C/No of 33 dB -Hz.
- Telemetry performance < 2 dB from theoretical PSK.
- Carrier Dynamic Range - 75 dB

- Carrier Search Range - ±200 KHz
- Carrier Doppler Rate - ±3000 Hz/sec
- Carrier Search Rate - up to 696 KHz/sec at C/No of 38 dB -Hz.
- Signal Strength Detector - ±1 dB over 75 dB range

Figures 3 and 4 show measured data for Range and Range Rate from a previous designed receiver using identical measurement algorithms.

R/P BLOCK DIAGRAM

The R/P Block Diagram is shown in figure 2. The equipment is configured as a single 12 inch chassis. The same capability in present tracking station configurations requires approximately 11/2 racks of equipment. The MTBF is approximately 4000 hours as compared to about 400 hours for present configurations.

The small size, high reliability, versatility and performance is achieved by digital hardware, microprocessors and processing algorithms utilizing the digital hardware and microprocessors. Specifically, eight microprocessors are utilized as follows:

- A TI TMS320 16-Bit Digital Signal Processor to perform FFT spectral analysis for carrier search and detection.
- Two TI TMS320 Digital Signal Processors in each Telemetry Channel for telemetry channel carrier and clock search and reconstruction.
- An Intel 8751 8 Bit microprocessor in each Telemetry Channel for control and status operations.
- A single board computer utilizing the Motorola 68020 16 Bit microprocessor for performing carrier tracking acquisition/tracking, range code acquisition/tracking, range and range rate computation signal quality measurements and general R/P control and statusing.

The R/P utilizes 12 A/D converters to convert signals to digital form for microprocessor execution of algorithms. In addition, 3 D/A converters and 6 numerically controlled oscillators (NCOs) are utilized to convert microprocessor computed signals back to analog variables (voltage and frequency).

A key digital element is the STI-designed NCO which forms reconstructed carrier, subcarrier and range clock and telemetry data clock references. This device, a single chip, replaces Voltage Controlled Oscillators (VCO).

The R/P microprocessor executed Algorithms allows the user to input a priori data on range, range rate, signal strength and C/No. In this way, acquisition times are significantly improved. In addition, all receiving/processing algorithms are firmware controlled, a feature that allows receiver features to be changed without the necessity of altering receiver hardware.

Approximately 70% of the R/P utilizes digital hardware to implement the receiving functions. The eight microprocessors implement 12,000 lines of code and use 32 kilobytes of RAM and ROM.

An earlier version of the R/P has been developed and tested for the Air Force TMGS program (without the Telemetry channel capability). An advanced version is being developed for the Air Force ARTS program (the telemetry channels being packaged separately).

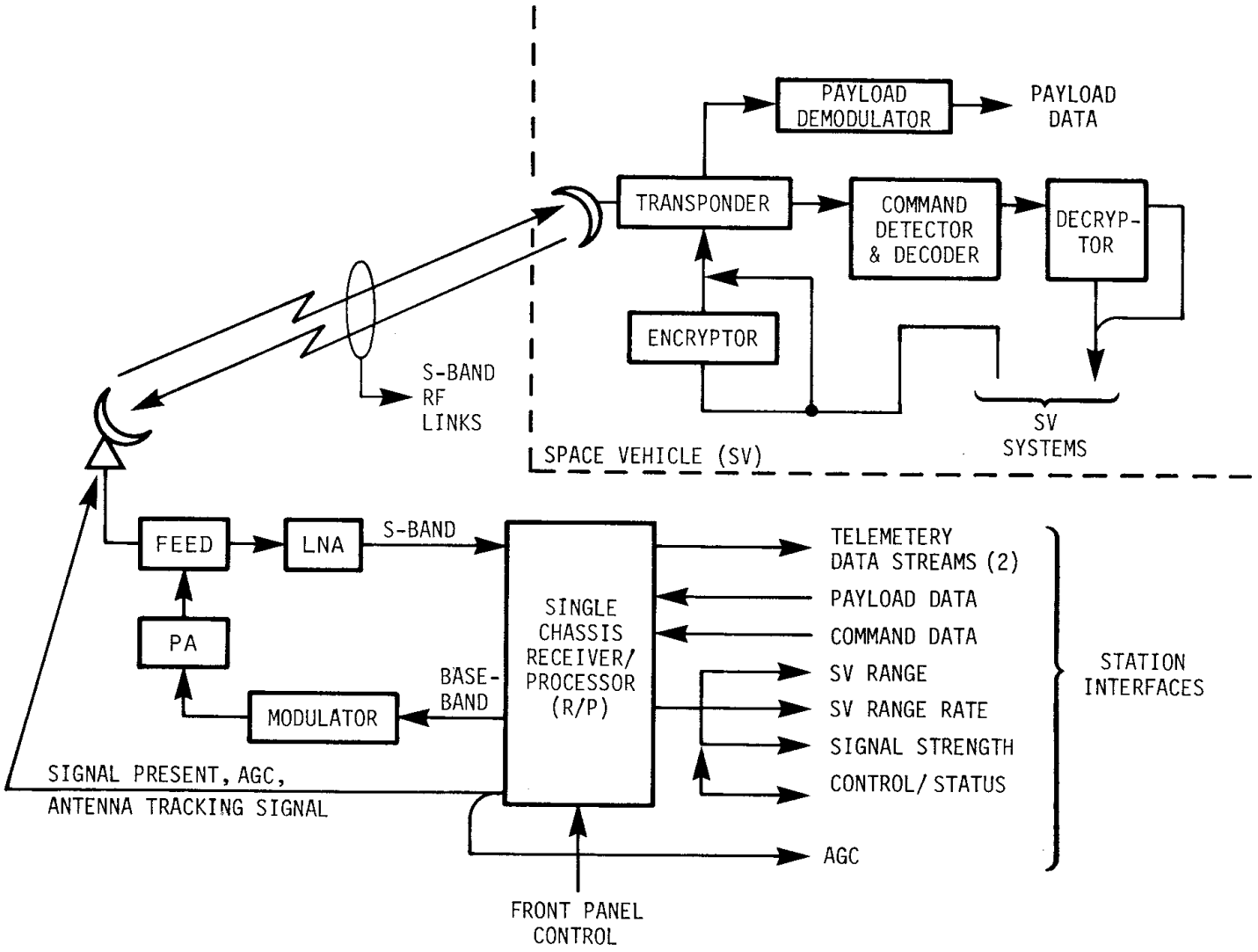

FIGURE 1 SGLS SYSTEM BLOCK DIAGRAM

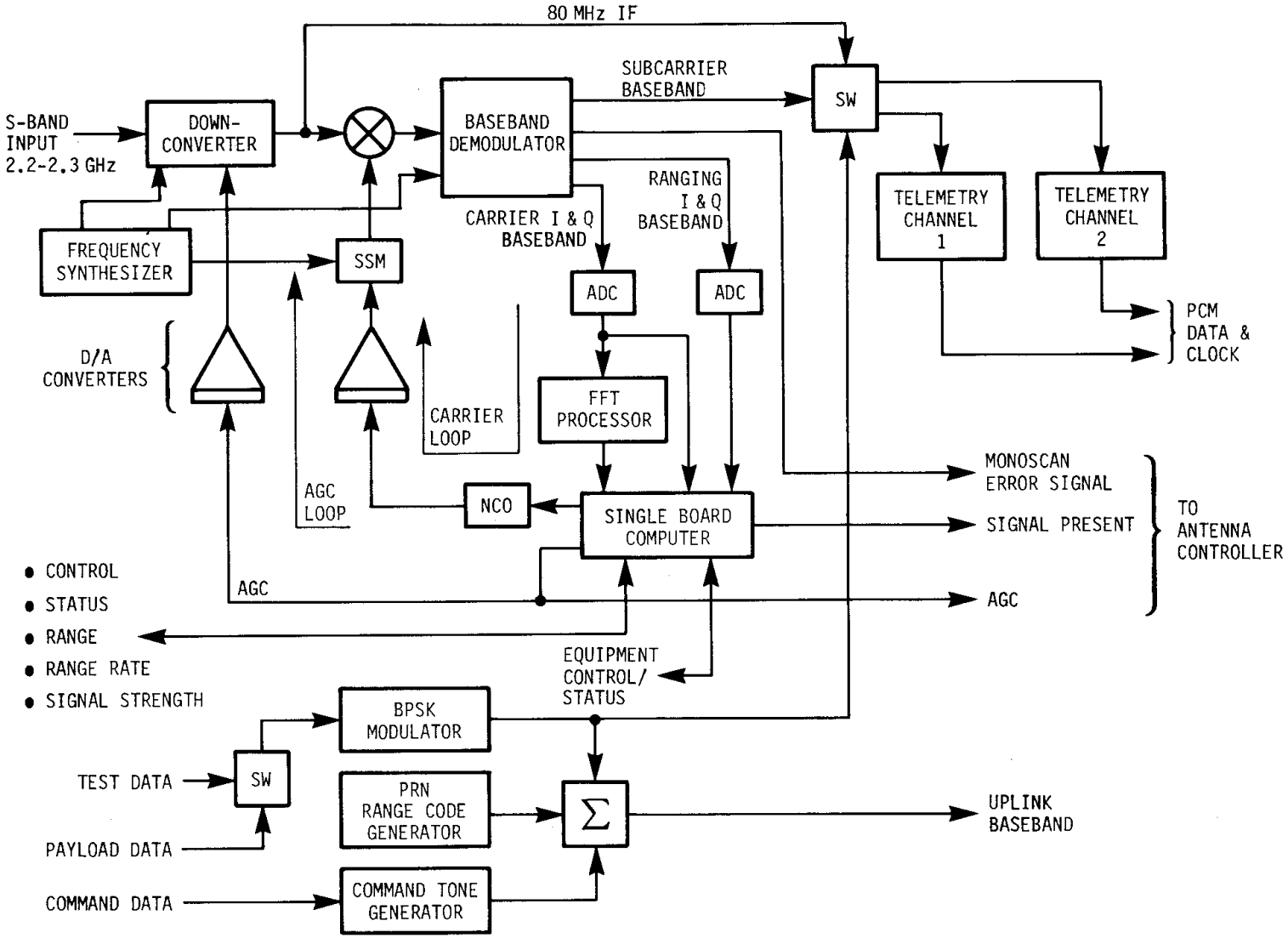

FIGURE 2 R/P SIMPLIFIED BLOCK DIAGRAM

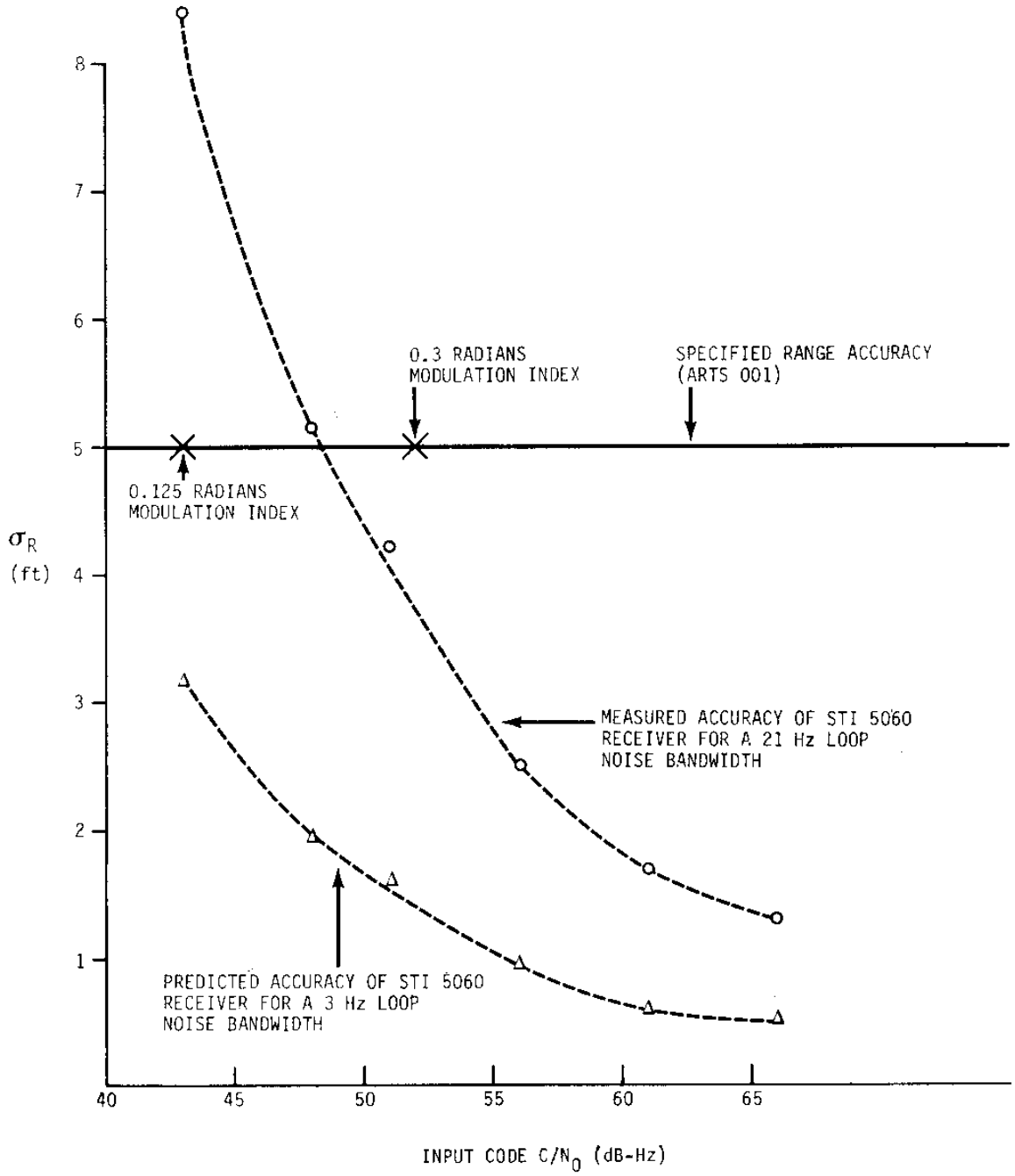

FIGURE 3 TRR 5061 RECEIVER DESIGN ONE WAY RANGE MEASUREMENT ACCURACY

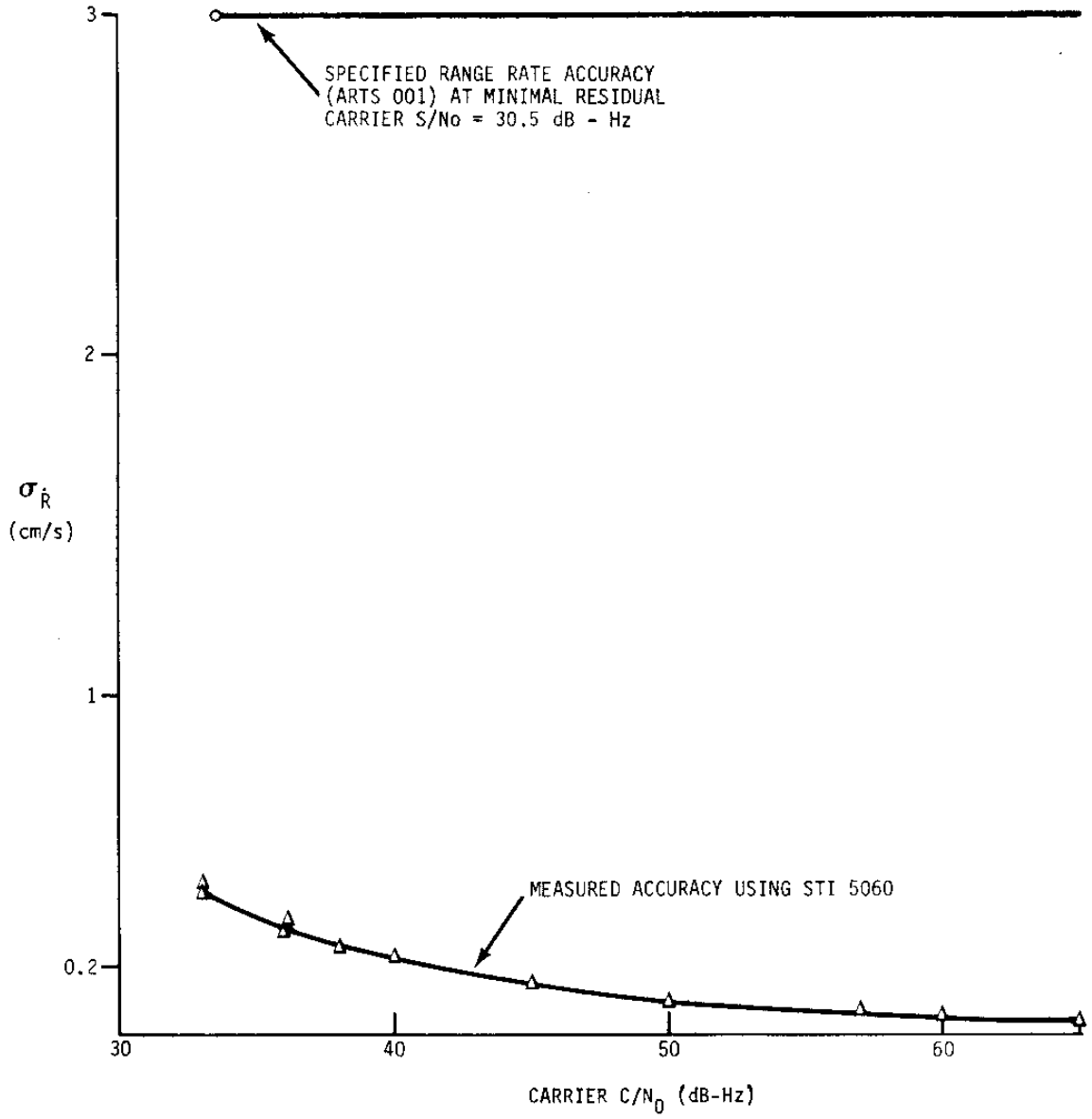

FIGURE 4 TRR 5061 RECEIVER DESIGN RANGE RATE MEASUREMENT ACCURACY