Block IV Ranging Demodulator Assembly

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The Block IV Ranging Demodulator Assembly is a 10-MHz ranging receiver operating on the automatic-gain-controlled output of either a Block III or Block IV DSIF receiver. It demodulates the 10-MHz carrier that has been phase modulated with range code to provide two range correlation voltages to the Planetary Ranging Assembly. The design of the Ranging Demodulator Assembly, which encompasses range code correlation and demodulation of the 10-MHz carrier, is compatible with either composite or sequential range code schemes. Manual control of the Block IV Ranging Demodulator Assembly is straightforward and easy to comprehend, which will serve to minimize operator expense and operator errors. Computer control capability is provided and may be implemented as soon as a suitable interface is developed.

I. Introduction

The planetary ranging system is a two-way radio link employing an active transponder in the spacecraft. Basically, the system operates by transmitting a carrier signal modulated by a suitable code. Upon receipt of the ranging signal, the spacecraft detects the code and then modulates it onto a downlink carrier. The ground station receives the downlink signal from the spacecraft and detects the code. The two-way spacecraft range, in time units, is determined by comparison of the phase of the received code with that of the transmitted code.

II. Block IV Ranging Demodulator Assembly

The Ranging Demodulator Assembly (RDA) is a 10-MHz special-purpose receiver whose function is to demodulate the range code modulated IF signal from the DSIF receiver. Historically, there have been two planetary ranging systems, both built as developmental tasks. The two systems differ in several ways, but fundamental among the differences is the coding scheme employed. One system (Refs. 1, 2, and 3) uses a composite pseudo-random code scheme and was termed alternatively the Tau, MV67 or PN system. The other system (Refs. 4, 5, and 6) utilized a sequential binary code and was called the Mu or SQ Wave system. The two distinct ranging systems exhibit unique advantages. The sequential system, because all of its energy is concentrated in one component at any given time, has a signal-to-noise ratio advantage (18 dB) which results in shorter clock acquisition times. The composite system, because its code is pseudo-random, spreads its energy over a wide spectrum and creates less interference for other signals. The Block IV RDA is independent of coding schemes and will operate equally well with either.

The Block IV RDA is designed in accordance with the requirements set forth in the DSIF Data System Development Plan (DSDP), 803-3. It will operate from either the Block III or Block IV DSIF receiver and will therefore perform ranging demodulation for either S- or X-band frequencies. The construction, packaging, and design philosophy followed in the Block IV RDA results in a very compact receiver (12¼ in. of standard rack) as may be seen from Fig. 1.

Future performance requirements, explicit as well as implicit, indicate that operator expense should be minimized and that ultimate computer control should be planned. As may be seen from Fig. 1, the Block IV RDA manual controls are convenient and easy to comprehend. The phase calibration operation, which is adjustment of the reference signal, is achieved by depressing a single button. Confirmation indicators for each module as well as one representing the quality of the reference signal are provided. The simplified operation of the Block IV RDA will result in lower operator costs and also fewer operator errors.

In the future it will be necessary to operate ground stations, to the extent possible, by remote control. System configuration, failure analysis, and fault location will be controlled by computers. The Block IV RDA is fully compatible with computer control, providing computer accessible configuration and monitor points. The gating to select between computer or manual control is designed into the Block IV RDA and a manual/computer select switch is provided on the control panel.

III. Functional Specifications

The functional specifications of the Block IV RDA are shown in Table 1. The range modulation delay variation for the entire DSS (12 h) is specified at 1 m or less. Range delay variation has been allocated to the various DSS components such that when root-sum-squared the total is less than 1 m. The range delay allocated to the combined RDA/Planetary Ranging Assembly (PRA) is 30 cm. The RDA/PRA division of delay is equal, meaning that the RDA is allocated 15 cm, or less. This allocation is in units of apparent spacecraft position; therefore, because the ranging system operates over a two-way link, the range delay variation in units of electrical path length for the RDA is 30 cm or less.

Digital dumping (Ref. 7) is a technique which provides a practical alternative to integrate and dump, without the attendant hardware constraints. The digital dump time constant (single RC) of the final dc amplifier is 0.36 ± 0.2 s.

The interface between the RDA and PRA is through an analog-to-digital converter located in the RDA. Output correlation voltages are converted, upon command from the PRA, to an 8-bit digital word having an offset binary code. There are two A-D converters, one for each channel, and they are employed by the phase-calibrate circuitry during calibration.

IV. Operation

The input to the RDA is a 10-MHz carrier, phase modulated with a binary code. The code may be either pseudorandom (composite) or sequential binary. Figure 2 is a functional-level block diagram of the RDA. The phase-modulated signal from the receiver (selected by the Control Unit from two receiver outputs) is applied to a digital attenuator. Attenuation is set according to the ratio of ranging sideband power to carrier power and serves to maintain the full output of the RDA (at the A-D converter input) at 5 Vdc. After attenuation, the phase-modulated signal is divided into two channels in order to facilitate dual channel tracking. The phase-modulated signal is then demodulated with the local model of the transmitted code. The result is a 10-MHz signal, orthogonal to the carrier, whose amplitude is proportional to the correlation of the received code by the local model. Further amplification and bandlimiting is achieved before the signal is applied to a coherent amplitude detector (CAD). The CAD is a mixer having a reference of 10 MHz that is orthogonal to the carrier. This arrangement will amplitude detect the correlation signal which is then passed through a dc amplifier before presentation to the A-D converter.

The Block IV RDA Control Unit serves two main functions. First, it provides for input selection from one of two DSIF receivers or one of two test signals. Secondly, upon command, it adjusts (phase calibrates) the phase shifters in the CADs. Phase calibration is achieved through a digital feedback loop encompassing the A-D converters (Ref. 8).

References

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Table 1. RDA performance parameters

Functional characteristic	Required capability
Input center frequency	10 MHz $\pm$10 Hz
Power in (AGC'd carrier)	-55 dBm
Noise power density (max)	-55 dBM/Hz
Bandwidth (pre-correlation)	8 MHz at -1 dB
Gain	124 $\pm$1 dB
Modulation index control range	51 dB in 0.2-dB steps
Number of correlation channels	2
Channel gain balance ($G_{chan\ 1} - G_{chan\ 0}$)	$\leq \pm 1$ dB
Modulation phase stability (in 12 h)	$\leq$30 cm (electrical path)
Control/monitoring	Computer/manual
Output voltage	$\pm$5V (into 50 Ω)
Output offset voltage	0 $\pm$50 mV
Output integration time constant (final)	0.36 $\pm$0.02 s
Output interface	8-bit A-D converter
Computer control interface	NASA/JPL Standard

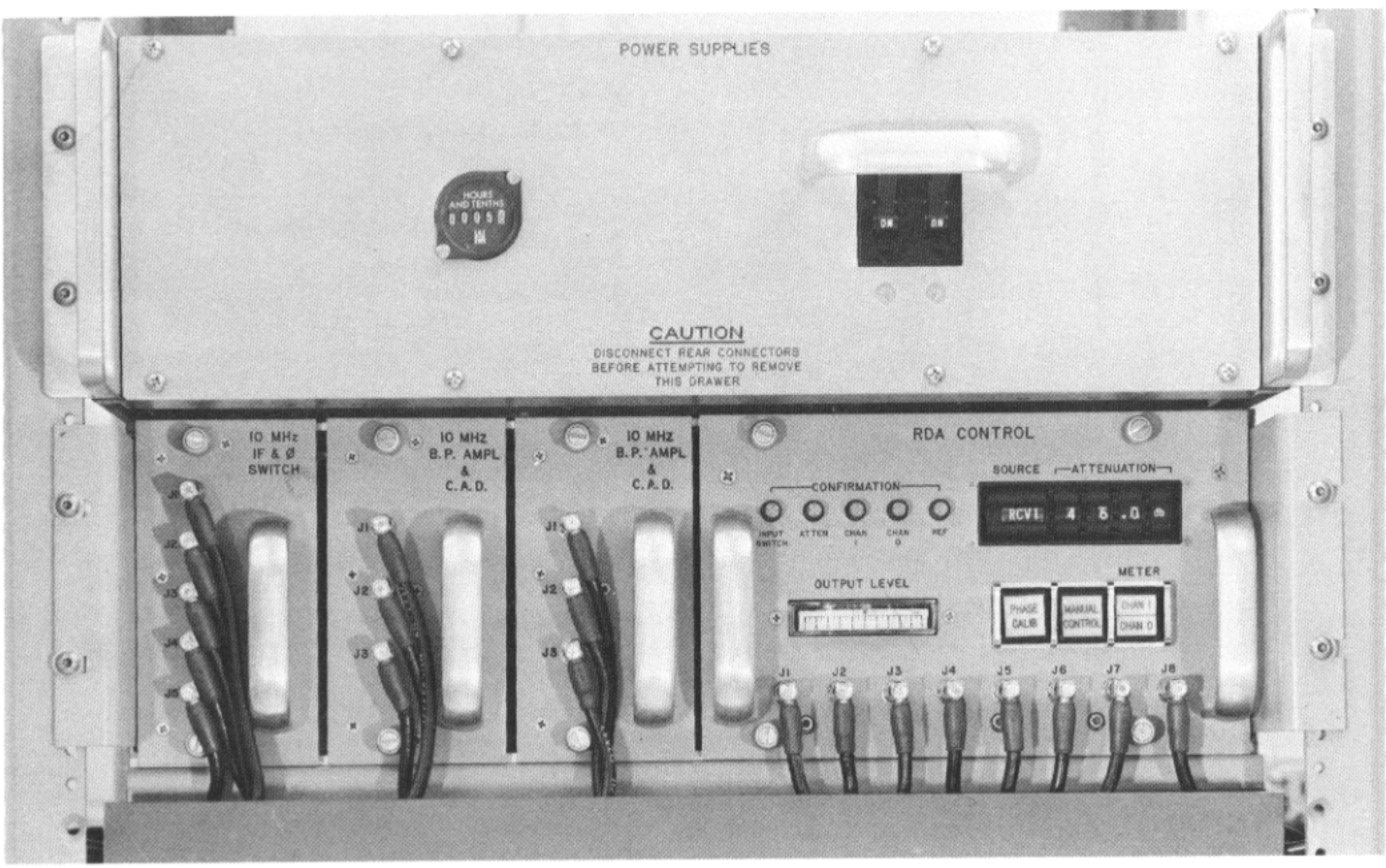

Fig. 1. Ranging demodulator assembly

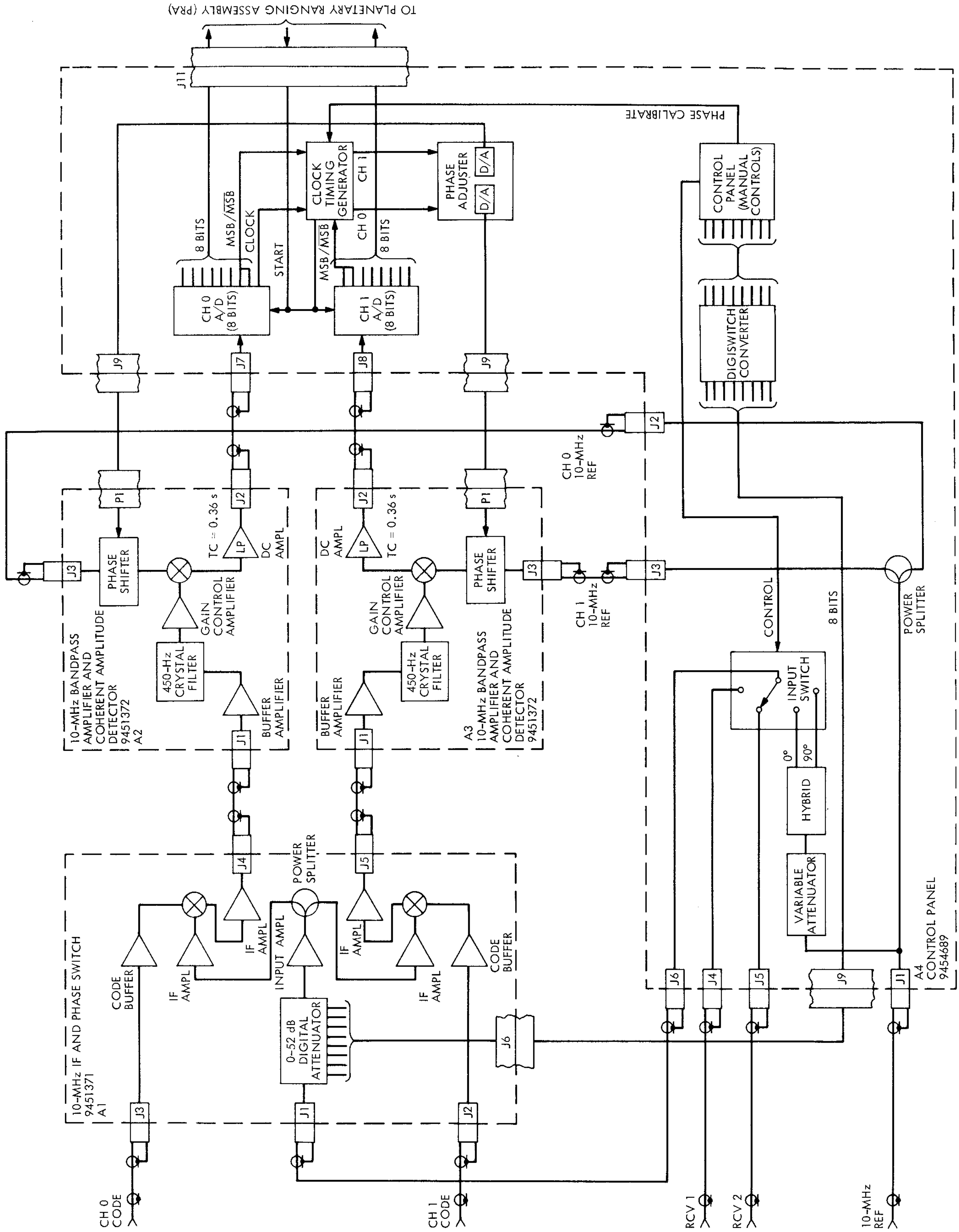

Fig. 2. Functional block diagram—ranging demodulator assembly