RYAN ELECTRONICS

# RYAN MODEL 520 RADAR ALTIMETER

FINAL ENGINEERING REPORT

15 OCTOBER 1964

Prepared under NASA Contract NAS8-2459
George C. Marshall Space Flight Center

Ryan Report 52067-2
Final Engineering Report

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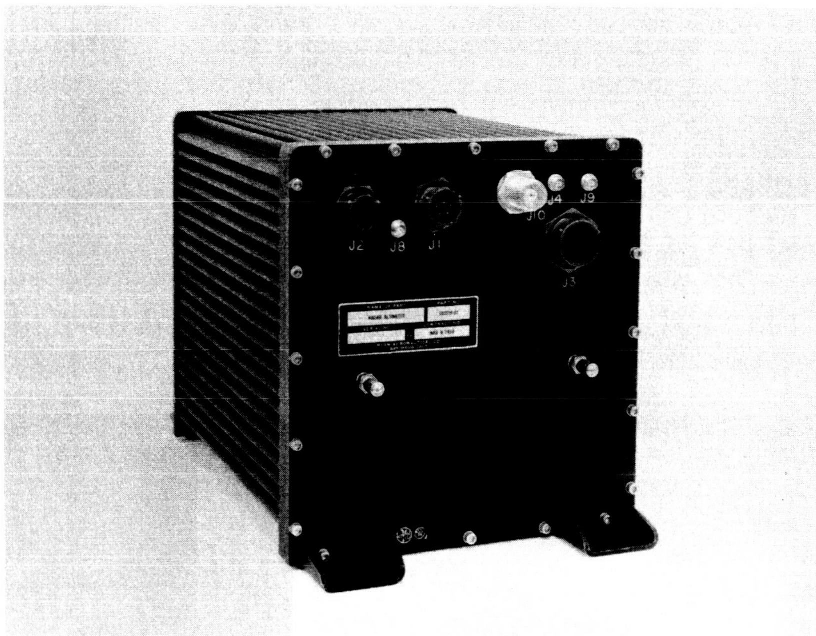
Report No. 52067-2




MODEL 520 ALTIMETER

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1.0 INTRODUCTION

The program described in this report is an extension of Contract NAS8-2459 initiated by the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration on 15 November 1963. Modification 12 to the contract covered the fabrication and delivery of a quantity of four altitude measuring equipments designated Ryan Model 520 for use in a SATURN vehicle. A previous final engineering report, Ryan Report No. 52067-1, covered the contract period from August 1961 through September 1963. Since all of the basic design information was included in the previous report, this report will include program activities and technical details concerning the equipment since incorporation of Modification 12 to the contract.

1.1 Modification 12 to the contract required the delivery of four additional Radar Altimeters identical to those delivered under the original contract except for the following modifications:

1.1.1 The timer sub-assembly must provide an elapsed time interval counter with a capacity of 16 bits and a time resolution of 1/36 of a second.

1.1.2 Provide an external reset capability in the elapsed time interval accumulator. The reset signal is supplied from external vehicle networks and is a level change from 28 volts DC to ground through relay contacts. After reset, the input remains at ground level.

1.1.3 The above changes to be accomplished in accordance with the requirements of Marshall Space Flight Center drawings.

1.1.4 Appendix A of the contract entitled specifications was amended to: (a) Add MSFC-STD-154, Printed Circuit Design and Construction, Standards for; (b) add MSFC-STD-158B, Soldering Electrical Components for Space Vehicles, Procedure for (delete sub-paragraph 2, Page 12 "Filtration"); (c) delete MSFC-PROC-257 and substitute therefore MSFC-PROC-293.

1.2 During the time Ryan was fabricating the four Altimeters, MSFC representatives determined that additional sensitivity would be required and that the transmitter must be isolated from the antenna. During a conference on 4 June 1964 it was agreed that modifications to the range tracker assembly and the RF subassembly must be made on Altimeters serial numbered 10 through 13. The modification to the RF subassembly was to provide sufficient isolation between the antenna and the transmitter to maintain transmitter frequency within ±0.5 mhz with VSWR changes up to three. The modifications to the range tracker subassembly were to provide the capability of acquiring and tracking a -93 dbm signal within 18 seconds while the vehicle travels at a vertical velocity of two kilometers per second. Ryan conducted extensive investigations to determine the optimum method of isolating the transmitter from the antenna. Detailed requirements for an RF receiver and isolator were provided in the form of a specification and the units procured from a qualified vendor.

## 2.0 TECHNICAL APPROACH

This paragraph describes the technical approach followed in meeting the requirements of Modification 12 to the Contract. In addition, this paragraph discusses the technical approach followed to improve the sensitivity of the Altimeter and to provide the required isolation between the transmitter and the antenna. Modifications were required in the modulator, range tracker, timer, IF amplifier and RF receiver portions of the Radar Altimeter.

2.1 Timer Modification. Modification 12 of Contract NAS8-2459 required that the timer subassembly be modified to provide an elapsed time interval counter with a capacity of 16 bits and a time resolution of 1/36 of a second. Since this modification had previously been incorporated by MSFC, the drawings covering this change were available from MSFC. The timer subassembly was procured from Brown Engineering Company who had produced previous models of the new timer. In addition to incorporating an elapsed time counter with a capacity of 16 bits, an external reset capability was also provided. The reset signal consists of a 20 volt DC signal which holds the counter in an OFF position. Upon removal of the 20 volt DC signal and upon applying a ground the counter is activated. As a result of the above modification the following changes were required in the Altimeter.

2.1.1 The front panel of the Altimeter was modified to accommodate a larger connector. The new connector is a Bendix Pygmy PT07C-22-55S and is used in position J-3.

2.1.2 Six wires were added to the connecting cable between the timer subassembly and J-3.

2.1.3 Since the timer subassembly was completely modified, changes were required in the specification and test procedure.

2.1.4 The modified Altimeters built under this program are identified by part no. 501019-G2.

2.1.5 A new nameplate was required because of the changed part number.

2.1.6 Test equipment was modified to accept the additional elapsed time outputs and to provide a reset signal.

2.2 Range Tracker Modifications. As part of the program to increase the sensitivity of the Altimeter the range tracker subassembly was extensively modified. The modifications to the range tracker provide the capability of acquiring at least a -93 dbm signal within 18 seconds while the vehicle travels at a velocity of two kilometers per second. Actual tests have shown that modifications resulted in the Altimeter acquiring up to a -96 dbm signal and continued to track a -99 dbm signal. The following modifications have been incorporated in the range trackers:

2.2.1 Error Detector Board

(1) The bandwidth of the video amplifier was reduced to enhance the signal to noise ratio. This was accomplished by the addition of L102 (680 microhenries) in place of CR101 and associated bias resistor R115. In addition, the value of R116 was changed to 22.1K.

(2) The gain of the video amplifier was increased by changing the value of R120 to 5.62K.

(3) The input network was modified to provide fixed differentiation and greater drive to the video amplifier. This was accomplished by increasing the value of C103 (220 micromicrofarads), reducing the value of C141 (.001 microfarads), increasing the value of R105 (270 ohms) and L101 (68 microhenries). High amplitude signals are limited by the addition of CR130 (1N3064) between terminals three and four with the anode of the diode at terminal three. Additional noise filtering is achieved by increasing the value of C142 (.01 microfarads).

(4) Filtering of the +20 volt DC supply was improved by deleting R101 and R102 and replacing them with a jumper wire.

(5) The operation of the zero adjust generator was improved by increasing the value of R173 (5.6K) and R174 (68K) and decreasing R179 (8.25K). The value of C101 was increased to 22 microfarads and the value of C129 was decreased to 100 micromicrofarads.

2.2.2 Filter Board. The bandwidth of the DC amplifier was decreased to a range of zero to 18 cycles per second by deleting C304 and R310 and increasing the value of R308 to 3.3 megohms. R310 was replaced by a jumper wire. These changes allow the tracker to acquire a -93 dbm signal in 18 seconds (nominal) when traveling at a two kilometer per second rate.

2.2.3 Automatic Gain Control Board.

(1) The temperature sensitive components, RT502 and RT503, were deleted.

(2) The relay drive circuit was desensitized to avoid ambiguous acquisitions because of increased sensitivity in the video amplifier. This was accomplished by decreasing the value of R515 (33K) and increasing the value of R516 (4.7K).

(3) The impedance to the pulse differential amplifier was increased by increasing the value of R524 (698 ohms).

(4) The input to the relay was modified to allow greater integration. This was accomplished by adding C515 (4.7 microfarads) from terminal 9 to E503.

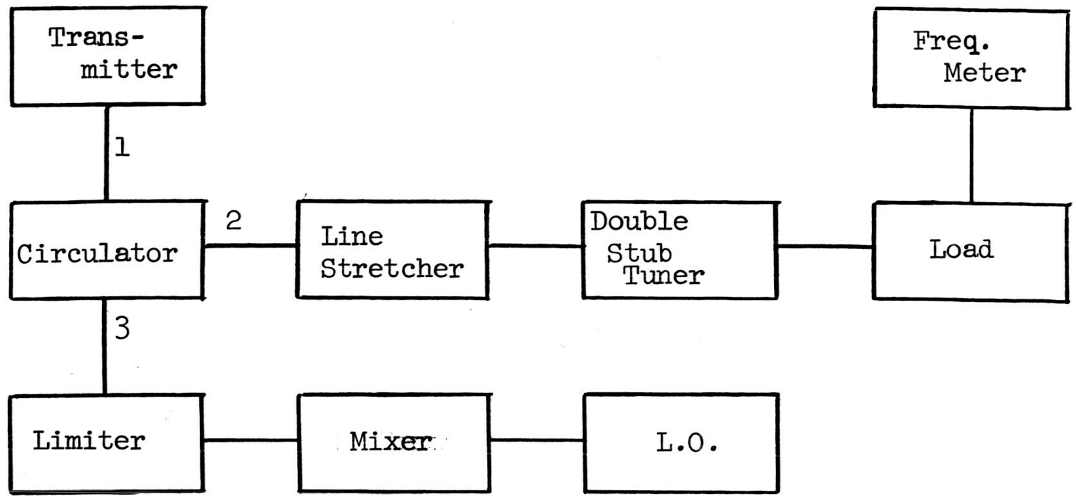
(5) The performance of the noise AGC circuit was improved by increasing R546 (1K) and R550 (11.8K) and decreasing R549 (82K) and R543 (56K).

(6) The operation of the fixed AGC circuit was improved by the addition of filtering capacitor C514 (8.2 microfarads) from the junction of R553 and R554 to ground.

2.3 Investigation of Transmitter Isolation. MSFC representatives stated that one major problem existed which jeopardized the use of the Radar Altimeter. It was determined that the antenna load VSWR varied from approximately 1.5 to 3 when the SATURN gantry was in place. The variation in VSWR caused wide frequency variations in the transmitter. The wide variations in frequency made it impossible to calibrate the Altimeter prior to flight. Ryan instigated investigations to determine if suitable isolation could be provided to eliminate frequency variations. Consequently a three port circulator was procured and isolation vs. frequency tests begun. The test setup is shown in Figure 2-1.

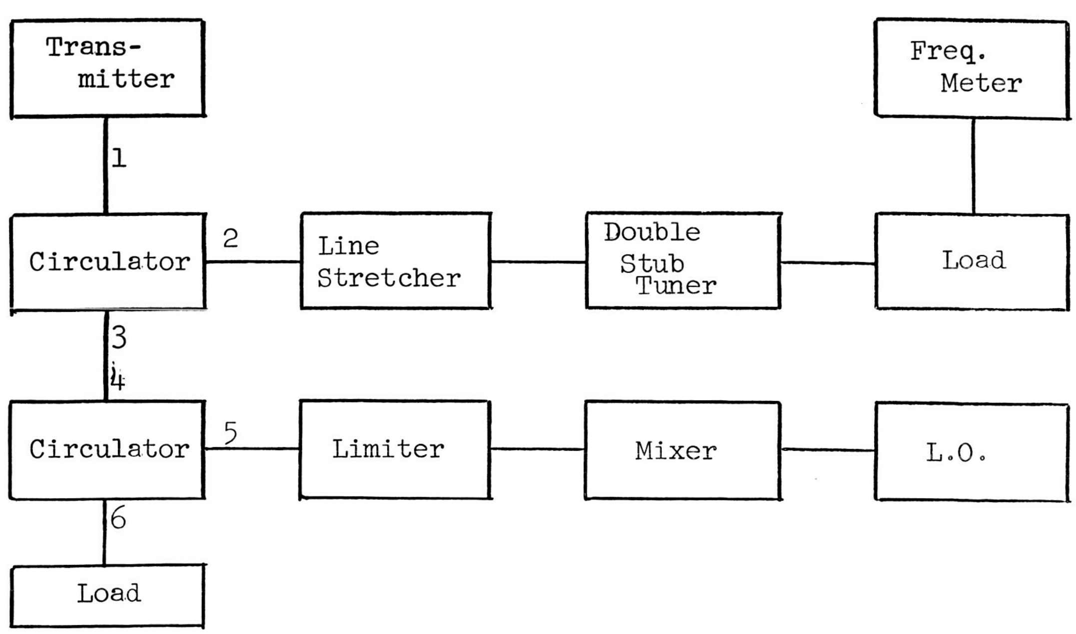
Isolation from port #2 to port #1 was 26 db. The VSWR at port #3 varied from 1.15 with the LO on to 3 with the LO off. The VSWR and phase of the load was varied from 1.1 to 4 and the phase was shifted a total of 180 degrees. The following data was obtained in this test:

| | | FREQUENCY | | |
|---|---|---|---|---|
| | | MIN. | MAX. | |
| VSWR | POWER | (with phase change) | | ΔFREQ. |
| 1.25 | Peaked | 1604 mhz | 1609 mhz | 5 mhz |
| 2.0 | " | 1601 | 1613 | 12 |
| 3.0 | " | 1595 | 1617.5 | 22.5 |
| 1.25 | Undercoupled | 1608.5 | 1612 | 3.5 |
| 2.0 | " | 1605 | 1616 | 11 |
| 3.0 | " | 1603 | 1619.5 | 16.5 |
| 4.0 | " | 1602.5 | 1621.5 | 19 |
| 1.25 | Overcoupled | 1606 | 1611 | 5 |




SINGLE CIRCULATOR TEST SETUP

Figure 2-1




DOUBLE CIRCULATOR TEST SETUP

Figure 2-2

Since the frequency varied over 20 mhz during the above test, a second three port circulator was procured so that even greater isolation could be provided. The two three port circulators were included in the system as shown in Figure 2-2.

With the VSWR set at 1.12 the system noise figure was measured at 7.8 db. The VSWR was then changed from 1.12 up to 3 and at each setting the phase was changed a full 180 degrees. The following data was obtained during this test:

| VSWR | FREQUENCY MIN. (with phase change) | FREQUENCY MAX. (with phase change) | FREQ. |
|---|---|---|---|
| 1.12 | [illegible] | [illegible] | [illegible] |
| 2.0 | 1607.8 mhz | 1609.4 mhz | 1.6 mhz |
| 3.0 | 1607.5 | 1609.5 | 2.0 |

The above results showed a great improvement over the previous use of a single three port circulator. It was determined that one of the three port circulators did not have sufficient isolation at the frequencies being used. From the results of the above tests it was determined that a four port circulator would be required. Specifications were written outlining the requirements for a receiver which would include a circulator-limiter, local oscillator and signal mixer which would provide sufficient isolation to maintain transmitter frequency within ±0.5 mhz with load VSWR variations up to 3.0 and phase changes up to 180 degrees. The complete specification for the radio frequency assembly is Ryan Specification No. 0000720021 and is included as Appendix I in this report. The portion of this specification covering the circulator-limiter and mixer was used to procure the RF receivers which were installed in Altimeters serial numbered 10 through 13.

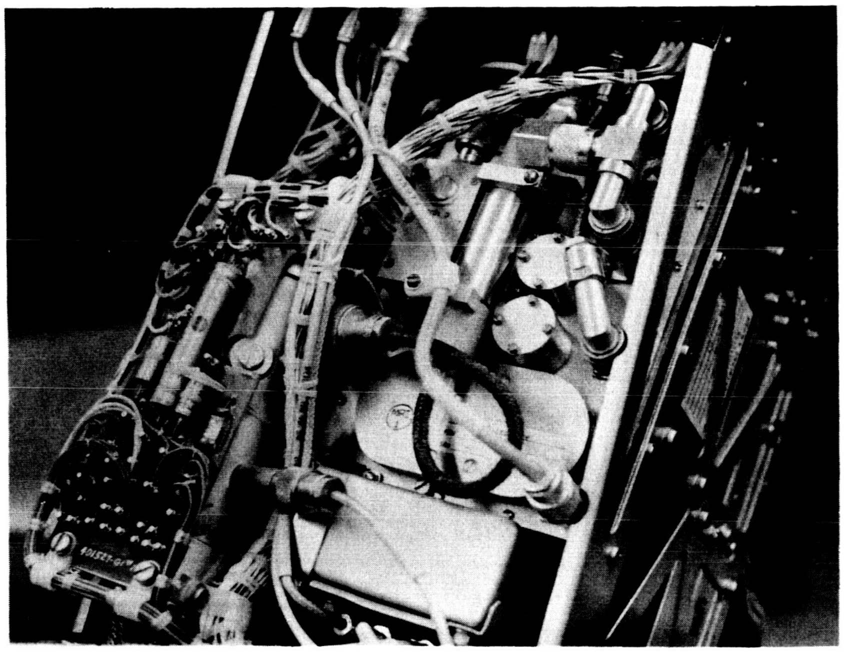
2.3.1 After the first RF assembly was assembled in prototype form it was determined that a four port circulator would not provide sufficient isolation to maintain frequency stability within 0.5 mhz. In order to accomplish the desired isolation, a coaxial isolator was inserted in the line between the transmitter cavity and the circulator. The results of the tests on the RF subassembly are as follows:

| VSWR | FREQUENCY MIN. * | MAX. | Δ FREQ. | MAX. |
|---|---|---|---|---|
| 1.05 | 1610.4 mhz | 1610.6 mhz | 0.2 mhz | |
| 2.0 | 1610.5 | 1610.8 | 0.3 | 0.4 |
| 3.0 | 1610.5 | 1610.8 | 0.3 | |

* Variation with Phase Change

The requirement to use the isolator as well as a four port circulator led to additional problems caused by excessive insertion loss. Insertion loss of the isolator-circulator combination added up to almost 1.8 db which caused a 1.8 kw loss of power from the transmitter. This loss in power caused the output from the transmitter to be less than 5 kw which is the minimum acceptable by specification. Further changes were made in both the isolator and the circulator to reduce the insertion loss and provide over 5.0 kw power.

2.3.2 RF Assembly Packaging. Procurement time for the RF assembly was extremely short because of the necessity to meet the flight schedule of SATURN vehicle SA-7. A total of six weeks was allowed to fabricate and evaluate a prototype RF assembly and deliver a complete flight unit. The RF assembly includes a four port circulator, varactor diode limiter, and hybrid mixer assembly all in one package. The local oscillator and coaxial isolator are mounted on the package. Because of the small space available in the Altimeter, the size of the RF assembly was extremely restricted. Figure 2-3 shows the installation of the RF assembly in the Altimeter. The use of air strip

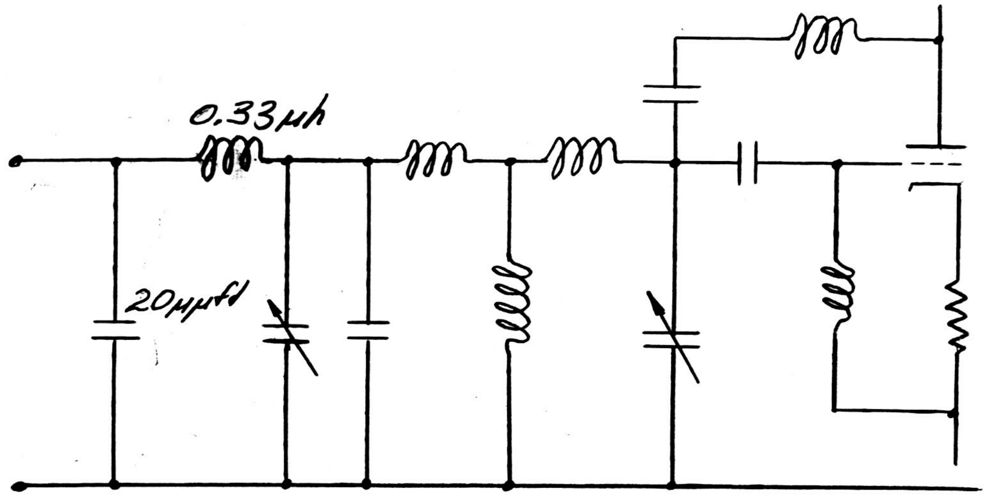


INSTALLATION OF RF ASSEMBLY IN ALTIMETER

Figure 2-3

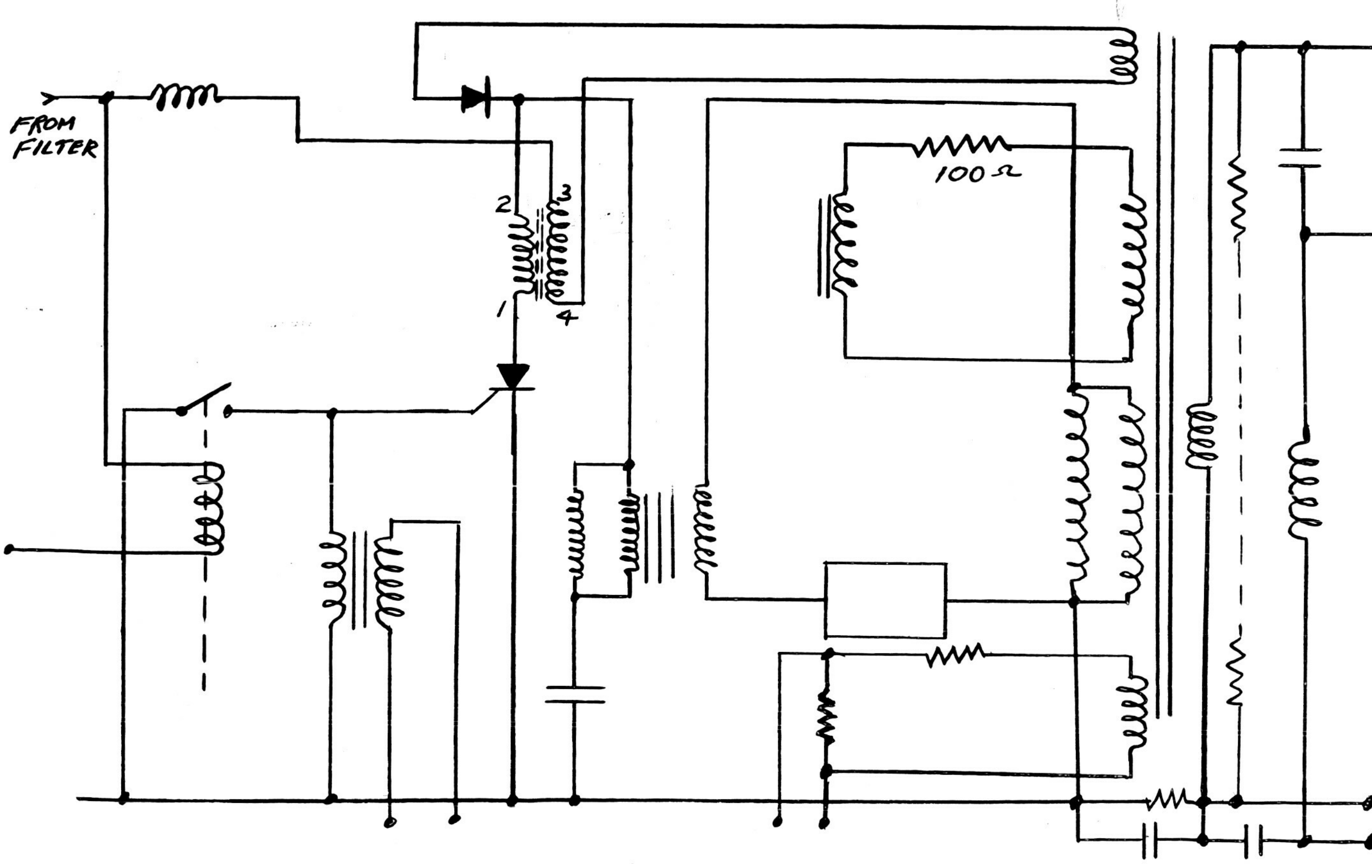
transmission line allowed the construction of the RF assembly in the small size needed. The air strip type construction also permitted the installation of diode balance adjustments in the balanced mixer. An optimum noise figure can be achieved by carefully adjusting the balance controls. Detailed information on the calibration of the RF assembly is given in Paragraph 3.2 below.

2.4 Matching Mixer Output to IF Amplifier. The first RF receiver was installed in an Altimeter for system checkout early in August 1964. The RF receiver provided satisfactory isolation between the transmitter cavity and the antenna load. All other parameters were satisfactory except for the overall system sensitivity. The overall system sensitivity prior to the inclusion of the RF assembly allowed acquisition of -95 dbm signals. After incorporation of the RF assembly, acquisition of only -86 dbm signals was possible. It was determined that insertion loss was not causing all of the loss in sensitivity. The decrease in sensitivity was attributed to the impedance match between the mixer and the IF amplifier. The mixer crystal holders were modified to reduce the capacitance from a total of 35 micromicrofarads to 27 micromicrofarads. The reduction in capacitance improved the sensitivity by 3 db which was still not sufficient to meet the specification requirements. Additional reduction in the capacitance of the mixer crystal holders did not improve the sensitivity. Modifications were made to the IF amplifier input circuitry to provide a proper match for the output impedance of the crystal mixer. The final input circuit consisted of a shunt capacity of 20 micromicrofarads and a series inductance of 0.33 microhenries in addition to the existing input circuit as shown in Figure 2-4. This modification increased the sensitivity to the same as measured prior to the insertion of the new RF assembly.




IF AMPLIFIER INPUT CIRCUIT

Figure 2-4



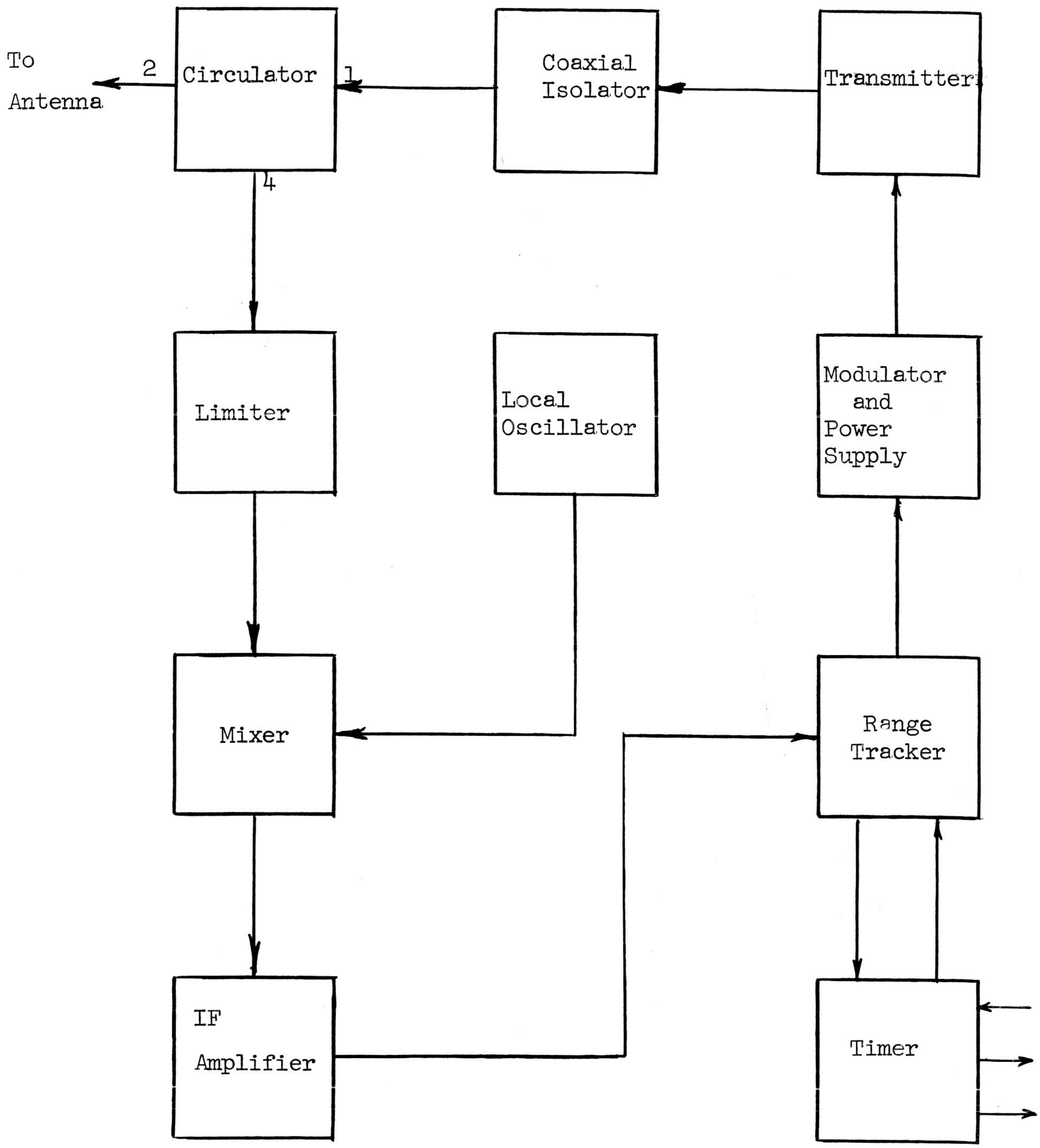

MODULATOR CIRCUIT CHANGES

Figure 2-5

2.5 Modulator Modifications. Early in the program it was determined that the modulator was providing a second pulse of approximately 20 to 100 volts amplitude approximately 0.6 ms after the initial trigger pulse. This second pulse was entering the receiver and causing the range tracker gate to be pulled down to the lower end of the search gate. This signal appeared as a -93 dbm signal and therefore limited the sensitivity of the Altimeter. The modulator was returned to the vendor and changes were incorporated which effectively eliminated the second trigger pulse. Changes made to the modulator are shown in the schematic of Figure 2-5.

## 3.0 DETAIL FACTUAL DATA

3.1 General Description. The general description provided for the Model 520 Radar Altimeter in Ryan Report No. 52067-1 applies to the Radar Altimeters provided for the follow-on order. No external changes have been incorporated in the four follow-on Altimeters identified by serial numbers 10 through 13. Because of the internal changes to the RF assembly and the range tracker, the part number of the Altimeters was changed to 501019-G2. Changes to the RF assembly are shown in the block diagram, Figure 3-1. Trigger pulses from the modulator are fed to the transmitter which in turn transmits the one microsecond wide pulse through an isolator and ports one and two of a four port circulator. Returned signals are fed back into port two of the circulator, out through port four and on to the limiters and mixer. The output from the local oscillator is also fed to a mixer and the resultant IF signal from the mixer is fed to the IF amplifier. In addition to the changes in the IF amplifier subassembly, the timer subassembly has been modified to




RADAR ALTIMETER, BLOCK DIAGRAM

Figure 3-1

provide a 16 bit elapsed time counter which is triggered at the rate of 36 pulses a second. The elapsed time counter can be reset to zero by an external reset pulse. A summary of the major equipment specifications is given in the following table.

TABLE 3-1

| | |
|---|---|
| **Transmitter** | |
| Type | Re-entrant cavity and triode |
| Frequency | 1610 ± 5 mhz |
| Pulse width | 0.8 to 1.1 microseconds |
| Peak power | 5 km |
| PRF | 144 pps |
| *Frequency stability | ± 0.5 mhz |
| *With load VSWR changes up to 3. | |
| **Receiver** | |
| Type | Superheterodyne |
| Center frequency | Within ± 0.7 mhz of transmitter frequency |
| Bandpass | 3.0 ± 1.0 mhz |
| Noise figure | 8 db max. |
| **Timer** | |
| Clock frequency | 21.233664 ± 0.0000212 mhz |
| Trigger pulse frequency | 144 ± 0.002 pps |
| **System Tracking Requirements** | |
| Accuracy | ±30.5 meters |
| Velocity | 6 km/sec max. |
| Acquisition | Must acquire 2 km/sec signal within 18 seconds |
| Sensitivity | -93 dbm |
| Range | 50 to 400 km |

TABLE 3-1

(Continued)

Output Signal Characteristics

| | |
|---|---|
| Altitude word (18 bits) | "0" = 0 to 0.5 vdc<br>"1" = 4.5 to 5.5 vdc |
| Elapsed time word (16 bits) | "0" = 0 to 0.5 vdc<br>"1" = 4.5 to 5.5 vdc |
| Inhibit | Off = 0 to 0.5 vdc<br>On = 4.5 to 5.5 vdc |
| Reliability | Search = 0 ± 0.2 vdc<br>Track = 4.0 to 5.0 vdc |
| AGC | -0.6 to 0 vdc |
| Transmit signal | HV on = -0.1 ± 0.02 vdc<br>HV off = 0 ± 0.02 vdc |
| Filter output | 5.0 vdc max. |
| Power supply | 1.25 ± 0.25 vdc |

3.2 The RF subassembly provided in Altimeters serial numbered 10 through 13 requires a slightly different calibration procedure. The new procedure is as follows:

3.2.1 Limiter setup

(1) Disconnect J13 (isolator) from the RF subassembly and connect the isolator output through a 20 db coupler to the dummy load.

(2) Monitor the output signal frequency. Adjust C1020 on the transmitter cavity for a frequency of 1610 mhz. Peak the transmitter output power and recheck the frequency.

(3) Connect the isolator (J13) to the RF subassembly and connect the output (J10) to the dummy load through a calibrated double stub tuner and the directional coupler.

(4) Remove the local oscillator and monitor leakage power at J15.

(5) Remove mixer diodes from their holders.

(6) With the transmitter energized, vary VSWR between one and three and observe the leakage power at J15. Minimize the leakage power by adjusting the tuning slugs under the varactor housing. A power reading of less than 0.05 milliwatts is required.

(7) Recycle VSWR variations to insure proper setting.

3.2.2 Receiver setup

(1) Set the local oscillator output to 1.6 milliwatts and connect output to J15. Install the mixer crystals in their holders and remove the double stub tuner from the load. Check the crystal diode balance by measuring current between the mixer output and ground. The reading should be less than five microamps.

(2) Carefully adjust controls located beneath and adjacent to the crystal holders until any unbalance is minimized.

(3) Setup the system for a noise figure test. While observing the noise figure meter, tune the crystal diode controls to minimize noise figure. Additional noise figure improvement may be obtained by adjusting the two large tuning slugs on the side opposite from the varactor housing.

(4) Additional noise figure improvement is sometimes possible by adjusting C3002 on the IF amplifier.

4.0 PROGRAM ACTIVITIES

4.1 Modification 12 of Contract NAS8-2459 was initiated on 15 November 1963. Four Model 520 Radar Altimeters with the following modifications were required by the addendum.

4.1.1 Modify timer subassembly to provide an elapsed time interval counter with a capacity of 16 bits and a time resolution of 1/36 of a second.

4.1.2 Provide an external reset capability for the time interval accumulator. The reset signal to be suppled from external vehicle networks.

4.1.3 Appendix A of the contract entitled "Specifications" was amended to:

(1) Add MSFC-STD-154, Printed Circuit Design and Standards for.

(2) Add MSFC-158B, Soldering Electrical Components for Space Vehicles, Procedure for, (delete sub-paragraph 2, Page 12, "Filtration").

(3) Delete MSFC-PROC-257 and substitute therefore MSFC-PROC-293.

4.1.4 All waivers to specifications generated under the basic contract as amended were applicable to Modification 12. The following unit waivers were considered applicable on the follow-on contract:

(1) Plating solution may be Sel-Rex Autronex PC acid gold or Sel-Rex bright gold cyanide, or equivalent, provided other solutions conform to MIL-G-45204.

(a) Total weight shall be 27 pounds maximum.

(b) IF bandwidth of the receiver shall be 3±1 mhz.

(3) Identification may be accomplished in accordance with Para. 3.1.19.7 of MIL-E-5400D where it is impractical to identify parts or components as specified in MIL-STD-16B.

(4) Resistors and diodes may be mounted vertically in the tracker subassembly in lieu of resting

them flat against printed circuit boards as required by Para. 3.1.5 of ABMA drawing 8931071.

(5) Nylon ribbon lacing may be used in lieu of glass lacing cord as required by ABMA-PD-E-53.

(6) Reference Para. 1.4 of the revised sales order. Para. 2, Page 12 "Filtration" of MSFC-STD-158B is deleted.

(7) All specifications contained in the contract, as amended, requiring electrical and environmental testing and resulting test data shall be waived as it would otherwise apply to the timer subassembly being subcontracted from Brown Engineering Company, Huntsville, Alabama for incorporation into the additional four Altimeters.

4.2 On 29 January 1964 SATURN vehicle SA-5 was successfully flown with Altimeter serial number 2 aboard. After approximately 300 seconds of flight the Altimeter locked onto the return signal for approximately 12 seconds and then for the following 100 seconds was intermittently on and off lock. Evaluation of the altitude data during this portion of the flight indicated that the averaged Altimeter readings were within 30 meters of alternate methods of measuring altitude. The altitude during this portion of the flight was over 200 kilometers. During the flight the AGC level remained the same with motors on and off and the intermittent lock-on ocurred similarly under both conditions. This fact led to the conclusion that vibration levels were not the cause of the intermittent lock-on. The conclusion reached by representatives of MSFC is that additional sensitivity in the Altimeter would provide a higher confidence level in meeting the program objectives. Ryan had been independently investigating possible approaches to improving the sensitivity of the Altimeter. These investigations led to the belief that the tracker subassembly could be improved as much as 10 db. Proposals to improve the tracker subassembly were submitted to Marshall Space Flight Center.

4.3 Modifications to the range tracker subassembly of Altimeter serial number 10 were incorporated prior to the required delivery date. The modifications provided tracking of -94 dbm signals and acquisition of -90 dbm signals. Initial lock-on at low altitudes and low relative velocities was assumed as a mission requirement. Therefore, acquisition sensitivity was not considered to be as important as obtaining a much improved tracking sensitivity. Additional modifications were incorporated to limit the bandwidth of the tracker integrators, thus slowing down acquisition time but improving tracker sensitivity. The modifications incorporated in the tracker allowed tracking -98 dbm signals and acquisition of -91 dbm signals. Altimeter serial number 10 completed acceptance testing at Ryan and was hand carried to Marshall Space Flight Center on 7 April 1964 for evaluation. Data obtained during the final acceptance test of the Altimeter are shown in the Appendix. Tests conducted at Marshall Space Flight Center showed that serial number 10 could reacquire a -92 dbm signal when the tracking gate was positioned 100 microseconds from the signal and it could track a -100 dbm signal. MSFC representatives, however, expressed a desire to improve the acquisition time since they were interested in obtaining data during the ascent portion of the flight. In order to investigate the required improvements in sensitivity and isolation between the transmitter and the antenna load, an extension in the delivery schedule was requested.

4.4 Ryan proposed modifications to the tracker assembly with the objective of obtaining a greater acquisition and tracking sensitivity. Also proposed was the incorporation of a modified

TRAK Microwave RF assembly which was designed to isolate the antenna from the transmitter. MSFC representatives rejected the proposal on the basis that the cost of the RF assembly modification was excessive. Ryan obtained alternate approaches to the modification of the RF assembly. An alternate approach was selected and in early June 1964, Ryan proposed modifications to Altimeter serial numbers 10, 11, 12 and 13 which would accomplish the following:

4.4.1 Modification of the range tracker subassebly to allow acquisition of a -93 dbm signal within 18 seconds with vertical velocity of 2 kilometers per second.

4.4.2 Increase the functional reliability of the Altimeter by isolating the transmitter from the antenna to prevent frequency pulling with VSWR changes.

4.5 Altimeter serial number 12 was subjected to final acceptance testing in mid-August 1964. This unit passed the requirement to provide isolation between the antenna and the transmitter cavity with VSWR changes up to three and 180 degree phase changes in the antenna load. The transmitter frequency remained well within a 0.5 mhz variation. Altimeter serial number 12 could acquire -96 dbm signals and track -99 dbm signals. This Altimeter was hand carried to MSFC by a Ryan representative on 16 August 1964. Subsequent testing of Altimeters revealed that the insertion loss in the RF subassembly caused the output transmit power to be marginal. Additional changes in the receiver allowed a further reduction in insertion loss in both the isolator and the circulator.

4.6 On 18 September 1964 SATURN vehicle SA-7 was successfully launched from Cape Kennedy. Altimeter serial number 12 was aboard SA-7, and tracked the return signal from approximately 170 seconds after lift off to 800 seconds after lift off. Preliminary data shows that the accuracy of Altimeter data compares favorable with data from other systems. The last two Altimeters were shipped on 9 October 1964.

## 5.0 CONCLUSIONS

The requirements of Modification 12 and Modification 14 to NAS8-2459 were to provide four production Altimeters with modifications to improve the sensitivity to allow tracking and acquisition of a -93 dbm signal and to isolate the antenna from the transmitter cavity. The Altimeters all exceeded the sensitivity requirement and all provided the necessary isolation between the antenna and transmitter. In addition to the above modifications to the Altimeter, the impedance match between the mixer output and the input of the IF amplifier was modified to provide optimum sensitivity. Modifications to the modulator subassembly resulted in the elimination of the second low amplitude trigger pulse which also affected the sensitivity of the Altimeter.

## 6.0 RECOMMENDATIONS

6.1 During the design, production and testing of the Ryan Model 520 Altimeter various suggestions have been made for improvement in performance. New techniques and advanced technology have afforded the opportunity to extend the capabilities of the Altimeter even further. A study program is recommended to develop modifications to the Model 520 Radar Altimeter which will have as a design objective the ability to acquire and track a -103 dbm signal. This signal would be acquired within 30 seconds nominal when the vertical velocity of the vehicle is a maximum of 2 kilometers per second. In order to extend the sensitivity of the Model 520 Radar Altimeter, it is suggested that a tunnel diode RF pre-amplifier be incorporated and further modifications to the range tracker subassembly be made. Modifications to the range tracker subassembly are required to delete the search-track relay and the nuvistors. A third recommendation would be to incorporate a completely solid state frequency standard which does not require temperature control. Also it is now possible to obtain a completely solid state IF amplifier. The following tasks should be accomplished during the study program.

6.1.1 A prototype tunnel diode amplifier, including a five port circulator, should be designed and fabricated and tested in an Altimeter. The tunnel diode RF pre-amplifier should meet the following performance characteristics:

Frequency: 1610 ±5 mhz
Noise figure: 5.5 db maximum, 4.5 db typical
Gain: 17 db minimum
Temperature range: -20°C to +100°C
Dynamic range of input: -55 to -103 dbm
Maximum surge input: -7 dbm

6.1.2 The present ability of the range tracker subassembly to acquire and track signals weaker than -96 dbm is limited by the relatively insensitive search-track relay circuit. Replacement of the acquisition relay in the tracker is recommended in order to extend the ability to acquire weaker signals. In addition, the DC amplifier portion of the range tracker should be modified to include the use of all solid state components. Deletion of the nuvistors would provide greater reliability and less power drain.

6.1.3 Improvements in the design of the delay generator portion of the range tracker subassembly should be accomplished and should result in a significant improvement in jitter.

6.1.4 Completely solid state frequency standards which do not require temperature stabilized ovens are now available. Investigations into the procurement of such a clock source for the Altimeter application should be made.

6.1.5 It is also recommended that modifications to the IF amplifier subassembly be made to provide a completely solid state amplifier. Present state of the art in IF amplifier design would allow elimination of the nuvistor in the input stage of input amplifier and provide a much smaller size package.

6.2 The successful performance of the Altimeter aboard SATURN vehicle SA-7 leads to the conclusion that accurate, reliable Altimeters can be provided for use as basic navigation devices in future space vehicles.

# APPENDIX

RYAN
ELECTRONICS

SPECIFICATION NO. 00 007 20 021
DATE 27 May 1964
PAGES 9

PROCUREMENT SPECIFICATION
FOR
RADIO FREQUENCY ASSEMBLY

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**REVISIONS**

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# PROCUREMENT SPECIFICATION
# FOR
# RADIO FREQUENCY ASSEMBLY

## 1.0 SCOPE

1.1 Scope - This specification establishes the requirements for the design, fabrication, test, and performance of a Radio Frequency Assembly to be used in the Radar Altimeter for the SATURN space vehicle.

1.2 Interpretation - For the purpose of this specification, the Radio Frequency Assembly, the Manufacturer, and Ryan Electronics shall hereinafter be referred to as the "unit", "Vendor", and "Contractor" respectively.

1.3 Classification - The unit shall be of one type.

## 2.0 APPLICABLE DOCUMENTS

2.1 General - The following documents of the issue in effect on the date of invitation for bids from a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

| | |
|---|---|
| MIL-I-26600 | Interference Control Requirements |
| MIL-D-70327 | Drawings, Engineering and Associated Lists |
| NPC 200-3 | NASA Quality Publication |
| MSFC-STD-154 | Printed Circuit Design and Construction Standards |
| ABMA-DWG-A8931071 | Printed Circuit Soldering and Inspection Procedure |
| ABMA-PD-E-53 | Electrical Wiring Procedures |
| G & C Division(MSFC) Design Guide Lines | Parts, Materials and Processes |
| MSFC-158B | Soldering Electrical Connections for Space Vehicles |

2.2 Availability of Documents - When requesting specifications, standards, and publications, refer to both title and number. Copies of this specification and applicable specifications required by the Vendor in connection with specific procurement functions may be obtained upon application to the Contractor.

2.3 Precedence of Documents - When the requirement of the purchase order, this specification or applicable subsidiary specifications are in conflict, the following precedence shall apply:

(1) Purchase Order - The Purchase Order shall have precedence over any specification.

(2) This Specification - This specification shall have precedence over all applicable subsidiary specifications. Any deviation from this specification, or from subsidiary specifications where applicable, shall be specifically approved in writing by the Contractor.

(3) Referenced Specifications - Any referenced specification shall have precedence over all applicable subsidiary specifications referenced therein. All referenced specifications shall apply to the extent specified.

3.0 REQUIREMENTS

3.1 Parts and Materials - Premium quality components shall be used throughout. The Vendor shall use G & C Division (MSFC) Design Guide Lines covering parts, materials and processes to the fullest extent practicable. Exceptions to this requirement may be granted only by written authorization of the Contractor and will be granted only in those instances where it can be shown that the existing guide lines are lacking in necessary requirements or are inadequate for use.

3.1.1 Solid State Devices - Solid state devices shall be used to the greatest practical extent but the use of electron tubes or hybrid design will be permitted if necessary to comply with this specification, provided the weight and power consumption limits of this specification are not exceeded.

3.2 Design and Construction

3.2.1 General - Simplicity of design, stability, interchangeability, and operational reliability shall be the prime considerations in the design and construction of the unit.

3.2.2 Construction - Integrated construction shall be used to the greatest extent practicable to minimize interconnections and provide a compact unit.

3.2.2.1 Workmanship - Printed circuit design and construction shall be in accordance with MSFC-STD-154. Printed circuit soldering and inspection procedures shall be in accordance with ABMA DWG-A8931071 and electrical connections shall be soldered in accordance with MSFC-158B with subparagraph 2, page 12 "Air Filtration" deleted.

3.2.2.2 Wiring - Electrical wiring procedures shall be in accordance with ABMA-PD-E-53.

3.2.3 Environmental Requirements

3.2.3.1 Temperature - The unit shall be capable of operating at temperature extremes of -20 degrees C. to + 100 degrees C (design objective is + 125°C). The temperature of the unit will be stabilized at the extreme temperature and maintained at this temperature for a period of two hours after which time operational tests will be conducted. During the two-hour period, the unit will be in an operating condition.

3.2.3.2 Vibration - The unit shall be capable of withstanding a sinusoidal vibration in each of its three major axes without adverse effects on its operation. The vibration frequency will be swept from 10 cps to 2,000 cps to 10 cps in 15 minutes, sweeping twice for each of the three axes for a total of 6 sweeps, at the following conditions: (All resonant frequencies will be noted).

20 to 50 cps at 2 g's

50 to 110 cps at 0.016 inches DA displacement

110 to 2,000 cps at 10 g's

Resonant frequencies will be subjected to 10 minutes vibration in each of the three major axes at the following conditions:

20 to 45 cps at 2 g's
45 to 95 cps at 0.016 inches DA displacement
95 to 2,000 cps at 10 g's

3.2.3.3 Shock - The unit shall be capable of withstanding six shocks in each of the three major planes without adverse effects on its operation. The unit will be operating during this test. The shock level will be as follows:

20 g's for 10 milliseconds (triangular wave) or
20 g's for 8 milliseconds (sine wave) or
20 g's for 6 milliseconds (square wave)

3.2.3.4 Acceleration - The unit shall be capable of withstanding 15 g's of acceleration without adverse effects on its operation. The unit will be subjected to acceleration in six mounting positions in succession. The positions will be such that the radial acceleration force is applied to each of these axes. The acceleration time will be 5 minutes for each position.

3.2.4 Mechanical Requirements

3.2.4.1 Total Weight - The total weight of the unit shall be a minimum consistent with good design and shall not exceed 3.0 pounds.

3.2.4.2 Configuration - The configuration of the unit shall be subject to the approval of the Contractor.

3.2.5 Electrical Requirements

3.2.5.1 Radio Frequency Interference - The unit shall conform to Specification MIL-I-26600 in respect to radiated and conducted interference and spurious responses.

3.2.5.2. Transmitter

3.2.5.2.1 Test Points - A test point shall be provided to monitor the signal of 3.2.5.2.3 (2). This test point shall be capable of operating into an impedance of 93 ohms (nominal) without adversely affecting the monitored circuits. The test point shall be isolated to the extent that accidental grounding will not damage components in the set.

3.2.5.2.2 Inputs - The unit shall be supplied with the following inputs:

(1) Power: 6.3 ± 0.5% VDC power at 1.1 amps for filament supply to be supplied from bifilar winding in modulator.

(2) Signal: A pulse from the modulator with the following characteristics:

a) 3,500 volts peak
b) 17.5 kw power min.
c) P.R.F. of 144 cps.
d) Ripple on pulse less than 10% of total pulse amplitude.
e) Pulse width 1.05 microsecond ±0.15 microsecond at 50% point.
f) Rise time (10 to 80%) 0.1 microsecond max.
g) Fall time (10 to 80%)0.5 microsecond max.
h) Droop less than 10% over the pulse width

3.2.5.2.3 Outputs - The unit shall supply the following outputs:

(1) Signal

(a) A 5 to 10 kw RF pulse.
(b) Pulse width 0.8 to 1.1 microsecond.
(c) Rise time 0.1 microsecond max. (10 to 90%)
(d) P.R.F. of 144 cps.
(e) Duty cycle of 0.000137 nominal.
(f) Transmitter frequency of 1.610 ± 0.005 kmc.
(g) Load impedance of 50 ohms

(2) A power monitor equal in all respects to the pulse of 3.2.5.4 (1) except the output voltage shall be minus 0.5 ± 0.1 volt across a nominal 93 ohm output.

3.2.5.2.4 Transmitter Characteristics

(1) Power Output 5 kw min.
(2) Frequency 1.610 ± 0.005 kmc.
(3) Duty Cycle 0.000137 nominal.

(4) Pulse width 0.8 to 1.1 microsecond.

(5) Rise time (10 to 90%) 0.1 microsecond max.

(6) P.R.F. of 144 cps.

(7) Antenna load impedance 50 ohms

3.2.5.3 Receiver - The R.F. receiver shall comprise a four port circulator - limiter, a local oscillator and a balanced mixer. The receiver shall provide sufficient antenna load isolation to maintain transmitter frequency within ± 0.5 mc with load VSWR variations up to 3.0 and phase changes up to 180°. The balanced mixer shall provide a 30 mc I.F. signal. The single frequency noise figure shall be 8.0 db maximum when utilizing an I.F. amplifier with a noise figure of 1.5 db.

3.2.5.3.1 Circulator - Limiter - The four port circulator shall accept the transmit signal of 3.2.5.2.3 (1) and route it to the antenna connection. The circulator - limiter shall provide antenna load isolation described above and provide protection for the mixer diodes and shall route the received signal to the mixer.

(1) Inputs:

a) The transmitter output pulse described in 3.2.5.2.3 (1) shall be routed to the antenna which has a 50 ohm input impedance.

b) A return signal from the target at a power level between - 7 dbm and -96 dbm.

(2) Outputs:

a) The transmitter pulse of (1) (a) above attenuated a maximum of 0.5 db.

b) The input signal of (1) (b) above attenuated by a maximum of 0.5 db. This signal shall be supplied to the signal mixer.

3.2.5.3.2 Local Oscillator - The local oscillator shall provide a 1580 mc signal to the balanced mixer. The L.O. frequency shall be adjustable plus or minus 5 mc. Power output shall be adjustable from 1 to 10 mw. The L.O. - transmitter signal frequency difference shall be 30 ± 0.5 mc under all environmental conditions.

(1) Inputs:

+ 150 vdc unregulated

6.3 ± 0.2 vdc

(2) Output:

Sine wave, 1580 mc, 0-10 mw, to drive balanced crystal mixer.

3.2.5.3.3 Signal Mixer - The mixer shall be balanced with a single output and shall utilize semi-conductor diodes that are accessible for replacement.

(1) Inputs:

a) The circulator - limiter output of 3.2.5.3.1.

b) The local oscillator output of 3.2.5.3.2.

(2) Output: A 30 mc signal for insertion into an I.F. Amplifier. The output impedance shall be 135 ohms and 20 micromicrofarads.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Quality Control - The Vendor shall maintain a quality control system in accordance with NASA Quality Publication NPC 200-3. This system shall be adequate to ssure that the unit meets all the requirements of this specification. Records of all variations, rejections and acceptances shall be maintained through all phases of fabrication and assembly. These records shall be available to the Contractor upon request.

4.2 Reliability Control - The nature and the mission of the space vehicle demand a high degree of reliability. The Vendor shall establish a reliability control program which will ensure a high degree of reliability and submit a copy of this program to the Contractor for review and approval when required by the Purchase Order.

4.3 Acceptance Testing - Each unit submitted for acceptance shall be tested to determine that the unit meets all the electrical requirements of this specification. The vendor shall provide test data showing the results of acceptance testing. Ryan purchasing shall be notified at least 2 working days prior to acceptance testing to allow witnessing of these tests by Ryan. Radio Frequency Interference Testing per MIL-I-26600 shall be conducted at Ryan as a part of the environmental testing.

4.4 Test Procedures - The Vendor shall prepare acceptance test procedures for the unit and submit these procedures to the Contractor for review and approval. The test procedures shall include calibration instructions, a list of test equipment used to perform the tests, and a step-by-step procedure for conducting the tests. The acceptance tests shall be conducted at a location designated in the purchase order.

5.0 PREPARATION FOR DELIVERY

5.1 General - All units shall be preserved, packaged, packed and marked for shipment as specified in the purchase order.

6.0 NOTES

6.1 Monthly Progress Reports - When specified in the purchase order, monthly progress reports shall be submitted to the Contractor and shall include the following information:

(1) A brief statement of work accomplished to start of current reporting period.

(2) A description of the work performed during the current report period including all work whether yielding positive or negative results. Design discussions, results of tests both in raw and summary forms and their interpretations, and plans and schedules of work contemplated for the ensuing month shall be included. Sufficient descriptions of experimental or test conditions shall be provided to establish validity of interpretation beyond reasonable doubt.

(3) All pertinent sketches or drawings.

(4) All pertinent calculations and theoretical analyses.

(5) A statement of the number of man-hours expended for: (a) engineering, (b) drafting, (c) fabrication, and (d) other functions in accomplishing the work performed during the report period.

(6) Any other information such as schedule changes, procurement difficulties, etc., that will assist in evaluating the progress by the Vendor.

6.2 Manufacturing Drawings - A complete set of reproducible manufacturing drawings conforming to Specification MIL-D-70327 shall be provided when and as specified in the purchase order.

6.3 Purchase Order Discrepancies - Discrepancies or departures from the specified requirements of the purchase order shall be identified and submitted to the Contractor for disposition.

6.4 Rework - Cost of rework and transportation of units necessary to correct defects found during acceptance and environmental testing at Ryan shall be borne by the vendor. Vendor engineering and liaison cost, if required during environmental testing, shall be borne by the vendor.

# RYAN ELECTRONICS

REPORT NO. 52065-1B

Test ACCEPTANCE

Eqpt. MODEL 520

Serial No. 10

Date 4-7-64

Test Engr. [illegible]

Witness [illegible]

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.1 | Trans. Freq. | 1610 ±5 MC | 1613.5 |
| 3.2 (4) (e) | High Freq. | As Measured | 1614.25 |
| (d) | Low Freq. | As Measured | 1611.75 |
| (5) (b) | Bandpass | 3.0 ±1.0 MC | 2.5 |
| (e) | Center Freq. | Equal to 3.1 within 0.5 MC | 1613.25 |
| 3.3 (3) (f) | Noise Ind. | As Measured | 7.72 |
| (g) | Cable Loss | As Measured | 0.72 |
| (h) | Noise Figure | Shall not exceed 8.0 db | 7.0 |
| 3.4 | PRF | 14400 ±2 counts | 14400 |
| 3.5 | Pulse Width | From 0.8 to 1.1 µs. | 0.8 |
| | Rise Time | Less than 0.1 µs. (10% to 90%) | 0.1 |
| | Decay Time | Less than 0.5 µs. (90% to 10%) | 0.2 |
| 3.6 | Trans. Power | 5 KW Min. | 9KW |
| 3.7 | Clock Freq. | $212.33664 \times 10^6$ ±212 counts | 212.33668 |
| | Clock Freq. | ~~100~~ 1800 ±2 counts | 1800 |
| 3.8 | Vert. Velocity | Ascending at | |
| | | 50 to 175 KM | OK |
| | | 175 to 400 KM | OK |
| | | Descending at | |
| | | 400 to 175 KM | OK |
| | | 175 to 50 KM | OK |
| 3.9 | Overall System Accuracy | 2411.63 ±0.2034 µs. | 2411.62 |
| | | 1459.18 ±0.2034 µs. | 1459.2 |
| | | 386.17 ±0.2034 µs. | 386.2 |
| 3.10 | Inhibit Signal | 5 ±0.5 VDC | 4.8 |
| | | 0 ±0.5 VDC | 0.25 |

Data Sheet
Sheet 1 of 3

CH Henry

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| 3.10 | (b) | Elapsed Time Word | 5 ±0.5VDC <br> Indicator ON <br> 0 ±0.5 VDC <br> Indicators OFF |

Measured

| IND. | ON | OFF | IND | ON | OFF |
|---|---|---|---|---|---|
| $2^{0}$ | 4.6 | .2 | $2^{9}$ | 4.7 | .2 |
| $2^{1}$ | 4.5 | .2 | $2^{10}$ | 4.7 | .2 |
| $2^{2}$ | 4.7 | .2 | $2^{11}$ | 4.7 | .2 |
| $2^{3}$ | 4.7 | .2 | $2^{12}$ | 4.7 | .2 |
| $2^{4}$ | 4.7 | .2 | $2^{13}$ | 4.7 | .19 |
| $2^{5}$ | 4.7 | .2 | $2^{14}$ | 4.7 | .2 |
| $2^{6}$ | 4.7 | .18 | $2^{15}$ | 4.7 | .18 |
| $2^{7}$ | 4.7 | .17 | | | |
| $2^{8}$ | 4.7 | .16 | | | |

| | | Test | Reqmnt. |
|---|---|---|---|
| | (c) | Altitude Word | 5 ±0.5 VDC <br> Indicator ON <br> 0 ±0.5 VDC <br> Indicator OFF |

| IND. | ON | OFF |
|---|---|---|
| $2^{0}$ | 5.2 | 0 |
| $2^{1}$ | 5.2 | 0 |
| $2^{2}$ | 5.2 | 0 |
| $2^{3}$ | 5.2 | 0 |
| $2^{4}$ | 5.2 | 0 |
| $2^{5}$ | 5.2 | 0 |
| $2^{6}$ | 5.2 | 0 |
| $2^{7}$ | 5.2 | 0 |
| $2^{8}$ | 5.2 | 0 |
| $2^{9}$ | 5.2 | 0 |
| $2^{10}$ | 5.2 | .2 |
| $2^{11}$ | 5.2 | .2 |
| $2^{12}$ | 5.2 | .2 |
| $2^{13}$ | 5.2 | .2 |
| $2^{14}$ | 5.2 | .2 |
| $2^{15}$ | 5.2 | .2 |
| $2^{16}$ | 5.2 | .2 |
| $2^{17}$ | 5.2 | .2 |

NOTE: Indicators $2^{0}$ through $2^{4}$ may jitter too much for an accurate voltage measurement. For these check that the voltage is present or absent.

Data Sheet
Sheet 2 of 3



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C H Henry

Ryan E

# RYAN ELECTRONICS
REPORT NO. 52065-1B

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.10 | (d) Power Supply | 1.25 ±0.25 VDC | 1.3 |
| | | No Ground Effect | OK |
| | (e) Filter Output | Varying Voltage | |
| | | from 0.5 to 5.0 VDC | 0.165 to 4.1 |
| | | No Ground Effect | OK |
| | (f) AGC | Approx. -0.6 to 0.0 VDC | -0.5 to -.07 |
| | | No Ground Effect | OK |
| | (g) Reliability | Track 4.5 ±0.5 VDC | 4.7 |
| | | Search 0 ±0.2 VDC | 0.14 |
| | | No Ground Effect | OK |
| | (h) Transmit Sig. | H.V. ON -0.1 ±0.02 VDC | -0.08 |
| | | H.V. OFF 0 ±0.02 VDC | -0.008 |
| | | No Ground Effect | OK |
| 3.11 | Power Consumption | Oven OFF-less than 65 W. | 64.4 |
| | | Oven ON-less than 80 W. | 75.6 |

Data Sheet
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# RYAN ELECTRONICS
REPORT NO. 52065-1B

Test *Acceptance* Date *Sept 14 1964*

Eqpt. *Rad Altimeter* Test Engr. *L D Ellerton*

Serial No. *10* Witness *C H Henry* FTE 7 E

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.1 | Trans. Freq. | 1610 ±5 MC | *1610.25* |
| 3.2 (4) (e) | High Freq. | As Measured | *1611.5* |
| (d) | Low Freq. | As Measured | *1608.8* |
| (5) (b) | Bandpass | 3.0 ±1.0 MC | *2.7* |
| (e) | Center Freq. | Equal to 3.1 within 0.5 MC. | *1610.15* |
| 3.3 (3) (f) | Noise Ind. | As Measured | *6.7* |
| (g) | Cable Loss | As Measured | *0.72* |
| (h) | Noise Figure | Shall not exceed 8.0 db | *7.98* |
| 3.4 | PRF | 14400 ±2 counts | *14400* |
| 3.5 | Pulse Width | From 0.8 to 1.1 µs. | *0.82* |
| | Rise Time | Less than 0.1 µs. (10% to 90%) | *.096* |
| | Decay Time | Less than 0.5 µs. (90% to 10%) | *.32* |
| 3.6 | Trans. Power | 5 KW Min. | *5.5 KW* |
| 3.7 | Clock Freq. | $212.33664 \times 10^6$ ±212 counts | *212.33662* |
| | Clock Freq. | *1800* ~~100~~ ±2 counts | *1800.0* |
| 3.8 | Vert. Velocity | Ascending at<br>50 to 175 KM<br>175 to 400 KM | <br>*OK*<br>*OK* |
| | | Descending at<br>400 to 175 KM<br>175 to 50 KM | <br>*OK*<br>*OK* |
| 3.9 | Overall System Accuracy | 2411.63 ±0.2034 µs.<br>1459.18 ±0.2034 µs.<br>386.17 ±0.2034 µs. | *2411.60*<br>*1459.20*<br>*386.20* |
| 3.10 | Inhibit Signal | 5 ±0.5 VDC<br>0 ±0.5 VDC | *+4.8*<br>*+0.25* |
| | *Acquisition Time* | *18 sec. max.* | *15.0* |

*MHO.*

Data Sheet
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Whatton FILE 7-E

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.10 | (d) Power Supply | 1.25 ±0.25 VDC | 1.31 VDC |
| | | No Ground Effect | OK |
| | (e) Filter Output | Varying Voltage | |
| | | ~~from 0.5 to~~ 5.0 VDC - MAX MJO. | ~~1~~ 4.6 VDC |
| | | No Ground Effect | OK |
| | (f) AGC | Approx. -0.6 to 0.0 VDC | -0.5 to -0.08 |
| | | No Ground Effect | OK |
| | (g) Reliability | Track 4.5 ±0.5 VDC | 4.78 |
| | | Search 0 ±0.2 VDC | 0.15 |
| | | No Ground Effect | OK |
| | (h) Transmit Sig. | H.V. ON -0.1 ±0.02 VDC | -.100 ~~-.057~~ |
| | | H.V. OFF 0 ±0.02 VDC | -.008 |
| | | No Ground Effect | OK |
| 3.11 | Power Consumption | Oven OFF-less than 65 W. | 64.8 W |
| | | Oven ON-less than 80 W. | 78.9 W |

3.12 Transmitter Stability / Additional Test (MJO.)

| VSWR | FREQ. (MCS) | Δ FREQ (MCS) (MAX = 1 MCS) |
|---|---|---|
| 1.15:1 | 1610.25 | |
| 2:1 | 1610.1 | .15 |
| 3:1 | 1609.9 | .25 |

Data Sheet
Sheet 3 of 3



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FTE 7 E

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| 3.10 | (b) | Elapsed Time Word | 5 ±0.5VDC Indicator ON; 0 ±0.5 VDC Indicators OFF |

Measured

| IND. | ON | OFF | IND | ON | OFF |
|---|---|---|---|---|---|
| $2^0$ | 4.6 | 0.15 | $2^9$ | 4.7 | 0.2 |
| $2^1$ | 4.6 | 0.15 | $2^{10}$ | 4.7 | 0.2 |
| $2^2$ | 4.6 | 0.15 | $2^{11}$ | 4.7 | 0.2 |
| $2^3$ | 4.4 | 0.15 | $2^{12}$ | 4.8 | 0.2 |
| $2^4$ | 4.6 | 0.15 | $2^{13}$ | 4.7 | 0.2 |
| $2^5$ | 4.6 | 0.15 | $2^{14}$ | 4.7 | 0.2 |
| $2^6$ | 4.7 | 0.15 | $2^{15}$ | 4.1 | .18 |
| $2^7$ | 4.7 | 0.06 | | | |
| $2^8$ | 4.8 | 0.06 | | | |

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| | (c) | Altitude Word | 5 ±0.5 VDC Indicator ON; 0 ±0.5 VDC Indicator OFF |

| IND. | ON | OFF |
|---|---|---|
| $2^0$ | 5.1 | 0.1 |
| $2^1$ | " | " |
| $2^2$ | " | " |
| $2^3$ | " | " |
| $2^4$ | 5.0 | 0.15 |
| $2^5$ | " | " |
| $2^6$ | " | " |
| $2^7$ | " | " |
| $2^8$ | " | " |
| $2^9$ | 4.9 | 0.10 |
| $2^{10}$ | 5.0 | 0.12 |
| $2^{11}$ | 5.0 | 0.1 |
| $2^{12}$ | 5.0 | 0.1 |
| $2^{13}$ | 5.0 | 0.14 |
| $2^{14}$ | 4.9 | 0.1 |
| $2^{15}$ | 5.0 | 0.1 |
| $2^{16}$ | 5.0 | 0.1 |
| $2^{17}$ | 5.0 | 0.1 |

NOTE: Indicators $2^0$ through $2^4$ may jitter too much for an accurate voltage measurement. For these check that the voltage is present or absent.

Syst. consts. (power test)

cable loss (tx to coupler) 0.72 db

directional coupler 22.10

attenuator 9.82

32.64

less dial Reading - 9.5

28.14 db

Data Sheet
Sheet 2 of 3



5-B

RYAN ELECTRONICS

REPORT NO. 52065-1B

Test *Acceptance* Date *2 Sept '64*

Eqpt. *Rad Alt. 5010194* Test Engr. *[illegible]*

Serial No. *11* Witness *[illegible]*

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.1 | Trans. Freq. | 1610 ±5 MC | *1610.5* |
| 3.2 (4) (e) | High Freq. | As Measured | *1611.5* |
| (d) | Low Freq. | As Measured | *1609.1* |
| (5) (b) | Bandpass | 3.0 ±1.0 MC | *2.4* |
| (e) | Center Freq. | Equal to 3.1 within 0.5 MC | *1610.3* |
| 3.3 (3) (f) | Noise Ind. | As Measured | *8.5* |
| (g) | Cable Loss | As Measured | *.72* |
| (h) | Noise Figure | Shall not exceed 8.0 db | *7.78* |
| 3.4 | PRF | 14400 ±2 counts | *14400* |
| 3.5 | Pulse Width | From 0.8 to 1.1 µs | *.82* |
| | Rise Time | Less than 0.1 µs. (10% to 90%) | *.095* |
| | Decay Time | Less than 0.5 µs. (90% to 10%) | *.25* |
| 3.6 | Trans. Power | 5 KW Min. | *5.3KW.* |
| 3.7 | Clock Freq. | $212.33664 \times 10^6$ ±212 counts | *$212.33659 \times 10^6$* |
| | Clock Freq. | *1600* ~~100~~ ±2 counts *MKO* | *1600.0* |
| 3.8 | Vert. Velocity | Ascending at | |
| | | 50 to 175 KM | *OK* |
| | | 175 to 400 KM | *OK* |
| | | Descending at | |
| | | 400 to 175 KM | *OK* |
| | | 175 to 50 KM | *OK* |
| 3.9 | Overall System Accuracy | 2411.63 ±0.2034 µs. | *Error ±0.15 µsec* |
| | | 1459.18 ±0.2034 µs. | *Error ±0.06 µsec* |
| | | 386.17 ±0.2034 µs. | *Error ±0.10 µsec* |
| 3.10 | Inhibit Signal | 5 ±0.5 VDC | *4.5 vdc* |
| | | 0 ±0.5 VDC | *0.2 vdc* |
| | *Acquisition Time* | *18 sec max* *MKO* | *18 sec* |

Data Sheet
Sheet 1 of 3



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| Par. | | Test | Reqmnt. |
|---|---|---|---|
| 3.10 | (b) | Elapsed Time Word | 5 ±0.5VDC Indicator ON<br>0 ±0.5 VDC Indicators OFF |

Measured

| IND. | ON | OFF | IND | ON | OFF |
|---|---|---|---|---|---|
| $2^0$ | 4.5 | 0.2 | $2^9$ | 4.7 | 0.2 |
| $2^1$ | 4.6 | " | $2^{10}$ | " | 0.17 |
| $2^2$ | " | " | $2^{11}$ | " | 0.2 |
| $2^3$ | " | " | $2^{12}$ | " | 0.19 |
| $2^4$ | " | 0.15 | $2^{13}$ | " | 0.2 |
| $2^5$ | " | " | $2^{14}$ | " | 0.17 |
| $2^6$ | 4.7 | 0.2 | $2^{15}$ | " | 0.18 |
| $2^7$ | " | 0.15 | | | |
| $2^8$ | " | 0.2 | | | |

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| | (c) | Altitude Word | 5 ±0.5 VDC Indicator ON<br>0 ±0.5 VDC Indicator OFF |

| IND. | ON | OFF |
|---|---|---|
| $2^0$ | 5.1 | 0.15 |
| $2^1$ | " | " |
| $2^2$ | " | 0.15 |
| $2^3$ | " | " |
| $2^4$ | " | " |
| $2^5$ | 5.0 | " |
| $2^6$ | 5.0 | 0.2 |
| $2^7$ | " | 0.15 |
| $2^8$ | " | 0.2 |
| $2^9$ | 5.0 | 0.15 |
| $2^{10}$ | 4.9 | 0.15 |
| $2^{11}$ | 4.9 | 0.2 |
| $2^{12}$ | 5.0 | 0.18 |
| $2^{13}$ | 5.0 | 0.13 |
| $2^{14}$ | 5.0 | 0.13 |
| $2^{15}$ | 5.0 | 0.15 |
| $2^{16}$ | 5.0 | 0.15 |
| $2^{17}$ | 5.0 | 0.15 |

NOTE: Indicators $2^0$ through $2^4$ may jitter too much for an accurate voltage measurement. For these check that the voltage is present or absent.

Data Sheet
Sheet 2 of 3



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| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.10 | (d) Power Supply | 1.25 ±0.25 VDC | 1.33 vdc |
| | | No Ground Effect | NO |
| | (e) Filter Output | Varying Voltage | |
| | | ~~from 0.5 to~~ 5.0 VDC MAX | 0.16 to 4.4 |
| | | No Ground Effect | No |
| | (f) AGC | Approx. -0.6 to 0.0 VDC | -0.583 to -0.09 vdc |
| | | No Ground Effect | NO |
| | (g) Reliability | Track 4.5 ±0.5 VDC | +4.7 vdc |
| | | Search 0 ±0.2 VDC | 0.15 vdc |
| | | No Ground Effect | NO |
| | (h) Transmit Sig. | H.V. ON -0.1 ±0.02 VDC | -0.09 |
| | | H.V. OFF 0 ±0.02 VDC | -0.01 |
| | | No Ground Effect | NO |
| 3.11 | Power Consumption | Oven OFF-less than 65 W. | 65 w |
| | | Oven ON-less than 80 W. | 79 w |

MLO

3.6 TX Power MEASUREMENTS. Additional test added.

MLO

3.6.1 LOSSES.

| | |
|---|---|
| CABLE LOSS | 0.72 db |
| COUPLER LOSS | 22.10 db |
| ATTENUATOR | 9.82 db |
| | 32.64 db |
| METER READING | -4.8 db |
| | 27.84 db = 5.3 KW. |

3.12 Transmitter stability.

| VSWR | Freq. | ΔF |
|---|---|---|
| 1.15 : 1 | 1610.5 | .4 mcs |
| 2 : 1 | 1610.1 | .4 mcs. |
| 3 : 1 | 1610.1 | |

Data Sheet
Sheet 3 of 3



9-B

# RYAN ELECTRONICS

REPORT NO. 52065-1B

Test Acceptance  Date Oct 5 1964

Eqpt. Rad Alt Mod 520  Test Engr. [illegible]

Serial No. 11  Witness [illegible]  FTE 7

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.1 | Trans. Freq. | 1610 ±5 MC | 1609.5 |
| 3.2 (4) (e) | High Freq. | As Measured | 1610.9 |
| (d) | Low Freq. | As Measured | 1608.8 |
| (5) (b) | Bandpass | 3.0 ±1.0 MC | 2.1 |
| (e) | Center Freq. | Equal to 3.1 within 0.5 MC | 1609.85 |
| 3.3 (3) (f) | Noise Ind. | As Measured | 8.2 |
| (g) | Cable Loss | As Measured | .72 |
| (h) | Noise Figure | Shall not exceed 8.0 db | 7.48 |
| 3.4 | PRF | 14400 ±2 counts | 14400.0 |
| 3.5 | Pulse Width | From 0.8 to 1.1 µs. | .82 |
| | Rise Time | Less than 0.1 µs. (10% to 90%) | .090 |
| | Decay Time | Less than 0.5 µs. (90% to 10%) | .35 |
| 3.6 | Trans. Power | 5 KW Min. | 5.5 KW |
| 3.7 | Clock Freq. | $212.33664 \times 10^6$ ±212 counts | 21233657 |
| | Clock Freq. | 1800 ±2 ~~100 ±2~~ counts | 1800 |
| 3.8 | Vert. Velocity | Ascending at | |
| | | 50 to 175 KM | OK |
| | | 175 to 400 KM | OK |
| | | Descending at | |
| | | 400 to 175 KM | OK |
| | | 175 to 50 KM | OK |
| 3.9 | Overall System Accuracy | 2411.63 ±0.2034 µs. | 2411.60 |
| | | 1459.18 ±0.2034 µs. | 1459.10 |
| | | 386.17 ±0.2034 µs. | 386.20 |
| 3.10 | Inhibit Signal | 5 ±0.5 VDC | 5.0 |
| | | 0 ±0.5 VDC | .45 |
| | Acquisition Time | 18 sec Max | 14 sec. |

M.f.

Data Sheet
Sheet 1 of 3



10-B

FTE 7 E

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| 3.10 | (b) | Elapsed Time Word | 5 ±0.5VDC<br>Indicator ON<br>0 ±0.5 VDC<br>Indicators OFF |

Measured

| IND. | ON | OFF | IND | ON | OFF |
|---|---|---|---|---|---|
| $2^0$ | 4.7 | .2 | $2^9$ | 4.7 | .23 |
| $2^1$ | 4.7 | .2 | $2^{10}$ | 4.7 | .20 |
| $2^2$ | 4.7 | .2 | $2^{11}$ | 4.7 | .23 |
| $2^3$ | 4.7 | .2 | $2^{12}$ | 4.7 | .23 |
| $2^4$ | 4.7 | .125 | $2^{13}$ | 4.7 | .21 |
| $2^5$ | 4.7 | .125 | $2^{14}$ | | .22 |
| $2^6$ | 4.7 | .22 | $2^{15}$ | 4.7 | .22 |
| $2^7$ | 4.7 | .20 | | | |
| $2^8$ | 4.7 | .24 | | | |

| | | Test | Reqmnt. |
|---|---|---|---|
| | (c) | Altitude Word | 5 ±0.5 VDC<br>Indicator ON<br>0 ±0.5 VDC<br>Indicator OFF |

| IND. | ON | OFF |
|---|---|---|
| $2^0$ | 5.2 | .14 |
| $2^1$ | 5.2 | .15 |
| $2^2$ | 5.15 | .15 |
| $2^3$ | 5.2 | .15 |
| $2^4$ | 5.2 | .12 |
| $2^5$ | 5.3 | .12 |
| $2^6$ | 5.2 | .12 |
| $2^7$ | 5.2 | .12 |
| $2^8$ | 5.3 | .12 |
| $2^9$ | 4.93 | .13 |
| $2^{10}$ | 4.97 | .15 |
| $2^{11}$ | 5.01 | .13 |
| $2^{12}$ | 4.95 | .112 |
| $2^{13}$ | 4.99 | .102 |
| $2^{14}$ | 4.93 | .09 |
| $2^{15}$ | 4.97 | .12 |
| $2^{16}$ | 4.95 | .14 |
| $2^{17}$ | 4.98 | .112 |

NOTE: Indicators $2^0$ through $2^4$ may jitter too much for an accurate voltage measurement. For these check that the voltage is present or absent.

Data Sheet
Sheet 2 of 3



11-B

FTE

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.10 | (d) Power Supply | 1.25 ±0.25 VDC | 1.316 |
| | | No Ground Effect | OK |
| | (e) Filter Output | Varying Voltage | |
| | | MYO ~~from 0.5 to~~ 5.0 VDC. MAX | +.158 To 3.54 |
| | | No Ground Effect | OK |
| | (f) AGC | Approx. -0.6 to 0.0 VDC | -5.86 -.083 |
| | | No Ground Effect | OK |
| | (g) Reliability | Track 4.5 ±0.5 VDC | 4.803 |
| | | Search 0 ±0.2 VDC | .12 |
| | | No Ground Effect | OK |
| | (h) Transmit Sig. | H.V. ON -0.1 ±0.02 VDC | -.106 |
| | | H.V. OFF 0 ±0.02 VDC | 0.015 |
| | | No Ground Effect | OK |
| 3.11 | Power Consumption | Oven OFF-less than 65 W. | 64.84 |
| | | Oven ON-less than 80 W. | 79.04 |

3.12 TRANSMITTER STABILITY: Additional Test (MYO)

| VSWR | FREQ | Δ FREQ (MAX = 1 MCS) |
|---|---|---|
| 1.15 | 1609.5 | .1 |
| 2 | 1609.4 | .25 |
| 3 | 1609.25 | |

Data Sheet
Sheet 3 of 3



12-B

**RYAN ELECTRONICS**

**REPORT NO. 52065-1B**

Test FINAL ACCEPTANCE AFTER MOD 12 Date 15 AUG 64

Eqpt. RADAR ALTIMETER Test Engr. D. ELLERTSON

Serial No. Twelve Witness RYAN, BUWEPS

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.1 | Trans. Freq. | 1610 ±5 MC | 1611.3 mc/s |
| 3.2 (4) (e) | High Freq. | As Measured | 1613.6 mc/s |
| (d) | Low Freq. | As Measured | 1610.0 mc/s |
| (5) (b) | Bandpass | 3.0 ±1.0 MC | 3.6 mc/s |
| (e) | Center Freq. | Equal to 3.1 within 0.5 MC. | 1611.8 mc/s |
| 3.3 (3) (f) | Noise Ind. | As Measured | 8.8 db |
| (g) | Cable Loss | As Measured | 0.72 db |
| (h) | Noise Figure | Shall not exceed 8.0 db | 8.08 db |
| 3.4 | PRF | 14400 ±2 counts | 14400 |
| 3.5 | Pulse Width | From 0.8 to 1.1 µs. | 0.86 µsec. |
| | Rise Time | Less than 0.1 µs. (10% to 90%) | < .1 µsec |
| | Decay Time | Less than 0.5 µs. (90% to 10%) | .25 ~~µ~~sec |
| 3.6 | Trans. Power | 5 KW Min. | 6.9 KW |
| 3.7 | Clock Freq. | 212.33664 x $10^6$ ±212 counts | 212.33681 |
| | Clock Freq. | 1800 counts ±2 | 1800 counts |
| 3.8 | Vert. Velocity | Ascending at<br>50 to 175 KM<br>175 to 400 KM | 50 to 175 KM<br>175 to 400 KM |
| | | Descending at<br>400 to 175 KM<br>175 to 50 KM | 400 to 175 KM<br>175 to 50 KM |
| 3.9 | Overall System Accuracy | 2411.63 ±0.2034 µs.<br>1459.18 ±0.2034 µs.<br>386.17 ±0.2034 µs. | 2411.6 µS<br>1459.1 µS<br>386.1 µS |
| 3.10 | Inhibit Signal | 5 ±0.5 VDC<br>0 ±0.5 VDC | 4.8 VDC<br>0.48 VDC |

Data Sheet
Sheet 1 of 3



13-B

C24 1

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| 3.10 | (b) | Elapsed Time Word | 5 ±0.5VDC Indicator ON<br>0 ±0.5 VDC Indicators OFF |

Measured

| IND. | ON | OFF | IND. | ON | OFF |
|---|---|---|---|---|---|
| $2^0$ | 4.8 | 0.2 | $2^9$ | 4.8 | 0.2 |
| $2^1$ | 4.85 | 0.2 | $2^{10}$ | 4.8 | 0.25 |
| $2^2$ | 4.8 | 0.2 | $2^{11}$ | 4.8 | 0.25 |
| $2^3$ | 4.8 | 0.2 | $2^{12}$ | 4.8 | 0.2 |
| $2^4$ | 4.85 | 0.22 | $2^{13}$ | 4.75 | 0.2 |
| $2^5$ | 4.8 | 0.25 | $2^{14}$ | 4.8 | 0.25 |
| $2^6$ | 4.8 | 0.20 | $2^{15}$ | 4.8 | 0.2 |
| $2^7$ | 4.8 | 0.20 | | | |
| $2^8$ | 4.8 | 0.20 | | | |

(c) Altitude Word — 5 ±0.5 VDC Indicator ON; 0 ±0.5 VDC Indicator OFF

| IND. | ON | OFF |
|---|---|---|
| $2^0$ | 5.4 | 0.1 |
| $2^1$ | 5.4 | 0.1 |
| $2^2$ | 5.4 | 0.1 |
| $2^3$ | 5.4 | 0.1 |
| $2^4$ | 5.5 | 0.1 |
| $2^5$ | 5.5 | 0.1 |
| $2^6$ | 5.5 | 0.1 |
| $2^7$ | 5.45 | 0.15 |
| $2^8$ | 5.45 | 0.15 |
| $2^9$ | 5.4 | 0.1 |
| $2^{10}$ | 5.4 | 0.1 |
| $2^{11}$ | 5.4 | 0.1 |
| $2^{12}$ | 5.4 | 0.1 |
| $2^{13}$ | 5.4 | 0.1 |
| $2^{14}$ | 5.4 | 0.1 |
| $2^{15}$ | 5.4 | 0.1 |
| $2^{16}$ | 5.4 | 0.1 |
| $2^{17}$ | 5.4 | 0.1 |

NOTE: Indicators $2^0$ through $2^4$ may jitter too much for an accurate voltage measurement. For these check that the voltage is present or absent.

CONTRACTUAL ADDITION: ACQUISITION TIME WILL BE 18 SECONDS OR LESS WITH THE FOLLOWING TEST CONDITIONS. −93 dbm SIGNAL INPUT / VERTICAL VELOCITY 2 KM/SEC

RESULTS = 21 SECONDS

WAIVED BY BILL CASE, NASA ENGR RESP. FOR ALTIMETER SECTION OF SATURN. ALSO ALT CONTRACT REP OFFICER PER TELECON 15 AUG 64 1:15 PDST

Data Sheet
Sheet 2 of 3



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E24

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.10 | (d) Power Supply | 1.25 ±0.25 VDC | +1.329 VDC |
| | | No Ground Effect | NONE |
| | (e) Filter Output | Varying Voltage | |
| | | from 0.5 to 5.0 VDC | 4.399 to 0.179 VDC |
| | | No Ground Effect | NONE |
| | (f) AGC | Approx. -0.6 to 0.0 VDC | -0.579 to 0.080 VDC |
| | | No Ground Effect | NONE |
| | (g) Reliability | Track 4.5 ±0.5 VDC | +4.719 |
| | | Search 0 ±0.2 VDC | 0.179 |
| | | No Ground Effect | NONE |
| | (h) Transmit Sig. | H.V. ON -0.1 ±0.02 VDC | -0.081 |
| | | H.V. OFF 0 ±0.02 VDC | 0.019 |
| | | No Ground Effect | NONE |
| 3.11 | Power Consumption | Oven OFF-less than 65 W. | 63.558 W |
| | | Oven ON-less than 80 W. | 77.463 W |

SYSTEM CALIBRATION

CABLE LOSSes

| | |
|---|---|
| SIGNAL GENERATOR TO DIRECTION CPLR | 0.70 db |
| XMTR TO " " | 0.72 db |
| COUPLING LOSS | 22.10 db |
| ATTENUATOR, NARDA MODEL 757-20 S/N 729 | 18.64 db |

INSERTION LOSS

| | |
|---|---|
| DUAL DIRECTION CPLR, NARDA 3022 S/N 144 | .12 db |

Data Sheet
Sheet 3 of 3

SYSTEM CONSTANTS = 42.28 db



15-B

## REFERENCE INFORMATION.

123

USING HEWLETT PACKARD LINE-STRETCHER TO ACHIEVE A PHASE SHIFT FROM 0° to > 180°, PLUS A DOUBLE STUB TUNER USED TO OBTAIN A MISMATCH (VSWR) OF 1.15, 2, & 3 to 1. The below TABLE IS THE RESULTS, SPEC REQMTS ARE $\leq \pm 0.5$ mc/s FREQ SHIFT WITH THE ABOVE INPUTS.

| $\phi$ SHIFT | VSWR | | READ FREQ | | |
|---|---|---|---|---|---|
| 0° | 1.05 | | 1611.7 | mc/s | $\Delta f = 0$ |
| > 180° | 1.05 | | 1611.7 | " | |
| 0° | 1.15 | | 1611.5 | " | |
| > 180° | 1.15 | $\Delta f = .1$ mc/s | 1611.4 | " | |
| 0° | 2.0 | $\Delta f = .4$ mc/s | 1611.5 | " | |
| > 180° | 2.0 | | 1611.9 | " | |
| 0° | 3.0 | | 1611.3 | " | |
| > 180° | 3.0 | $\Delta f = .6$ mc/s | 1611.0 | " | |
| 90° | 3.0 | | 1611.6 | " | |

all readings are in spec using a $\pm$ .5 mc/s tolerance

Ryan

# RYAN ELECTRONICS

REPORT NO. 52065-1B

Test Acceptance

Eqpt. Rad Altimeter Mod 520

Serial No. 13

Date Oct 5 1964

Test Engr. E. Martin

Witness CWH

| Par. | Test | Reqmnt. | Measured |
|---|---|---|---|
| 3.1 | Trans. Freq. | 1610 ±5 MC | 1610.0 ~~[illegible]~~ |
| 3.2 (4) (e) | High Freq. | As Measured | 1611.5 |
| (d) | Low Freq. | As Measured | 1609.0 |
| (5) (b) | Bandpass | 3.0 ±1.0 MC | 2.5 |
| (e) | Center Freq. | Equal to 3.1 within 0.5 MC. | 1610.25 |
| 3.3 (3) (f) | Noise Ind. | As Measured | 8.8 |
| (g) | Cable Loss | As Measured | .72 |
| (h) | Noise Figure | Shall not exceed 8.0 db | 8.08 |
| 3.4 | PRF | 14400 ±2 counts | 14400 |
| 3.5 | Pulse Width | From 0.8 to 1.1 $\mu$s. | .82 |
| | Rise Time | Less than 0.1 $\mu$s. (10% to 90%) | .10 |
| | Decay Time | Less than 0.5 $\mu$s. (90% to 10%) | .55 |
| 3.6 | Trans. Power | 5 KW Min. | 5.4 KW |
| 3.7 | Clock Freq. | $212.33664 \times 10^6$ ±212 counts | 212336.58 |
| | Clock Freq. | 1800 ~~100~~ ±2 counts | 1800 |
| 3.8 | Vert. Velocity | Ascending at | |
| | | 50 to 175 KM | OK |
| | | 175 to 400 KM | OK |
| | | Descending at | |
| | | 400 to 175 KM | OK |
| | | 175 to 50 KM | OK |
| 3.9 | Overall System Accuracy | 2411.63 ±0.2034 $\mu$s. | 2411.60 |
| | | 1459.18 ±0.2034 $\mu$s. | 1459.15 |
| | | 386.17 ±0.2034 $\mu$s. | 386.2 |
| 3.10 | Inhibit Signal | 5 ±0.5 VDC | 4.8 |
| | | 0 ±0.5 VDC | .15 |
| | Acquisition | 18 Sec. | 23 Sec. |

Data Sheet
Sheet 1 of 3

13-B

FTE 7-E

| Par. | | Test | Reqmnt. |
|---|---|---|---|
| 3.10 | (b) | Elapsed Time Word | 5 ±0.5VDC<br>Indicator ON<br>0 ±0.5 VDC<br>Indicators OFF |

Measured

| IND. | ON | OFF | IND | ON | OFF |
|---|---|---|---|---|---|
| $2^0$ | 4.8 | .2 | $2^9$ | 4.75 | .21 |
| $2^1$ | 4.8 | .15 | $2^{10}$ | 4.75 | .22 |
| $2^2$ | 4.8 | .15 | $2^{11}$ | 4.75 | .20 |
| $2^3$ | 4.8 | .15 | $2^{12}$ | 4.75 | .21 |
| $2^4$ | 4.8 | .15 | $2^{13}$ | 4.72 | .21 |
| $2^5$ | 4.8 | .15 | $2^{14}$ | 4.73 | .22 |
| $2^6$ | 4.8 | .2 | $2^{15}$ | 4.75 | .21 |
| $2^7$ | 4.8 | .2 | | | |
| $2^8$. | 4.75 | .21 | | | |

| | Test | Reqmnt. |
|---|---|---|
| (c) | Altitude Word | 5 ±0.5 VDC<br>Indicator ON<br>0 ±0.5 VDC<br>Indicator OFF |

| IND. | ON | OFF |
|---|---|---|
| $2^0$ | 5.3 | .10 |
| $2^1$ | 5.3 | .10 |
| $2^2$ | 5.25 | .10 |
| $2^3$ | 5.3 | .10 |
| $2^4$ | 5.3 | .10 |
| $2^5$ | 5.3 | .10 |
| $2^6$ | 5.3 | .05 |
| $2^7$ | 5.3 | .05 |
| $2^8$ | 5.3 | .05 |
| $2^9$ | 5.3 | .05 |
| $2^{10}$ | 5.3 | .10 |
| $2^{11}$ | 5.3 | .10 |
| $2^{12}$ | 5.25 | .10 |
| $2^{13}$ | 5.3 | .10 |
| $2^{14}$ | 5.3 | .10 |
| $2^{15}$ | 5.25 | .10 |
| $2^{16}$ | 5.3 | .05 |
| $2^{17}$ | 5.3 | .05 |

NOTE: Indicators $2^0$ through $2^4$ may jitter too much for an accurate voltage measurement. For these check that the voltage is present or absent.

Data Sheet
Sheet 2 of 3



18-B

| Par. | Test | | Reqmnt. | Measured |
|---|---|---|---|---|
| 3.10 | (d) | Power Supply | 1.25 ±0.25 VDC | 1.247 |
| | | | No Ground Effect | OK |
| | (e) | Filter Output | Varying Voltage | |
| | | | from 0.5 to 5.0 VDC | .269 – 4.32 |
| | | | No Ground Effect | OK |
| | (f) | AGC | Approx. -0.6 to 0.0 VDC | -5.84 to 0.090 |
| | | | No Ground Effect | OK |
| | (g) | Reliability | Track 4.5 ±0.5 VDC | 4.73 |
| | | | Search 0 ±0.2 VDC | 0.17 |
| | | | No Ground Effect | OK |
| | (h) | Transmit Sig. | H.V. ON -0.1 ±0.02 VDC | .095 |
| | | | H.V. OFF 0 ±0.02 VDC | 0.015 |
| | | | No Ground Effect | OK |
| 3.11 | Power Consumption | | Oven OFF-less than 65 W. | 63.04 |
| | | | Oven ON-less than 80 W. | 78.6 |

Frequency Stability

| VSWR | freq | Δf | (1 Mc MAX) |
|---|---|---|---|
| 1.15:1 | 1610.0 | 0 | |
| 2:1 | 1610.0 | .2 | |
| 3:1 | 1609.8 | | |

Data Sheet
Sheet 3 of 3



19-B