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APP. A

APPENDIX A

SPECIFICATION
(Third Revision)

Submitted as part of the Final Report

for RF Test Console on JPL

Contract No. 950144

NAS 7-100

CONTRIBUTOR: G. R. Vaughan

DATE: February 1, 1965

WESTINGHOUSE DEFENSE AND SPACE CENTER

SURFACE DIVISION

ADVANCED DEVELOPMENT ENGINEERING

TABLE OF CONTENTS

65-225 ARP-A

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

1. SCOPE

1.1 Scope. This Specification covers the requirements for the design and fabrication of special RF test equipment to be used as a precision transmitter-receiver combination designated an "RF Test Console."

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date for invitation of bids, form a part of this specification:

SPECIFICATIONS

Jet Propulsion Laboratory

* 20016	General Specification, Workmanship Requirements for Electronic Equipment
* 20018	General Specification, Cable Assemblies, Fabrication of
20061	JPL Preferred Parts List, Reliable Electronic Components
30609	JPL Standard Specification, Racks for Ground Equipment

* See para. 3.8 for exceptions

Military

MIL-F-14072	Finishes for Ground Signal Equipment

3. REQUIREMENTS

3.1 Conflicting requirements. Conflicting requirements between this

65-335

specification and any specification referenced herein shall be referred in writing to the JPL cognizant engineer and to the JPL procurement representative for interpretation and clarification.

3.2 Deviation from requirements. Any deviation from the requirements of this specification or any specification or drawing referenced herein shall be considered a design change. Requests for such changes shall be submitted in writing to the JPL cognizant engineer and to the procurement representative. Authorization of such changes shall be obtained in writing from the JPL procurement division.

3.3 Design. Any detailed electrical and mechanical design not specified by JPL shall be accomplished by the contractor. The requirements of this specification are detailed to the extent considered necessary to obtain the desired mechanical and electrical performance.

3.3.1 Design approval. The contractor shall submit final design drawings, sketches, schematics, etc., for the JPL cognizant engineer's approval prior to fabrication; any design approval or purported consent by JPL personnel shall in no way waive or release the contractor from any performance requirements, specifications, or characteristics as set forth in this specification.

3.3.2 Design objectives. The objectives in the design of the RF test console, in order of priority, shall be:

a. Accuracy and repeatibility of electrical performance.

b. Reliability, ease of trouble-shooting, and repair.

c. Simplicity of operation and maintenance.

65-335
ACC. 6

3.4 General performance characteristics. The RF test console shall consist functionally of a transmitter, noise source, linear mixer, and receiver as shown in Figure 1, plus additional special and commercial test equipment.

3.4.1 Transmitters. The console shall contain two (2) transmitters, each with a center frequency of 50 Mc. One shall produce phase-modulation of the carrier and the other, frequency-modulation of the carrier with applied input voltage.

3.4.2 Noise Source. The console shall contain a stable source of white Gaussian noise.

3.4.3 Power output monitors. The individual power outputs of the transmitter and noise source shall be continuously monitored with suitable power sensitive devices.

3.4.4 Linear signal/noise mixer. The RF test console shall contain a power mixer which will linearly add the transmitter and noise source outputs to create an accurately known signal-to-noise ratio (SNR).

3.4.5 Receivers. The console shall contain three (3) receivers with the following demodulation characteristics: phase-lock PM, phase-lock FM, and conventional FM.

3.4.6 Test instrumentation. The console shall contain additional special and commercial test equipment as required to make it reasonably self-contained under normal checkout and test conditions.

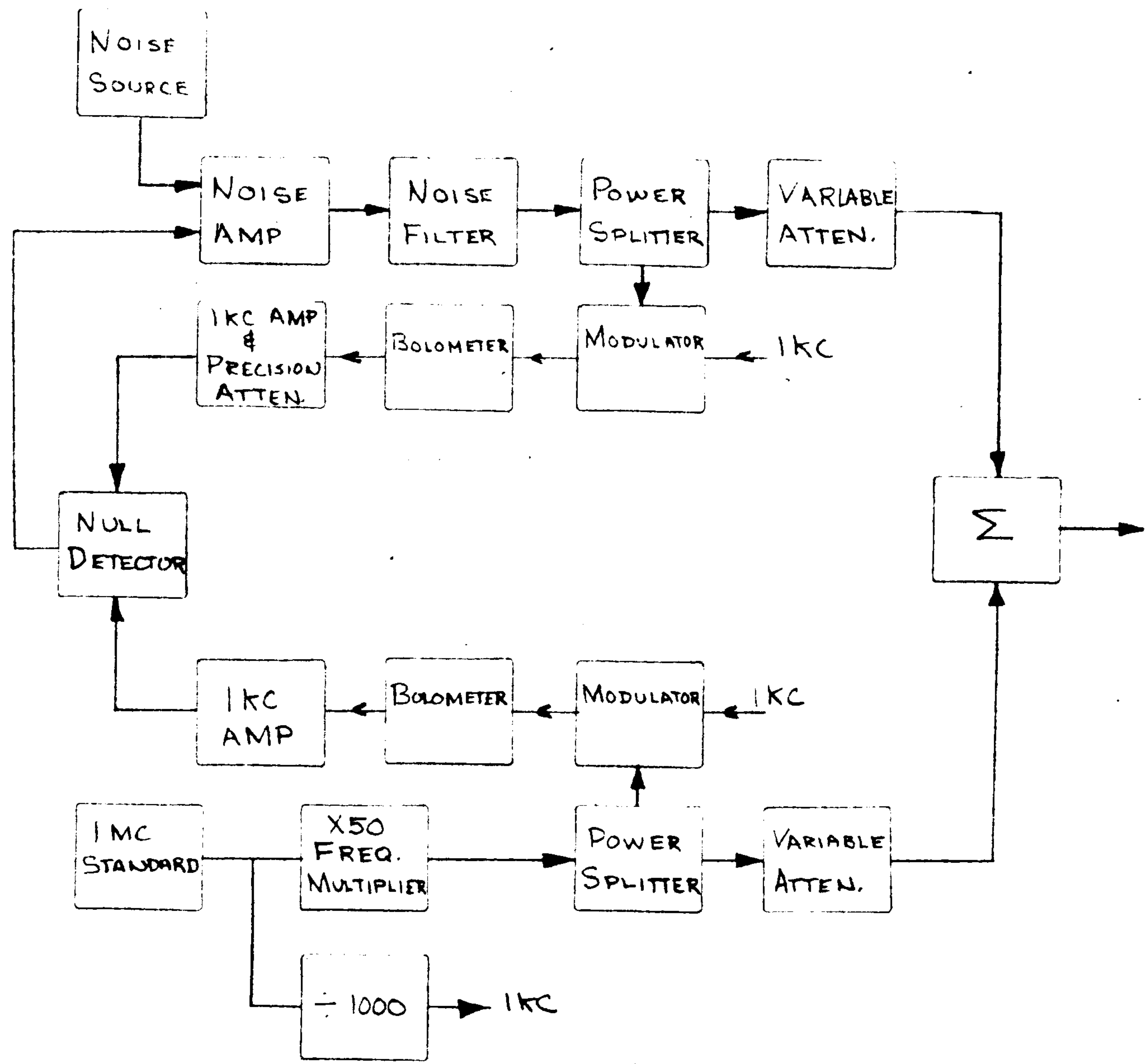

FIGURE 1 R.F. TEST CONSOLE S/N SUMMER FUNCTIONAL BLOCK DIAGRAM

3.5 Detailed characteristics. The detailed design of the RF test console shall conform to the following performance specifications:

3.5.1 PM operational modes. The console shall be capable of narrow-band/large modulation index and wide-band/small modulation index PM operation, as well as narrow-band AM operation, simultaneously.

3.5.1.1 General PM characteristics. The PM transmitter-receiver pair shall exhibit the following general characteristics:

3.5.1.1.1 Frequency stability. The frequency stability of both the transmitter frequency source and the receiver reference oscillator shall be as follows:

a. Each shall have a short-term stability, measured over a one-minute period, of 1 part in 10^7.

b. Each shall have a long-term stability, measured over a four hour period of five (5) parts in 10^7.

3.5.1.1.2 Phase stability. The phase stability of the unmodulated transmitter-receiver pair shall be such as to cause no more than a one (1) degree RMS phase error in a noise-free phase-coherent receiver with a $2B_L$ of 3.0 cps.

3.5.1.1.3 Fidelity. The fidelity of the transmitter-receiver pair shall be such that all spurious sidebands within the modulation passband are 30 db guaranteed 40 db design goal, below modulated carrier or 40 db guaranteed 50 db design goal, below unmodulated power when the

65-335
ARPA

transmitter is modulated with two (2) pure sinusoids of any frequency and at modulation indices within the phase modulator design limits specified in 3.5.1.3.3. The distortion specification refers to distortion above and beyond that contributed by the receiver sinusoidal phase detector.

3:5.1.2 PM transmitter. The console shall contain a PM transmitter, shown functionally in Figure 2, with the following characteristics:

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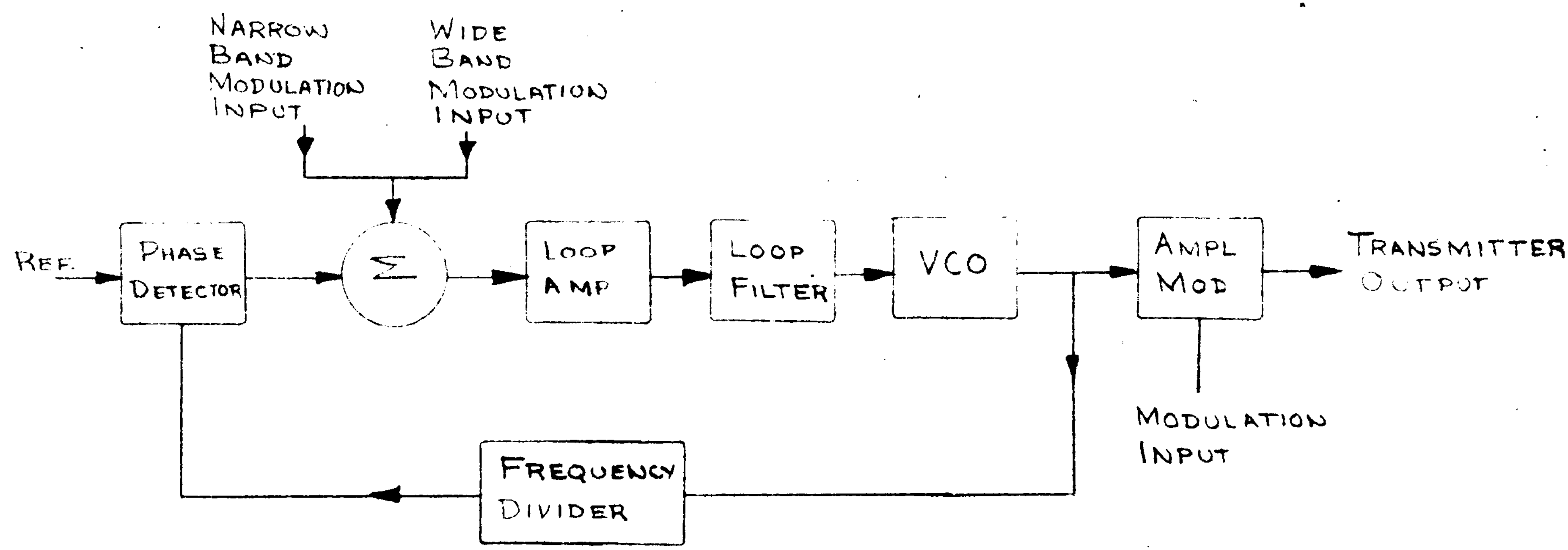


FIGURE 2 P.M. TRANSMITTER FUNCTIONAL BLOCK DIAGRAM

3.5.1.2.1 Frequency. The transmitter center frequency shall be exactly 50 MC and shall be continuously tunable $\pm$ 500 cps about this frequency by manual control.

3.5.1.2.2 Power output. The transmitter power output shall be sufficient to drive the signal/noise mixer specified in 3.5.3. Its stability requirements are specified in 3.5.3.2.

3.5.1.2.3 Phase modulators. The transmitter shall contain both narrow and wideband phase modulators with the following characteristics:

a. Frequency response. The frequency response of the narrow and wideband phase modulators shall be constant within $\pm$ 0.1db from dc to 500 kc, and within $\pm$ 0.5db from 500 kc to 1.5 Mc, relative to the dc response.

b. Phase deviation. The narrow-band modulator shall be capable of deviating the carrier $\pm$ 3.0 radians peak, and the wideband modulator, $\pm$1.0 radian peak.

c. Deviation linearity. The characteristics of the phase modulators shall be sufficiently linear to meet the fidelity requirements of 3.5.1.1.3.

d. Incidental AM. Incidental amplitude modulation due to phase modulation shall be kept sufficiently low to meet the fidelity requirements of 3.5.1.1.3.

3.5.1.2.5 Amplitude modulator. The transmitter shall contain a narrowband amplitude modulator with the following characteristics:

a. Frequency response. The frequency response of the amplitude modulator shall be constant within ± 0.1 db from dc to 5.0 kc.

b. Percent modulation. The modulator shall be capable of amplitude modulating the carrier ± 50 percent in voltage.

c. Modulator linearity. The amplitude modulation shall be linear with applied signal voltage to within 5% guarenteed, 1% design goal.

d. Incidental FM and PM. Incidental angle modulation due to amplitude modulation shall be negligible. With respect to the inherent --- per 3.5.1.1.2.

3.5.1.2.6 Bandwidth. The overall FM transmitter bandwidth shall be consistent with the above performance specifications.

3.5.1.2.7 Transmitter reference output. The transmitter shall have an unmodulated 50 MC output compatible with the requirements of the phase noise measurement specified in 3.5.1.5 and with the transmitter test instrumentation specified in 3.6.4.

3.5.1.3 PM receiver. The console shall contain a phase-lock PM receiver, shown functionally in Figure 3, with the following characteristics:

3.5.1.3.1 Input Amplifier. The PM receiver input amplifier shall have the following characteristics:

a. Bandwidth. The passband of the 50 MC input amplifier shall be a minimum of 10 Mc at the 3 db points, and shall be flat to within $\pm$ 0.25 db within $\pm$ 2 Mc of the center frequency.

b. Phase linearity. The phase characteristics of the input amplifier shall be sufficiently linear and symmetrical so asto meet the fidelity requirements of 3.5.1.1.3.

c. AGC response. The gain of the input amplifier shall be AGC controlled over a 30 db range.

3.5.1.3.2 Voltage -controlled oscillator. The voltage controlled oscillator used in the PM receiver shall be crystal-controlled and have the following characteristics:

a. Frequency. The center frequency of VCO No. 1 shall be adjustable to exactly 60 Mc. (1 Mc Multiplied to 60 Mc)

b. Stability. The frequency and phase stability of the VCO shall be consistent with the transmitter-receiver pair phase stability specified in 3.5.1.1.2.

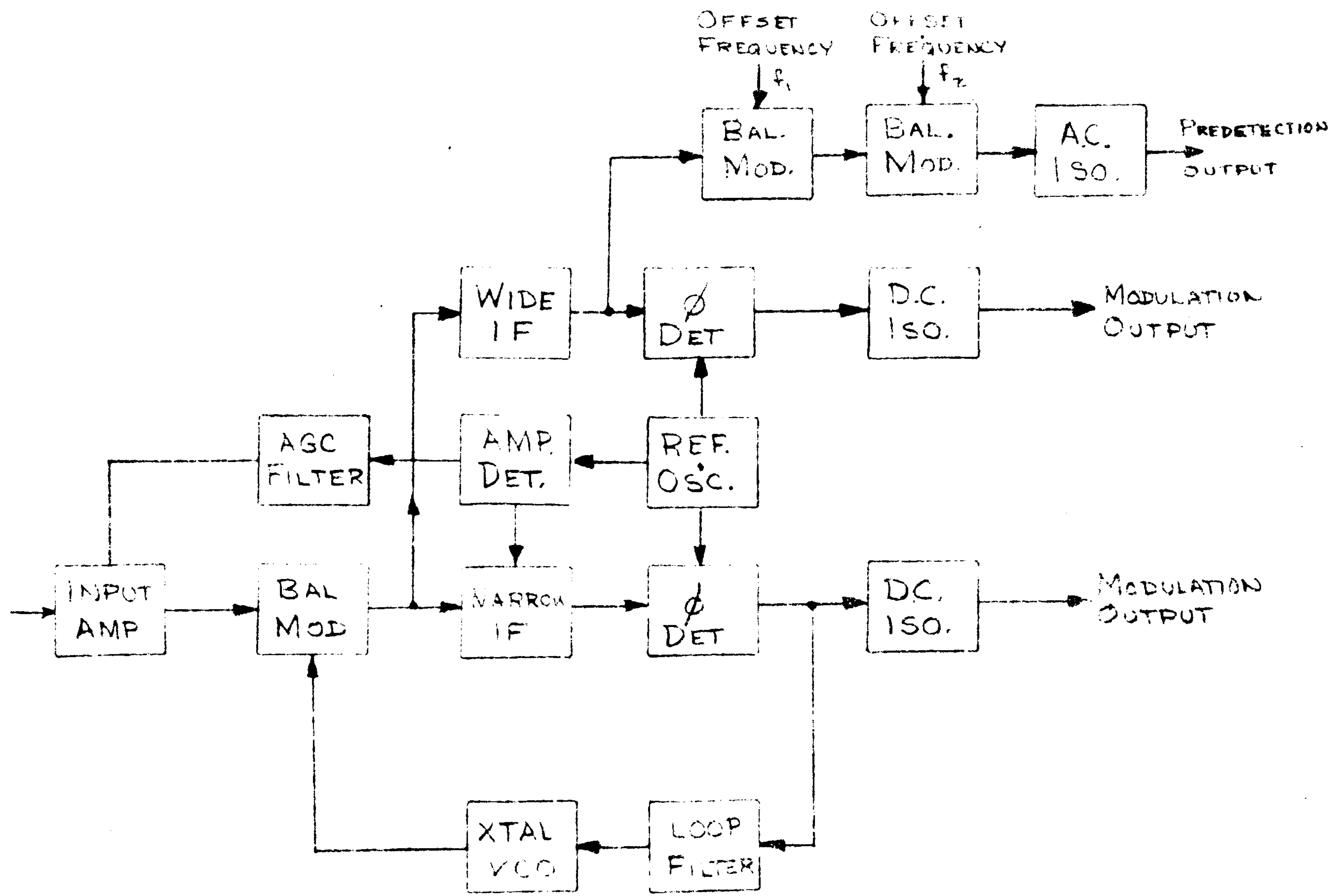


FIGURE 3 PM RECEIVER CONFIGURATION FUNCTIONAL BLOCK DIAGRAM

c. Manual tuning. It shall be possible to manually tune the VCO for the purpose of initially acquiring the transmitter frequency and for subsequently creating controlled loop static phase errors as large as ± 30° during system testing. The VCO detuning range shall be ± 500 cps. The referenced phase error is attributed to maximum detuning and reduced loop gain.

d. Locked condition. It shall be possible to essentially ground the VCO input and thereby lock it at its zero-voltage quiescent frequency, or to connect its input to a variable dc voltage source, for the purpose of testing the loop in an open condition.

3.5.1.3.3 Balanced modulators. The PM receiver shall contain three (3) balanced modulators, as shown in Figure 3. They shall be functionally equivalent to ideal voltage multipliers in the time domain, or translators in the frequency domain, such that all spurious and feedthrough products are 50 db quaranteed, 60 db design goal, below the desired output.

3.5.1.3.4 IF amplifiers. The receiver shall contain two (2) 10 MC IF amplifiers with the following characteristics:

a. Narrowband IF. The narrowband predetection IF amplifier shall have a 3 db bandwidth of 2.0 kc, and a phase response that is symmetrical within ± 5° for frequencies within ± 1 kc (± 6 kc Design Goal) of center frequency. It shall be possible to simply and reliably replace this module and thereby change the characteristics of the predetection bandwidth.

b. Wideband IF. The wideband IF amplifier shall have a minimum 3 db bandwidth of 6 Mc, and shall be flat to within ± 0.5 db within ± 1.5 Mc of the center frequency. Its phase response shall be symmetric within ± 5° over the 6 Mc passband, and sufficiently linear so as to meet the fidelity requirements of 3.5.1.1.3.

c. The wideband and narrowband IF amplifiers will track in phase within ± 5° over ± 33 C/S about the center frequency. At center frequency the tracking will be within 20 degrees as determined by the limiter and AGC phase shift over the dynamic range of the system, but it will be possible to manually adjust out this phase error with the reference phase shifter.

3.5.1.3.5 Reference oscillator. The PM receiver reference oscillator shall have a fixed-frequency output tunable to exactly 10 Mc. 1 Mc multiplier to 10 Mc Its frequency and phase stability shall be consistent with the stability requirements of 3.5.1.1.1 and 3.5.1.1.2

3.5.1.3.6 Phase detectors. The PM receiver shall have two (2) phase detectors with the following characteristics:

17

a. Bandwidth. The wideband phase detector 3 db video bandwidth shall be a minimum of 5 Mc design goal, 8 Mc.

b. Fidelity. The phase detectors shall be functionally equivalent to ideal voltage multipliers in the time domain, consistent with the transmitter-receiver fidelity specification of 3.5.1.1.3. The phase detector linearity shall be in accordance with a sin Θ transfer of Video output vs signal phase.

c. Gain constant. Each phase detector shall contain a hard limiter such that its gain, measured in volts/radian, will be consistent with the operating conditions, described in 3.5.1.3.7. It shall be possible to easily bypass this limiter for certain system tests, in which case the stability of the phase detector gain constant will be determined by the accuracy of the AGC system.

d. Phase adjustment. Each phase detector shall contain a variable phase shift network in series with the reference oscillator input and of sufficient adjustment range to permit precise balancing of both open and closed phase loops.

3.5.1.3.7 Phase loop gain. The PM receiver loop gain shall be sufficiently large such that the residual loop static phase error is negligible (one degree) over the normal receiver operating frequency range as determined by the transmitter tuning range and the system frequency instabilities, when the VCO is tuned to its zero-voltage quiescent frequency. The loop gain stability over this same range shall be within $\pm$ 3 percent of nominal.

65-335
Att A

3.5.1.3.8 Loop filter. The phase-lock PM receiver shall have the following loop characteristics:

a. Configuration. It shall be possible to operate with either an active or passive loop filter as shown in Figure 4.

b. Bandwidths. The receiver shall have four (4) standard loop noise bandwidths of 3, 12, 20 and 48 cps in the passive configuration, defined at the receiver absolute threshold SNR operating point. It shall be possible to simply and reliably change the loop filter components in order to operate with either the same bandwidths at different defined threshold points, or with any other loop noise bandwidth from 1 to 1000 cps.

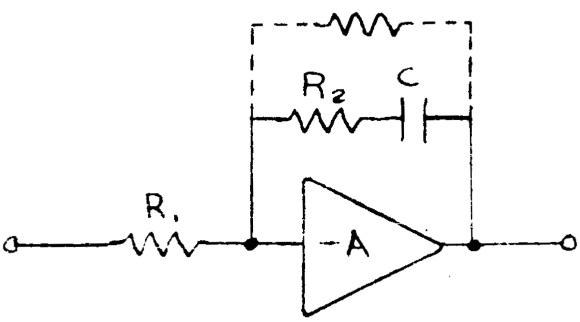
c. Component tolerances. The resistive loop filter component values shall be accurate to within ± 1 percent and the capacitive components, to within ± 3 percent.

3.5.1.3.9 Amplitude detector. The PM receiver shall contain a coherent amplitude detector with the following characteristics:

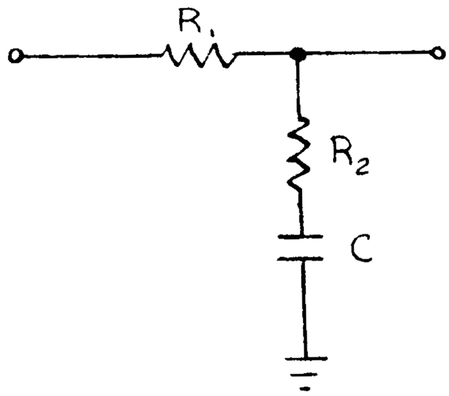
a. Bandwidth. The bandwidth of the amplitude detector shall be sufficiently wide that the overall transmitter-receiver AM characteristics are determined only by the transmitter modulator.

b. Linearity. The relationship between carrier input voltage amplitude and detector output voltage shall be linear to within ± 3% guaranteed,

65-335



a. Active Loop Filter



b. Passive Loop Filter

Figure 4 Loop Filter Configurations

± 1% design goal, under both static and dynamic conditions.

c. Phase adjustment. The amplitude detector shall contain a variable phase shift network in series with the reference oscillator input and of sufficient adjustment range to permit precise balancing of the AGC loop.

d. Manual gain control. A means of manually controlling the receiver gain over its entire operating range of 30 db shall be provided.

3.5.1.3.10 AGC loop gain. The AGC loop gain shall be greater than 20 over its entire operating range such that the variation in the coherent receiver output, measured at the narrowband IF amplifier output, shall not vary more than ± 0.3 db for an input signal level variation of ± 6 db about its design center.

3.5.1.3.11 AGC filter. The phase-lock PM receiver shall have an AGC filter with the following characteristics:

a. Configuration. The AGC loop filter shall be a passive single-pole RC low-pass filter.

b. Bandwidths. The AGC loop shall have four (4) standard loop noise bandwidths of 0.01, 0.1, 1.0, and 10 cps. It shall be possible to simply and reliably change the filter components in order to operate with any other noise bandwidth within this same range.

c. Component tolerances. The AGC filter shall adhere to the same component tolerances as specified in 3.5.1.3.8c. The loop filter component tolerances for AGC loop noise bandwidth of .01 cps shall be accurate to within ± 5%.

3.5.1.3.12 Offset frequency. The offset frequency, f_1, f_2 shall be exactly 40 and 55 MC such that the predetection recording spectrum will be centered at 5 Mc. It shall be possible to easily replace this reference with an externally supplied frequency.

3.5.1.3.13 DC isolation amplifiers. Amplifiers with dc response shall be provided to isolate the signal sources from external equipment, amplify or attenuate the signals to a reasonable output level, and to filter out unwanted higher-order spectral components where necessary. Where practical, it shall be possible to easily change the gain and bandwidth of these amplifiers over a moderate range by means of passive feedback components. The nominal output level shall be +10 dbm.

3.5.1.3.14 AC isolation amplifier. An ac amplifier shall be provided to isolate the predetection recording output from external equipment, amplify or attenuate the signal to a reasonable output level, and to filter out the unwanted higher-order spectral components. If practical, it shall be possible to easily change the gain and bandwidths of this amplifier over a moderate range. The nominal output level shall be 10 dbm.

3.5.1.4 PM predetection playback. It shall be possible to easily modify the configuration of the PM receiver, as shown in Figure 5, in order to coherently demodulate PM signals previously predetection recorded.

65-325
APP. H

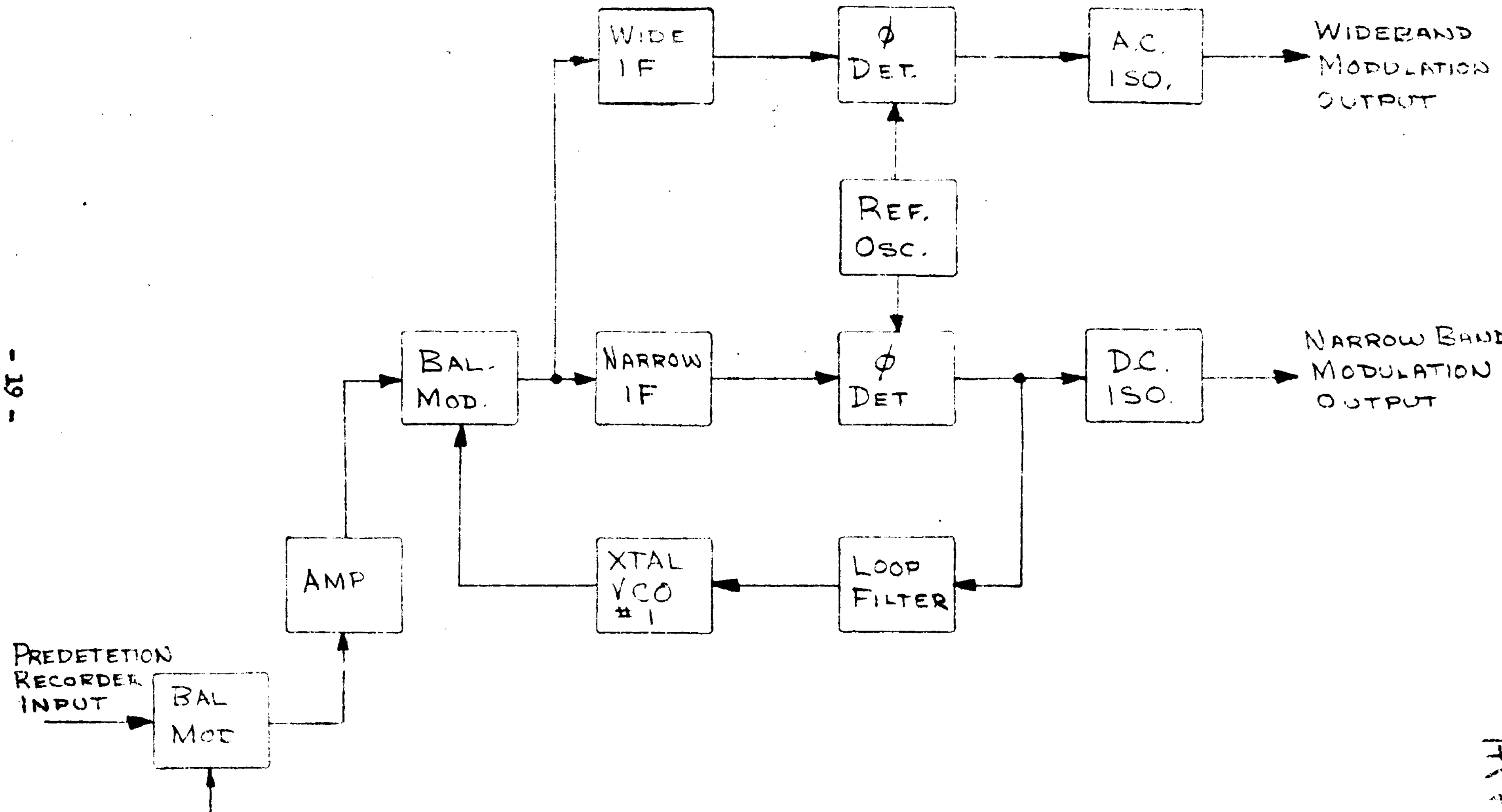


FIGURE 5 P.M. RECEIVER IN PREDETECTION PLAYBACK CONFIGURATION

23

3.5.1.4.1 Voltage Controlled Oscillator

When operating in the predetection recording playback configuration the same VCO shall be used as when the phase modulated carrier is derived from the S/N Summer.

3.5.1.4.2 Deleted

3.5.1.5 Phase noise instrumentation

Special Test Instrumentation shall be provided for the purpose of making accurate phase noise density function, variance and spectrum measurements during PM system tests as shown in figure 6.

3.5.1.5.1 Balanced Modulator

The balanced modulator shall be identical to that specified in 3.5.1.3.3.

3.5.1.5.2 IF Amplifier

The IF amplifier shall be identical to the narrowband IF specified in 3.5.1.3.4a.

3.5.1.5.3 Phase Shifter

The phase shifter shall operate at a frequency of 10 MC and provide a continuously variable phase shift to 0 to 360° or $\pm 180^\circ$. It shall have a calibrated dial accurate to within $\pm 1^\circ$ over this range.

3.5.1.5.4 Limiters

The phase noise test instrumentation shall contain two (2) identical limiters with the following characteristics:

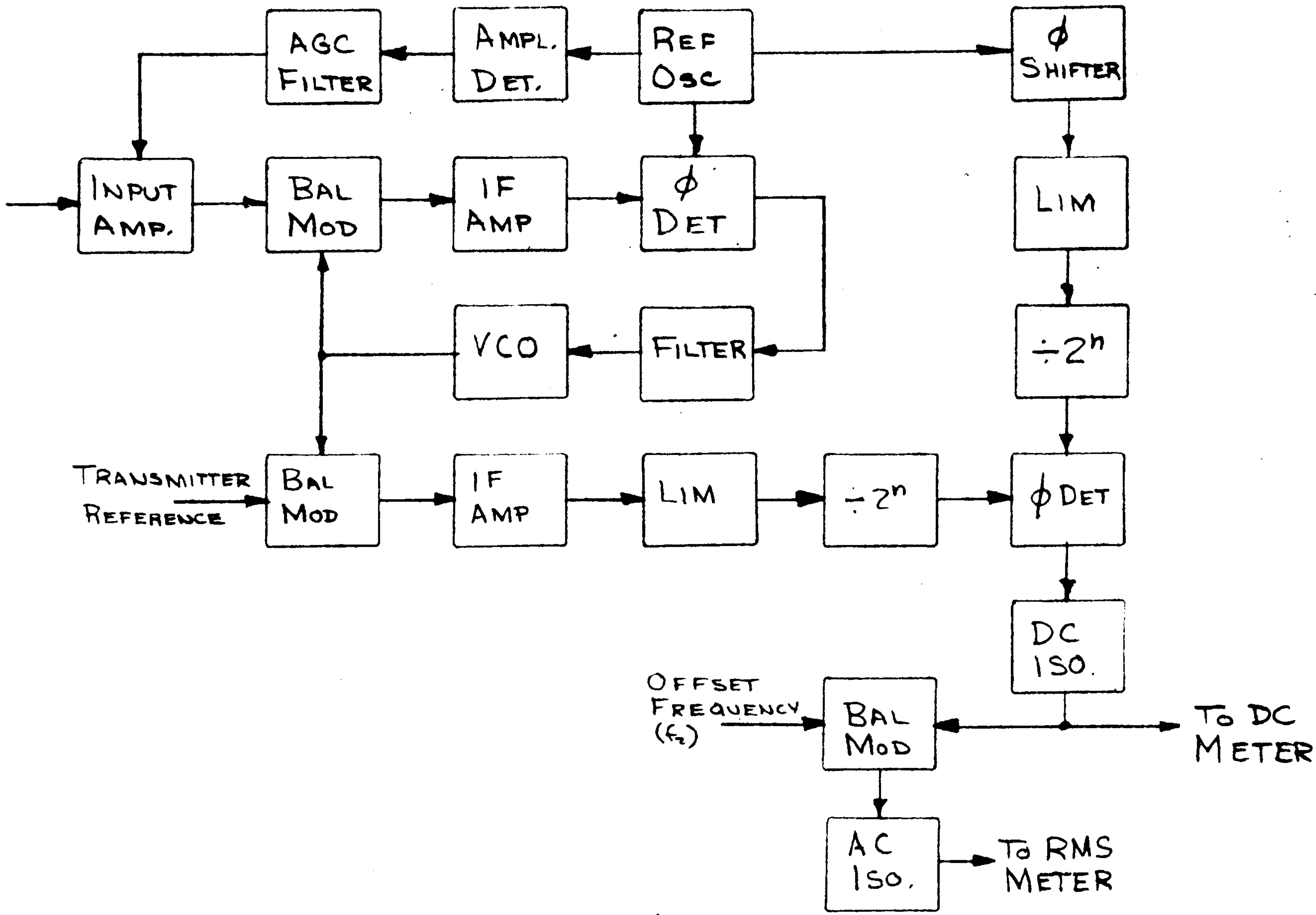


FIGURE 6 PHASE NOISE MEASUREMENT

a. Delay The limiters peak jitter shall be no greater than 1 usec.

b. Rise Time The 10 to 90 per rise and fall times shall be identical and no greater than 5 nanosec. Identical rise and fall times are a design goal.

c. Symmetry. The limiters shall introduce no measureable asmmetry in the output square wave duty cycle.

3.5.1.5.5 Binary Dividers

The two binary dividers shall be identical shall have output waveforms which conform to these for the limiters above and shall be capable of division by 2, 4 or 8 (The delay of 3 cascaded binary dividers will be of the order of 16.5 nanoseconds when connected as a parallel clocked divider)

3.5.1.5.6 Phase Detector

The phase detector shall be capable of operating at 5, 2.5 and 1.25 mc. Its output voltage shall be a linear function (within 1%) of the input phase difference and differ from this only due to the finite input waveform rise and fall times and droop.

3.5.1.5.7 DC isolation Amplifier

The dc isolation amplifier shall be identical to those specified in 3.5.1.3.13.

3.5.1.5.8 Offset Frequency

The offset frequency f_2 shall be approximately 1.0 KC. It shall be possible to easily replace this reference with an extrnally supplied frequency.

3.5.1.5.9 Balanced Modulator

The balanced modulator shall be of the chopper phase detector type and shall be capable of operating with any offset frequency between 100 cps and 10 KC.

3.5.1.5.10 AC isolation amplifier

If required, an isolation amplifier shall be provided to isolate the balanced modulator output from external equipment. This amplifier need only have ac response, but may be a dc amplifier for the sake of simplicity.

3.5.2 FM Operational Modes

The RF test console shall contain a wideband FM transmitter capable of operating in either AFC or non-AFC modes and both conventional and phase-lock FM demodulators.

3.5.2.1 General FM Characteristics

The FM transmitter receiver pair shall exhibit the following general characteristics:

3.5.2.1.1 Frequency Stability

The frequency stability (design goal) of the FM transmitter-receiver pair shall be such as to cause less than 15 cps RMS residual FM with the transmitter operating in the AFC mode and 60 cps rms residual FM with the transmitter in the non-AFC mode measured at the output of either the conventional or phase lock FM receiver in a 500 KC bandwidth.

3.5.2.1.2 Static linearity.

The transmitter-receiver pair shall exhibit a static linearity of ± 0.5 percent over the full-scale frequency deviation with the non-AFC transmitter and either receiver above and beyond the inherent sinusoidal phase detector non-linearity. (A Design Goal)

3.5.2.1.3 Dynamic linearity.

The transmitter-receiver pair shall exhibit a dynamic linearity of ± 1.0 percent over all combinations of modulating frequency and frequency deviation in both AFC and non-AFC transmitter modes and with either receiver above and beyond the inherent sinusoidal phase detector non-linearity. (A Design Goal).

3.5.2.2 FM transmitter.

The console shall contain a wideband FM transmitter, shown functionally in Figure 7, with the following characteristics:

3.5.2.2.1 Frequency.

The transmitter center frequency shall be adjustable to exactly 50 Mc and shall be continuously tunable ± 500 cps about this frequency by manual control.

3.5.2.2.2 Power output.

The transmitter power output shall be sufficient to drive the signal/noise mixer specified in 3.5.3. Its stability requirements are specified in 3.5.3.2.

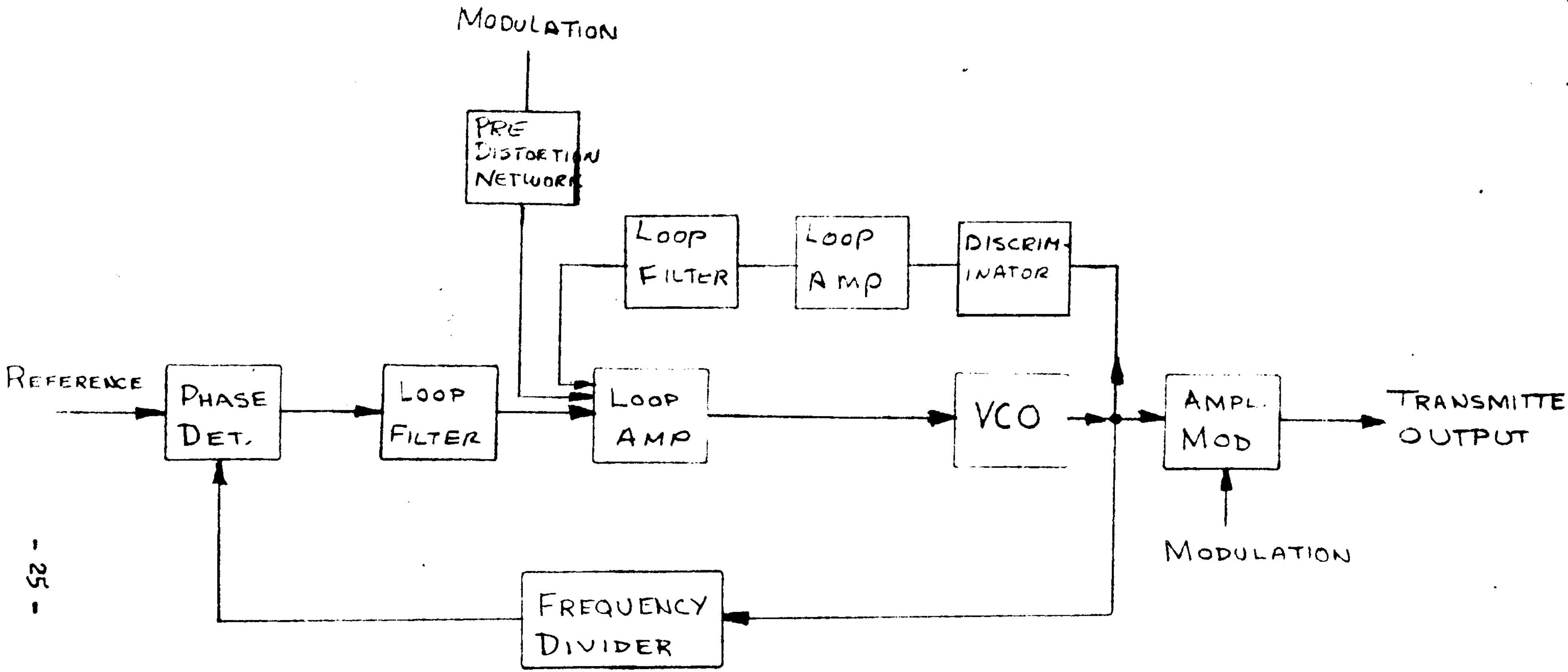


FIGURE 7 FM TRANSMITTER

65-325
APP A

3.5.2.2.3 <u>Frequency modulator.</u>

The transmitter shall contain a wideband frequency modulator with the following characteristics:

a. Frequency response. The frequency response of the frequency modulator shall be constant within ± 0.1 db from 50 C/S to 100 kc and ± 0.5 db from 3 cps to 50 C/S and 100 KC to 500 kc. (A Design Goal)

b. Frequency deviation. The modulator shall be capable of deviating the carrier ± 500 kc about its center frequency with a maximum modulation index of 512 in the AFC mode.

c. Deviation linearity. The characteristics of the frequency modulator shall be sufficiently linear to meet the static and dynamic linearity requirements of 3.5.2.1.2 and 3.5.2.1.3.

3.5.2.2.4 AFC operation.

The FM transmitter shall be capable of operating either with or without automatic frequency control. In the AFC mode its modulation response shall be from 3 cps to 500 kc, and in the non-AFC mode, from dc to 500 kc.

3.5.2.2.5 Deleted

3.5.2.2.6 Amplitude modulator.

The FM transmitter shall contain a narrowband amplitude modulator with characteristics identical to that in the PM transmitter as specified in 3.5.1.2.5.

3.5.2.2.7 Deleted

3.5.2.2.8 Bandwidth

The overall FM transmitter bandwidth shall be consistent with the above performance specifications.

3.5.2.2.9 Transmitter reference output. The FM transmitter reference output shall be identical to that for the PM transmitter.

3.5.2.3 FM receivers.

The console shall contain a dual FM receiver containing both conventional and phase-lock FM detectors, shown functionally in Figure 5, with the following characteristics: Both receivers should have the same output sensitivity.

3.5.2.3.1 Input band-pass filter. The dual FM receiver shall contain three (3) easily interchangeable band-pass filters with the following characteristics:

a. Bandwidths: The input filters shall have half-power bandwidths within ± 2 percent of 1 Mc, 100 kc, and 10 kc.

b. Amplitude characteristics. The amplitude response shall be established by the 3 DB bandwidth and the phase characteristic.

c. Phase linearity. The filter phase characteristic shall be linear as established by a Bessel, Gaussian or equiripple phase response.

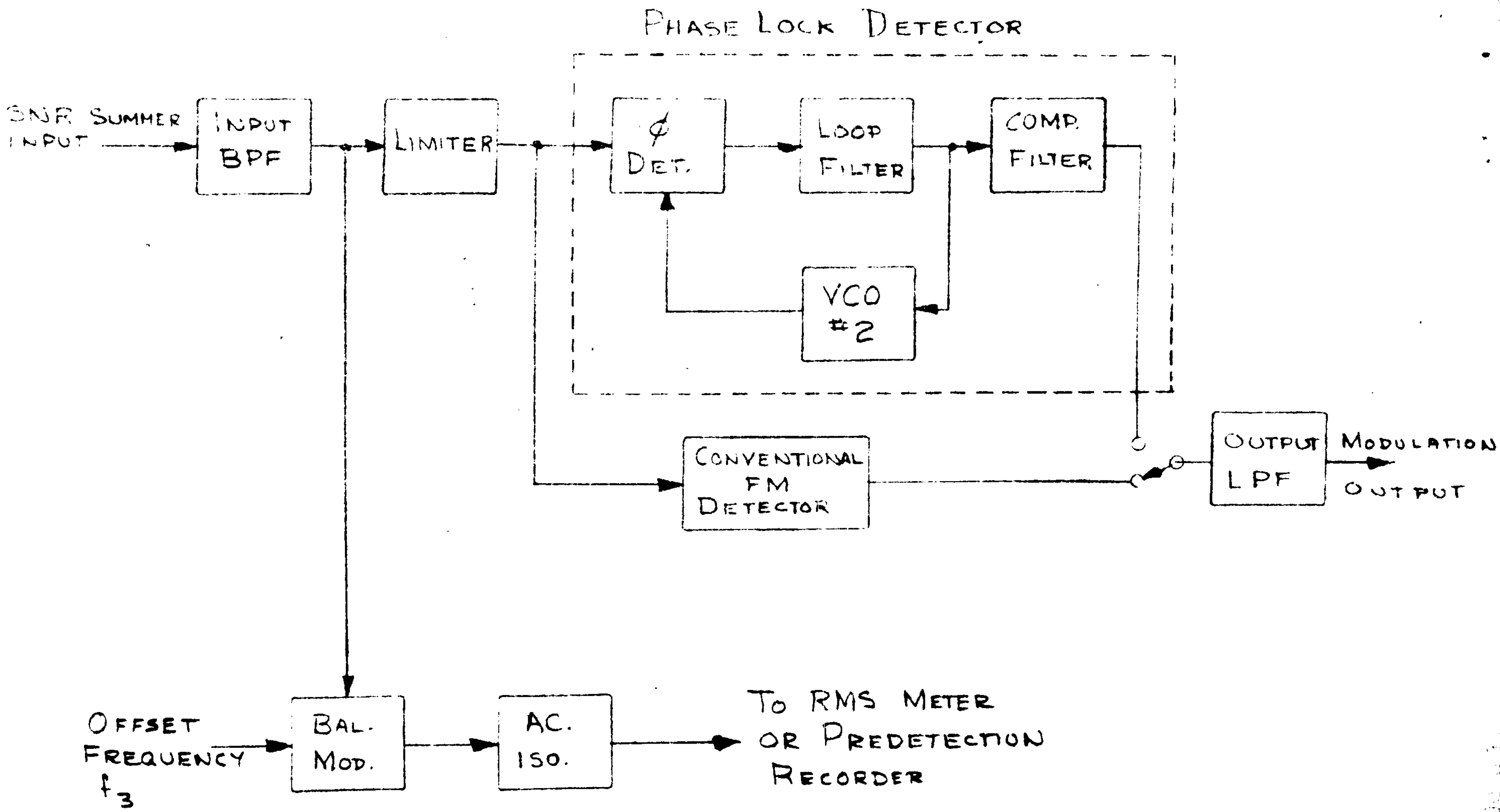


FIGURE 8 DUAL F.M. RECEIVER CONFIGURATION
FUNCTIONAL BLOCK DIAGRAM

3.5.2.3.2 Limiter.

The dual FM receiver shall contain a hard limiter following the input band-pass filter with the following characteristics:

a. Dynamic range. The limiter shall have a dynamic range of 60 db minimum.

b. Output waveform. The limiter output waveform shall have delay, rise and fall-times, symmetry, and droop characteristics consistent with the requirements of the FM detectors which follow it.

3.5.2.3.3 Conventional FM detector.

The dual FM receiver shall contain a conventional FM detector with performance characteristics consistent with the frequency stability, and static and dynamic linearity requirements of 3.5.2.1.1, 3.5.2.1.2, and 3.5.2.1.3.

3.5.2.3.4 Phase-lock FM detector.

The dual FM receiver shall contain a modulation-tracking phase-lock FM detector with the following characteristics:

a. Voltage-controlled oscillator. The voltage-controlled oscillator No. 3 shall have a center frequency of exactly 50 Mc, deviation capability consistent with the transmitter modulator characteristics specified in 3.5.2.2.3b., linearity consistent with the static and dynamic linearity specified in 3.5.2.12 and 3.5.2.1.3. and sufficient stability to satisfy the overall transmitter-receiver stability specified in 3.5.2.1.1.

b. Phase detector. The phase detector bandwidth shall be consistent with the transmitter modulator frequency response specified in 3.5.2.2.3a. It shall be of sufficient fidelity to meet the dynamic linearity requirements of 3.5.2.1.3. Aside from the inherent non linearity of a sinusoidal phase detector.

c. Loop gain. The loop gain shall be sufficiently large such that under conditions of peak transmitter deviation the steady state loop phase error due to finite loop gain will be less than 10°. The loop gain stability shall be $\pm$ 5 percent over all operating conditions.

d. Loop filter. The loop filter shall be of the passive configuration as shown in Figure 4b. Three(3) standard loop information bandwidths of 3, 30, and 300 kc shall be supplied, with component tolerances as specified in 3.5.1.3.8c. It shall be possible to simply and reliably change the loop filter components in order to operate with any information bandwidth from 100 cps to 1.0 Mc.

e. Compensation filter. A single-pole RC low-pass filter shall be employed at the loop filter output such that the overall phase-lock FM detector transfer function is that of a "pure" loop. The component tolerances and interchangeability shall be the same as for the loop filter. The "pure" loop transfer function will be modified by the loop poles contributed by the loop phase detector, VCO and Amplifier.

3.5.2.3.5 Output low-pass filter. The dual FM receiver shall contain a single low-pass output filter with the following characteristics:

a. Response characteristics. The output filter shall have more than 3 poles and shall have either constant amplitude or linear phase response characteristics manually operational amplifier selectable. (6 Filters Selectable or Active Filters)

b. Bandwidths. The output filter shall have three (3) standard bandwidths of 1, 10, and 100 kc. It shall be possible to simply and reliably change the bandwidth determining components in order to operate with any bandwidth from 10 cps to 500 kc. (Replaceable modules or active filters)

3.5.2.3.6 Offset frequency.

The offset frequency, f_3, shall be exactly 55 Mc such that the output spectrum will be centered at 5 Mc. It shall be possible to easily replace this reference with an externally supplied frequency.

3.5.2.3.7 Balanced modulator. The balanced modulator shall be identical to those specified in 3.5.1.3.3.

3.5.2.3.8 AC isolation amplifier. The ac isolation amplifier shall be identical to that specified in 3.5.1.3.14.

3.5.2.4 FM predetection playback. It shall be possible to easily modify the configuration of the FM receiver, as shown in Figure 9, in order to demodulate FM signals previously predetection recorded.

3.5.3 Linear signal/noise mixer. The RF test console shall contain a precision linear signal/noise mixer, shown functionally in Figure 1.

3.5.3.1 General characteristics.

The linear signal/noise mixer shall have the following characteristics.

3.5.3.1.1 Function.

It shall be the function of the signal/noise mixer to accurately monitor the signal and noise source power outputs, attenuate them accurately, and linearly sum them in order to create a stable, accurate signal/noise ratio (SNR). The SNR shall be defined as the ratio of the total unmodulated transmitter power to the noise power density at the transmitter output frequency.

3.5.3.1.2 Dynamic range.

The signal/noise mixer shall be capable of accurately creating SNRs, as previously defined, from 0 to 100.0db. In addition, it shall be possible to easily create no-noise and no-signal conditions for system tests.

3.5.3.2 Signal sources.

In the normal mode of operation, the source of the test signals shall be the 50 mc PM or FM transmitters specified in 3.5.1.2 and 3.5.2.2. It shall be possible to easily substitute other 50 mc signal sources for special system tests.

3.5.3.2.1 Signal power stability.

The stability of the PM and FM transmitter power outputs shall be better than ± 0.1 db over a four (4) hour period.

3.5.3.3 Noise source.

The linear signal/noise mixer shall contain a stable 50 Mc source.

3.5.3.3.1 Noise characteristics.

The noise source shall have the following characteristics:

a. Amplitude distribution.

The noise source shall have a Gaussian amplitude distribution. The linear voltage dynamic range of all elements in series with the noise source shall be at least three (3) times the rms value of the noise voltage.

b. Bandwidth. The noise power spectral density shall be constant within ± 0.05 db over a bandwidth from 48 to 52 Mc. (a design goal).

3.5.3.3.2 Noise power stability.

The stability of the noise source power output shall be better than ± 0.1 db over a four (4) hour period.

3.5.3.4 Overall absoluate accuracy.

The signal/noise mixer shall be sufficiently accurate and stable that SNRs, as previously defined in 3.5.3.1.1. accurate to ± 0.3db can be set and maintained over a four (4) hour period. This accuracy tolerance shall include the error contributions of the signal and noise source power output instability. The constituent parts of the signal/noise mixer shall have the following characteristics:

3.5.3.4.1 Power splitters.

The power splitters shall be calibrated and have sufficiently stable characteristics such that they contribute negligible error to the resultant SNR.

3.5.3.4.2 Reference filter.

The signal/noise mixer shall contain a reference band-pass filter centered at exactly 50 Mc. Its noise bandwidth and center frequency insertion loss shall be sufficiently stable, and known with sufficient accuracy, that it contributes neglible error to the resultant SNR.

3.5.3.4.3 Power monitors.

The signal/noise mixer shall contain at least one (1), and may contain two (2), power monitors for the purpose of accurately establishing reference signal and noise power levels. The power monitor(s) shall be readable to better than 0.05 db and shall contribute no more than ± 0.1 db total uncertainty in the resultant SNR.

3.5.3.4.4. Precision attenuators.

The signal/noise mixer shall contain one (1), and may contain two (2), precision attenuators with sufficient attenuation range to meet the SNR dynamic range specified in 3.5.3.2.1. The attenuator(s) shall contribute to more than ± 0.1 db uncertainty in the resulting SNR.

3.5.3.4.5 Precision adder.

The precision mixer shall linearly sum the attenuated signal and noise power functions in order to create the desired SNR. It shall be calibrated and have sufficient stability over its entire dynamic range such that it contributes negligible error to the resultant SNR.

3.5.3.5 SNR resolution. It shall be possible to create any SNR from 0 to 100.0 db in increments of 0.1 db.

3.5.3.6 SNR repeatability.

It shall be possible to repeat a given SNR setting to within ± 0.05 db in any four (4) hour period.

3.5.4 Transmitter test instrumentation.

The IF test console shall contain the following special purpose test instrumentation shown in Figure 10 for the purpose of monitoring, and making measurements of, the modulated PM and FM transmitter outputs:

3.5.4.1 Spectrum display.

The Console shall contain a device which will continuously display the modulated transmitter spectrum. Its sweep width shall be adjustable from approximately ± 1 kc to ± 1.5 Mc about the transmitter center frequency.

3.5.4.2 Spectrum analysis.

It shall be possible to translate the modulated transmitter spectrum to some convenient spectral position for the purpose of making an accurate, high-resolution spectral analysis. This instrumentation shall have the following characteristics:

3.5.4.2.1 Offset frequency.

It shall be possible to select any one of the following frequencies as the translation reference, f_4 = 50.01, 50.02, 50.05, 50.1, 50.2 or 50.5 mc. In addition, it shall be possible to easily substitute any externally supplied reference frequency within this same range.

3.5.4.2.2 Balanced modulator.

The balanced modulator shall be functionally equivalent to those specified in 3.5.1.3.3.

3.5.4.2.3 AC isolation amplifier.

The isolation amplifier shall be identical to that specified in 3.5.1.3.12.

3.5.4.3 Carrier suppression measurement. It shall be possible to perform an in-phase coherent detection of the transmitter output, both modulated and unmodulated, in order to measure the carrier suppression to a high degree of accuracy during system tests. This instrumentation shall have the following characteristics:

3.5.4.3.1 Phase shifter. The phase shifter shall operate at a frequency of 50 Mc and provide a continuously variable phase shift of 0 to 360° or ± 180°. It shall have a calibrated dial accurate to within ± 1° over this range.

3.5.4.3.2 Amplitude detector.

The amplitude detector shall be equivalent to an ideal voltage multiplier in the time domain, or translator in the frequency domain.

Its output voltage shall be a linear function of carrier input voltage amplitude within $\pm$ 3% guaranteed, $\pm$ 1% design goal.

3.5.4.3.3 DC isolation amplifier.

The dc isolation amplifier shall be identical to those specified in 3.5.1.3.13.

3.5.5 Commercial test equipment.

The RF test console shall contain, but not necessarily be limited to commercial test equipment of the following types:

3.5.5.1 Frequency counter.

A digital frequency counter shall be provided for the purpose of directly measuring any frequency generated within the console.

3.5.5.2 Sine wave oscillator

A sine wave oscillator shall be provided for the purpose of simulating modulation inputs up to a frequency of 1.5 Mc.

3.5.5.3 Function generator.

An audio function generator capable of generating low-frequency sine, square, and triangular waveforms shall be provided.

3.5.5.4 Oscilloscope.

An oscilloscope shall be provided for the purpose of directly viewing any signals generated within the console.

3.5.5.5 Digital Voltmeter.

A digital dc voltmeter, with limited ac capability, shall be provided for the purpose of accurately measuring internal supply voltages, AGC voltages, static system linearity, carrier suppression voltages, etc.

3.5.5.6 True RMS voltmeter.

A wideband true rms voltmeter shall be provided for the purpose of accurately measuring phase noise variance, signal/noise ratios, and mean-square values of complex waveforms.

3.5.5.7 Spectrum analyzer.

A high-resolution spectrum (waveform) analyzer shall be provided for the purpose of accurately measuring the spectral components in the transmitted or received spectra.

3.5.5.8 Spectrum display.

A device shall be provided for the purpose of continuously displaying the transmitter output spectrum.

3.6 Fabrication.

The RF test console shall be fabricated according to the following requirements.

3.6.1 General considerations.

3.6.1.1 Duplication of common equipment.

The console shall never be operated in both PM and FM modes simultaneously; therefore, within the constraint of reasonable operational complexity there shall be no duplication of common equipment or modules in these two configurations.

3.6.1.2 Solid state circuitry.

Solid state design shall be used in preference to vacuum tube design wherever this can be done without sacrificing accuracy or stability.

3.6.1.3 Use of available equipment

Wherever possible, preference shall be given to the use of available commercial equipment and modules as opposed to special purpose design. As an example, the use of high-performance operational amplifiers as a standard "building-block" shall be emphasized during the design.

3.6.1.4 Interchangeability.

All parts shall be directly and completely interchangeable with each other with respect to installation and operation.

3.6.2 Controls and meters.

3.6.2.1 Controls.

There shall be sufficient controls provided to enable a trained operator to check-out and operate the console with moderate ease. All tuning and operating controls of the console shall be so designed that their setting, position, or adjustment shall not be altered when the console is subjected to the environmental and service conditions specified in 3.7.

3.6.2.2 Meters.

Where appropriate from the standpoint of operator convenience, visual indication of important system parameters shall be provided.

3.6.3 Materials, parts and processes.

Materials, parts and processes used in the design, fabrication, and assembly of the items covered by this specification shall conform to the applicable specified herein. The contractor's selection shall assure the highest uniform quality and condition of items; such selection shall be subject to the approval of JPL.

3.6.3.1 Selection of parts.

The selection of parts, where applicable, shall adhere to JPL Specification 20061. Components substituted shall be at least of proven equivalent quality; such selection shall be subject to approval of the JPL cognizant engineer.

3.6.3.2 Dissimilar metals.

Dissimilar metals shall not be used in intimate contact unless protected against electrolytic corrosion in accordance with the requirements of Specification MIL-F-14072, that portion pertaining to intermetallic contact.

3.6.3.3 Protective treatment.

Where materials used are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will chip, crack or scale with age or extremes of environment shall be avoided.

3.6.3.4 Adhesives.

All adhesives shall be water resistance and shall be durable under the service conditions defined in this specification.

3.6.4 Cables and Connectors.

Cables, connectors and interconnecting cable assemblies shall be in accordance with JPL Specification 20018. Cable assemblies shall be so arranged and wired that no "hot" leads are terminated in pins or other exposed contacts which could be accidentally shorted or touched. Leads in multi-conductor cable assemblies shall be color coded to facilitate identification. RF cables and connectors shall be chosen so as to meet the performance specifications above, and the interterence specifications of 3.6.6.

3.6.5 Identification and marking.

All assemblies of special instrumentation, modules, cables, and connectors shall be clearly identified as to function and location in some self-consistent manner.

3.6.6 Interference.

The RF test console shall have a maximum practical protection from the effects of electrical and radio interference signals, and shall not generate undesired signals which might adversely affect other equipment operating in the same vicinity. The following requirements shall apply:

3.6.6.1 Coherent interference.

Internal interference by coherent leakage signals within the console shall be a minimum of 60 db below the designed signal under all operating conditions.

3.6.6.2 Spurious interference

Response within the console to both internally and externally generated spurious signals shall be a minimum of 60 db below the normal signal levels under all operating conditions.

3.6.6.3 Radiated interference.

Radiation of any signal generated within the console shall be less than -120 dbm as measured at a distance of 1 meter in any direction from the console.

3.6.7 Power.

The console shall be designed to the following power specifications:

3.6.7.1 Primary power.

The console shall operate from primary input power with the following characteristics:

a.	Voltages:	115 $\pm$ 10 volts
b.	Frequency:	60 $\pm$ 1 cps
c.	Phase:	Single, 3 wire

There shall be a main circuit breaker in series with the primary power and located at a convenient place on the front of the console.

3.6.7.2 Regulated power.

The console shall contain all necessary regulated power sources. All power supplies shall be mounted in the lower portion of the console, shall have voltage and current meters, and shall have individual primary power switches.

3.6.8 Racks.

The RF test console shall be housed in a maximum of four (4) standard racks, in accordance with the requirements of JPL Specification 30609.

3.6.8.1 Paint

The outside surfaces of special equipment, including the racks and front panels, shall be painted in a manner to be defined by the JPL cognizant engineer. Commercial equipment shall be supplied with the Vendor's standard finish.

45

3.6.8.2 Layout.

The rack layout shall conform to good human engineering practices.

3.6.8.3 Deleted.

3.6.8.4 Panel Marking.

All identifications and markings on control and instrument panels shall be applied by the silk screen stencil method.

3.7 Environmental and service condition.

The RF test console shall be designed and constructed such that no fixed part or module shall become loose or damaged, and no degradation of performance shall occur when the console is subjected to the following conditions:

3.7.1 Temperature.

The console shall be capable of operating over an ambient temperature range of 10 to 40°C.

3.7.2 Humidity.

The console shall be capable of operating over an ambient relative humidity range of 0 to 90%.

3.7.3 Altitude.

The console shall be capable of being stored, non-operating at any altitude from 0 to 30,000 feet.

41

65-333 APP A

3.7.4 Transportation handling.

The console shall be constructed to withstand the rigors of ground and air transportation.

3.8 Workmanship.

Uniformity of shapes, dimensions, and performance shall permit interchangeability of replaceable components and complete units. There shall be no cracks, breaks, chips, bends, burrs, loose solder, loose attaching parts, loose electrical connections, or any other evidence of poor workmanship such that the unit is unsuitable for the purpose intended. The unit shall be clean and free of foreign materials. Workmanship shall be in accordance with JPL Specifications 20016 and 20018 with the following exceptions:

1. Soldered connections shall be given 100% visual inspection under 3X to 6X magnification on modules and chassis, and 100% visual inspection with the naked eye on cabinet wiring.

2. Vendor certification on materials and processes, as specified by JPL specification 20016, will not be required.

3. Modules (Sub-chassis units) will be fabricated to meet good commercial practice. These units will be wired by engineers and technicians. All other work, chassis wiring and fabrication, cabinet wiring and fabrication will be done by Model Shop personnel and will meet JPL specs 20016 and 20018.

4. QUALITY ASSURANCE PROVISIONS

4.1 Contractor's inspection.

The contractor's and subcontractor's inspection shall include such visual, electrical and mechanical examination and testing of materials, subassemblies, parts and accessories, including source items, during the process of manufacture as may be required to assure that the complete console will meet all the requirements of this specification. The test set shall be subject to complete examination by JPL prior to and following delivery.

4.2 Performance test.

The RF test console shall be tested at the contractor's facility, in the presence of the JPL cognizant engineer, to determine full compliance with the performance requirements of this specification. The contractor shall assure to the satisfaction of JPL, that he has available, and utilizes correctly, measuring and test equipment of the required accuracy and calibration, and that the instruments are of the proper type and range, to make measurements of the required accuracy. The contractor shall have a set of master gauges, secondary standards, or appropriate instruments to conduct regularly schedule calibrations of his inspection and test equipment, or shall be able to prove that his instruments have been recently calibrated against the appropriate secondary standards at another facility.

4.3 Rejection and resubmittal.

The RF test console shall be subjected to a complete performance test at JPL before acceptance. In the event of failure of any portion of the console to conform to specifications, the entire console or that portion which failed will be rejected and returned to the contractor for rework. Prior to resubmittal, the contractor shall

65 335
AFP A

confirm the failure or performance deviation, inform JPL of the corrective action taken, and submit test data to verify conformance to this specification. JPL shall then retest the console or that portion which was resubmitted before final acceptance.

5. PREPARATION FOR DELIVERY

5.1 <u>Packing for shipping</u>.

The RF test console shall be packed for shipment in a manner conforming to the requirements of Uniform Freight Classification for rail shipment, National Motor Freight Classification for truck shipment, Parcel Post Regulations, and the regulations of other carriers as applicable to the mode of transportation.