AN ADAPTIVE AIRBORNE VHF/UHF TRANSMITTER SYSTEM

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Summary The impending 1970 change-over of telemetry RF links from VHF (215-265 MHz) to UHF (1435-1545 and 2100-2200 MHz) requires a quantum jump in the state-of-the-art of solid-state transmitters. This problem is compounded by the fact that in certain instances, especially for spacecraft and special applications, there is still a need for transmitters at many different VHF and lower UHF frequencies between 136 MHz and 1 GHz. Therefore, the optimum RF product line is represented by a modular transmitter system composed of fundamental building blocks which will permit the assembly of transmitters capable of producing from 50 watts at 136 MHz to 1/2-watt at 5500 MHz with minimal variations in the over-all mechanical configuration. This adaptive transmitter system must also be able to provide optional features such as power-to-case ground isolation, modulation-to-power ground isolation, turn-on current limiting, either frequency of phase modulation remote turn-on capabilities, and internal telemetry functions of temperature, RF power, dc voltage.

Additional design requirements for such a transmitter system are wideband frequency response and carrier deviation capabilities so that the transmitter may handle real-time video signal for use with television, radar and infra-red transmission systems. This paper describes the design alternatives and the conceptual approaches that were used in development of such an adaptive transmitter system. Performance data presented is typical of that achieved from L-band and S-band units.

Design Objectives An analysis was made of the basic design alternatives in each of the three critical areas of modulation technique, frequency synthesizing and the most advantageous frequency for RF power amplification. The design objective was that the basic circuits for the transmitter system would be essentially the same, with significant differences being limited primarily to the frequencies used for RF power amplification and the multiplication scheme used to obtain the carrier frequency. Each of the electrical circuit concepts was also analyzed from the mechanical implementation viewpoint in order to achieve a maximum degree of commonality of the end-item, regardless of the carrier frequency and RF power level.

To allow circuit versatility, high volume production capability, and use of significant product experience, the transmitters were designed for modular assembly. The modules are; the frequency synthesizer, the power amplifier, the multiplier/filter assembly and regulator/ housing assembly. The complete transmitter is offered in either a completely sealed environmental housing or a smaller humidity sealed housing.

Modulation Techniques Three basic modulation techniques were considered for the transmitter-modulator. These are:

a. The crystal pulling (VCXO) method,
b. The closed-loop frequency correction method, and
c. The open-loop heterodyne (FMO) method.

Crystal pulling is desirable for narrowband application as it affords good stability. However, high bit rate PCM and wideband video requirements would eliminate the selection of the VCXO modulators, since the crystal frequency cannot be pulled far enough to provide the necessary carrier deviation and still maintain acceptable levels of linearity and distortion.

The closed-loop method of frequency synthesizing is most desirable from the standpoint of spurious products. It also presents the easiest method of obtaining the extremely stringent carrier stability requirements of IRIG Document 106-66. However, it has two principal drawbacks; (1) very complicated circuitry is required to provide frequency response down to dc, and (2) the sophisticated circuitry involved adds significantly to the cost and complexity (also reducing reliability). With the closed-loop technique additional circuitry is also required to maintain frequency lock during wideband modulation.

The open-loop heterodyne method permits the use of a high frequency FMO, which is capable of wideband (DC to 10 MHz) deviation characteristics. The use of a free-running FMO, however, does somewhat complicate the temperature compensation requirements. The problems of spurious response are minimized in the open-loop heterodyne modulator providing the proper transfer ratio and mixer product separation are selected.

Balancing all three conceptual approaches against flexibility, cost, size, weight, reliability and wideband response, the open-loop heterodyne frequency synthesis technique affords the most reliable and trouble-free operation for high volume production. This concept was also selected for the adaptive transmitter system as it permits direct interchangeability of an FM synthesizer with a PM synthesizer.

Frequency Synthesizing Closely interrelated with the selection of the basic modulation technique is the choice of frequencies for the crystal and frequency modulated oscillators. The crystal and FMO frequencies must provide the best compromise between incidental FM and carrier stability with a minimum of spurious products. It is also desirable to transfer the FM oscillator at the highest frequency possible in order to obtain the least incidental FM and the best frequency stability. At the same time, the greater the separation between the FMO and crystal oscillator products, the easier it is to attenuate unwanted signals. Since these are divergent parameters, a compromise is necessary. The frequency synthesis table shown on Figure 1 presents a typical set of frequencies and multiplication factors which may be used in the development of a single frequency synthesizer assembly, that in conjunction with the proper passive multiplier (where required), will generate any carrier frequency from 136 MHz to 5.5 GHz.

Recently available components and new packaging techniques now permit the design of free-running RF oscillator operating at frequencies up to 90 MHz with better than .005 stability. By cross compensating the FMO frequency drift with temperature to oppose that of the crystal oscillator, it is possible to obtain a net frequency stability (excluding dynamic environments) of better than .001% across a 75°C temperature range. L-band transmitters have been delivered which exhibited carrier stability of better than ±0.0013% across a temperature range of -55C to +85C. A typical curve of carrier stability versus temperature that has been achieved in production is shown on Figure 2.

One of the principal benefits obtained by using a high frequency FMO is that modulation frequency response from dc to greater than 10 MHz can readily be achieved. A frequency response curve of a video transmitter is shown in Figure 3. With this transmission bandwidth capability, methods of communication become feasible that previously could not be obtained with FM equipment. It is now possible to operate wideband solid-state video systems such as the Teledyne microeye television camera (Model No. KXO-600) with the transmitters to form a compact, and highly reliable video transmission system. The wideband transmitter also provides a vehicle for recently available high speed PCM systems such as TTC’s PCM system (the Model CT-200).

One of the principal criteria in the success of the FM versions of the adaptive transmission system has been the use of a high-frequency FMO with an extremely well decoupled modulation circuit. The higher frequency that the VCO is operated, the less the change in capacity across the oscillator tank that is required in order to provide wideband modulation. At the higher frequencies (above 50 MHz) it is only necessary to use one variable capacitance diode in order to achieve the desired carrier deviation. This diode in turn may be operated on a very narrow position of the Δc vs. Δe curve, significantly improving linearity.

For example, an FMO operating in the vicinity of 75 MHz can be deviated ±2-1/2 MHz with better than 1% linearity. When multiplied 4-times (as in an S-band transmitter) this translates to a carrier deviation of ±10 MHz.

Measurement techniques limit the useful (accuracy in the) measurement of linearity. A more meaningful measurement of transmitter performance is intermodulation distortion. Although linearity and intermodulation (IM) distortion are related, intermodulation is a more meaningful measurement considering applications requiring the handling of high data rates. Low IM distortion is especially important for video and FM/FM systems. It is very practical to design a high frequency transmitter with low IM distortion, however, it cannot be achieved by adding multipliers to low frequency synthesizers that fundamentally cannot produce extremely linear modulation characteristics. A typical IM curve achieved on the adaptive transmitter modulator is shown on Figure 4.

As indicated by the curve, if the total number of modulating frequencies are increased, while the total peak deviation remains constant, the number of intermodulation products increase but their relative level decreases. Therefore, the less the deviation, the lower the IM.

When greater long term stability is required and the characteristics of phase modulation can be tolerated, the phase modulated synthesizer can be used. The phase modulator is dc coupled to provide linear phase response from dc to greater than 5 MHz. The wideband response of the phase modulator makes it ideal for use with high speed PCM such as the TTC Model CT-200 10-megabit model PCM system. The phase modulator can also be used with low frequency PCM systems or VCO’S, however, it is not practical for use in wideband video systems.

A problem encountered at the higher modulating frequencies, is the phase shift as a function shunt capacitance, caused by the modulation input or interconnecting modulation cables. If cables longer than a foot are used, it becomes necessary to use a low impedance driving source. An optional internal amplifier, with response from dc to 5 MHz, an input resistance greater than 2 megohms and an input capacitance less than 5 pf (which is contributed mainly by the connector) can be supplied. However, the increased cost and current drain, and this decreased reliability generally would not warrant the use of the amplifier. If a short piece of cable were used in order to reduce the shunt capacity, the benefit of the amplifier would be overcome. Therefore, it is more practical to use a low impedance amplifier driving the line, eliminate the modulation input amplifier from the transmitter and increase the input capacitance so that greater deviation sensitivity can be realized. With a video response of 4 MHz and low IM distortion, the input capacitance is typically 35 pf for an input sensitivity of .6 MHz/volt. Any lowering of input capacitance is achieved at the expense of IM distortion or stability.

RF Power Amplification Extensive investigation was made into the optimum frequency for RF power amplification. For carrier powers up to 2 watts minimum at frequencies below 2 GHz, or 10 watts minimum at a carrier frequency up to 800 MHz, the optimum approach is to amplify at the carrier frequency. For higher power and high frequencies, it is necessary at this time to perform the RF power amplification at dome lower frequency and multiply with step-recovery diode multipliers.

One of the principal design considerations of the RF power amplifier is the need to attain production repeatability with devices which typically have Beta variations between 15 and 130. Another consideration is the trade-off between the reliability derating requirements for spacecraft applications, and the need to drive the high frequency devices sufficiently hard so that no sub-chip instabilities are experienced, which would result in sub-multiple harmonic oscillation of portions of the transistor and ultimate failure of the device.

The final consideration from the production standpoint is the selection of amplifier circuits with broad enough bandpass characteristics which will permit a 10-1 change in the resonant frequency of the tank circuit and still use LC components which are small and mechanically interchangeable. This complicates the problems of reflected impedance and admittance which must be considered in the design of interstage coupling, even though they become quite involved because the transistor parameters are both complex and frequency dependent. To reduce the problems associated with interaction between amplifier stages, each amplifier is double-tuned and mechanically shielded to prevent electromagnetic coupling throughout the amplifier chassis. Double-tuned circuits, although more expensive in production, provide the required bandpass characteristics permitting the amplifiers to maintain good skirt selectivity. This is essential in order to provide the wideband amplification characteristics associated with video modulation.

In the final design, each stage was tested for assurance that stable operation is obtained at any collector voltage from 0-30 volts regardless of the drive and modulation conditions. This includes operation with VSWR’s up to 50:1. Although every effort was made to achieve maximum gain per stage no unreliable regenerative circuits such as emitter tuning were used.

RF Power Stabilization In order to minimize variations in RF output power as a function of supply voltage changes in temperature, it is necessary to use both voltage regulation and gain control in the RF amplifier chain. The supply voltage to the RF power amplifiers must be clamped at the low-end supply voltage (plus peak negative power line conducted noise) in order to eliminate any AM on the collector supply which would appear as IFM, at the output of a series of cascaded amplifiers. This essentially makes the transmitter a constant current device. It also minimizes the open-loop compensation requirements necessary to offset the effects of power variations vs. temperature.

As dc to rf efficiency is closely related to the variation in supply voltage, since at all voltages above the minimum level represent power dissipated across the series regulator, a dc to dc converter was considered. The gain in dc to rf efficiency by having a higher (29V) collector supply, for all but the higher power units, is offset by the conversion losses of the regulated converter. Also, when trading off cost, size, weight and reliability against efficiency it was decided to use the clamp regulated B+ supply approach instead of the converter.

Looking at typical efficiencies of an S-band transmitter using the frequency synthesis and amplification frequencies shown on Table I, it may be seen that the range of supply voltage variation has the greater effect on the lower power transmitters (0. 5 to 2 watts, as shown on Figure 5). In the lower power transmitters the efficiency drops off because the frequency synthesizer and voltage regulator become a more significant portion of the total power consumed while contributing nothing to the output power. Above the 4-watt region, with the synthesis techniques used, the efficiency begins to drop off due to the operation of two or more devices in parallel in the final RF amplifier, in order to meet reliability derating requirements. Both of these curves are moved upward on the ordinate where the RF power amplification is performed at the output frequency.

With a highly stable RF amplifier, chain it is possible to use open-loop compensation techniques to supplement the internal voltage regulators and restrain RF power variations to less than 2 db across the combined variations in supply voltage and temperature.

To prevent self destruction of the transmitter, the higher powered amplifiers incorporate a temperature sensing element in the gain control circuitry to provide a reduction in output power, when the chassis temperature has reached a pre-determined point.

At frequencies above 1 GHz, connector and cable losses can be significant. For module interconnection within the transmitter, short lengths of low-loss cable have been used. Although any type of rf output connector can be accommodated it is important to select a low-loss connector such as the type TNC and calibrate all transmission cables for insertion loss at the carrier frequency.

VSWR Considerations With lower power transmitters it is possible to eliminate a circulator and load and still provide for operation into high VSWR’s and an open- or short-circuit as the antenna terminal. However, provisions must be made in the mechanical design to incorporate a circulator and load in the higher powered transmitters so that the final stage will not be damaged by operation under these conditions. A circulator and load is also necessary for applications where several transmitters are multiplexed to a single antenna, in order to minimize spurious signal generation. The circulator also provides constant loading to the filter assembly so that external impedance variations and spurious signals have no effect on filter performance.

Grounds Isolation There are several methods of providing signal-to-case ground isolation, the most common being a dc to dc converter for operation of the entire transmitter. This, of course, is the most costly, bulky and least reliable solution, and as discussed earlier was not selected for the adaptive transmission system.

Mica button capacitors can be used to isolate the dc ground. However, with this technique it is difficult to guarantee over 1-megohm. dc isolation even with preconditioning of the capacitors. The major drawback with this concept is the difficulty in making repairs. When a capacitor becomes leaky, it is necessary to physically isolate a parallel unit on a series buss, which is virtually impossible due to the inaccessibility of many of these capacitors after the unit is completely assembled. The optimum solution proved to be the use of a small, low-power converter for power to signal ground isolation in the input stage, with electrical isolation of each of the subchassis from the housing for power to case ground isolation. This, of course, implies the design of a case with a case in order to meet the RFI requirements. Beryllium oxide isolators between the chassis and the housing provide the power to case ground isolation. A low power, sine-wave oscillator/rectifier, with secondary regulation, provides an isolated bias for the modulator. This eliminates any switching spikes and their associated EMI problems.

Voltage Regulation The rf power amplifiers must have as high a supply voltage (noise-free) as possible for maximum efficiency. Some power line noise can be tolerated, depending on the IFM limitations, therefore, it is not necessary to regulate well below the low-end peak noise point. At the same time, the frequency sensitive portions of the transmitter, (the synthesizer) cannot tolerate any supply line variations. For these reasons, dual voltage regulators are necessary for optimum dc to rf efficiency.

A clamp regulator set to the user’s low-line voltage plus peak negative noise is used to supply the rf power amplifier assembly. This provides the PA with the highest collector voltage available for a particular application. A smaller regulator, operating in the vicinity of 17-19 volts, is used to power the frequency synthesizer so that none of the frequency sensitive portions of the transmitter are affected by variations in the supply line voltage. In the packaging of the dual regulators, space is allocated for the incorporation of reverse voltage protection and low-level control logic for remote turn-on control. Provisions are also made for current limiting and restriction of rate of change (current). This is especially important in the higher powered transmitters where it is necessary to limit the current at turn-on in order to meet restricted battery buss load capacities.

Frequency Multiplication For transmitters where the output power level and/or the carrier frequency is beyond the present capabilities of the state-of-the-art semiconductors, it is necessary to develop the RF power at a lower frequency and multiply the frequency with step-recovery diodes. Here there are two fundamental approaches which can be used as far as the mechanization of the multiplication circuitry. One is to incorporate the diodes in a stripline multiplier circuit; the second is to use coaxial cavities. Each approach has advantages and disadvantages (detailed in several papers) so that selection of the concept used for the adaptive system was based primarily on the best efficiency, best heat transfer, mechanical rigidity, and the compatibility of the mechanical configuration of the frequency multiplier with the rest of the transmitter subassemblies. The frequency synthesizer and RF power amplifier chassis and housing were designed in such a manner that in versions where frequency multiplication is required, the optimum mechanical configuration (32 to 42 cubic inches) with RF power levels up to 10 watts at frequencies above 1 GHz is achieved by using coaxial cavities. The principal advantage of the coaxial cavity in the adaptive system is that a single cavity can be used for all frequencies from 1000 MHz to 2.5 GHz with very little degradation in multiplication efficiency. This allows the fabrication of a single mechanical structure for the multiplier subassembly all transmitters requiring passive frequency multiplication. A smaller cavity of course is used for carriers between 2.5 GHz and 5.0 GHz. The primary variations in any of the cavity Multipliers are whether there are 1 or 2 frequency multiplication diodes (cascaded) used, and whether each diode is used as a doubler or a tripler (reference Figure 1).

Triple-tuned bandpass filters were used following the crystal multiplier and the mixer in order to provide the narrow passband characteristics necessary to reject all products other than the desired frequency. This permits the establishment of the spurious response characteristics in the low-level stages of the transmitter, so that the output filter need only attenuate harmonic energy (a bandpass filter for step-recovery diode frequency, and a low pass filter for units performing RF power amplification of the output frequency).

In transmitters using passive frequency multiplication, a triple-tuned bandpass filter is incorporated between the multiplier cavity and the circulator and load in order to attenuate the unwanted harmonics to acceptable EMI levels. Of course, in the lower powered transmitters where frequency multiplication is not required, a low pass filter is substituted in place of the bandpass filter as only harmonic energy from the RF power amplifier chain need be attenuated (spurious response is established within the frequency synthesizer chassis). A block diagram of a typical FM S-band transmitter is shown on Figure 6.

Mechanical Design Considerations In order to minimize the mechanical configurations in a transmitter system with this broad a range of carrier frequencies and RF power levels, it is necessary to divide the transmitter into fundamental functional blocks. These are the voltage regulator, the frequency synthesizer, the RF power amplifier, the frequency multiplier/filter (where required) and the housing.

The frequency synthesizer is essentially a complete low-powered transmitter tha provides from 20 to 100 milliwatts drive power for the RF power amplifier assembly. In the open-loop heterodyne FM version the synthesizer consists of an FMO and buffer, a crystal oscillator, a crystal multiplier, a mixer amplifier, and two stages of amplification at the desired output frequency (the PA drive frequency). In the PM version a lower frequency crystal oscillator is followed by a phase modulator and multipliers to generate the PA drive frequency and two stages of power amplification.

Two basic chassis were designed for the RF power amplifiers. They are essentially identical except that one chassis contains six stage (for the higher powered transmitters), while the other chassis has a capacity of up to 5 stages (for the lower powered transmitters). This packaging concept produces certain size penalties for the 1/2 to 2-watt transmitter. However, it provides a high degree of production commonality so that a 2-watt transmitter may be offered in a larger housing at a lower price than a transmitter which is packaged for minimum size and weight.

Each stage of the power amplifier chain is packaged in a completely isolated section of the PA chassis. Feedthrough coupling capacitors are used for interstage connection so that when the PA chassis is mounted within the housing, there is no possibility for electromagnetic coupling around any of the stages of the cascaded PA string. Provision is made underneath the final amplifier transistors for the hot spot telemetry thermistor.

Several different regulator configurations have been designed depending upon theminimum power level of the transmitter and whether or not the ancillary functions of remote turn-on, internal voltage telemetry, current limiting and reverse polarity protection are required. Essentially all of the regulator assemblies are composed of two series regulators; the clamp regulated series regulator for the power amplifier chain and the 17-volt regulator for the frequency synthesizer chassis. All regulator subassemblies have been packaged to be mechanically interchangeable within the transmitter housing.

The frequency multiplier/bandpass filter chassis uses quarter-wave, foreshortened coaxial cavities. The cavities are mac ined from a single block of aluminum in order to minimize detuning effects caused by the broad variations in temperature to which the transmitter is subjected. The step-recovery diodes are mounted within the cavity walls (the input and output walls of the multiplier cavity) in order to optimize heat transfer from the diode to the housing.

Space has been allocated within the transmitter housing to insert a 20-watt circulator and load between the output of the coaxial cavity bandpass filter and the RF output connector on the housing. This allows the circulator to be incorporated in all versions of the transmitter where several transmitters are to be multiplexed to a single antenna, (in order to minimize intermodulation distortion) even though the lower power units do not require open- and short-circuit protection to prevent damage. The circulator, of course, is included as standard in the higher power transmitters.

The housing for the transmitter is divided into three basic cavities; one for the frequency synthesizer, one for the voltage regulators, and one for the power amplifier and frequency multiplier chassis. Mechanical and electrical isolation is obtained between each of the three cavities in the housing. When the chassis are installed in the housing, all the tuning adjustments are accessible so that tune-up may be accomplished through access holes in the special test housing covers. In this manner there is a minimum interaction between the final tuning process and the performance achieved when the permanent covers are installed. Production test parameters have been established so that all four of the major transmitter subassemblies can be assembled and tested on an individual subassembly basis. This minimizes the final acceptance test time after each of the subassemblies is married within a single housing.

The housing has been designed with two different types of case sealing. One is for short-term missile flight where the transmitter only operates in a vacuum environment for a short period of time, while the other is for survival of extended periods in a space environment. The housing for short term vacuum environments uses conductive gasket material to provide a conductive surface between the housing and its covers (for EMI) while providing an air-tight seal. For continuous space environment an 11011 ring type gasket has been used in both the top and bottom covers. This requires the housing to be extended approximately 1/4-inch in the length and width dimensions in order to provide the added flat surface for the sealing of the “O” ring gasket.

Provisions have been made for the incorporation of an air pressure valve for use in pressurizing the sealed housing where required. This access to the transmitter housing also provides the capability of performing helium leak checks in order to ascertain that the seal integrity has been maintained after manufacture and electrical testing.

For low transmission loss, low loss cable should be used. Many different connector options are available depending upon customer requirements. The standard transmitter is provided in a three-connector configuration with a single connector for dc power, modulation input, and RF output.

Gold-plating is used in all of the chassis subassemblies in order to provide an optimum ground plane for conduction of ‘ the RF currents. The housing is plated with electroless nickel as this offers an extremely durable finish with sufficiently high coefficients of reflectivity and emissivity for certain spacecraft applications. Due to the extremely small size of the housing there is inadequate service area available for radiation cooling in a thermal vacuum environment, and therefore it is necessary to mount the transmitter to a heatsink capable of carrying away the latent heat which varies with the minimum power output of the transmitter. An exploded view of the transmitter subassemblies is shown on Figure 7.

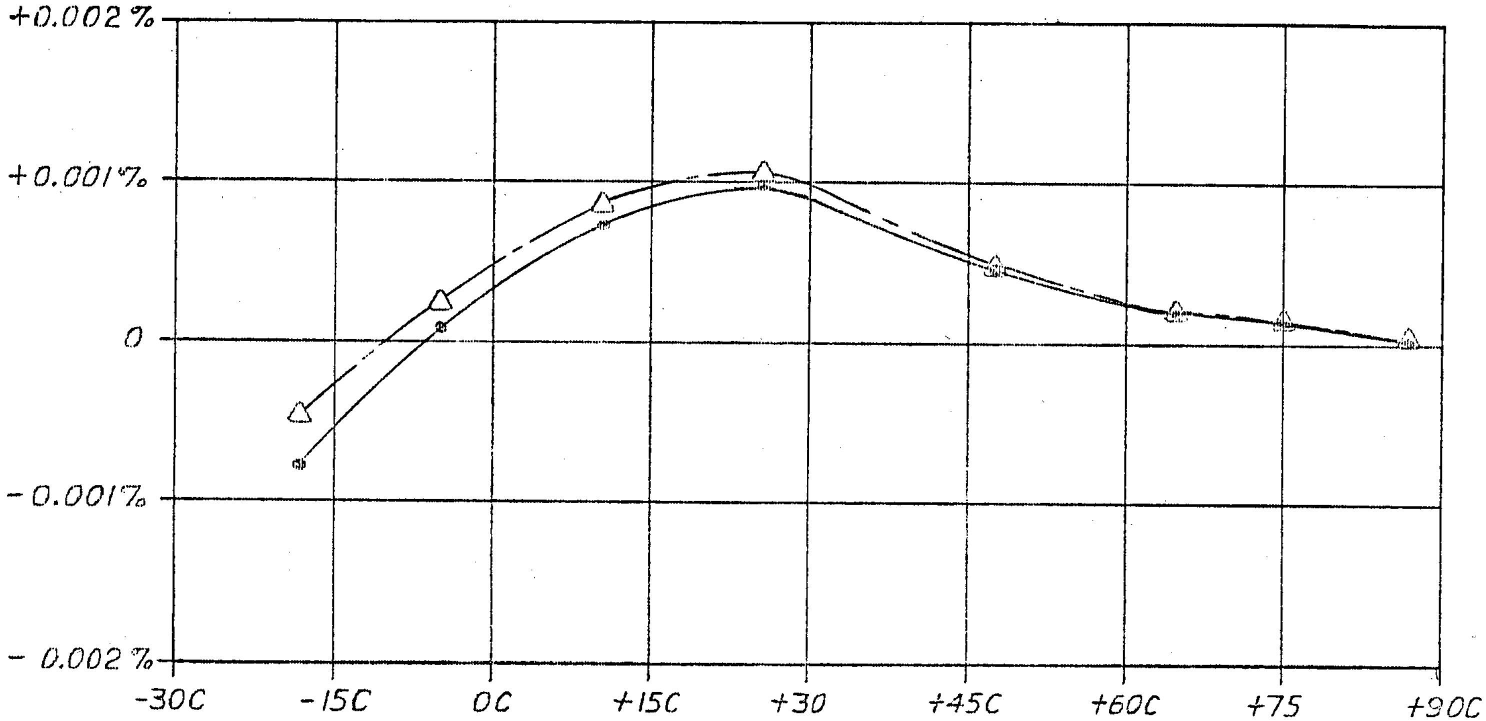
TELEDYNE TELEMETRY COMPANY

BASIC FREQUENCY SYNTHESIS -- VHF/UHF TRANSMITTER LINE

Model No.	f xtal	Xtal Multi	Xtal Inject Freq.	FMO	Xfer Ratio	Mixer Harmonic Separ.	f_a P. A.	S. R. D. Multi.	Carr. f_c	Max. P_o	Max. dbw (MHz)	Max. Baseband Resp. (MHz)
TR-136	100	x1	100	36	3:1	36%	136	---	136	50W	±.25	1.0
TR-250	100	x2	200	50	4:1	20%	250	---	250	50W	±1.0	1.5
TR-400	115	x4	460	60	7.7:1	15%	400	---	400	25W	±2.0	4.5
TR-800	121	x6	726	74	9.8:1	9%	800	---	800	15W	±3.0	8.0
TR-1400	109	x5	545	50	9:1	12%	486	x3	1455	10W	±7.5	8.0
TR-2200	98	x5	490	68	7:1	12%	558	x2 x2	2232	10W	±10.0	8.0
TR-3400	100	x5	500	75	6.5:1	13%	575	x3 x2	3450	2W	±15.0	8.0
TR-5000	100	x5	500	75	6.5:1	13%	575	x3 x3	5022	1/2W	±20.0	8.0

Fig. 1

TR-2200M SERIES TRANSMITTERS
CARRIER STABILITY Vs TEMPERATURES △1
(TR-2200.5 S/N 502)



NOTES:

△1 READINGS TAKEN 2 MIN. AFTER TURNON

△2 △– – –△ E_{SUPPLY} 36 VDC

●——● E_{SUPPLY} 28 VDC

FIGURE 2

UHF VIDEO TRANSMITTER
TYPICAL FREQUENCY RESPONSE
METHOD: BESSEL FUNCTION

TEST EQUIPMENT
1) HP 8551B
SPECTRUM ANALYZER
2) HP 652A
SIGNAL GENERATOR
3) HP 5245L
COUNTER

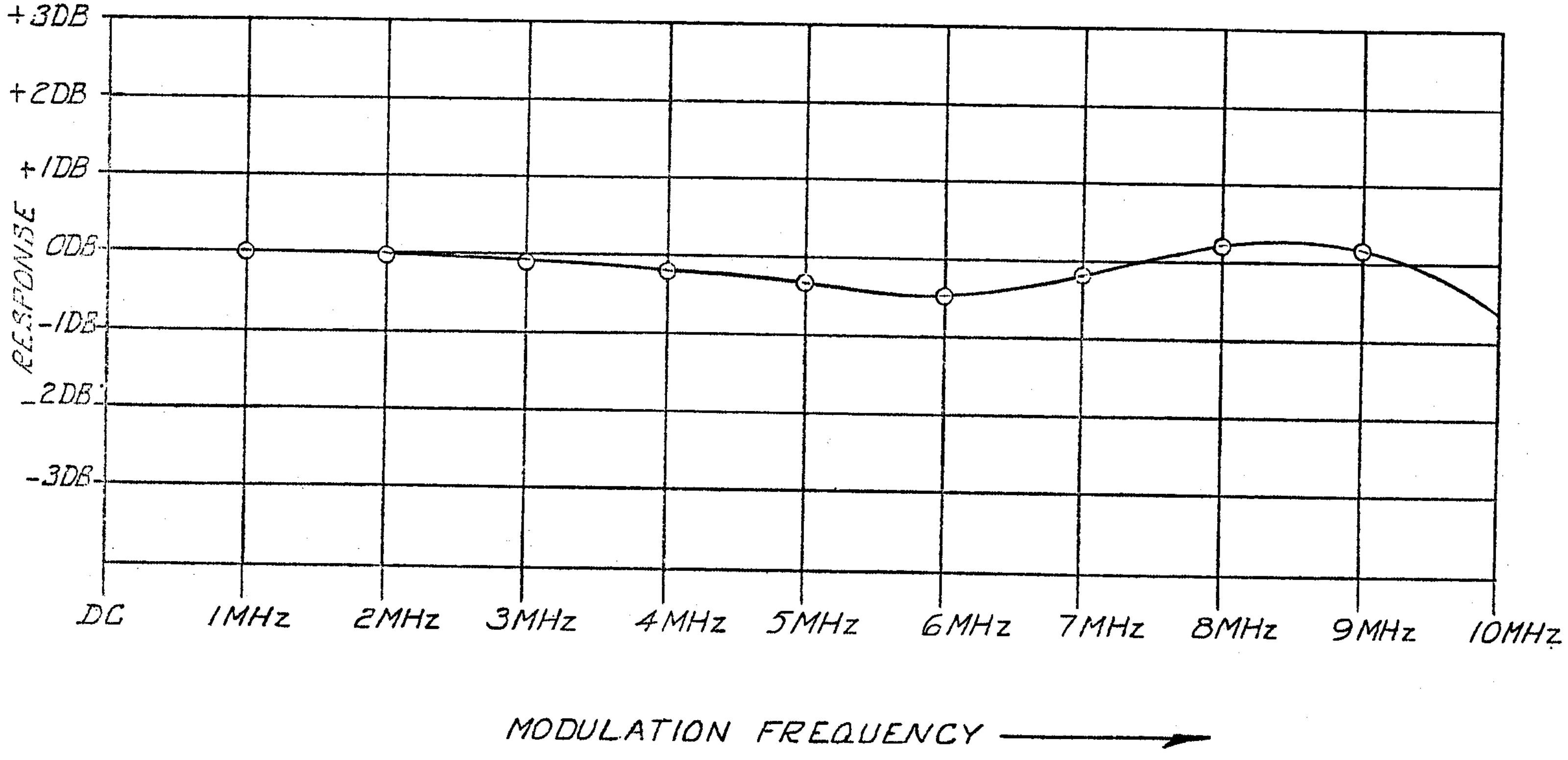


FIGURE 3

MODEL TR-2210 TRANSMITTER
3-TONE INTERMODULATION TEST

TEST EQUIPMENT
1) HP 8551B
SPECTRUM ANALYZER
2) HP 652A
SIGNAL GENERATOR

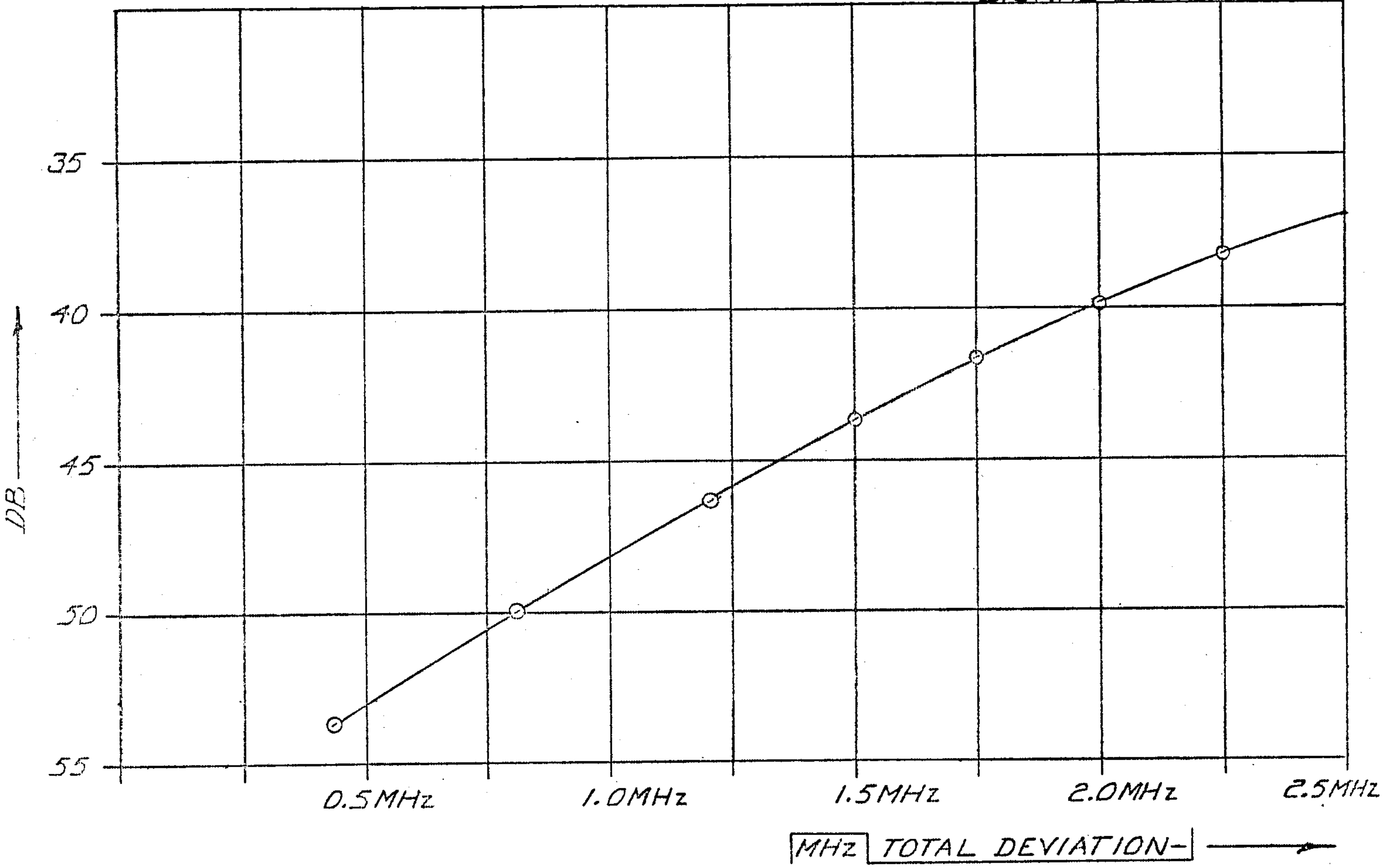
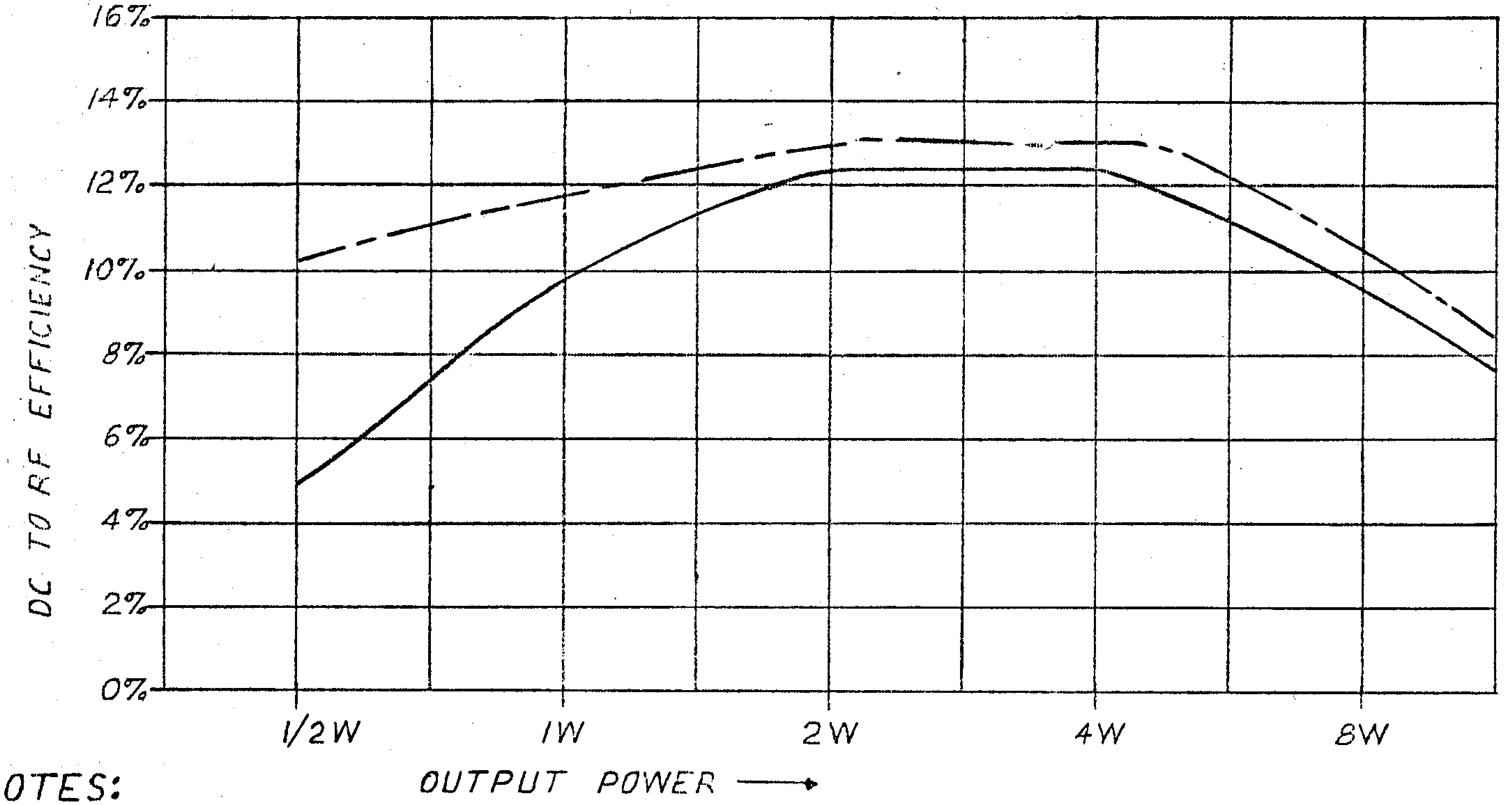


FIGURE 4

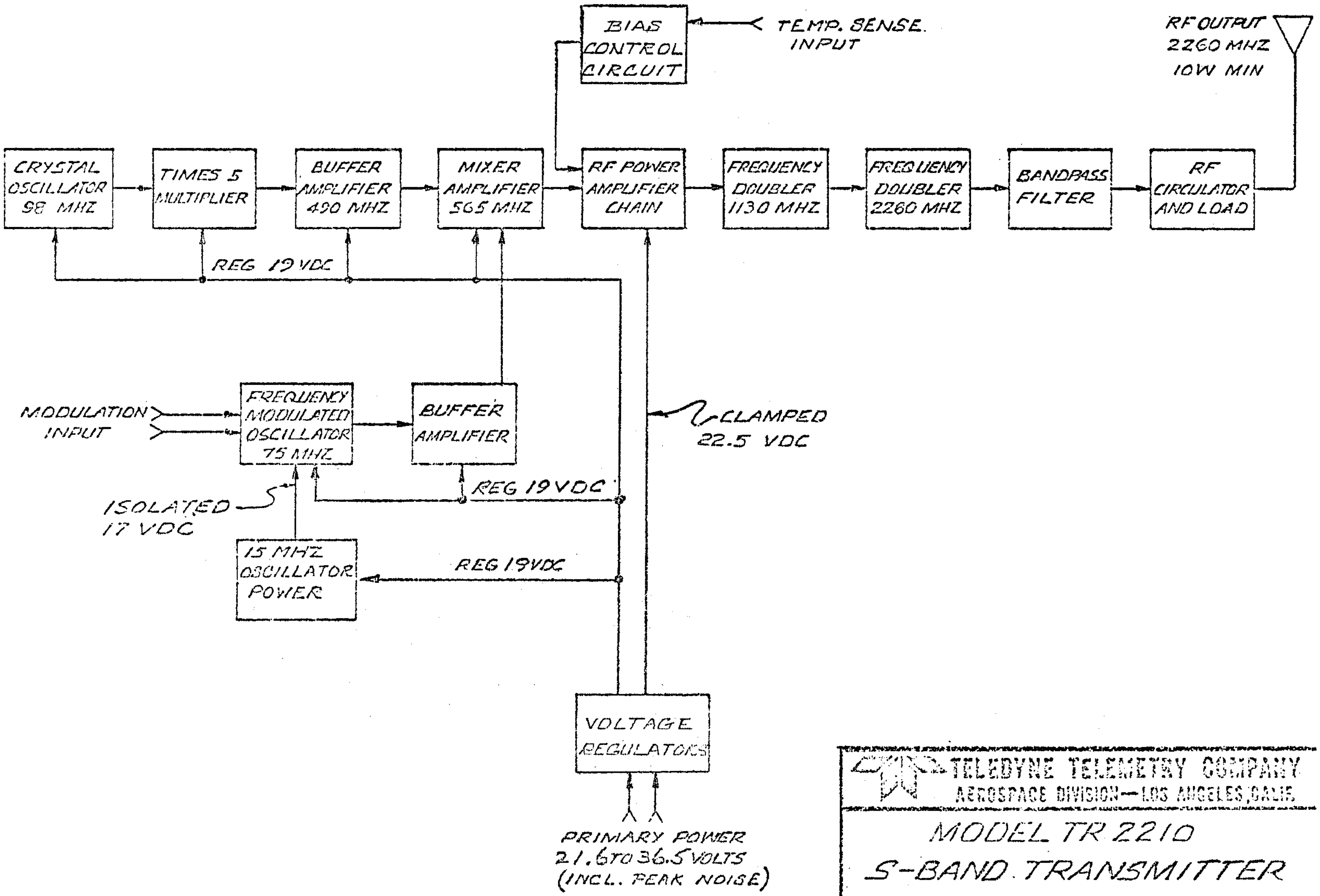
TYPICAL EFFICIENCIES-S BAND TRANSMITTERS



NOTES:

1. – – – E_{SUPPLY} 24V
—— E_{SUPPLY} 28V

FIGURE 5



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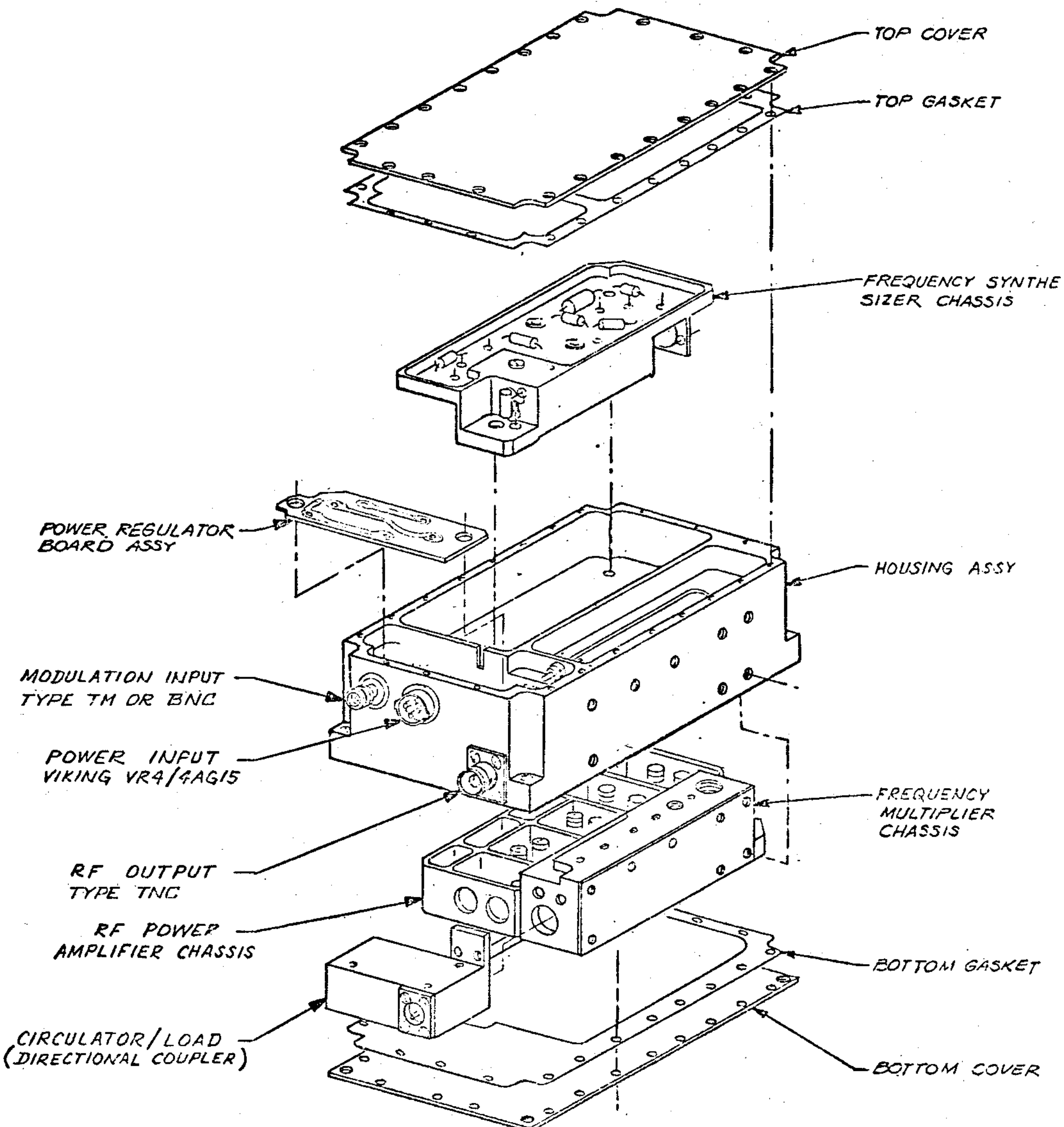
MODEL TR 2210
S-BAND TRANSMITTER
FIGURE 6



VOLUME = 42 CU IN. MAX.
WEIGHT = 40 OZ MAX.

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VHF/UHF TRANSMITTER
NON-PRESSURIZED CASE

SIZE			REV
	22406	FIGURE 7	
SCALE		SHEET	