TECHNICAL SPECIFICATIONS
HFT–40K

OPERATING PARAMETERS	
FREQUENCY RANGE	2–30MHz multi-channel or synthesized in 100Hz increments.
FREQUENCY STABILITY	One part in 10^6 per day. Optional one part in 10^8 day and higher.
MODES OF OPERATION	CW, AM, AME, USB, LSB, 2ISB, FSK, FAX. Optional 4ISB.
POWER OUTPUT	40,000 watts PEP (SSB). 20,000 watts average (CW/FSK).
OUTPUT IMPEDANCE	50 ohms unbalanced. Output network will match into a 2:1 load VSWR.
TUNING	Automatic with front-panel, over-ride of all operating controls.
AUDIO PARAMETERS	
SIDEBAND RESPONSE	250–3040Hz CCIR + 1.5db. Optional 250–6080Hz CCIR; equalized filters; others.
INPUTS	Audio: Two independent 600 ohm channels. –20 to + 5dbm.Optional 4-channel ISB. Mike: Front panel jack for low-level dynamic input. –55db into 47,000 ohms. FSK: Rear panel connector of 75 baud or higher. + 42.5/85/170/425Hz shifts; others. Input 20/60ma, 50 or 100 volts, dry contact, +/– to ground. FAX: Rear panel connector for up to 800Hz linear shift. Input + 1 to + 10vdc.
CONTROL	Front panel "fader" controls ease selection of line or mike inputs for USB or LSB.
RF PARAMETERS	
SIDEBAND REJECTION	500Hz tone is minimum 50db below PEP in the unwanted sideband.
SPURIOUS SIGNALS	Minimum 50db below PEP.
DISTORTION	Minimum 35db below either tone of a two-tone test at rated PEP output.
HUM and NOISE	Minimum 50db PEP at least 120Hz removed from carrier.
CARRIER SUPPRESSION	Selectable at –6/–20/–30/–55db (adjustable).
HARMONIC SUPPRESSION	Minimum 45db below PEP without accessory TFP output filter.
SPECIAL FEATURES	
REMOTE CONTROL	Full remote control frequency, mode, carrier, power output, antenna selection, antenna direction, and keying is available with SCR or TCR control systems.
METERING	Front panel meters and indicators provide continuous status display of transmitter operation to the module level.
SAFETY	Each transmitter module is fully high-voltage interlocked with fuse, overload, and audible alarm protection. Protective plates - labelled in red - are used throughout.
ALDC	Automatic load and drive control is included to improve linearity, limit distortion, and provide a relatively constant output during input peaks or load changes.
CONSTRUCTION	Completely solid-state, including power supply, up to the final RF output stages. US/Military Standard components are used whenever practicable.
ENVIRONMENTAL and INSTALLATION	
COOLING	Filtered, forced air in semi-pressurized cabinet. Nominal 900cfm airflow.
OPERATING CONDITIONS	0° to 50°C. Up to 90% relative humidity at MSL.
STORAGE CONDITIONS	–30° to + 75°C. Up to 90% relative humidity at MSL.
PRIMARY POWER	230 VAC, 50/60Hz. Three-phase with + 10% taps. Nominal 70KW at 0.97pf. Optional 380 VAC, 50/60Hz. Three-phase. Other ratings on request.
HEAT DISSIPATION	Nominal 28KW.
SIZE and WEIGHT	85" (216cm) high x 99" (215cm) wide x 44" (112cm) deep. 5400 pounds/2455Kg. Size and weight varies slightly with accessories selected.
SHIPPING DATA	Commercial packing for U.S. shipment. Special packing available at additional cost. Sixteen (16) containers. Largest 82" x 42" x 51".Weight/cube –10,400lbs./745 cu.ft.
LOOSE ITEMS	Technical manual (2) and mating RF/signal connectors.
ORDERING INFORMATION	
MODELS	HFT–40K/J Synthesized 40KW HF/ISB Transmitter.

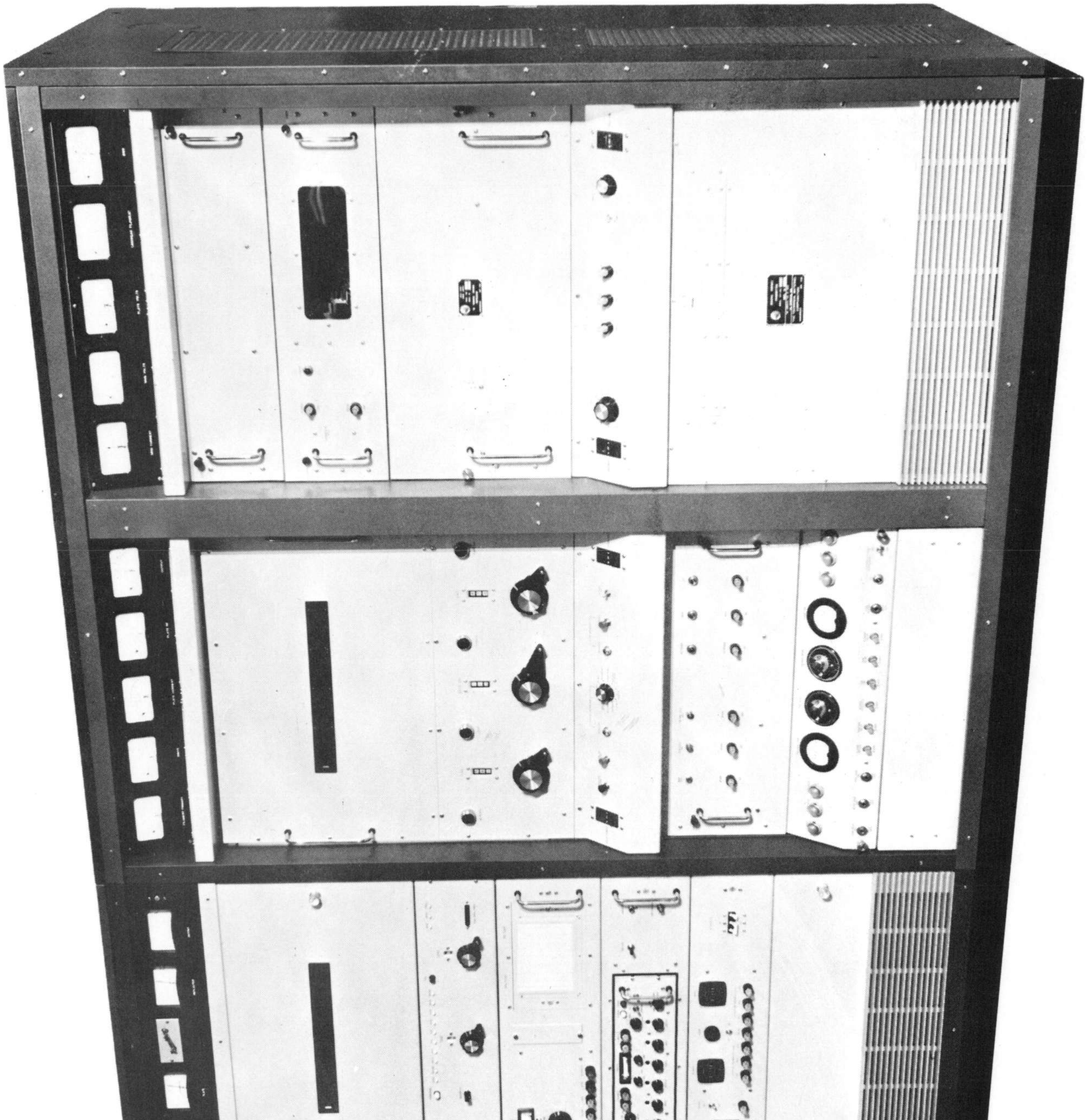
ACCESSORY PRODUCTS are described in sections 4 - 9 of the General Catalog and include RF/antenna, terminal, data, connector and power equipment. **TECHNICAL SERVICES** in design, engineering, training, and related areas are described in section 10. **OPTIONS** are listed after each TMC product in part A of the Price List.

Technical Analysis

of

HIGH FREQUENCY TRANSMITTER

MODEL HFT-40K



GENERAL DESCRIPTION AND FEATURES

The HFT-40K series of TMS transmitter systems provide the capability of long haul, point-to-point communications in the high frequency range of 2.0 to 29.9999MHz. The transmitters are an outgrowth of over 30 years experience in TMC developing, manufacturing, installing and maintaining high power HF systems. From the earlier GPT-40K series (U.S.Military AN/FRT-40), the HFT-40K series has evolved with the technology of modern electronics until today it is unequalled in technical performance. The many active installations worldwide attest to the proven design of the HFT-40K series.

TMC has long used the "building block" approach in the design of its equipment. This approach enables any communications station to expand or alter its capability without replacing entire systems. As an example, the GPT-40K (AN/FRT-40) transmitters required an entire side-rack of equipment to produce the RF excitation for the 40KW linear amplifier. Today a single unit designed by TMC and occupying less than six inches of rack space does the same job better and is completely compatible with the older transmitters. This building block approach is used in the HFT-40K series and in addition to providing a variety of capabilities, results in commonality of parts, compatibility between equipments, and significant cost savings.

The HFT-40K series is actually an entire family of 40KW transmitter systems, each with a broad range of capabilities. The basic models provide either multi-channel or synthesized operation in the CW, AME, USB, LSB or two-channel ISB modes. Operating modes for AM, FSK, AFSK, FAX and four-channel ISB are also available depending on the type of service required. Automated tuning of the transmitter system is normally provided although completely manual tuning is available. Automated transmitter systems designed by TMC can be locally or remotely controlled. In either case, any operator can assume complete control of the system by manually overriding the transmitter functions at the front panel. This manual override feature is particularly important when operating under emergency or maintenance conditions.

All parts and assemblies in the HFT-40K series are accessible from the front of the transmitter to facilitate maintenance. No access is required from the sides or rear. Several units are mounted on track slides with interconnect cables of sufficient length to permit full operation of the equipment when the slides are extended to their maximum length. This feature is a result of TMC's experience with many "confining" installations where operating space was at a minimum. The transportable communications vans designed and installed by TMC for the U.S. Navy are examples of how valuable space can best be utilized. Such experience is one reason why the HFT-40K can provide 40,000 watts of RF power (Average) reliability in less than 30 square feet of floor space. In fact, the HFT-40K for its size is the smallest, lightest (5,400 pounds installed) and most efficient 40KW transmitter available today.

The HFT-40K series of transmitter systems is grouped by capability as follows:

<u>Model HFT-40KE</u>

Multi-Channel CW/AME/USB/LSB/ISB/AFSK/AFAX

<u>Model HFT-40KJ</u>

Synthesized CW/AM/AME/FSK/FAX/USB/LSB/ISB

<u>Model HFT-40KJA</u>

Synthesized CW/AM/AME/FSK/FAX/USB/LSB/ISB (4-Channel)

The following sections describe in detail the physical and electrical characteristics of the HFT-40K series of transmitter systems.

PHYSICAL DESCRIPTION

The basic transmitter system is housed in three completely enclosed metal cabinets capable of being operated as a single mechanical and electrical assembly. All components of the transmitter are housed in these cabinets with access ports cut into the base and top assemblies for routing of RF power, primary power and external connections. For remotely controlled transmitters, a standard cabinet is bolted to the left frame for control units or terminal equipment required for operation. All cabinets are designed for rigid mounting to a deck or properly constructed flooring.

The three main cabinets are functionally separated into 1) the 10KW driver; 2) the 40KW linear amplifier; and 3) the 40KW power supply. Each transmitter section is further described below.

Cabinet #1 - 10KW Driver

The main meter panel located across the top section of this cabinet contains four meters that monitor the status of critical circuits during operation of the system. They include 1) PA screen current meter; 2) PA plate current meter; 3) reflected power meter; and 4) PA output meter. In addition, the IPA drawer, described in following paragraphs, has a multi-meter designed to monitor RF plate currents in the first, second and intermediate amplifier circuits.

The next section down houses the power amplifier (PA) containing the ceramic/uniaxial power amplifier tube (4CX10000J) particularly designed for sideband operation. This tube is capable of dissipating in excess of 10,000 watts average power. The PA section houses the output circuit - a modified parallel-L designed to match into an unbalanced load of 50 ohms. The PA bandswitch and coil assembly located in this compartment is constructed with self-cleaning contacts designed to operate in excess of 10,000 times under rated loads without development of imperfections or of appreciable wear leading to erratic operation. The number of pressure contacts has been held to a minimum while still providing the necessary redundancy to assure reliable, trouble-free operation of the system. Automatic tuning and loading components are also located in the PA compartment along with an automatically switched harmonic filter which decreases the harmonic content of the PA signal.

Under the PA compartment is the main control panel for the transmitter. This panel enables direct manual control of the 10KW driver. Located on this panel are controls for positioning of the bandswitch, tuning and loading of the PA, adjusting ALDC, switching high voltage on or off, and initiating the automated tuning sequence. Lights are used to indicate when the interlock safety circuit is complete; when the system is in a ready condition; and the position of the bandswitch in the PA section.

The intermediate power amplifier (IPA) drawer, located under the main control panel, houses the RF components for the IPA. The IPA consists of two broad-band amplifier stages and a final amplifier stage that provide approximately 500 watts drive to the PA section. The final IPA and second amplifier tubes are air-cooled by a self-contained blower within the drawer. Bandswitching of the IPA final is accomplished with the same bandswitch control as is used for the PA section on the main control panel. The 10KW driver bias supply and 24 volt-dc supply are also located in the IPA section along with the servo amplifiers and process control circuits for automated tuning.

The exciter drawer under the IPA normally houses a multi-channel or synthesized exciter which provides drive to the IPA. However, a four-channel ISB exciter or other external source, microwave or telephone terminal units, remote control units audio frequency shift keyers, and other related accessories require additional rack space which is available in an adjacent side cabinet. In this instance, the exciter drawer is fitted with a blank panel. For monitoring and testing purposes a test, input jack, and exciter monitor jack are mounted on the exciter drawer.

The 10KW driver power panel and power supply occupy the bottom two sections. The power panel controls the application of primary power, filament and screen voltages to the IPA and PA sections of the transmitter. Also located on this panel is a high voltage aural alarm, plate and filament elapsed time meters, and an on/off switch controlling AC power to the exciter drawer. The high voltage transformer and associated power supply components which provide plate and screen voltages to the RF amplifiers are located in this compartment.

Cabinet #2 - 40KW Final Amplifier (F/PA)

The final main meter panel is located at the top of the frame and contains five meters to monitor RF drive voltage, plate current, filament transformer voltage, RF plate voltage and output power.

Directly below this panel is the final power amplifier compartment which contains all bandswitch, tuning and loading components including the final tube, an ML6697 triode, capable of dissipating 20,000 watts average power. The output circuit is a pi-network configuration designed to match into a 50-ohm unbalanced load. The PA bandswitch and coil assemblies are constructed with durable self-cleaning contacts designed to operate in excess of 10,000 times under rated loads without development of imperfections or appreciable wear. The number of pressure contacts is held to a minimum while still providing the necessary redundancy to assure reliable operation of the system. All tuning controls for manual override are located on the front panel of this section including lamp indicators for high voltage, ready and fault.

The next section down is the 40KW PA Control Panel, which monitors the interlock circuits associated with the PA and PS frames as well as controlling the application of main AC power and high voltage. Other controls enable manual release of the bandswitch and high voltage reset. The automatic processor control is also located in this section.

The PA bias supply under the control panel contains two power supplies and adjustments for overload trip. In addition, a PA relay panel under the bias supply is used to protect various circuits in the PA and PS cabinets. The time delay and elapse time meters are mounted on this panel for use with the interlock system.

Cabinet #3 - 40KW Power Supply

The entire cabinet contains the high voltage power supply, the protective crowbar circuitry, and metering used to monitor the operation of the PA circuits. The high voltage power supply uses solid-state rectifiers throughout. This improves reliability and reduces loss through heat dissipation in the supply. The crowbar drawer contains circuits which protect the transmitter against excessive discharge currents in the high voltage supply. Various fuses and indicator lamps provide extra protection to the supply.

The side cabinet, required for external equipment used with the transmitter system, is normally bolted to the right end of the transmitter next to Cabinet #1. This facilitates connections in the transmitter control and power circuits through access ports in the base section. The HFT-40K/JA series of synthesized four-channel ISB transmitters uses such a cabinet to house the exciter and translator units.

The entire transmitter system is cooled by filtered, forced air which enters from the bottom front of the cabinets and is exhausted out the top. Self-contained blowers of sufficient capacity cool the equipment at the specified maximum ambient temperature which would tend to damage it or reduce its useful life. Alternate air ducting is available to meet specific installation requirements. Environmentally, the transmitter operates continuously in any ambient temperature between $0^{o}C$ and $52^{o}C$ at any value of humidity up to 95%. The system will not be materially affected under storage conditions of $-30^{o}C$ to $85^{o}C$ and humidity of up to 95%.

The entire transmitter system is (high voltage) interlocked for personnel safety and designed to prevent personnel from accidentally coming in contact with electrical potentials (MIL-E-16400 applies). The outside casing and main frame, i.e. all external parts exclusive of output terminals, are at ground potential when the system is properly installed and in operation. All control knobs are insulated and control shafts grounded. Primary power (line) input terminals are protected by an insulating cover and identified by warning labels attached to the equipment. Each compartment in the transmitter system is shielded both internally and externally.

The usual method of ducting internal and external cables is through access ports in the base assembly below the power supply. These external cables are then terminated on strips conveniently located to the cable openings and readily accessible to the technician. When not in use, access ports are covered with removeable plates. Provision has been made for alternate cable ducting depending on specific installation requirements. In general, cable ducting through the base compartment results in a neat and pleasing appearance from any viewing angle.

The transmitter system operates from a primary power source of 230 volts AC, 50 or 60Hz, with additional taps for operation of 195 to 240 VAC or 390 to 480 VAC. All sources are three phase delta. Power consumption does not exceed 75KW and the power factor is not less than .95.

The transmitter system without side cabinet but including exciter, 4" (8 cm) mounting base and harmonic filters has the outside dimensions 76 inches (200 cm) high x 98 inches (249 cm) wide x 44 inches (112 cm) deep, and weighs less than 5400 pounds installed. The side rack adds 21 inches (53 cm) to the width and approximately 250 pounds (12 kg) to the weight of the system depending on the accessory equipment installed.

FUNCTIONAL DESCRIPTION

The HFT-40K series of transmitting systems are designed and constructed around the "building block" principle. As a result, this system could be described as containing three transmitters that are integrated into one by using a common exciter for control and drive. The transmitter system is a complete, self-contained functional unit which requires only the application of power, signal and antenna lines to meet all performance specifications. It is designed for reliability, simplicity and ease of operation consistent with operating requirements. As a result, the transmitter will operate continuously under full load with a 100% duty cycle within the environmental operating conditions specified.

The HFT-40K system consists of four functional groups: 1) exciter; 2) RF amplifier; 3) power distribution; and 4) control. Reference is made to the simplified block diagram of the transmitter system on the next page showing the interrelationship of each system.

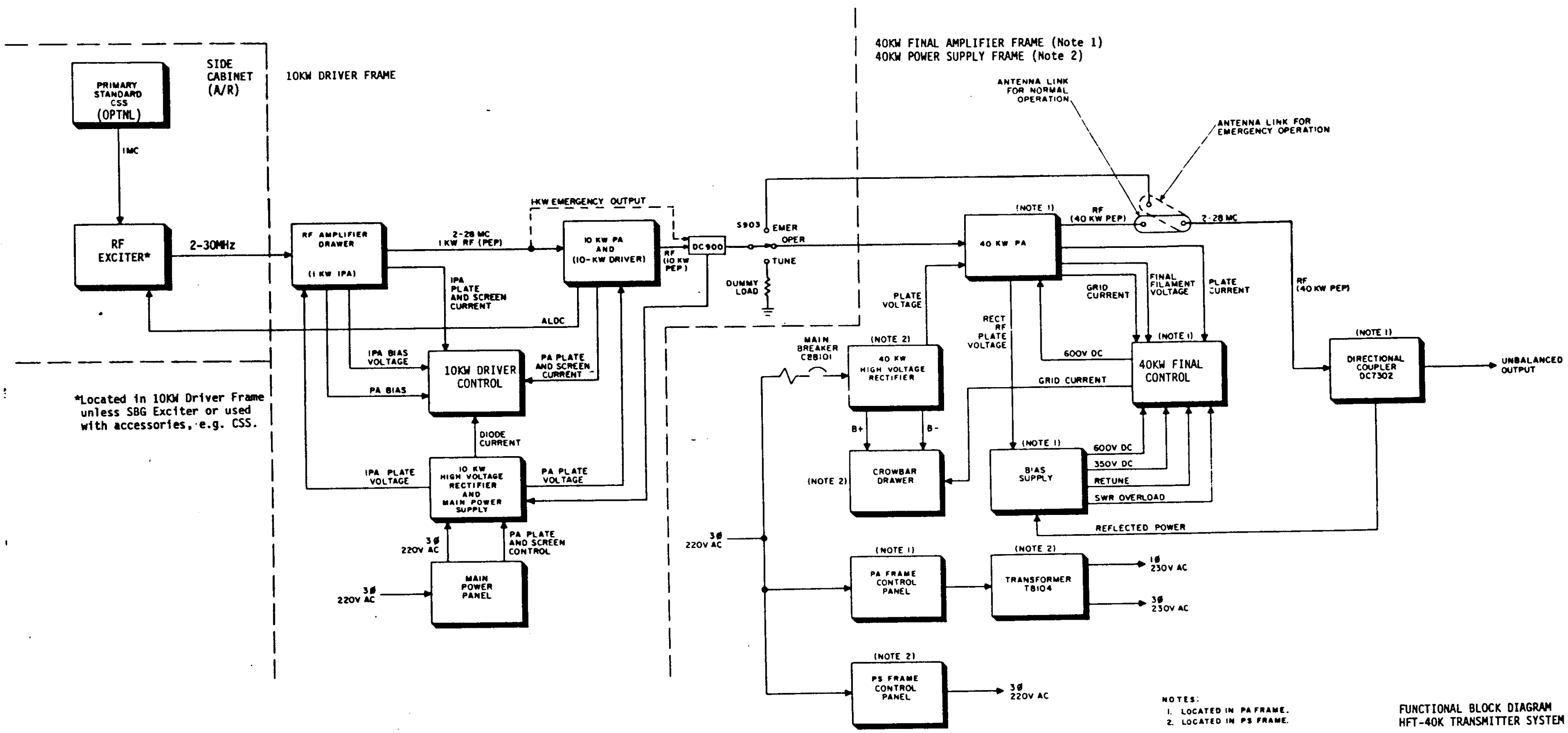
The operations described in the following paragraphs are applicable to both manually-tuned and automatically-tuned transmitters. The only essential difference is whether an operator controls each functional group or the operator gives command to an internal processor that takes control of the entire tuning sequence.

Basically, the exciter, which requires no tuning or peaking, provides a low-level RF signal to drive the first amplifier stage which in turn drives succeeding stages. The path of the RF signal is routed through the amplifier stages, the harmonic filter, output metering circuits and finally to a 50-ohm transmitting antenna or dummy load. Tuning capacitors are used to resonate the higher power amplifier stages.

One of three types of exciters is used to provide the required RF drive:

Model SME-5 for HFT-40KE Multi-Channel Transmitter
Model MMX-2 for HFT-40KJ Synthesized Transmitter
Model SBG-4 for HFT-40KJA Synthesized Transmitter with 4-channel ISB capability.

The following paragraphs describe each exciter and functional unit in detail.



FUNCTIONAL BLOCK DIAGRAM
HFT-40K TRANSMITTER SYSTEM

Exciter, SME-5

The SME-5 exciter is used with the Model HFT-40KE transmitter and provides the required RF drive in all operating modes.

The SME-5 is a solid-state exciter that can provide up to 100mw of RF drive in the frequency range of 2.0 to 30MHz by selection of one of eight discrete channels. An internal oscillator provides a minimum stability to the selected frequency of one part in 10^6 per day. Modulation capabilities (operating modes) include CW, MCW, AME, USB, LSB, 2-channel ISB, AFSK and AFAX with the bandwidth of either sideband, 250-3040Hz (CCIR). Optional bandwidths are available.

An eight-position rotary switch mounted on the front panel provides for channel selection to one of eight pre-set frequencies in the 2.0 to 30MHz range. No tuning or peaking is required to obtain full output from the exciter. Outputs may also be adjusted independently depending on the operating frequencies of each channel.

The principles of operation of both LSB and USB are identical. For ease of explanation only LSB operation is described. When following the USB operation, LSB switch S1 is replaced by USB switch S2. Audio input from an external source is fed through input filter A17 to the primary of transformer A20T1. The output is taken at the potentiometer A20R6 and fed to the LSB input selector switch S1. S1 routes the selected input through LSB LEVEL adjust potentiometer R3 to the transformer A20T2. The output is also fed to a metering circuit A7, through meter switch S9. The meter M1 is mounted on the front panel and enables the operator to set the correct audio level. The IF board is a modulator-oscillator. It combines the audio signal with the local oscillator frequency of 1750kHz. The modulated output of the IF board is fed to the mixer-doubler A13. The mixer-doubler is controlled by channel switch S4. It doubles, under certain conditions, the input signal from the HF oscillator A12 and mixes it with the intermediate frequency supplied by the IF board A9. The HF oscillator is also controlled by channel switch S4. The output of the mixer-doubler A13 can be any one of the 8 channel frequencies selected by channel switch S4. The selected output of A13 is fed to the appropriate section of RF amplifier A14. The RF amplifier consists of eight boards, only one of which is operative at a time as determined by the channel switch. The output of the RF amplifier is fed to the wideband amplifier A15, which delivers the maximum RF output of 100mw PEP into a 50-ohm load, sufficient to drive any TMC transmitter.

The carbon microphone, the dynamic microphone input or the CW input, when selected are fed through an AF amplifier and oscillator board A20. The output of A20, a 1000Hz or compressed AF signal at a level of -20dbm to +10dbm is coupled to A9 as an audio input.

FSK inputs are first fed through input filter A18 to FSK board A1. The FSK inputs being in the form of teletype information is converted into an audio input in the board A1 and fed to the S1A-6 for onward transmission in the same manner as line audio input.

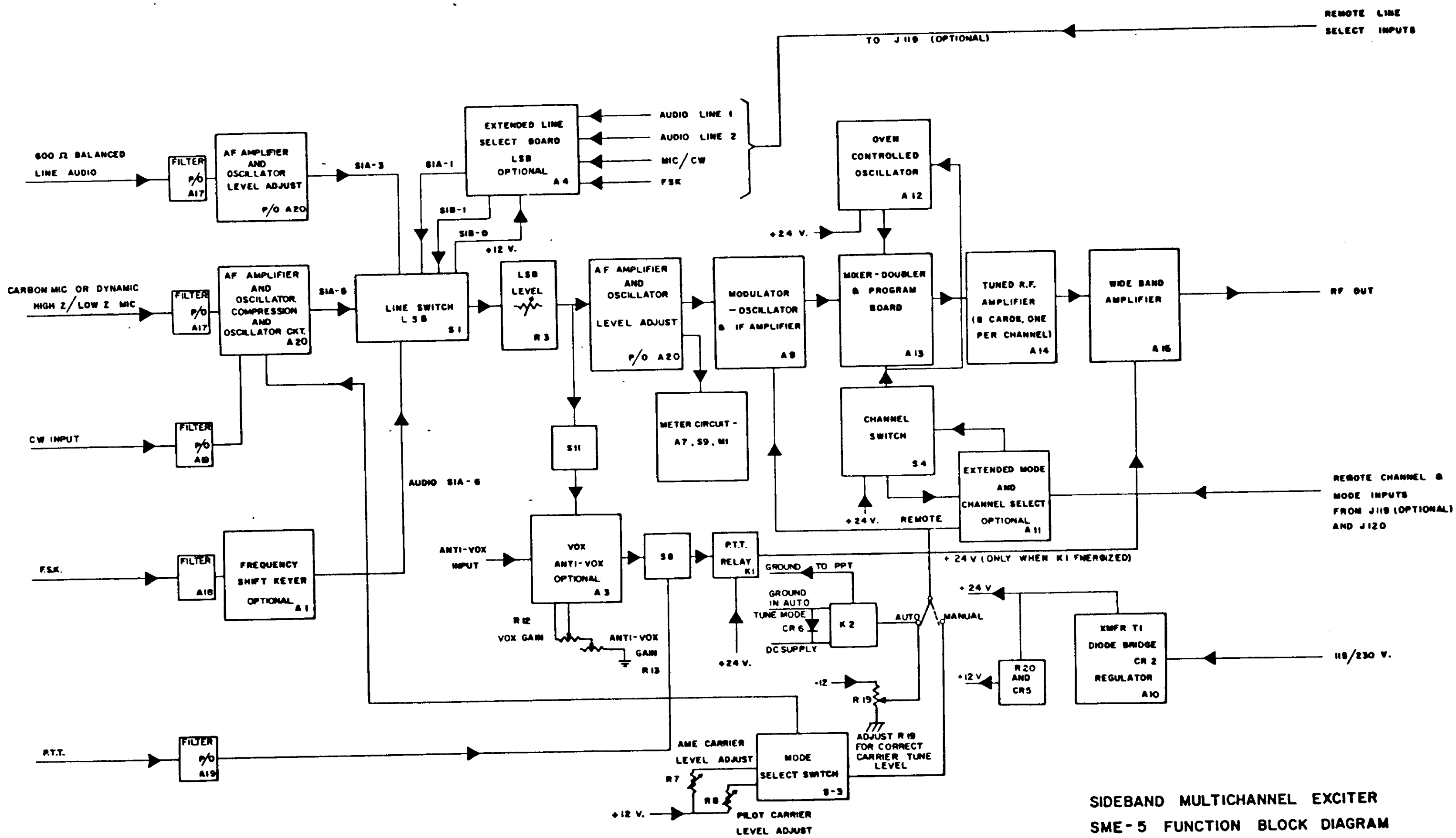
VOX/ANTI-VOX is operated by switching VOX USB/LSB switch on the rear panel to any position. A portion of audio is fed to VOX/ANTI-VOX board A3, where the predetermined level of audio operates relay K1 (S8 in VOX position). When energized, K1 applies +24 volts to wideband amplifier A15.

Extended line select boards A4 (LSB) and/or A5 (USB) (both optional) are provided for remote control of the unit. When S1/S2 is in REMOTE position, +12 volts is supplied to the relay in A4 (A5) which in turn routes the selected input for transmitting in the usual manner.

Extended mode and channel select ALL (optional) is provided for selection of channel and/or mode from remote location. This board operates when S4 is in REMOTE position.

The SME-5 is designed for track-slide mounting in a standard 19-inch rack. All operator controls are mounted on the front panel of the unit. The remaining controls, all connectors and terminal strips are located on the rear panel. Whenever possible, electronic components are mounted on printed circuit cards that plug into connectors on the main chassis.

The exciter operates from a 115 or 230 volt, single phase, 50 or 60Hz primary power source. The power supply section consists of a transformer, rectifier and regulator which provides the +12 VDC and +24 VDC for operation. All power circuits are fused to protect components from damage due to excessive transients or surges.



SIDEBAND MULTICHANNEL EXCITER
SME-5 FUNCTION BLOCK DIAGRAM
(LSB OPERATION ONLY)

Exciter, Model MMX-2

The MMX-2 exciter is used with the HFT-40KJ transmitter and provides the required RF drive in all operating modes.

The MMX-2 is a solid-state exciter that can provide up to 250mw of RF drive in the frequency range of 2.0 to 29.9999MHz in 100Hz steps. An internal standard provides a minimum stability to the selected frequency of one part in 10^8 per day. An external standard, the CSS-2, can be used to stabilize the output frequency to one part in 10^9 per day (short term) and five parts in 10^9 per week (long term) as an option. The modulation capabilities (operating modes) include CW, AM, USB, LSB, 2-channel ISB, FSK and FAX with the bandwidth of either sideband, 250-3040Hz (CCIR). Optional bandwidths are available depending on requirements.

Six direct-reading, digital switches mounted on the front panel provide for carrier frequency selection in the 2.0 to 29.9999MHz range. The basic 1MHz signal from the internal or external standard is used to develop basic signal frequencies that synthesize the RF carrier output.

Referring to the block diagram, the spectrum generator board Z101 develops seven basic signal frequencies from the incoming precision 1MHz signal. The 1MHz input is amplified and sent to the mixer-divider circuits. The 1MHz input is also clipped, divided by a factor of 10 and applied to a 100kHz spectrum generator; this output, containing the 100kHz fundamental, plus harmonics, is applied to the comb filter circuits. The 1MHz input is squared to produce a 1MHz spectrum containing the required harmonics for generation of five additional output frequencies of 8, 12, 13, 14 and 40MHz. The 8MHz output is applied to the mixer-dividers; the 40MHz output is coupled to the frequency translator for determination of final output frequency range; and the 12, 13 and 14MHz outputs are sent to the step generator circuits for derivation of the frequency ranges.

The 100kHz spectrum output signal is applied to the two comb filter boards, Z102 and Z103. Circuits on these boards produce 12 precise output frequencies from 0.8 to 1.9 MHz in 100kHz steps and apply them to the frequency switching network. These frequencies are generated by exciting corresponding crystal-filters at the appropriate harmonic of the 100kHz spectrum input.

The 8MHz basic signal is mixed with the selected mixing frequencies in mixer-divider boards Z104, Z105 and in mixer-final board Z106; the output signal from mixer-final Z106 establishes the four least significant digits of the output frequency and is applied to the translator board, Z112.

The step generator boards Z110, Z111 and Z113 contain mixer and multiplier circuits that derive the two most significant digit frequencies of the selected output frequency. Step generator board Z113 contains the 12MHz mixer circuits and the X2 multiplier circuits for the three frequency ranges. The three frequency ranges are combined in this board by a summing amplifier and coupled as the 104MHz to 132MHz to the translator Z112.

The carrier generator board Z109 receives a 1MHz standard input signal and divides this frequency by four to obtain a 250kHz basic subcarrier signal; this subcarrier is amplitude-modulated in AM mode of operation, is shifted in frequency by teletype mark and space modulation in FSK mode of operation, is applied to balanced modulators in the sideband generator board Z107 to derive upper and lower single-sideband signals and is applied to the frequency shift generator board Z108 for CW mode of operation and for carrier reinsertion when desired. The 250kHz is also multiplied by 11 on the carrier generator board to produce the 2.75MHz carrier which is applied to a mixer circuit in the frequency shift generator board. The 2.75MHz carrier is combined with the modulated 250kHz signal to produce an AM, a single-sideband (SSB) or independent sideband (ISB) output with a 3MHz center frequency.

The sideband generator board Z107 contains a microphone audio pre-amplifier and an audio impedance-matching transformer for translation of an external 600-ohm balanced or unbalanced audio line to a 500-ohm audio for application to the upper sideband (USB), lower sideband (LSB) and AM modulator circuits. Two balanced modulators produce the upper and/or lower sideband intelligence from the 250kHz signal subcarrier and the incoming USB and LSB audio signals; the 250kHz subcarrier is suppressed. The resulting USB and LSB signals are sent to the frequency shift generator board Z108.

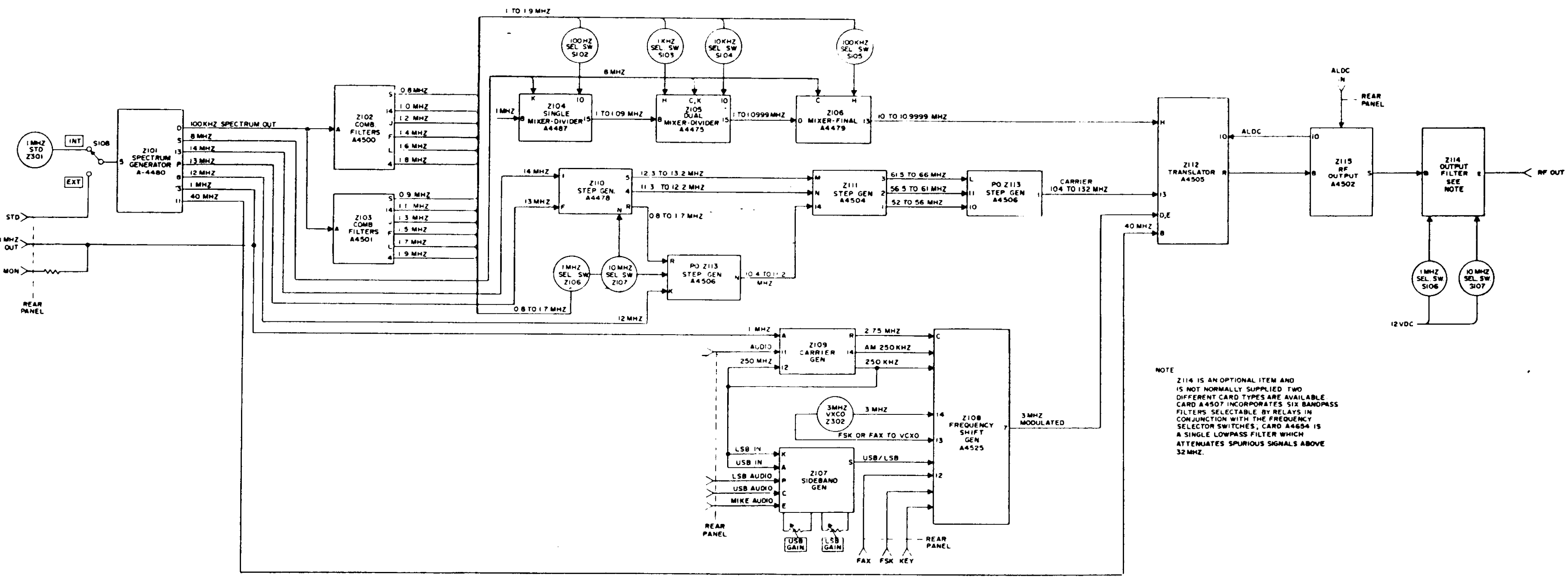
The frequency shift generator board Z108 contains two circuit sections: the frequency shift generator section and the converter section. The frequency shift generator section provides either frequency shift keyer (FSK) or facsimile (FAX) modes of operation. The FSK mode applies the 250kHz subcarrier to the keyer modulator which also receives external teletype input via the FS Loop Switch. The 250kHz subcarrier is modulated by the teletype current input producing a shift in frequency above and below the 250kHz center frequency representing marks and spaces. This shift is rectified and translated to a DC level which is then amplified and applied to the modulation input of the 3MHz voltage-controlled crystal oscillator (VXCO) which produces the required frequency shift above and below the 3MHz center frequency. The FAX mode connects an external FAX signal through a DC regulator circuit which produces a variable DC level at the input of the VXCO thereby producing the required frequency shift of the 3MHz center frequency output signal. The converter section of Z108 mixes the incoming 2.75MHz carrier signal with the selected modulation signal (250kHz AM, USB, LSB, ISB or CW from the carrier and sideband generator boards). The modulated 3MHz sum signal is amplified and sent as modulation to the translator board Z112.

The translator board Z112 contains an X3 multiplier circuit which produces a 120MHz frequency from the 40MHz basic signal and mixer circuits that mix the selected carrier frequency of the four least significant digits with the 3MHz modulator frequencies and mix the modulated sum frequency with the selected step generator frequency representing the two most significant digits of the selected carrier frequency. When the upper frequency range (20 – 29.9999MHz) is selected, a ground enable is applied to a filter in series with the RF signal from the RF OUTPUT control. Therefore, the RF signal is pre-filtered prior to being applied to RF output section Z115.

The RF output board Z115 amplifies the incoming RF carrier frequency and produces an automatic level DC voltage (ALDC) for feedback to the translator board Z112. The ALDC is used to control the RF output level. A metering circuit monitors the collector currents of the three amplifiers on RF output section Z115 and the RF output level of the selected frequency; these parameters are selected by a METER switch and displayed on the front panel MONITOR meter.

The MMX-2 is a direct reading device that displays all operating settings on the front panel. These include the functions of frequency, mode, carrier suppression, and RF output. All functions can be remotely controlled. No tuning or peaking is required when operating frequencies are selected. This exciter provides sufficient drive for any TMC transmitter system.

The MMX-2 is nomenclatured by the U.S. Military as MD-846/UR.



NOTE

Z114 IS AN OPTIONAL ITEM AND IS NOT NORMALLY SUPPLIED TWO DIFFERENT CARD TYPES ARE AVAILABLE CARD A4507 INCORPORATES SIX BANDPASS FILTERS SELECTABLE BY RELAYS IN CONJUNCTION WITH THE FREQUENCY SELECTOR SWITCHES; CARD A4654 IS A SINGLE LOWPASS FILTER WHICH ATTENUATES SPURIOUS SIGNALS ABOVE 32 MHZ.

Exciter, Block Diagram

Exciter, Model SBG-4

The SBG-4 exciter is used with the HFT-1KJA transmitter and provides the required RF drive in all operating modes.

The SBG-4 is a solid state, dual-unit exciter system consisting of a sideband exciter and translator. The exciter system yields an RF output up to 250 milliwatts in the frequency range of 2.0 to 29.9999MHz at a minimum stability of one part in 10^8 per day. An external standard, the CSS-2 can be used to stabilize the output frequency to one part in 10^9 per day (short term) and five parts in 10^9 per week (long term) as an option.

The sideband exciter portion of the system is a solid-state unit which provides the primary stage of frequency conversion and frequency division multiplexing in a four-channel ISB transmitter system. Each unit accepts up to four 600-ohm audio input signals, processes each separately, then combines them to yield an independent sideband output that is centered at 1.75MHz. This composite RF signal (1.75MHz) is then applied as the intermediate frequency input of the RF Translator.

The RF Translator is also solid-state and generates the necessary mixing frequencies to translate the 1.75MHz IF input to a selectable RF output range. The translator functions as an RF frequency exciter that provides AM, USB or ISB intelligence on an RF carrier frequency between 2.0 and 29.9999MHz. The translator is normally mounted directly above the sideband exciter in an equipment cabinet.

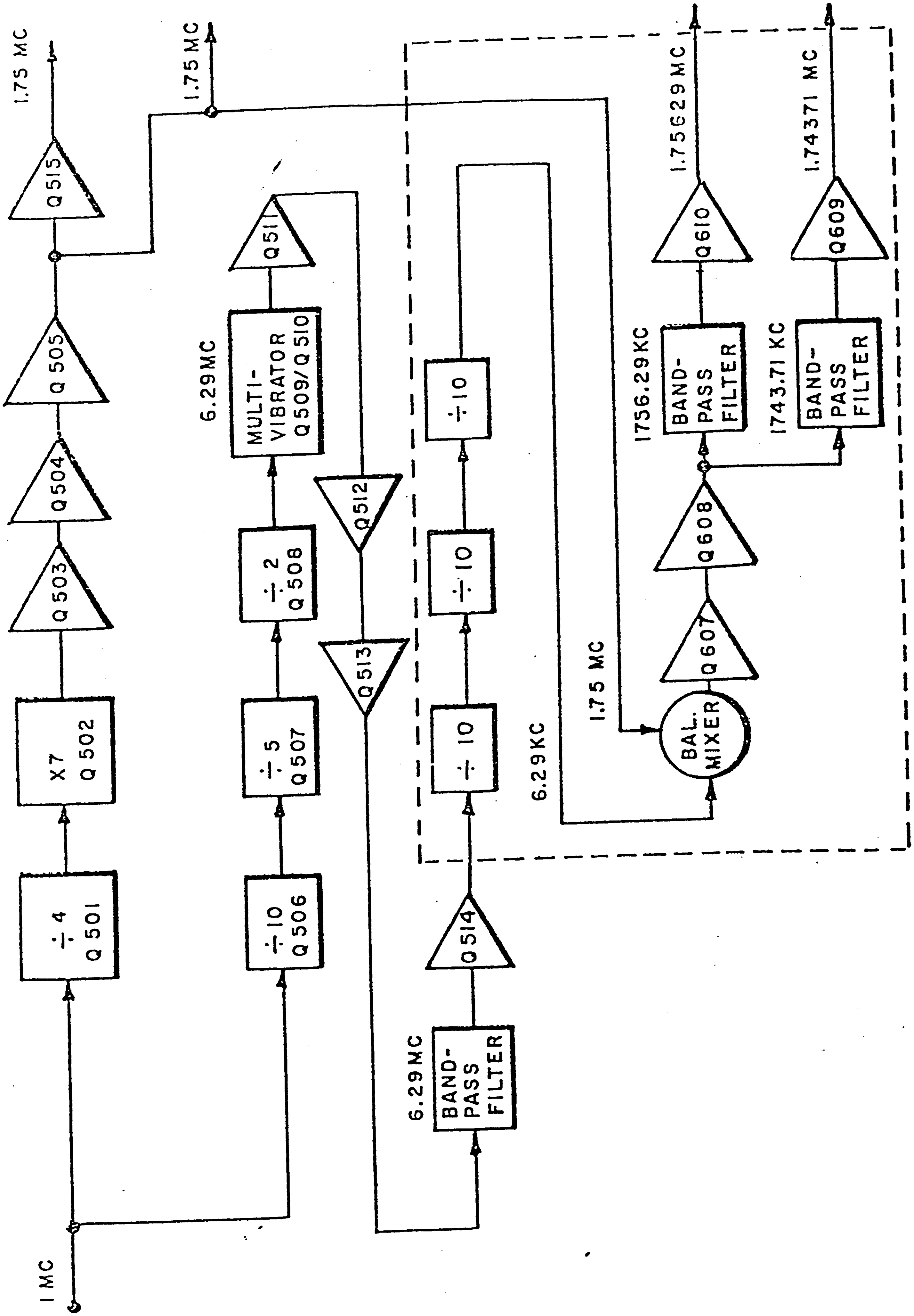
The translator and exciter are direct reading devices that display all operating settings on the front panel. These include the functions of frequency, mode, carrier suppression, RF output, channel activity and channel priority. All functions can be remotely controlled and no tuning or peaking is required when operating frequencies are selected. The exciter system provides sufficient drive for any TMC transmitter system.

The sideband exciter unit supplies a 1.75MHz signal output about which all input information is centered. A 1MHz signal from the translator unit is supplied to a series of digital modules connected for a divide by 4 and divide by 100. Two separate outputs are achieved, the first supplying 250kHz output signals, the second output supplying 10kHz signals. The 10kHz signals are applied to a harmonic corresponding to 6.290MHz. This signal is then divided by 1000 to produce an output of 6.290MHz which feeds a balanced mixer which receives as its second input, a signal of 1.75kHz (250kHz x 7). The output of the balanced mixer then consists of two signals which are desired, and filtered through to produce outputs of 1743.710kHz and 1756.290kHz. Four audio inputs, corresponding to channels A1, A2, B1 and B2 are applied to separate balanced modulators. Channels A1 and B1 receive as their second input, a 1.750kHz signal. Channel A2 receives 1756.290kHz as its second input signal, and channel B2 receives 1743.710kHz as its second input signal. This establishes the proper relationship for each channel. The outputs of the balanced modulators then enter their respective filters where final processing is accomplished producing only the desired sideband output and suppressing carrier/unwanted sideband output by 70db. These outputs are then combined in a summing network and amplified to approximately 100mv across 50 ohms.

The translator unit consists of a series of filters, mixers-dividers and step generators that serve to translate the 1.750MHz IF intelligence to the operating frequency. This is achieved by using an internal (or external) 1MHz standard oscillator from which is derived, using a generator, seven fundamental frequencies phase-locked to the standard. These outputs are 1, 8, 12, 12, 14, 40MHz and a 100kHz spectrum. The 100kHz spectrum is fed to two comb filters which produce 12 discrete frequencies from 0.8 to 1.9MHz in 100kHz steps. These frequencies are applied to the frequency select switch network controlled by the six knobs on the front panel. Depending on the position of the four right-hand switches, the output from the comb filter is mixed with the 8MHz frequency from the spectrum generator and the resultant frequency of 10.0 to 10.9999MHz is then applied to the RF translator. This 10MHz signal is mixed with a 3MHz signal derived from mixing the 1MHz standard output and the 1.750MHz output from the exciter unit previously discussed. (The sideband intelligence is contained in this 1.750MHz signal.) The output of this balanced mixer is then fed to a second balanced mixer which has as its second input the 40MHz signal from the spectrum generator. The output of this mixer is then fed to a third mixer which has as its second input one component of the 12, 13 and 14MHz signals from the spectrum generator. This last signal is actually the resultant of the 12, 13 and 14MHz signals mixed with the 0.8 to 1.9MHz output of the comb filter as determined by the two left-hand frequency switches on the front panel. The output of the third mixer is thereafter amplified and becomes the 2.0 to 29.9999MHz RF output of the exciter.

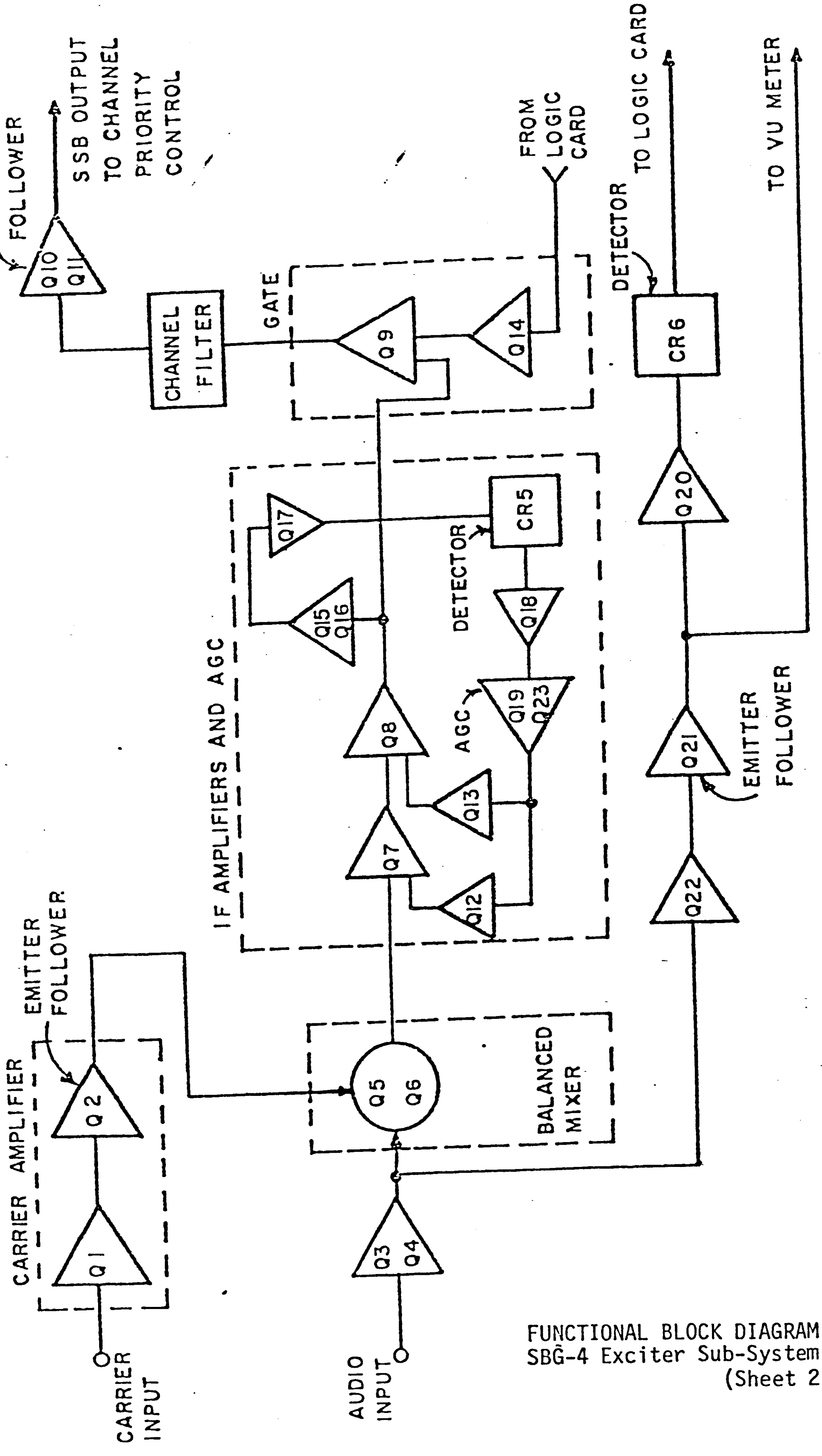
Three simplified block diagrams on the next few pages follow the path of the signal through the exciter system.

The SBG-4 consists of two electronic frequency converters, nomenclatured by the U.S. Military as CV-2644/URT and CV-2645/URT. The SBG-4 is the exciter portion of the AN/URT-37(v) transmitter system and the outgrowth of the AN/URA-30 modulator-oscillator group developed by TMC.

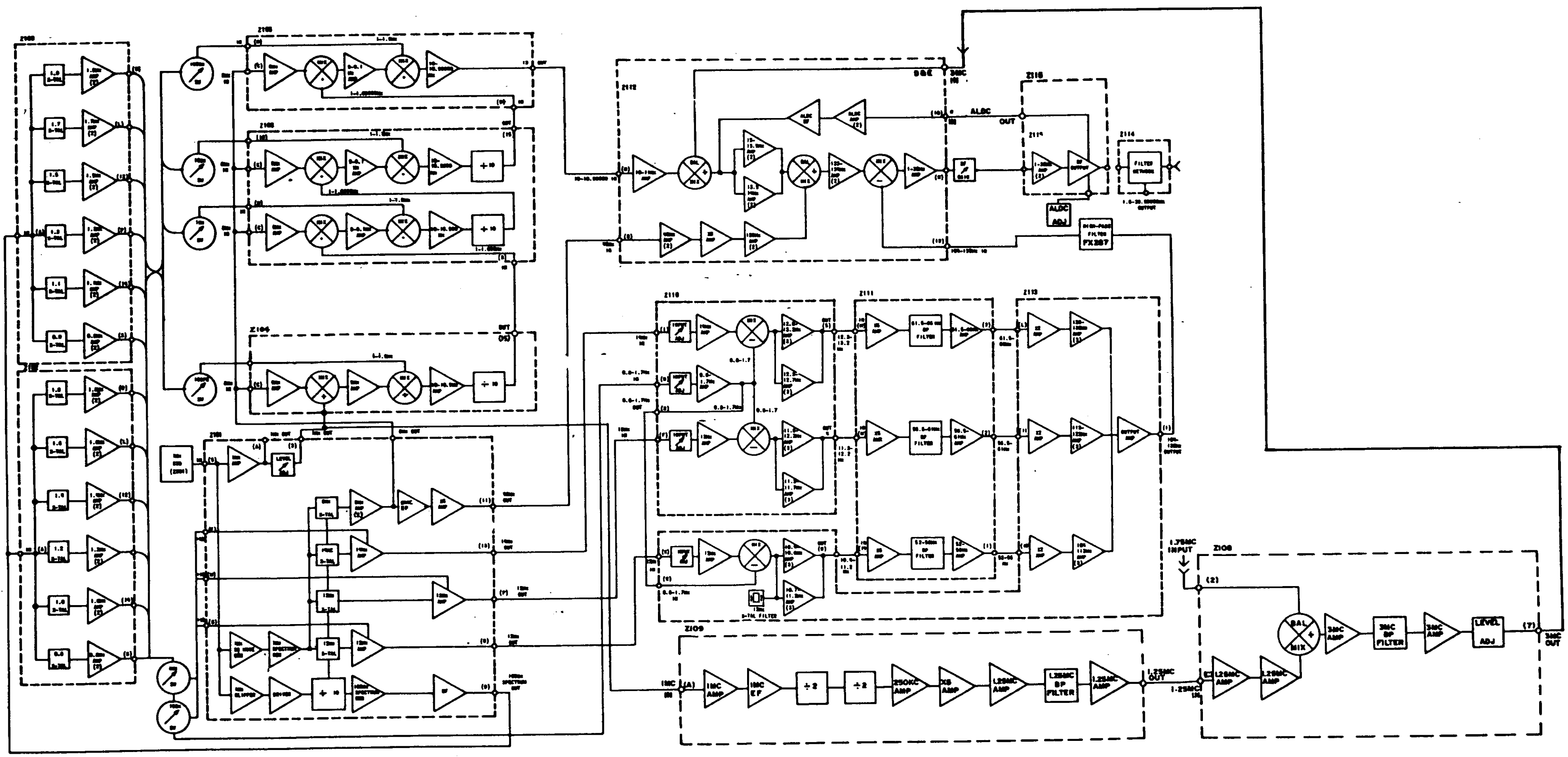


FUNCTIONAL BLOCK DIAGRAM
SBG-4 Exciter Sub-System

(Sheet 1 of 2)



FUNCTIONAL BLOCK DIAGRAM
SBG-4 Exciter Sub-System
(Sheet 2 of 2)



FUNCTIONAL BLOCK DIAGRAM
SBG-4 Translator Sub-System

RF Amplifier

The RF output from the exciter is nominally 100 milliwatts and is applied through an RF gain control to the grid of the first RF amplifier stage in the 10KW driver. This stage operates as a broadband class A amplifier providing an amplification of approximately five (5). The RF output at the plate of this stage is routed through a coupling network consisting of capacitors and a transformer to the input grid of the second amplifier stage.

The second amplifier also acts as a broadband class A amplifier providing additional amplification. Since both the first and second amplifiers are broadbanded, no resonate tuning to obtain output from the plate circuits is required. The output at the plate of the second amplifier is then coupled to the grid of the intermediate power amplifier (IPA) stage.

The IPA operates as a class AB_1 amplifier and provides the required drive to the 10KW power amplifier (PA) stages. The input to the IPA is automatically matched throughout the frequency range by a network inserted between the second amplifier and IPA stages. When RF power is applied from the exciter, the IPA tune capacitor is adjusted to resonate the IPA plate circuit to the frequency that appears at the grid circuit. The RF signal is thereby further amplified and routed through the previously-positioned IPA bandswitch assembly to the input of the 10KW PA stage.

The 10KW power amplifier operates as a class AB_1 amplifier providing 10,000 watts average or peak envelope power to the input of the 40KW final PA. The input power from the IPA is coupled to the filament cathode of the 10KW PA tube - a configuration normally referred to as RF grounded-grid, cathode-fed. The 10KW PA output circuit consists of a bandswitch assembly, load capacitor assembly, tune capacitor assembly, and harmonic filter assembly. The harmonic filter provides harmonic attenuation while the tune and load capacitors serve to match the output to the impedance of the 40KW final input.

As the tuning sequences through the various stages, RF indicators located across the top level of the 10KW driver and in the IPA drawer, monitor the performance of critical circuits in this section. In particular the following levels are monitored:

Plate Current Meter (IPA drawer) -
- First amplifier plate current
- Second amplifier plate current
- Intermediate power amplifier plate current

PA Screen Current Meter (Main Meter Panel)
- PA screen current of the final tube
- PA screen overload (illuminates at overload)

PA Plate Current Meter (Main Meter Panel)
PA plate current of the final tube.
Quiescence - set by PA bias pot.
Resonance - as point of resonace is reached
Total PA plate current at rated output
PA plate overload (illuminates at overload)

Reflected Power Meter (Main Meter Panel)
Reflected power - upper scale
SWR - lower scale

PA Output Power Meter (Main Meter Panel)
Average PA output power in kilowatts

The 40KW final power amplifier (F/PA) operates as a class AB_1 grounded-grid amplifier providing 40,000 watts peak envelope power to a 50-ohm antenna or dummy load. The input power from the 10KW driver (approximately 3.2KW for 40KW out) is coupled to the filament cathode of the 40KW PA tube. The output circuit of the final stage consists of a bandswitch assembly, load capacitor assembly, tune capacitor assembly, and harmonic filter assembly. The harmonic filter provides harmonic attenuation while the tune and load capacitors serve to match the impedance of a 50-ohm antenna system or dummy load up to a normal VSWR setting of 3:1.

RF indicators (meters) on the final PA and 40KW power supply cabinets are located across the top level and serve to monitor the performance of critical circuits in the 40KW final. In particular, the following is monitored:

40KW PA Cabinet
Filament Primary Voltage
RF Input Drive Voltage
Final Plate Current (DC)
Final Plate RF Output Voltage
RF Output Current (Unbalanced Load)

40KW PS Cabinet
Final Grid Current of Final Tube
Final Grid Voltage (Bias) of Final Tube
Final Plate Voltage (DC)
Crowbar Filament Voltage
VSWR at Output (Unbalanced Load)

An important feature of the 40KW final is its bypass system which enables the operator to route the RF around the final to the output. Covered in more detail under "Operating Procedures", this feature is particularly useful under emergency conditions. The output from the 10KW driver thereby becomes the transmitter system, providing 10,000 watts PEP and average to the load instead of 40,000 watts PEP and 20,000 watts average under normal conditions.

All bandswitching, tuning and loading is accomplished automatically in sequence in HFTA-40K and HFTR-40K transmitter system. Tuning time is nominally 15 seconds and less than 30 seconds under the worse conditions.

Power Distribution

The three-phase main power supplies are located in cabinets #1 and #3. Input terminals are provided at the rear of each compartment for application of power. Protective interlocks are used throughout the transmitter to prevent application of high voltage until specific requirements are met. Such safety precautions are designed into the system to prevent injury to personnel and damage to the transmitter. The interlock system is described in the Control section of this analysis. A simplified block diagram of the 10KW driver power distribution system appears on the next page.

Phases 1 and 2 are routed through the exciter drawer to supply AC power to the exciter independent of the position of the main power breaker. This enables the primary frequency standard in the exciter to maintain its specified stability even when the power amplifier section is undergoing maintenance with no primary power applied. A remote circuit breaker can be used to remove all AC input if required.

When the main power breaker is closed, three phase input power is applied to the PA and IPA blowers. Air vane switches, located in the blower air streams, are then opened, preventing a closure of phase 1 to the filament relay. Without this closure, AC input power is applied to the IPA and PA filament transformer. However, should one of the blowers fail to operate properly, the air switch will close, activating the filament relay and removing all AC power to the IPA and PA filaments. This sequence prevents damage to either power amplifier from lack of cooling air.

The interlock system in concert with the filament timer introduces a time delay when main power is first applied. This delay prevents the application of high voltage to the amplifier stages until the transmitter has warmed up. Such a delay increases tube life considerably and eliminates the effects of thermal shock to high power components.

All voltages are derived from the high and low voltage supplies in the system. The plate and screen bias voltages in particular are full-wave bridge rectified and then fully filtered to remove residual ripple. Zener regulators provide constant voltages to the plate and screens of the amplifier stages. DC return for the supply voltages are through the screen circuit breaker for plate voltages; the screen overload circuit for screen voltages; and fuses for the bias and 24 VDC control voltages. The 24 volt DC supply in the IPA drawer provides the control voltage for the entire transmitter system. During band changes, this control voltage is prevented from reaching the PTT switch by the bandswitch interlock system. The amplifier stages are thus kept at maximum bias, close to cutoff so that no RF power can be transferred through the switch contacts. This extends the useful life of the bandswitch and prevents inadvertent overload during band changes.

Control

Interlock and overload circuits provide protection for both operating personnel and equipment by preventing the application of any high voltage. Basically, the interlock/overload system is a series of switches located at strategic points throughout the transmitter system. Unitl all interlock switches are closed, no control voltage can be applied to the transmitter. Once all conditions are met, i.e. all interlocks mechanically closed and the time delay elapsed, the 24-volt control voltage is applied to the high voltage relay. If any interlocks open, such as might occur during excessive heat buildup or an inadvertent opening of a drawer or panel, the transmitter is automatically placed in an overload condition which prevents the application of high power. The high voltage switch must be depressed twice to restore high voltage once the fault is corrected.

The ALDC circuits (Automatic Load and Drive Control) provides negative feedback to the exciter to prevent excessive RF output. The ALDC threshold level can be adjusted by potentiometers. The ALDC voltage is derived by sampling the RF output at the harmonic filter.

The IPA, PA and F/PA bandswitches are also controlled by the application of 24 volts DC. By providing a ground to the bandswitch, AC voltages will be supplied to the PA bandswitch motor resulting in a stepping action of the bandswitch. While this indexing is taking place, the interlocks and relays prevent application of high voltage. The transmitter is thereby biased at or close to cut-off.

Automated tuning of the HFT-40K series is accomplished with a servo system controlled by two processors. Tuning time is nominally 15 seconds from the application of high voltage with a maximum limit of 30 seconds in the worse condition. The exciter operating frequency acts to pre-position the bandswitch as the front panel switches are either manually rotated or DC switched from a remote location (See RCST-1 for Transmitter Remote Control systems). Carrier suppression and operating mode are similarly selected but have no effect on the automated tuning of the transmitter. Once all exciter functions have been selected, the automated tuning sequence can begin.

Automated tuning, whether controlled locally or remotely, is initiated by the application of high voltage at the main control panel. This causes the IPA servo amplifier to go into a "search" mode while adjusting the tune level control to the RF drive at which the transmitter will auto tune. The IPA tuning capacitor begins turning as RF voltage is developed at the plate of the IPA output tube. The first two class A amplifiers are broadbanded and require no tuning.

to develop the necessary RF level to drive the IPA. When sufficient RF is developed at the IPA plate, a plate trigger will cause the tuning sequence to enter the "servo" mode. In this mode, a DC correction voltage fine tunes the IPA by comparing the phase relationship between the grid and plate circuits. As resonance is approached, the correction voltage drops to zero, the tuning sequence enters the "operate" mode, and the PA servo amplifier is triggered, going into its "search" mode.

The 10KW PA tune capacitor now begins its search for resonance. As the resonant point is approached, the resulting RF trigger voltage developed at the PA plate triggers the "servo" mode. A DC correction voltage from the PA phase detector adjusts the tune capacitor to resonance. When this correction voltage reaches zero (resonance of the PA), the "operate" mode is triggered and the load capacitor, previously held at minimum, is adjusted for correct loading.

With the 10KW driver in the "operate" mode, sufficient RF is developed at the output to trigger the "search" mode of the pre-positioned 40KW final. As resonance is reached in this stage, the PA plate RF triggers the "servo" mode. A DC correction voltage from the final PA phase detector adjusts the tune capacitor to resonance. The "operate" mode is triggered when this correction voltage reaches zero and the load capacitor is adjusted for correct loading. When proper loading is reached, the RF drive is adjusted for 20KW average power and the servo system is placed in a quiescent condition. The "READY" light is turned on and the transmitter is now ready for operation.

If a fault occurs in the tuning sequence, the sequence will halt for 60 seconds and then go into a "FAULT" condition, biasing the transmitter off. The sequence is reactivated by depressing the high voltage switch twice.

OPERATING PROCEDURES

Normal Conditions

Each TMC transmitter system consists of an exciter and a high power linear amplifier as a minimum. The method of tuning each system can be by manual adjustment or automated adjustment. At any time, the transmitter can be controlled locally - even with remotely controlled, automated systems - since all are equipped with a manual override feature. The next paragraphs outline the operations required for tuning the transmitter by manual/local control, automated/local control; or automated/remote control.

TMC transmitters are designed to operate continuously, the 24 hours per day, and should be placed in a stand-by (high voltage OFF) condition when not in use. As a consequence of this, TMC transmitter systems do not normally have motor-driven main power breakers. To prevent damage to the transmitter system, all connections from the power mains to ground and to the antenna system should be inspected prior to the application of power. Once an operator verifies that all is in order and RF properly routed through patch panels to a load, the main power and screen breakers should be placed in the ON position and the aural alarm turned OFF. The transmitter requires a few minutes to warm up before high voltage can be applied. When the interlock indicates all operating conditions are met, the transmitter is in a STANDBY condition, ready for the application of high voltage and keying information. A visual inspection of the transmitter system can also be made by the operator to verify that indicator lamps operate properly and overload needles are set to proper values.

Manual tuning of the transmitter by local control is accomplished as follows:

1) Optional preliminary check for quiescent operation
   a) Set exciter output to minimum
   b) Index bandswitch to verify operation
   c) Press high voltage ON
   d) Check PA PLATE meter for 500ma approximate
   e) Check IPA PLATE meter for 60 (220)ma
      (lever switch up or down determines value)

2) Reduce RF gain control to minimum and select operating frequency, operating mode, and carrier suppression level on exciter. Increase exciter drive to 100 mv approximate

3) Select proper band by indexing IPA, 10KW PA and 40KW PA bandswitches.

4) Increase RF GAIN for indication on IPA meter

5) Adjust IPA TUNE control for a current peak on the 10KW PA PLATE current meter.

6) Rotate 10KW PA TUNE control for a resonant on the 10KW PA PLATE current meter.

7) Rotate 10KW PA LOAD control for maximum reading on the 10KW PA OUTPUT meter.

8) Readjust IPA TUNE control for a peak reading on the 10KW PA OUTPUT meter.

9) Rotate the OUTPUT control on the 40K PA control panel for a PLATE CURRENT indication.

10) Adjust 40KW TUNE control for a dip on the PLATE CURRENT meter.

11) Readjust 10KW TUNE for a dip on the 10KW PLATE CURRENT meter.

12) Adjust 40KW LOAD control for maximum reading on the 40KW PA OUTPUT meter.

13) Repeat 10.

14) Repeat 12 and 13 until OUTPUT meter peaks for a 50-ohm load.

15) Increase RF GAIN control to increase PA output power level.

16) The transmitter is now tuned and ready for operation.

Automated tuning of the transmitter system follows generally the same sequence of operations by using a series of servo-feedback circuits that control bandswitching, tuning, loading and gain. The operator performs two basic operations after running a preliminary check (if required):

1) Press high voltage OFF and select operating frequency, operating mode, and carrier suppression level on exciter.

2) Initiate the tune sequence by pressing the high voltage ON.

3) In less than 30 seconds, the transmitter is ready for operation and the tuning systems are again placed in a standby condition waiting for the next tune (trigger) command.

NOTE: No adjustment of RF gain is required since the transmitter will automatically increase drive to a 40KW output level. This feature, however, can be overridden by selecting one of four previously-positioned output levels at the main control panel on the 10KW driver. These levels are adjusted by the operator.

Automated transmitters occasionally do not complete a tuning sequence successfully. In this case, TMC transmitters go into a FAULT condition and the high voltage does not turn on. By pressing the high voltage twice or performing the same operation at a remote site once the readback indicates a fault condition, the tuning sequence is again initiated. The procedure can be repeated as often as necessary until it is determined that maintenance is required on site.

Remote control of the automated transmitter is identical to local control except that the operator is using a program panel to select exciter functions and initiate the tuning system from a remote location. Under remote control, the automated transmitter receives command via a local control unit (decoder) which is placed next to the exciter. The exciter functions are DC switched. The transmitter system must be placed in a remote mode - an operation simply accomplished by throwing a remote/local switch on the main control panel. Similarly, local control of the transmitter can be assumed by using the same switch. A second pair of contacts determines whether the transmitter is to be manually or automatically tuned. A detailed explanation of the remote control system is covered in the Technical Analysis of Transmitter Remote Control System, Series RCST-1 for synthesized transmitters and RCMT-1 for multi-channel transmitters.

The next page covers typical operating levels of the transmitter at various frequencies.

Emergency Conditions

The probability of line or copy failure in the transmitter system is extremely small as is failure of the servo tuning mechanism. However, should there be a failure, all functions of the transmitter can be controlled from the front panel, locally, by the on-site operator. The transmitter system as previously discussed, is designed to protect itself first by kicking down if the malfunction could cause electrical or mechanical damage. This protection occurs for such conditions as loss of a primary power phase, excessive heat buildup in the final amplifier, overload at the output, or accessing the transmitter when it is in operation. No damage can occur if the exciter output is lost. By manual override of all functions, the transmitter can be returned to full operation in a matter of minutes.

TMC transmitters also consist of interchangeable building blocks. One exciter works equally well in any transmitter system. This feature of commonality of units and compatibility between systems reduces the threat posed by failure of any one sub-system. By interchanging assemblies or complete sub-systems, an emergency condition can be handled with ease.

The HFT-40K transmitter systems also contain a manual bypass circuit which routes the RF of the 10KW around the 40KW final amplifier in case the latter should fail.

Maintenance Conditions

The HFT-40K transmitter system is designed so that maintenance can be performed in place without moving equipment. A qualified technician can isolate any malfunction and correct it while the transmitter is in an operating test condition. This can take place only if the transmitter system interlocks are overridden mechanically by the technician. Access to the transmitter is through the front panel. The functional drawers, including exciter, are on track slides which enable complete, unrestricted access to the transmitter when fully extended. Monitor jacks and input/output terminal strips are provided in convenient locations if it becomes necessary to check out the system with an external exciter or an external programmer. Routing of the transmitter RF output to a dummy load gives an added benefit in enabling full test of the transmitter system at fully rated output without radiating power. Troubleshooting is covered in the next section.

TABLE 3-2. TRANSMITTER TUNING CHART, UNBALANCED OPERATION

10K (IPA) STAGE							40K (PA) STAGE													
BAND	PTE OSC SETTING	TUNE	LOAD	PLATE CURRENT	OUTPUT BALANCE	10KW LOAD CURRENT	FINAL BAND	TUNE	LOADING	DC PLATE CURRENT	PLATE RF	DC GRID CURRENT	40KW LOAD CURRENT	40KW S/D DB	20KW LOAD CURRENT	20KW S/D DB	RF DRIVE VOLTS	BALANCE	ANTENNA BAND
2-3	2500	543	660	.79	513	2.0	2-3	523	484	3.4	8.0	40	5.8	36	4.1	41	.45	576	2-12
2-3	3500	257	447	.65	435	2.1	2-3	276	437	3.5	6.5	10	5.8	37	4.1	42	.37	226	2-12
3-4	3500	303	527	.65	435	2.7	3-4	290	429	3.8	7.0	20	5.8	37	4.1	42	.38	226	2-12
3-4	2250	195	309	.62	377	2.1	3-4	225	393	3.6	6.2	10	5.8	36	4.1	41	.35	143	2-12
4-6	2250	288	440	.75	377	2.3	4-5	245	411	3.8	5.3	10	5.8	36	4.1	41	.34	143	2-12
4-6	2750	207	287	.65	369	1.4	4-5	206	324	3.2	5.8	0	5.7	35	4.0	40	.30	077	2-12
4-6	2750	207	287	.62	369	1.3	5-7	261	436	3.1	5.5	0	5.7	36	4.0	41	.28	077	2-12
4-6	3250	161	210	.60	373	1.2	5-7	220	365	3.0	5.0	0	5.2	35	3.7	40	.27	069	2-12
6-8	3250	223	268	.63	373	1.2	5-7	220	365	3.0	5.0	0	5.2	35	3.7	40	.27	069	2-12
6-8	3750	180	209	.66	356	1.3	5-7	186	289	3.4	4.5	0	5.5	35	3.9	40	.27	050	2-12
6-8	3750	180	209	.66	356	1.3	7-13	262	425	3.4	5.6	0	5.5	35	3.9	40	.31	050	2-12
6-8	2125	152	148	.75	342	1.3	7-13	236	337	3.7	4.3	0	5.5	35	3.9	40	.27	033	2-12
8-11	2125	212	320	.70	342	1.1	7-13	236	337	3.6	4.2	0	5.5	35	3.9	40	.25	033	2-12
11-15	3375	146	188	.95	342	3.0	7-13	005	208	5.4	2.5	0	5.8	35	4.1	40	.30	035	12-20
11-15	3375	146	188	.70	342	1.7	13-18	220	270	3.6	4.6	0	5.8	37	4.1	42	.29	035	12-20
15-19	2312.5	130	150	.75	330	1.3	13-18	071	205	3.4	4.0	0	6.2	36	4.3	41	.27	003	12-20
15-19	2312.5	130	150	.78	330	1.3	18-24	218	230	3.3	4.5	0	6.2	36	4.3	41	.29	003	12-20
19-24	3062.5	125	084	.80	329	1.6	18-24	136	181	3.6	4.2	10	5.8	36	4.1	41	.30	002	20-28
24-28	3062.5	192	148	.90	329	1.4	24-28	210	209	3.4	6.5	30	5.8	36	4.1	41	.38	002	20-28
24-28	3562.5	169	095	.85	325	2.2	24-28	121	191	3.4	5.0	30	6.4	35	4.5	40	.40	002	20-28

TEST 40K LOAD — CONDITIONS:

[hatched box] 600Ω BALANCED

[empty box] 50Ω UNBALANCED

REMARKS: ____________

DATE ________

MFG NO. ________

SERIAL NO ________

TESTED BY Mauw / Control

APPROVED BY [signature]

MODEL ________

THE TECHNICAL MATERIEL CORP.
MAMARONECK NEW YORK

TUNING CHART 2-28MC SYNTHESIZED

MAINTAINABILITY

Technical Manual

TMC technical manuals perform an important function in successfully maintaining HFT-40K transmitter systems. As a minimum, each manual consists of seven sections:

1) General Information
2) Installation
3) Operating Procedures
4) Principles of Operation
5) Maintenance and Troubleshooting
6) Replacement Parts
7) Drawings and Schematics

This breakdown simplifies the maintenance function by providing a ready reference for both operator and technician. Each manual is based on the actual equipment supplied and is updated by addenda sheets as changes in design occur. The manual can also be used as a training guide and as a reference for the ordering of spare parts.

The following pages are extracts from the HFT-40K Technical Manual showing contents and troubleshooting techniques. All of these features indicate the ease with which TMC transmitter systems are maintained when using the technical manual.

Preventive Maintenance

A key factor in the successful operation of this transmitter system is the degree to which preventive maintenance is performed. Dust, dirt or other destructive elements can cause the equipment to fail if conditions are allowed to continue over an extended period of time.

At periodic intervals, the equipment should be pulled out on its slides for internal cleaning and inspection. The wiring and all components should be visually inspected for accumulations of dirt, dust, corrosion, grease and other harmful substances. Removal of these elements by dusting or treating with a solvent is essential to extending the useful life of the equipment.

Troubleshooting and Repair (MTTR)

An important feature of the TMC transmitter system is the number of front panel indicators visible to the operator. Virtually all critical circuits are monitored by meters or lamps. The use of these indicators simplifies the troubleshooting process by directing attention to a specific area. Corrective action can then be taken immediately with a minimum of down time. In addition, all fault indications are listed in the technical manual with probable causes and suggested remedies.

Extender cards are provided for all printed circuit boards so that test points can easily be accessed by the technician. In addition, adjustment controls for automated tuning, overload, output, bias and ALDC are brought out to the front panel for ease of access by the technicians. All test points and adjustment controls are normally covered to protect both the operator and the equipment.

All low power circuits are mounted on removeable circuit cards mounted on slide-retainers. The higher power circuits up through the final amplifier section are composed of a series of interlocking assemblies that can easily be removed from the main frame. The final tube can be removed with ease from its socket. Test points are located in full view of the technician at specific locations throughout the system. These test points are clearly shown on technical manual schematics.

The Mean-Time-To-Repair (MTTR) is nominally forty (40) minutes for the entire transmitter system and is based on actual test times taken in the engineering laboratory under operating conditions. This MTTR figure will vary depending on the degree of the failure and the availability of spare parts. Interchangeable assemblies can be used to reduce MTTR further.

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LIST OF ILLUSTRATIONS

TABLE 3-8. RELAY COIL RESISTANCES

RELAY	TERMINALS	RESISTANCE (OHMS)
K7601	E7607-E7608 (Ovld winding) E7601: 7-8	Less than 1 1,100
K7602	E7609-E7610 (Ovld winding) E7602: 15-16	170 1,100
K7603	E7602: 17-18 E7603: 23-24	1,000 10,000
K7604	E7603: 25-26 E7604: 31-32	1,000 10,000
K7605	E7604: 33-34	11,000
K7606	E7605: 39-40	1,800
K7607	E7605: 45-46	Less than 1
K7608	E7611-E7612	Less than 1
K7609	E7606: 57-58	2.4

TABLE 3-9. CROWBAR DRAWER TROUBLESHOOTING

ITEM	INDICATION	PROBABLE TROUBLE	PROCEDURE
1	No reading on vtvm with switch S8301 in either the FILAMENT or RESERVOIR position; POWER indicator I8301 is not lit.	No primary power applied to transformer T8301.	Check fuse F8301. If fuse is open, check for shorts in crowbar drawer before replacing fuse. If fuse is good, check continuity of inductors L8301 and L8302.
2	No reading on vtvm with switch S9301 in either the FILAMENT or RESERVOIR position; filament of tube V8301 does not light; POWER indicator I8301 lights normally.	Transformer T8301 defective.	Check resistance of T8301 windings.
3	No reading on vtvm with switch S8301 in the FILAMENT position, normal reading in the RESERVOIR position.	Filament circuit of V8301 defective.	Check winding 3-4 of T8301. If open, replace T8301. If filament of V8301 is lit, check R8308 and FILAMENT contact of S8301.
4	No reading on vtvm with switch S8301 in the RESERVOIR position; normal reading in the FILAMENT position.	Reservoir circuit of V8301 defective.	Check winding 5-6 of T8301. Check continuity of RESERVOIR ADJ control R8305. Disconnect the meter from pins C and D of J8301 and connect it across pins 1 and 4 of the V8301 tube socket. If the reading is normal, check R8307 and the RESERVOIR contact of S8301. **NOTE** Reconnect the meter to pins C and D of J8301.
5	Incorrect reading on vtvm with switch S8301 in RESERVOIR position.	RESERVOIR ADJ control R8305 not set properly.	Adjust R8305 for vtvm voltage reading stamped on thyratron V8301.
6	No reading on vtvm with switch S8301 in either the FILAMENT or RESERVOIR position, but filament appears lit in thyratron V8301.	Meter circuit in crowbar drawer defective.	Disconnect the meter from pins C and D of J8301 and connect it across pins 1 and 4 and then 1 and 5 of the V8301 tube socket. If the readings are normal, check the continuity of switch S8301 and resistor R8309.

RELIABILITY

Equipment and Circuit Design

Designed into all TMC products is quality. From the time a circuit is first sketched on a drafting table, meticulous attention is given to minimizing the number and density of components while maximizing the functions performed. Whenever possible, solid-state components including large scale integrated (LSI) circuits are used. All of the modern TMC equipment is solid state except for the final tube circuits in the higher power linear amplifiers (1KW and above). This includes such sub-systems as the exciter, driver amplifiers, power supplies, and control circuits as well as such accessory equipment as frequency shift keyers and test generators. Maximizing the use of solid state components increases overall reliability by reducing the number of components needed to perform a given function and reducing the power requirement (stress) on the system. This improvement in reliability is reflected in a higher MTBF value (see below). Costs also decrease as the overall reliability improves since downtime, maintenance and the requirement for spare parts are all reduced. With each proven advance in modern technology, TMC modifies its designs to reduce cost and improve reliability while maintaining compatibility with older systems. Consequently, the reliability of TMC equipment, already well-known, improves with age as modern technologies are incorporated in designs. This attention to designing reliability into its transmitter systems is one reason why TMC equipment is selected more often to perform the most demanding jobs.

The reliability of electronic equipment is defined as the probability the equipment will perform properly for a desired length of time under the conditions (operational and environmental) for which it is designed. There are basic assumptions which underlie the construction of a mathematical model to be used to predict the reliability of equipment:

(1) Part failure rates are constant;
(2) Probability of part survival or part reliability follows a Poisson or exponential distribution;
(3) Parts within a particular equipment or the equipment within a particular system have a series relationship. That is, each part or each equipment must operate properly so that the function for which they are used can be performed.

Mathematically, the reliability of an item of equipment or a complete system is a function of the sum of the failure rates of the parts constituting the equipment or the equipment constituting the system. Normally, failure rates can be predicted for specific parts. However, for equipment in systems, failure rates are less precise since the time interval for which the equipment reliability is being determined is usually not well defined. Mean-Time-Between-Failure (MTBF) is used in this latter case and is equal to the reciprocal of the failure rate for the equipment.

The following steps were taken to calculate the reliability and the MTBF of the transmitter system:

(A) A list of all parts used in the design of the transmitter was compiled from material lists stored on magnetic disks on an IBM computer system.

(B) The failure rate of each part was determined using MIL-HDBK-217 Reliability Stress and Failure Rate Data for Electronic Equipment. In the case of equipment for which adequate test time was not available, a list of components with typically average failure rates was used. This list appears at the end of this Section.

(C) The predicted failure rate of each part was recorded on a magnetic disk. The summation of these failure rates yielded the failure rate for the entire equipment.

(D) The MTBF was then calculated by taking the reciprocal of the summation of the failure rates. Since the transmitter system has been operating well over 10,000 hours in the field, failure rates were calculated by computer and then modified to reflect actual performance.

The data for MTBF on the HFT-40K transmitter system was derived from actual installations in the following areas:

Nairobi, Kenya	United Nations
Bangkok, Thailand	United Nations
Ottawa, Canada	Government of Canada
Tel Aviv, Israel	Government of Israel
Dixon, CA, USA	US Government, Dept/Defense
Santiago, Chile	Government of Chile
Annapolis, MD, USA	US Government, Dept/Defense
Ismir, Turkey	US Government, Dept/Defense

Experienced over a period of 1,000 to 10,000 hours after acceptance, the transmitter average failure rate in terms of percent per 100,000 hours of operation is 1.64 including tubes. Without tubes, the failure rate reduced to 1.48. The calculated MTBF is 610 hours with tubes and 676 hours without tubes. Calculated from a computer analysis of the transmitter system using known stress values, the MTBF becomes:

594 hours with tubes
658 hours without tubes

The difference in values can be attributed to the type of service the transmitter system is used in. The computer analysis assume 24-hour per day operation at fully rated loads under severe environmental conditions. In actual fact, transmitter systems are routinely shut down for periodic maintenance such as cleaning and minor adjustment. This procedure serves to extend the useful life of the system.

Two important factors further affect MTBF values: (1) the age of the equipment, and (2) the degree of preventive maintenance. TMC has found through experience that new equipment (less than one year operating) and old equipment (greater than seven years operating) have more failures than normal for a given period of time. The "burning in" of new parts and the normal wear of old parts are the primary factors which contribute to this condition. Once corrected, the system gives extremely reliable service particularly if the basic preventive maintenance procedures are conscientiously followed throughout the 20-year life of the equipment.

TYPICAL AVERAGE FAILURE RATES*

Components	Estimated Failure Rates % per 100,000 Hours of Operation
Capacitors (general purpose)	0.01 - 0.6
Capacitors (electrolytic)	0.02 - 2.0
Crystal diodes	0.05
RF inductors	0.05
Integrated circuits	0.1
Meters	0.2
Motor/generators	0.04
Potentiometers	0.3
Relays	0.001 - 0.5
Resistors, fixed	0.01 - 0.3
Switches	0.01 - 0.1
Transformers	0.05 - 2.0
Transistors	0.2
Tubes (receiver types)	1.0 - 2.0
Tubes (high power, transmitting)	1.0 - 20.0
Soldered joints (dipped)	0.0001
Wrapped joints	less than 0.0001

*Based on actual performance from TMC field engineering and maintenance records