DEVELOPMENT OF THE CV-2138 (XAN-1) TELEMETRY AND MDI UHF DOWN CONVERTER

HUGH LILIENKAMP
Applied Research Department
Naval Avionics Facility
Indianapolis

Summary This paper describes the function and design of the CV-2138 (XAN-1) UHF Down Converter developed at the Naval Avionics Facility, Indianapolis, Indiana. This unit is part of the Navy's Tartar, Terrier, Talos missile UHF telemetry/miss-distance information (MDI) system AN/SKQ-2 (XAN-1) now under development at this Facility.

The converter, a dual-channel unit, receives signals in the 2200-2290 MHz and 1760-to-1850 MHz bands, and produces IF's of 240-330 MHz and 110-200 MHz respectively. The 1960 MHz local oscillator (LO) frequency, common to both channels, is supplied from a single source.

Introduction As a unit of the AN/SKQ-2 telemetry/MDI system, the CV-2138 converter is mounted on the receiving antenna pedestal near the antenna output in order to minimize input line losses and, hence, system noise figure (NF). The converter output is fed to the receiving-recording-scoring set which is located some distance from the converter (i.e., below deck aboard ship). The principal portion which controls noise figure and gain is comprised of a tunnel-diode preamplifier (TDA), balanced-mixer, IF amplifier, and amplifier/X4 multiplier which generates the 1960 MHz L0 frequency (see Figure 1). Front-end preselection and image-rejection filtering attenuate out-of-band signals.

System design goals require that the converter have a 5 db maximum NF @ 25° C, RF to IF gain of 30 db minimum across the 90 MHz bands, weigh 40 pounds maximum, be non-airconditioned, and operate over a -30° C to +65° C temperature range.

General Discussion Both CV-2138 channels are 90 MHz wide, the center frequency of the telemetry and miss-distance indication (MDI) channels are at 2245 MHz and 1805 MHz respectively. The 490 MHz input to the amplifier/X4 multiplier is generated by an ultra-stable source (i e., 2 parts in 10^9/day) which is remote to the converter. In the AN/SKQ-2 system, the 490 MHz is generated by a frequency synthesizer located in the receiving-recording-scoring set.

Originally it was planned to package the input diplexer and preselector filter separately from the converter. Due to the eventual TDA form factor, however, it became apparent that by slightly enlarging the converter package, the diplexer and filters could be included.

The primary voltage to the unit is 115 + 10 volts, 400 Hz, single phase at approximately 55 ma current drain. From this input the converter power supply generates the ± 12 VDC required internally.

With a 0.5 MHz bandwidth in the receiver following the converter, a desired system signal-to-noise ratio of 10 db, and a 5 db converter NF, the theoretical converter sensitivity calculates to -102 dbm. The TDA 1 db gain compression point determines the upper end of the dynamics range at approximately -44 dbm. Hence, the theoretical dynamic range of the unit is approximately 58 db.

The averages of the measured NF across the telemetry and MDI channels are 7.3 db and 7.1 db respectively; the averages of the measured sensitivity are -102 dmb and -103 dbm respectively. The sensitivity test was made using an HP spectrum analyzer, 100 KHz bandwidth. Front-end filtering in-band losses, of course, add to the measured NF at the TDA input (TDA input NF approximately 5 db).

Component Discussion In order to achieve a 5 db NF, a low-noise, relatively hign-gain preamplifier was required. Out of the high frequency amplifiers available at the beginning of the converter development (parametric amplifier, traveling-wave tube, and TDA), the TDA was selected for its relatively small size, simple circuitry, and low input power requirements. The input and output ports of the five-port TDA circulator are each terminated with 50 ohms insuring frequency stability over the operating bandwidth. The TDA has a gain and NF of 17 db and 4.5 db respectively @ 25° C.

Attention has been given to the image frequencies in the respective bands of 1630-1720 MHz (telemetry channel image frequency) and 2070-2160 MHz (MDI channel image frequency). The image-reject filters following the TDA provide 40 db minimum attenuation at these frequencies. They also provide 30 db attenuation at 1960 MHz in order to reduce L0 power which might be reflected out the signal input port of the mixer.

The balanced mixer of the microstripline hybrid-ring type, is etched from a double- clad teflon-glass dielectric board. The hybrid-ring provides 25 db minimum L0-to-signal-input port isolation. Schottky barrier (hot-carrier) diodes were chosen for the mixer due to their low noise properties, stable operation under varying L0 power, and relatively rugged construction.

As pointed out previously, L0 power for both mixers is supplied from the amplifier/ X4 multiplier in which a step-recovery diode (SRD) is used in a coaxial-cavity resonator. The cavity is tuned to pass the fourth harmonic of the 490 MHz input. The 1960 MHz is then split into nearly equal power levels by means of dual output cavities. A power level of 1 to 5 nw is required at the 490 MHz converter input.

The broadband IF amplifiers for the telemetry and MDI channels operate in bands of 240-330 MHz and 110-200 MHz respectively, and have a 30 db minimum gain. The noise figure and 1 db gain compression point of both units are approximately 5.5 db and -25 dbm respectively.

The two IF amplifier outputs are fed to the output diplexer where they are combined for transmission to the receiver through a single coaxial cable. The output diplexer consists of two filters, one a low-pass for 110-200 MHz, the other a high pass for 240-330 MHz. Each filter provides a minimum of 30 db rejection to frequencies in the other band.

From an input of 115 ± 10 volts, 400 Hz, the power supply generates ± 12 VDC for the TDA's, amplifier/X4 multiplier, and IF amps. The supply is both voltage regulated and current limited; regulation of the +12 volt is ± 1% while the -12 volt is regulated to ± 0.50% over the -30° C to +65° C operating temperature range.

Shown in Figure 3 are the low-pass filter, input diplexer, and preselector filters which provide 60 db minimum attenuation from dc to 0.95 times the lower cutoff frequency, and from 1.05 times the upper cutoff frequency to 10 times the upper cutoff frequency in each band.

The low-pass filter in front of the RF diplexer is a "varying-impedance" coaxial type. It has a cutoff frequency of 6 GHz maximum at the 3 db down points, and an inband insertion loss of 0.2 db maximum. This unit is designed to attenuate the second pass-band (4Xfo) of each preselector filter. Attenuations of 35 db minimum are presented to the second pass-band of the MDI preselector; attenuations of 60 db minimum are seen by the second pass-band of the telemetry preselector. From 8 GHz to 12 GHz the attenuation is 45 db minimum.

The RF diplexer contains a band-pass and a band-stop filter, each of which are centered at 1805 MHz. Hence, MDI channel frequencies are passed with minimum insertion loss through one output and attenuated through the other. Telemetry frequencies pass through the band-stop filter with minimum loss and are attenuated in the band-pass filter. Pertinent RF diplexer specifications are given below:

Band-Pass Section: fo = 1805 MHz

Insertion Loss   0.4 db maximum (1760-1850 MHz)

Off-Band Rejection   20 db minimum (2200-2290 MHz)
Second Pass-Band Center 3 fo

Band-Stop Section: fo = 1805 MHz
In-Band Rejection   20 db minimum
Off-Band Insertion Loss   0.2 db maximum (2200-2290 MHD
Second Pass-Band Center 3 fo

The preselector filters connected to the RF diplexer outputs are of the comb-fine variety and have an off-band rejection of 60 db minimum at approximately fo ± 7%. The attenuation is below 60 db at approximately 5 GHz in the MDI channel and 7.2 GHz in the telemetry channel. Theoretically the second pass-band is centered at 4 fo. The minimum bandwidth at the 1 db down points is 100 MHz, in-band insertion loss is 1 db maximum.

Shown in Figures 4 and 5 are internal views of the CV-2138 (XAN-1) UHF converter.

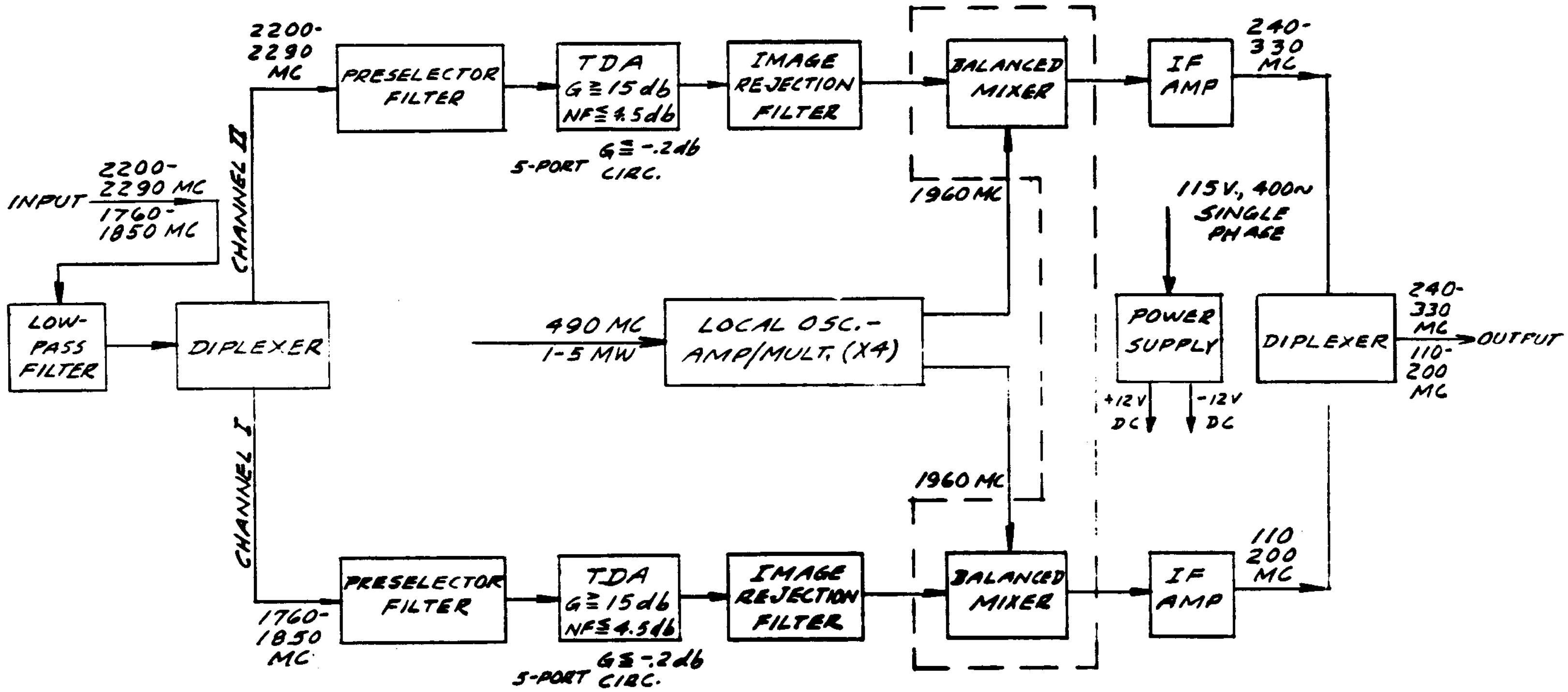

Figure 1. Frequency Converter Block Diagram CV-2138(XAN-1)/UK

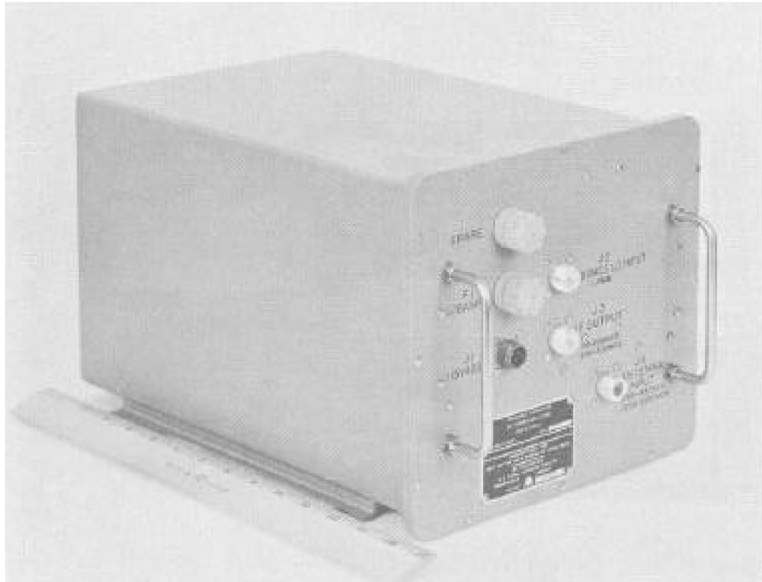

Figure 2. CV-2138(XAN-1) UHF Converter

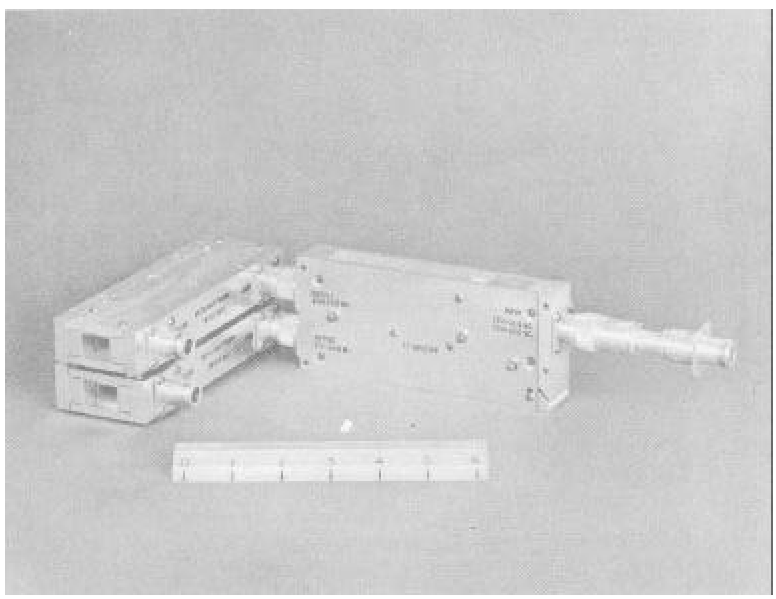

Figure 3. Input Filtering

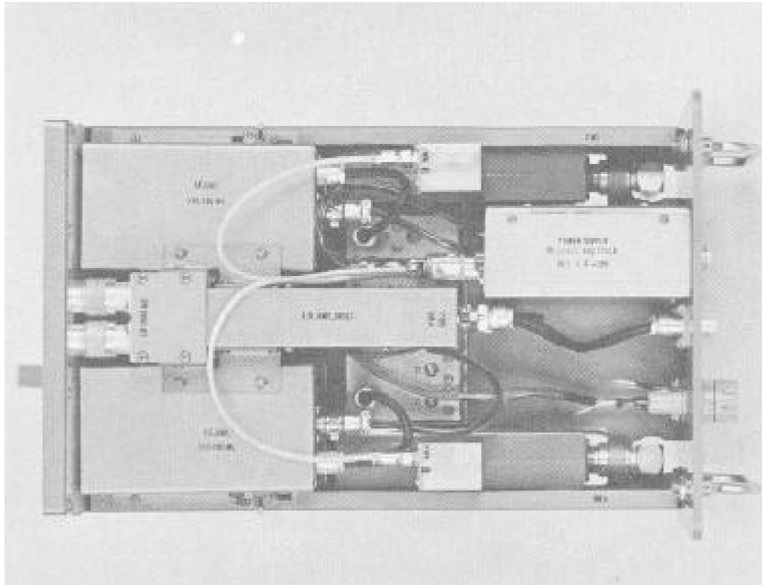

Figure 4. CV-2138(XAN-1) Internal, Top View

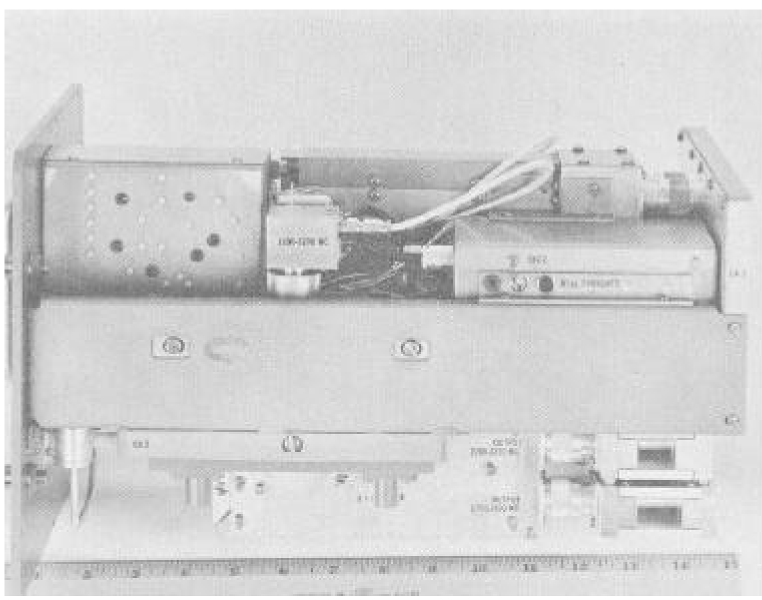

Figure 5. CV-2138(XAN-1) Internal, Side View