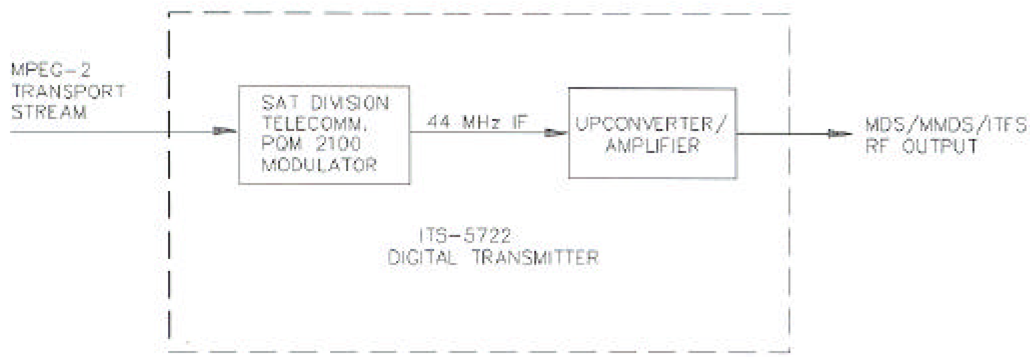
2.0 TECHNICAL DESCRIPTION

2.6 Block Diagrams

System Block Diagram:

The following is a system block diagram for the ITS-5722 digital transmitter. Detailed Block Diagrams and Schematics are included in Exhibit II.

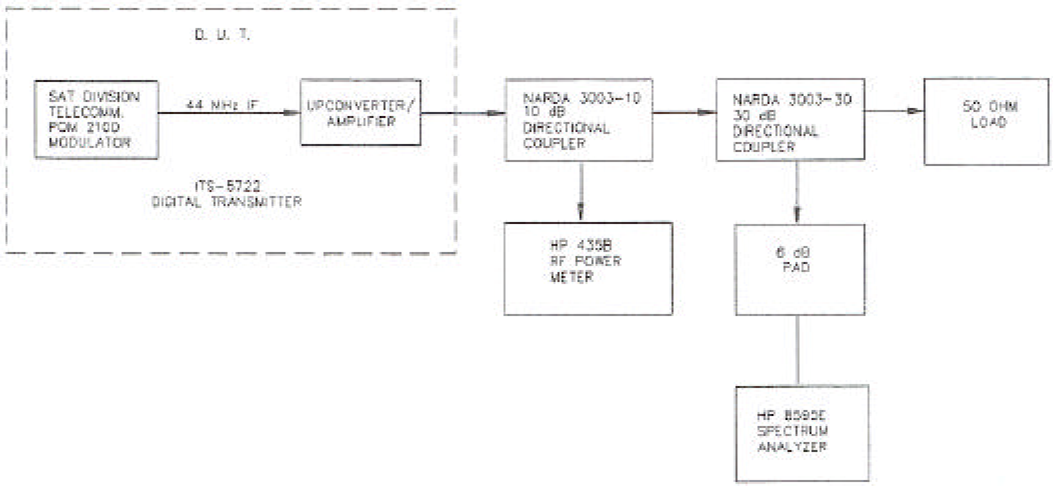


The data in the following sections was taken using the SAT Division Telecommunications PQM 2100 modulator. Two additional modulators were also evaluated (General Instruments Surfboard 407507-001-00 and Comstream CM720M) with comparable performance in all respects to that of the PQM 2100 shown in the following sections.

3.0 ENGINEERING DATA

3.1 RF Power Measurements

The following block diagram describes the test equipment set-up for the following measurement:



The output power of the ITS-5722 was adjusted to obtain 5 watts average RF output as observed on the power meter.

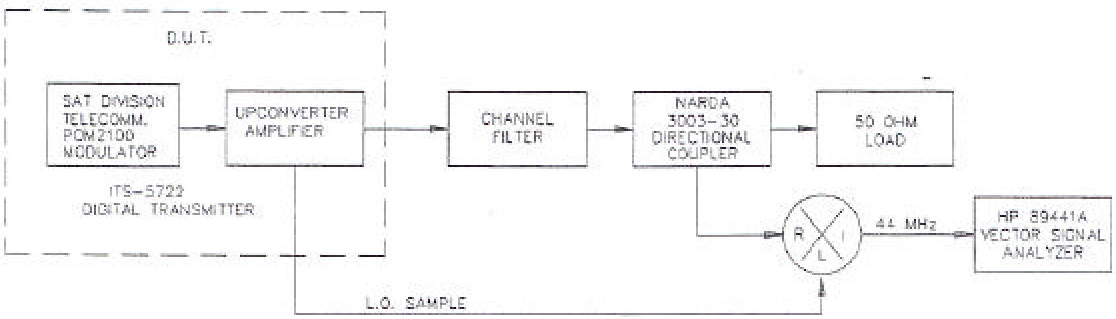
With the power level properly set to 5 watts average, all required test were performed and recorded in the following sections.

3.0 ENGINEERING DATA

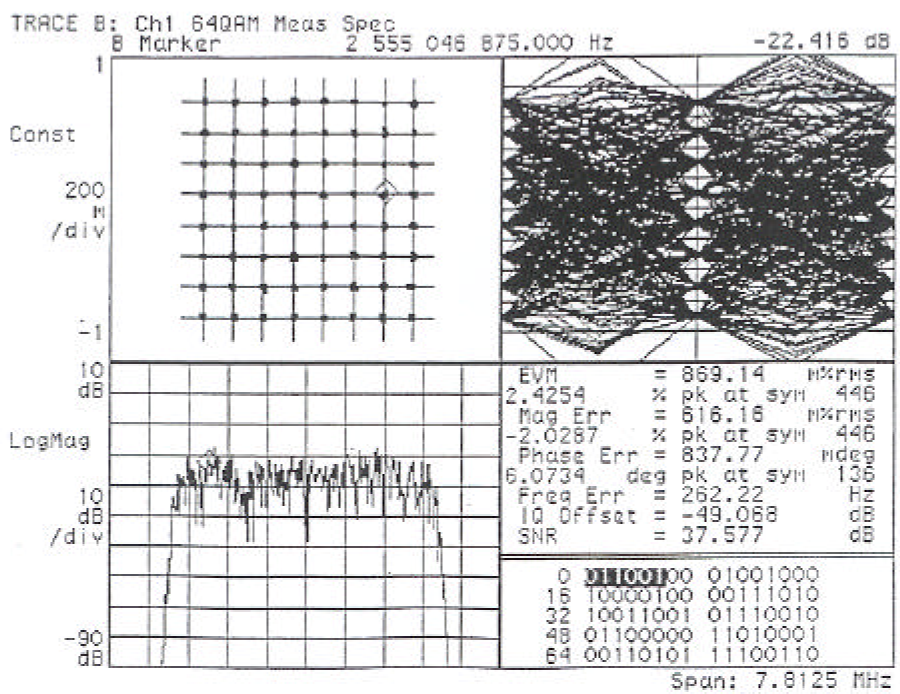
3.2 Modulation Characteristics

The modulator tray incorporates a modulation technique known as QAM, Quadrature Amplitude Modulation, which uses two carriers, each of the same frequency, but 90° apart in phase. This means that one carrier trails the other by one fourth of a cycle. Each is then phase and amplitude modulated by a portion of the digital input signal. The two modulated signals are then combined and transmitted as a single waveform. The spectrum of a QAM signal is noise-like in appearance and has a relatively stable average power and a widely varying peak-envelope-power (PEP). The power is normally referred to in average power. QAM, used in conjunction with digital compression, provides a high bandwidth efficiency allowing a data rate of 30 MBPS in a 6 MHz channel bandwidth.

The following information and diagram is for descriptive purposes only, since there are currently no FCC MMDS/ITFS regulations for digital modulation characteristics.



Typical QAM Demodulation Test Set-up



Typical Demodulated Vector Signal Analyzer Display

3.0 ENGINEERING DATA

3.2 Modulation Characteristics - continued

Constellation Diagram	(Upper left box) This diagram displays the in-phase signal (I) on the x-axis versus the quadrature phase signal (Q) on the y-axis. The points shown on the constellation vector diagram correspond only to the symbol clock time. These points are commonly referred to as detection decision points and are called symbols. Constellation diagrams help identify such things as amplitude imbalance, quadrature error or phase noise.
Eye Diagram	(Upper right box) Eye diagrams are commonly used in digital communication systems and help identify problems such as ISI (inter-symbol interference) and jitter. The eye diagram is the display of I (real) or Q (imaginary) signal versus the time that is triggered by the symbol clock.
Spectrum Display	(Lower left box) This display shows the spectrum of the QAM modulated signal and is useful for determining and adjusting the frequency response of the signal.
Error Vector Magnitude	(Lower right box) This parameter indicates the magnitude of the vector which connects the I Q reference signal phasor to the I Q measured signal phasor. The error vector magnitude (EVM) is computed by the square root of the sum of the squares for each complex pair of points, in the time record, normalized to a reference point.
Magnitude Error	(Lower right box) This parameter indicates the difference in amplitude between the I Q reference signal and the I Q measured signal. Magnitude error is an indication of the quality of the amplitude component of the modulated signal. Magnitude error might indicate a high incidental AM modulation on the signal.
Phase Error	(Lower right box) This parameter indicates the difference in phase between the I Q reference signal and the I Q measured signal. The magnitude of the parameter is an indication of the quality of the phase component of the modulated signal. Phase error might be attributed by high incidental FM modulation on the signal.
Frequency Error	(Lower right box) This parameter indicates the carrier frequency error in relation to the analyzer's center frequency and is measured in Hz. Typical examples of frequency error are errors in RF frequency, LO frequency or digitizer clock rate.

3.0 ENGINEERING DATA

3.2 Modulation Characteristics - continued

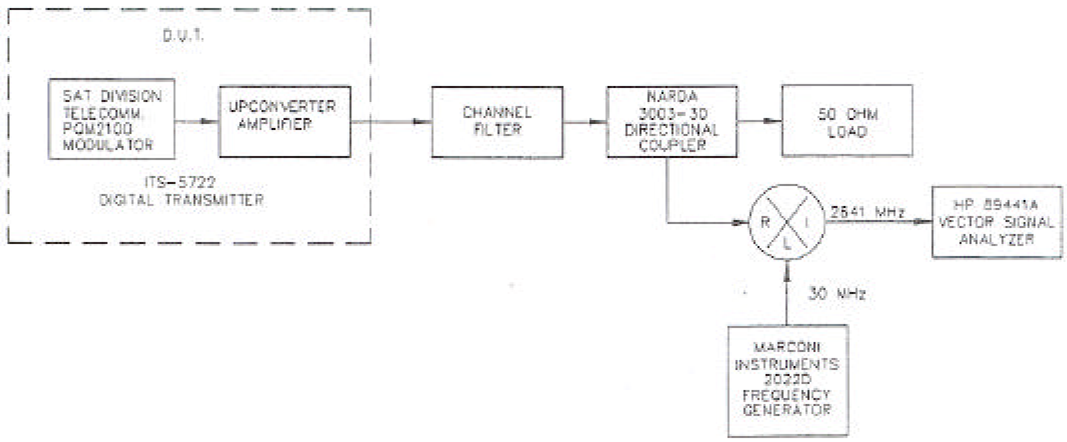
I Q Offset (Origin Offset)	(Lower right box) This parameter indicates the magnitude of the carrier feed-through (if the carrier is 100% suppressed, the I Q offset is zero). Carrier feed-through is an indication of the balance of the I Q modulator used to generate the modulated signal. If the modulator is balanced, the carrier is nulled by the RF spectrum. Imbalance in the I Q modulator results in carrier feed-through and appears as an origin offset in the constellation diagram.
Signal to Noise Ratio	(Lower right box) The signal to noise ratio (SNR) is the average symbol power of the transmitted waveform relative to the noise power. The noise power includes any term that causes the symbol to deviate from the ideal state position, such as additive noise, distortion and ISI (inter-symbol interference).
Detected Data	(Lower right box) The binary data in the box represents the detected or recovered data from the digitally modulated signal.

3.0 ENGINEERING DATA

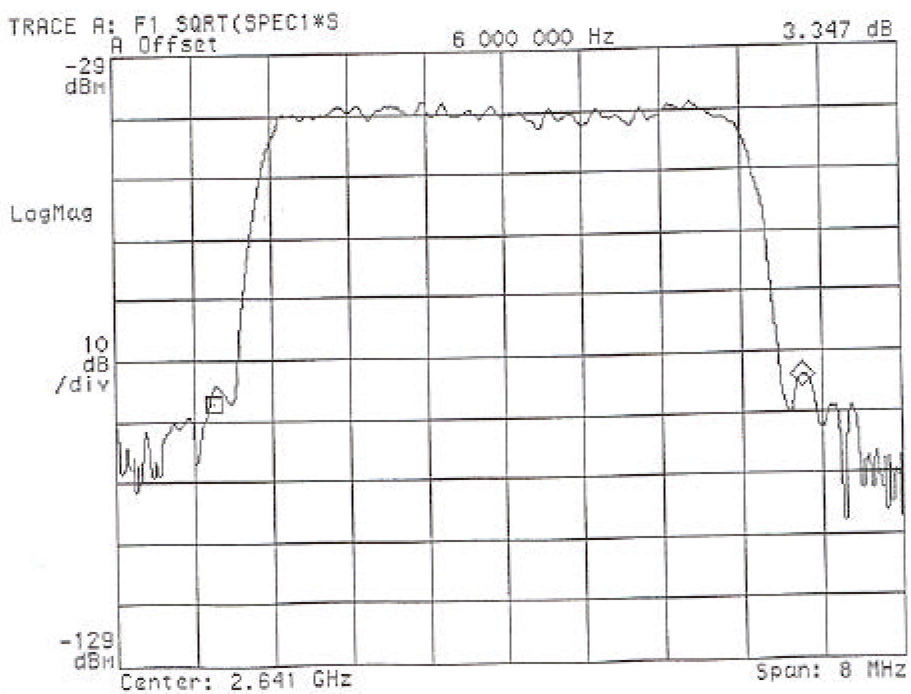
3.3 Occupied Bandwidth

Using the following test set-up, the transmitter was operated at maximum power and a plot of the transmitter occupied bandwidth spectrum was taken.

Note: The Resolution BW setting was adjusted to 100 KHz for this measurement.



Channel Occupied Bandwidth

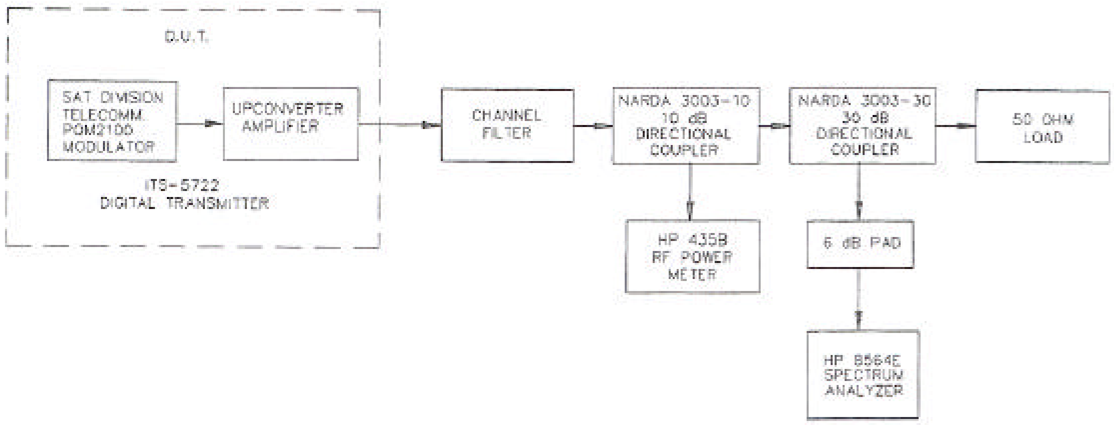


3.0 ENGINEERING DATA

3.4 Out-of-Band Power

Using the test set-up shown below, the spectrum outside of the specified channel was observed and the data was taken on all products above the -65 dB noise floor of the spectrum analyzer.

Spurious Emissions were observed on the analyzer at both 20 MHz and 40 MHz span (see spectrum plots on the following page). With the average in band signal set as the reference, the spurious emissions were observed. The measured data is shown in the table below for 5 watts (average) output power.

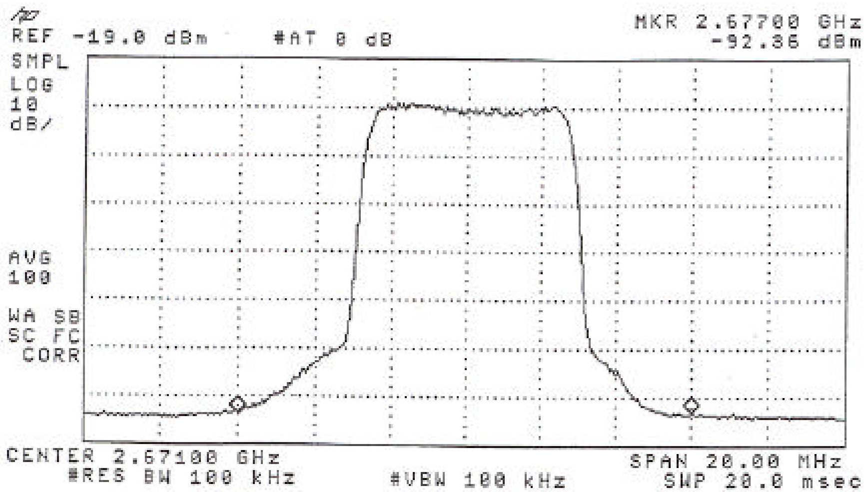


Frequency	Source	Level Observed
2671.00 MHz	Center of Channel	0 dB (reference)
44 MHz	IF	None Observed
2715.00 MHz	Local Oscillator	-63.5 dB
2668.00 MHz	Lower Channel Edge	-47.0 dB
2674.00 MHz	Upper Channel Edge	-44.0 dB
2665.00 MHz	3 MHz Below Channel	-62.0 dB
2677.00 MHz	3 MHz Above Channel	-63.0 dB
5342.00 MHz	2nd Harmonic	None Observed
8013.00 MHz	3rd Harmonic	None Observed
10684.00 MHz	4th Harmonic	None Observed
13355.00 MHz	5th Harmonic	None Observed
16026.00 MHz	6th Harmonic	None Observed
18697.00 MHz	7th Harmonic	None Observed
21368.00 MHz	8th Harmonic	None Observed
24039.00 MHz	9th Harmonic	None Observed
26710.00 MHz	10th Harmonic	None Observed

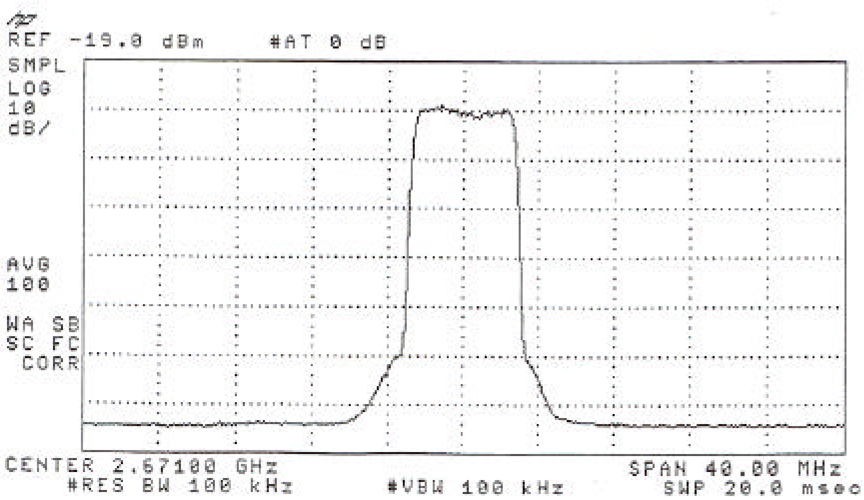
3.0 ENGINEERING DATA

3.4 Out-of-Band Power - continued

Spectrum Analyzer Plot (20 MHz Span):



Spectrum Analyzer Plot (40 MHz Span):



3.0 ENGINEERING DATA

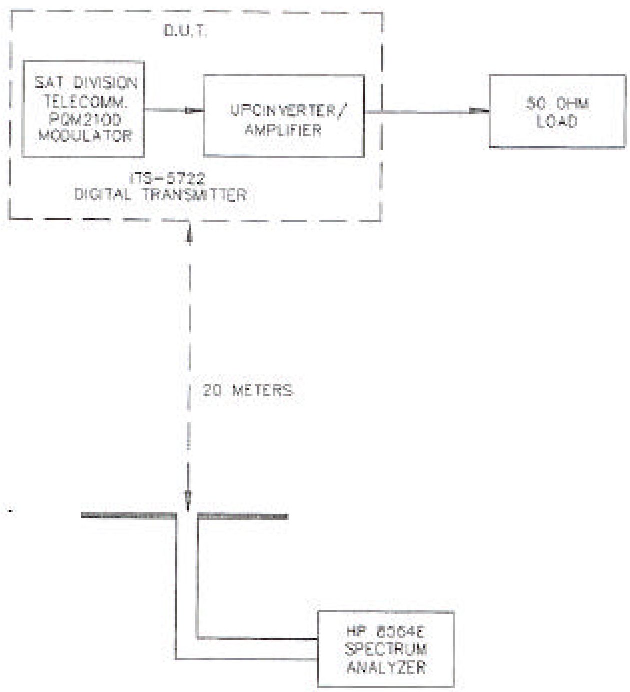
3.5 Radiated Emissions

Using the test set-up below, with the transmitter operating at 5 watts average output power and at a carrier frequency of 2671.00 MHz, the spectrum analyzer was moved 20 meters from the transmitter and connected to a dipole antenna cut to the IF frequency (44 MHz). This antenna was oriented to maximize the received level, and the data was recorded. The antenna was then cut to the carrier frequency, local oscillator frequency, and the second through the tenth harmonic frequencies of the transmitter and all signals received were maximized by antenna orientation, and their absolute levels were recorded.

With these various antennas the data was taken and recorded in the table on the following page.

Note: The spectrum analyzer had a maximum sensitivity of -110 dBm during these test.

Test Set-up:



3.0 ENGINEERING DATA

3.5 Radiated Emissions - continued

MEASURED LEVELS

Frequency	Source	Level Observed
2671.00 MHz	Center of Channel	-75 dB (reference)
44 MHz	IF	None Observed
2715.00 MHz	Local Oscillator	-85
5342.00 MHz	2nd Harmonic	None Observed
8013.00 MHz	3rd Harmonic	None Observed
10684.00 MHz	4th Harmonic	None Observed
13355.00 MHz	5th Harmonic	None Observed
16026.00 MHz	6th Harmonic	None Observed
18697.00 MHz	7th Harmonic	None Observed
21368.00 MHz	8th Harmonic	None Observed
24039.00 MHz	9th Harmonic	None Observed
26710.00 MHz	10th Harmonic	None Observed

The measured levels were then compared to the following reference level:

If all of the transmitter's power (5 Watts) was radiated by an isotropic radiator, the power density at 20 meters would be:

$$Pd = Pt/4\pi R^2 = 5/4\pi (20)^2 \cong 0.9947*10^{-3} \text{ w/m}^2$$

Using a dipole transmitting antenna increases this by 1.64 to:

$$1.64 * 0.9947\text{x}10^{-3} = 1.6313 \text{ x}10^{-3} \text{ w/m}^2$$

If a dipole receive antenna of area $1.64 * \lambda^2/4\pi$ is used to receive the signal, the received level would be:

$$1.6313 \text{ x}10^{-3} * 1.64 * \lambda^2/4\pi = 2.689 \text{ x}10^{-6}\text{w} = -55.7 \text{ dBw} = -25.7 \text{ dBm}$$

The receive levels were therefore at the following relative levels:

Frequency	Relative Measured Level (Ref = -25.7 dBm)
2671 MHz	**-49.3dBc**
2715 MHz	**-59.3 dBc**

The cabinet radiation was also checked with the receive dipole antenna cut to 2509.00 MHz, within very close proximity to the transmitter's trays, and the received level recorded at no time exceeded a level in excess of -10 dBm. The power density at this level would then be:

$$Pr/A = 5.7\text{x}10^{-3} \text{ mW/cm}^2$$

This level is far less than the current or proposed standard for safe radiation levels.

3.0 ENGINEERING DATA

3.6 Frequency Stability

The ITS-5722 is designed to operate using an external 10 MHz precise reference oscillator. The frequency stability of this external reference determines the frequency stability of the transmitter.

The frequency determining variables of the transmitter may be defined as follows:

F_{LO} = Desired local oscillator frequency
F_{IF} = Desired IF oscillator frequency
F_R = Desired external reference oscillator frequency
F_{RF} = Desired RF output frequency
E_{LO} = Local oscillator frequency offset error
E_{IF} = IF oscillator frequency offset error
E_R = External reference oscillator frequency offset error
E_{RF} = RF output frequency error

The PLL circuitry maintains a constant ratio between the external reference frequency and the output frequency of the oscillator. This ratio is defined below for both the LO and IF oscillators.

$G_{LO} = F_{LO}/F_R$
$G_{IF} = F_{IF}/F_R$

Any change in the external 10 MHz reference will effect a corresponding change in the output frequency such that the above ratios are maintained.

$$G_{LO} = (F_{LO} + E_{LO})/(F_R + E_R) = F_{LO}/F_R$$

$$G_{IF} = (F_{IF} + F_{IF})/(F_R + E_R) = F_{IF}/F_R$$

Solving for the change in output frequency yields:

$$E_{LO} = E_R * (F_{LO}/F_R) = E_R * G_{LO}$$

$$E_{IF} = E_R * (F_{IF}/F_R) = E_R * G_{IF}$$

The desired RF carrier frequency is equal to the LO frequency minus the IF frequency:

$$F_{RF} = F_{LO} - F_{IF}$$

The actual RF frequency, including any error introduced by the external reference, may be defined as follows:

$F_{RF} + E_{RF} = (F_{LO} + E_{LO}) - (F_{IF} + E_{IF})$
$F_{RF} + E_{RF} = (F_{LO} + F_{IF}) - (E_{LO} - E_{IF})$
$F_{RF} + E_{RF} = F_{RF} + (E_{LO} - E_{IF})$

3.0 ENGINEERING DATA

3.6 Frequency Stability - continued

Calculating for the error of the RF carrier yields:

$E_{RF} = (E_{LO} - E_{IF})$
$E_{RF} = E_R * G_{LO} - E_R * G_{IF}$
$E_{RF} = E_R (G_{LO} - G_{IF})$
$E_{RF} = E_R/F_R * (F_{LO} - F_{IF})$
$E_{RF} = E_R/F_R * F_{RF}$

Therefore, the error of the RF carrier is a function of the external 10 MHz reference error.

The maximum RF frequency error for this service is ±1.0 KHz. The highest channel frequency for this service (G4 = 2681.25 MHz) represents the worst case condition. With these values the maximum allowable reference error ($E_{R(max)}$) can be calculated.

$E_{R(max)} = 3.73$ Hz

The required reference oscillator stability may be calculated as follows:

Stability = $E_{R(max)}/F_R$
Stability = 3.73 Hz$/10 \times 10^6$ Hz $= 0.373 \times 10^{-6}$

Therefore, the RF frequency error of the ITS-5722 will not exceed ±1.0 KHz when operated with a precise reference oscillator with a stability equal to or better than 0.373×10^{-6}.

Commercially available GPS precise reference oscillators, such as the TRAK Systems 8821 which has a frequency stability of 1×10^{-9} over a temperature range of 0 to 50 °C, and a line voltage/frequency range from 85 to 265 VRMS/48 to 440 Hz (see TRAK Systems 8821 specifications on the following pages), insure a frequency stability within the tolerance specified in the Rules and Regulations for this service.

3.0 ENGINEERING DATA

3.7 Test Equipment

MODEL	MANUFACTURER	DESCRIPTION	SERIAL #
8564E	Hewlett Packard	Spect. Analyzer 9 KHz-40 GHz	Rental
8595E	Hewlett Packard	Spect. Analyzer 9 GHz- 6.5 GHz	3543A01613
3003-30	Narda	Directional Coupler	41991
3003-10	Narda	Directional Coupler	09049
435B	Hewlett Packard	RF Power Meter	2732009080
2349A	Hewlett Packard	30 Watt Power Head	3318A05525
2230	Tektronix	Oscilloscope	2230B025251
1992	Racal-Dana	Frequency Counter	950304
8135	Bird	50 Ohm Termination	8520
79	Fluke	Digital Multimeter	56660032
89441A	Hewlett Packard	Vector Sig. Analyzer (IF section)	3416A01020
89441A	Hewlett Packard	Vector Sig. Analyzer (RF Section)	3415A00333
2022D	Marconi Instruments	Signal Generator	119216/045