1.0 Technical Description

The M1310A biotelemetry transmitter is a small battery powered device used for the transmission of patient electrocardiograms (ECG'S) within hospital buildings. The M1310A transmits two ECG signals and status information that uniquely identifies the patient, the condition of the battery and ECG lead connection to the patient, and whether a push button has been activated or the patients heart pacer has fired.

The M1310A utilizes a shaped, continuous phase modulation for spectrum efficiency. The ECG'S are low frequency, .05 to 100 Hz, signals. The status bits are also slowly varying events.

The transmitter is packaged in a small plastic case with patient cable connector. The intended application is a continuous transmission for one week per set of batteries. Overall power consumption is minimized to attain battery life. The transmitter contains a motherboard, a printed circuit RF module assembled with single sided surface mount technology, two ECG hybrids, one power supply hybrid, and one hybrid for the digital signal processing and wave shaping.

The transmitter output power is 4 milliwatts. The patient cable is used as it's antenna.

2. Description of Active Devices:

Q1 Crystal Oscillator

Q1 is a Colpitts crystal oscillator that oscillates at 1/4 the transmitter frequency. The stage is biased at 1.0 mA with 2.2 VDC on the collector (2.2 mW).

The following components provide the functions identified:

SK1, CV2/C5, L2, CR1,and CR2 form a series resonant circuit that control the transmitter frequency.The circuit contains adjustment of transmitter frequency and direct frequency modulation. C3 also has significant affect on the oscillator frequency.

CV1, L1, C3 and C4 form a parallel resonant circuit that controlls the oscillator activity and cryatal overtone.

C8 acts as a bypass at the oscillator fourth harmonic. The bypassing increases the stage output at 465 MHz.

There is some interaction between the functions

SK1 Frequency determining crystal. This crystal is a 5th overtone packaged in a TO5 coldweld package. The crystal is specified for transmitter stability of +/- 6 PPM over the temperature range of 0 to 55 degrees C.

L3 Coil that neutralizes crystal shunt capacity

CV2 Part of oscillator resonant circuit. These capacitors
C5 provide frequency adjustment.

L2 Part of oscillator resonant circuit.

CR1 Part of oscillator resonant circuit. These varactors
CR2 provide frequency modulation. Varactor bias path is R6 (positive), and R7 R10 (return).

C3 Part of oscillator resonant circuit. Provide phase shift
C4 and impedance transformation to permit oscillation. These capacitors also make part of the activity resonant circuit.

CV1 Part of the activity resonant circuit. This trimmer is is tuned for maximum oscillator output.

L1 Part of the activity resonant circuit.

Q1 Oscillator transistor. The output of the oscillator is at the fourth harmonic, approximately 465 MHz. Capacitor C8 acts as a bypass at this frequency to increase output power.

C18, CV3, and L4 form a parallel resonant circuit with a loaded Q of 40 at 465 MHz. CapacitorC7 provides impedance matching to the base of Q3.

Q3 This transistor is the first of two cascoded cmplifier stages. The DC current thru the two stages is adjusted by variable resistor RV2. The range of current is from 0 mA to 6.0 mA. The nominal current is 1.8 mA. The emitter of Q3 is fully bypassed. The collector resonant circuit, CV5, C13 and L8 has a loaded Q of 40, and is tuned to 465 MHz. The DC power to this amplifier is a nominal 4 mW.
Capacitor C12 provides impedance matching to the base of Q2.

Q2 This transistor is the transmitter output amplifier. The DC power is 2.8VDC at 3.0 mA, or 8.4 mW. The DC power input is adjusted by RV2, the bias adjustment in the Q3 amplifier. The range of DC power in the output stage is 2.8 mW to 19.6 mW. The transmitter output power, 2 mW is maximized at a stage current of 3.0 mA. When the current is either increased or decreased, the transmitter output power decreses.

C11, L7 and CV4 form a parralel resonant circuit with a loaded Q of 40 at 465 MHz. Capacitor C16 provides impedance matching to a 50 ohm load.

3. Tune up procedure:

The transmitter is tuned up with a wattmeter and spectrum analyzer on the 50 ohm output, and a milliammeter on the DC power supply. The transmitter RF module is plugged into its test fixture. A 1 kHz 3.0 VPP source is connected to the modulation input.

Q1 Crystal Oscillator

Turn on the power and adjust variable resistor RV2 for 2 mA module DC current.

Connect the spectrum analyzer to the 50 ohm RF output of the test fixture. Set up the analyzer to display 0 to 1 GHz. Tune variable capacitor CV1 for maximum oscillator activity as seen on the analyzer.

Adjust variable resistor RV2 for 3.0 mA module DC current.

Q3 and Q2 Amplifiers

Sequentially adjust variable capacitors CV3, CV5, and CV4 for maximum output power at 465 MHz. Iterate this this step until 2 mW output power is obtained. While tuning these capacitors, maintain crystal harmonics at 118, 236, 353, 585, 702, and 820 MHz at least 42 dB below the carrier, and the second harmonic of the transmitter below 30 dB celow the carrier.

There shall be no other spurious products visible.

Q1 Frequency

Adjust capacitor CV2 for transmitter frequency +/- 100 Hz.

Deviation

Connect the modulation source to the test fixture. The modulation source is 1 kHz at 3.0 VPP. Adjust the deviation control, RV1, for 2.4 kHz (peak) deviation.

Turn off the power and remove the module.

4. Description of Frequency Determining and Stabalizing Circuitry:

Q1 Crystal Oscillator

Q1 is a Colpitts crystal oscillator that oscillates at 1/4 the transmitter frequency. The stage is biased at 1.0 mA with 2.2 VDC on the collector (2.2 mW).

The following components provide the functions identified:

SK1, CV2/C5, L2, CR1,and CR2 form a series resonant circuit that control the transmitter frequency.The circuit contains adjustment of transmitter frequency and direct frequency modulation. C3 also has significant affect on the oscillator frequency.

CV1, L1, C3 and C4 form a parallel resonant circuit that controlls the oscillator activity and cryatal overtone.

C8 acts as a bypass at the oscillator fourth harmonic. The bypassing increases the stage output at 465 MHz.

There is some interaction between the functions

SK1 Frequency determining crystal. This crystal is a 5th overtone packaged in a TO5 coldweld package. The crystal is specified for transmitter stability of +/- 6 PPM over the temperature range of 0 to 55 degrees C.

L3 Coil that neutralizes crystal shunt capacity. Proper neutralization has two affects. First, it reduces the tendency for the oscillator to free run at frequencies near the crystal frequency, and second, it maximizes the tuning range of the crystal controlled oscillation. This attribute keeps the transmitter modulation linearity induced distortion below 2%. This low distortion helps control the modulation sidelobes outside the channel.

CV2 Part of oscillator resonant circuit. These capacitors
C5 provide frequency adjustment. C5 is a NPO chip capacitor.

L2 Part of oscillator resonant circuit.

CR1 Part of oscillator resonant circuit. These varactors
CR2 provide frequency modulation. Varactor bias path is R6 (positive), and R7 R10 (return). The return is biased from a fixed 2.5 volt source. The positive derives its bias from the GMSK source in the digital hybrid. The GMSK source has levels between 1 and 4 volts.

5.0 Description of Circuits that limit spurious, modulation, and power

Circuits that limit spurious

There are three sources of spurious emissions within the M1310A:

(1) Harmonics of the 118 MHz crystal oscillator

(2) High frequency modulation products, derived from the switched mode power supply and timing oscillator.

(3) Harmonics of the 250 kHz switched mode power supply

Harmonics of the crystal oscillator are filtered by three cascaded LC filters: L4/C18/CV3, L8/CV5/C13, and C11/L7/CV4 inside the VCXO module. Each of these filters has a loaded Q of 40 and is tuned to 465 MHz. The alignment procedure of filters requieres the spurious crystal harmonics from 115 to 850 MHz be 42 dB below the carrier. The transmitter second harmonic, 930 MHz is 30 dB below the carrier at module test. Additional attenuation of spurious products above 600MHz is obtained by a stripline lowpass filter on the transmitter motherboard.

High frequency digital noise is attenuated by filtering the RF module 5 volt power supply with R11 and C9, and by filtering the modulation input with R8 and C21 inside the module.
An additional filtering of the power supply line is done on the motherboard by L151 and C181 .. C183. The 2.5 volt bias for the VCXO varactors is generated by OPAMP U116B and filtered by C160 on the motherboard.(part of power supply circuit)
Spurious modulation products are over 60 dB below the carrier.

Circuits that limit modulation

The transmitter modulation is obtained by superimposing the combined heartrate and FSK subcarrier signal on the DC varactor bias on varactors CR1 and CR2 inside the VCXO module.
The FSK subcarrier is generated by processor U10 as a square wave signal with a well defined 5V peak to peak amplitude. This square wave signal is filtered by the active bandpass filter around U209A. (lowpass of 3rd order, highpass 2nd order). This filtering results in a sine shaped FSK subcarrier modulation signal. The filter gain for the FSK filter sets a 2 volt peak to peak amplitude for the filtered FSK output signal.
The active filter also acts as a summing point for the FSK signal and the heartrate signal delivered by the active limiting OPAMP U205A. This OPAMP runs with a 5V single supply, so its maximum output signal will be less than 4 volts peak to peak. Heartrate signals, if too strong will be clipped by U205A. The following lowpass around U209A removes the higher frequency harmonics generated by this clipping. U209A runs with +8.5V/-3.5V supplies, so it is operated in a linear mode even if U205A is clipping. This behaviour results in a very well controlled modulation limitation.
The gain of filter OPAMP U209A sets the heartrate signal amplitude to 3.5V peak to peak maximum.
Together with the FSK signal, the modulation signal has a maximum amplitude of 5 volts peak to peak which is well below the maximum linear output range of OPAMP U 209A (8 volts peak to peak)

For 12.5 kHz channel spacing options (for France and Japan), switch U118A is closed. The voltage divider formed by R177 and R178 reduces the modulation signal amplitude to 3.5 volts peak to peak, resulting in a reduced RF deviation and thus a reduced RF bandwidth.

Analog switch U118B is normally open. It is used only for japanese options to send the transmitter ID signal after power on as required by the japanese ministery for telecommunications. This switch has no meaning for all other country options.

Circuits that limit power

The transmitter output power (max 4mW) is constrained by the bias conditions of Q2, and the load impedance as transformed by C16 and C11/L7/CV4 inside the VCXO module. For the design collector impedance (850 Ohms), the output power is constrained by voltage limiting for high transistor current bias and by current limiting for low transistor current bias. The output power has a maximum of 4mW for device current of 4.2mA. The transistor bias is a factory adjustment.