MONICOR Electronic Corporation

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Circuit Description
of the
Monicor Model M2000S
RF Modem

MONICOR ELECTRONIC CORP.
FCC ID: GES4BAM2000S
EXHIBIT #: 9A

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Circuit Description
Monicor M2000S RF Modem

I. Introduction

The M2000S consists of a Network Control Unit and a Portable RF modem. The Network Control Unit provides network control and communications between a host computer and up to 99 different peripheral devices linked via the M2000S Portable RF Modems. The M2000S is battery powered and operates in the UHF 450 - 470 MHz band. The RF data transmission rate is 4800 bits per second using FSK modulation with a nominal output power of 120 mW. Emission type is 11K2F1D.

B. M2000S

The circuitry in the M2000S is divided between the RF board and the digital board. The RF board contains the transmitter, receiver and antenna switch while the digital board contains a microprocessor, an RS-232 interface and signal processing circuitry. In addition each board contains DC switching circuitry and voltage regulation. The RF board is shielded by an enclosure formed by the case walls, and a metal cover.

1. RF Board

The M2000S transmitter is a 5 stage transmitter with a temperature compensated crystal controlled oscillator. A total of 7 transistor devices are used in the M2000S transmitter design. The nominal transmitter power output is 120 mW into a 50 ohm load with a nominal battery voltage of 7.5 volts dc.

The M2000S receiver is a dual conversion receiver using 6 transistor devices and 1 integrated circuit. The receiver employs low side receiver injection, a 21.4 MHz first I.F. and a 455 KHz second I.F.

Adjustable components are provided to align the receiver and to set the transmit frequency, receive frequency and transmit deviation to specification at final test.

2. Digital Board

The M2000S digital board acts as the network controller for the M2000S unit. The microprocessor controls the data flow from an RS-232 serial port, processes the messages, and will either transmit messages or receive messages via the RF board.

The digital board contains the signal processing circuitry for the transmitter and receiver circuits.

There are no adjustable components on this board.

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II. Detailed Description

A. RF Board

1. Transmitter

a. Oscillator/ Temperature Compensation

The transmitter uses a third overtone Colpitts crystal oscillator design with transistor Q10 as the active device. The operating frequency is set by third overtone crystal Y1. Capacitors C48 and C49, inductor L19 and resistor R35 insure that the crystal operates on the third overtone frequency. Frequency adjustment is provided by variable inductor L18. To reduce frequency variation due to change in battery voltage the oscillator is powered by a regulated +5 volt supply. The collector circuit for transistor Q10 is tuned to the 4th harmonic of Y1. The crystal frequency is equal to the transmit frequency divided by eight.

A temperature dependent voltage applied to varactor CR4, generated by compensation network consisting of resistors R62, R63 and R64 and thermistors RT1, RT2 and RT3. This network provides frequency stability exceeding $\pm$ .0005% over the temperature range of -30° to $+60^{\circ}$ centigrade. A temperature stable reference voltage (+5 volts) is provided to the temperature compensation network from the digital board through pin 6 of the interconnecting cable.

b. Buffer Amp/ Harmonic Filter

The output of the oscillator is amplified by transistor Q11 and the 4th harmonic of the oscillator crystal is selected by the bandpass filter consisting of capacitors C57 through C60 and inductors L23 through L25.

c. Multiplier

The output of the bandpass filter provides approximately a 0 dBm signal level to the base of transistor Q12. The collector load of transistor Q12 is tuned to the transmit frequency, provides broad band frequency doubling and an output power level of +7 dbm.

d. Pre-Driver / Driver

Capacitors C68 and C69 and inductor L28 match the output impedance of transistor Q12 to the driver transistor Q13. Transistor Q13 provides a nominal power gain of 5db and a power output of +12 dbm.

The broadband interstage matching network between the driver and the final output transistor Q14 consists of inductors L29 and L30 and capacitors C74 and C75. The final output transistor Q14 which operates Class C draws approximately 100 ma from the +7.5 volt supply and provides a nominal 120 mW power output. Driver amplifier harmonic filtering is achieved by a 3 section low pass matching and filter network consisting of capacitors C79 and C80 and inductor L33.

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e. Modulator

The modulation signal is passed from the digital board to the transmitter through pin 3 of the interconnecting cable. The modulation signal level and frequency content are well defined by the signal processing circuitry on the digital board. The modulation signal is attenuated by the resistive divider consisting of resistor R66 and the deviation adjustment variable resistor R65 which connects to varactor CR4 and frequency modulates the transmit oscillator.

2. Receiver

a. Helical Filters/ RF Amp

The RF preamplifier transistor Q1 is broadband low noise amplifier with input and output selectivity provided by tunable filters FL1 and FL2. The output of the RF preamplifier is impedance matched to the mixer transistor Q2 using capacitors C5 through C8 and inductors L2 and L3.

b. Mixer/ Crystal Filter/ IF Pre-amp

The collector of transistor Q2 is tuned to the desired I.F. of 21.4MHz using capacitors C14 and C15, inductor L14 and resistor R10. This network provides a proper impedance match to the 4 pole crystal filter FL3 and FL4. The output of the 4 pole crystal filter is impedance matched to transistor Q3 by capacitor C17 and inductor L5. Transistor Q3 serves as an IF preamplifier.

c. Integrated IF Circuit

The integrated IF circuit U2 provides IF limiting gain, 2nd local oscillator at 20.945MHz, and FM detection with a quadrature discriminator using inductor L6. The discriminator output contains the recovered data and is passed to the digital board through pin 7 of the interconnecting cable.

d. Oscillator/ Harmonic Filter / Multiplier

The receive oscillator is similar in design and function to the transmit oscillator with transistor Q4 as the active device. The operating frequency is set by third overtone crystal Y2. Capacitors C30 and C31, inductor L8 and resistor R21 insure that the crystal operates on the third overtone frequency. Frequency adjustment is provided by variable inductor L7. To reduce frequency variation due to change in battery voltage the oscillator is powered by the regulated +5 volt supply. The collector circuit for transistor Q4 is tuned to the 4th harmonic of Y2. The crystal frequency is equal to the difference of the receive frequency minus 21.4 MHz divided by eight.

A temperature dependent voltage applied to varactor CR5, generated by compensation network consisting of resistors R67, R68 and R69 and thermistors RT4, RT5 and RT6. This network provides frequency stability exceeding $\pm$ .0005% over the temperature range of -30° to $+60^{\circ}$ centigrade.

Additional filtering of the 4th harmonic of the crystal is provided by capacitors C98 and C34 through C37 and inductors L10 through L12. The 4th harmonic of the oscillator is doubled in transistor multiplier Q5. This is a broadband multiplier and provides a nominal injection level of -10dBm to the mixer stage Q2.

3. Antenna Switch

A PIN diode T/R switch is incorporated to provide antenna switching between receive and transmit sections. Additional harmonic filtering is provided by the T/R switch capacitors C84 and C85 and inductor L35. Connection to the daughter board P.A. is through a short section of RF coax cable.

4. DC Circuitry

a. Input Power

The unit is supplied 7.5 volts nominal from the digital board connected through pin 4 of the interconnecting cable. Two ground lines are provided by pins 2 and 8 of the interconnecting cable. Total transmitter current drain is 250ma maximum. A regulated +5 volt supply is also provided from the digital board through pin 6 of the interconnecting cable.

b. T and R Switches

A transmit enable signal is provided by the digital board through pin 1 of the interconnecting cable. This signal enables the transmit switch, consisting of transistors Q8 and a voltage regulator, applying voltage to the transmitter. In addition switched 7.5 volts is applied to the antenna T/R switch and voltage regulator U1.

A receive enable signal is provided by the digital board through pin 5 of the interconnecting cable. This signal enables the receive switch, consisting of transistors Q6 applying voltage to the receiver and voltage regulator U3.

c. +5 Volt Regulators

The voltage regulator U1 supplies regulated +5 volts to most of the transmitter power chain and transmitter oscillator. The voltage regulator U3 supplies regulated +5 volts to the receiver. U4 supplies regulated 5 volts to Q13.

5. Active Devices

The following main active devices are used on the M2000S RF board:

Q1	RF Post-amplifier
Q2	Mixer
Q3	IF Preamplifier
Q4	Oscillator
Q5	Frequency Multiplier
Q6	Receiver Power Switch
Q8	Transmitter Power Switch
Q10	Oscillator
Q11	Buffer Amplifier
Q12	Frequency Multiplier
Q13	Driver Amplifier
Q14	Final Output Amplifier
U1	Transmitter +5 Volt Regulator
U2	Integrated IF Circuit
U3	Receiver +5 Volt Regulator
U4	Transmitter +5 Volt Regulator

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B. Digital Board

1. Microprocessor/ Software

The microprocessor U1 controls the data flow from an RS-232 serial port, processes the messages, and will either transmit messages or receive messages via the RF board. The microprocessor coordinates this message passing and control with the software resident in EPROM U3. The microprocessor clock operates at the Y1 crystal frequency of 7.3728 MHz. Messages and other processing statistics are maintained in RAM U2 and EEROM U4.

The microprocessor independently controls both the receiver and the transmitter enable signals which connect to the RF board through pins 1 and 5 of the interconnecting cable. During transmit the operator is notified of the transmit condition via a green LED display.

2. RS 232 Interface

Communication with a digital computer peripheral or data collection component which provides asynchronous RS-232 data is accomplished by connecting the device to the RS-232 connector on the digital board. The RS-232 transmitter/receiver U14 provides the signal conversion between a binary format and an RS-232 format.

3. Signal Processing Circuitry

a. Transmit

i. Manchester Encoding

During transmit digital data is encoded with a Manchester Encoder-Decoder U16. This integrated circuit converts the digital binary signals to Manchester encoded format with the frequency of the output shifting between 2400 and 4800 Hz with a fixed amplitude.

ii. Modulation Filter/ TX Output

The voltage limited Manchester encoded data is filtered by a 6 section active low pass filter consisting of operational amplifiers U11-1, U11-2 and U11-3 with their associated components. This is a transitional filter design with linear phase in the pass band and a Butterworth response in the stop band. The conditioned transmit audio signal is passed to the transmitter section through Pin 3 of the interconnecting cable and provides FSK modulation to the transmitter.

b. Receive

i. Receive Audio Filter

During receive the received FSK signal from the RF board on pin 7 of the interconnecting cable is routed through the analog switch U15 and filtered by the active filter consisting of operational amplifier U11-2 and U11-3.

ii. Detector

Then the analog data is amplified and detected by operational amplifiers U11-4 and U12-4.

iii. Manchester Decoder

The detected receive data is applied to the Manchester encoder-decoder U16 and is converted to binary format for the microprocessor U1.

4. DC Circuitry

a. Battery Input/ On-Off Switch

Power is supplied to the digital board directly from the RJ-45 Connector through the power switch SW1. Power for the RF board is routed through and controlled by the digital board.

b. +5 Volt Regulator

Voltage regulator U17 provides accurate voltages for the digital board circuitry.

c. Low Battery Detector

The digital board contains a low battery detector U13. When a low battery is detected the microprocessor signals the operator with an optional flashing red LED indicator. If the operator continues to operate in the low power condition a second sensing circuit will halt the microprocessor, forcing a reset condition, which forces the transmitter to the OFF condition.

5. Active Devices

The following active devices are used on the digital board:

U1	Micro-controller
U2	Static RAM 8K x 8
U3	EPROM 32K x 8
U4	EEROM 1K x 1
U5	Octal Buffer and Line Driver
U6	Octal D Transparent Latch
U7	Quadruple 2-Input Positive OR
U8	Quadruple 2-Input Positive AND
U9	Hex Inverter
U10	Dual 4-Bit Binary Counter
U11	Quad Operational Amplifier
U12	Quad Operational Amplifier
U13	Low Battery Detector
U14	RS-232 Interface
U15	Quad Transmission Gate
U16	Manchester Encode/Decode
U17	IC +5 Volt Regulator