FSK Modem System

GENERAL DESCRIPTION

The XR-14412 contains all the necessary circuitry to construct a complete FSK modulator/demodulator (MODEM) system. Included is circuitry for pin-programmable frequency bands, either U.S. or foreign (CCITT) standards for low-speed MODEMS. The XR-14412 provides T^2L-compatible inputs and outputs. Included in the XR-14412 are features for self-testing and an echo suppression tone generator. The XR-14412 utilizes complementary MOS technology for low-power operation.

FEATURES

Simplex, Half-Duplex, and Full-Duplex Operation
Crystal Controlled
Answer or Originate Modes
Single Supply Operation
Self-test Mode
Selectable Data Rates—300, or 600 bps
T^2L- or CMOS-Compatible Inputs and Outputs
Echo Suppressor Disable Tone Generator
U.S. or Foreign (CCITT) Compatible

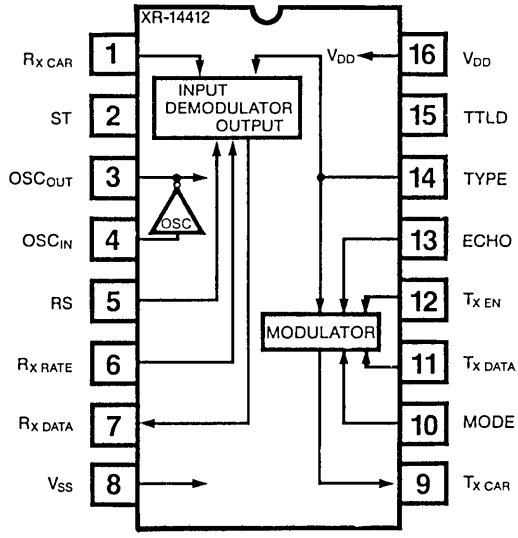
APPLICATIONS

Stand-Alone MODEMS
Remote Terminals
Acoustical Couplers
Built-in MODEMS

ABSOLUTE MAXIMUM RATINGS

Power Supply	
XR-14412F	15V
XR-14412V	6V
Any Input Voltage	V_{DD} + .5V to V_{SS} − .5V
Output Current from any Pin (Except Pins 7 or 8)	10 mA
Output Current from Pin 7 or 8	35 mA
Operating Temperature Range	−40°C to +85°C
Storage Temperature Range	−65°C to +150°C
Power Dissipation	
Ceramic Package	1000 mW
Derate Above T_A = +25°C	8.0 mW/°C
Plastic Package	625 mW
Derate Above T_A = +25°C	5.0 mW/°C

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part Number	Package	Operating Voltage Range
XR-14412FP	Plastic	4.75V to 15V
XR-14412VP	Plastic	4.75V to 6V
XR-14412FN	Ceramic	4.75V to 15V
XR-14412VN	Ceramic	4.75V to 6V

SYSTEM DESCRIPTION

The XR-14412 is basically comprised of two main components; the FSK modulator and demodulator. The modulator serves to convert or encode incoming binary data into two discrete frequencies. The pair of frequencies generated are determined by which standard (US or CCITT), and mode (answer or originate), are selected. These frequencies are within a range suitable for transmission over the telephone lines. The demodulator performs the opposite function by decoding the received pairs of frequencies into binary data. It also responds to those frequencies selected by the standard and mode selected. All functions within the XR-14412 are digital and controlled by a master clock. This clock is generated by an external crystal connected between the OSC_{IN} and OSC_{OUT} pins. As well as being used internally by the 14412, the clock may be used to clock other circuitry by using the OSC_{OUT} pin.

XR-14412

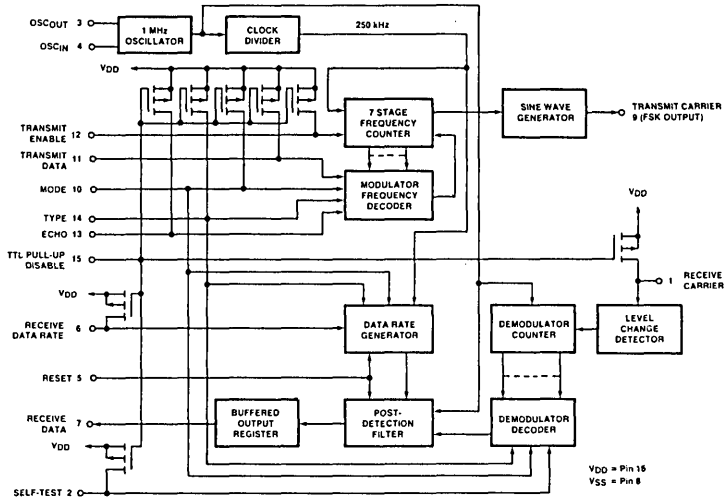
ELECTRICAL CHARACTERISTICS

SYMBOL	PARAMETERS	V_{DD}** Vdc	−40°C MIN	−40°C MAX	+25°C MIN	+25°C TYP	+25°C MAX	+85°C MIN	+85°C MAX	UNIT
V_{OL}	Output Voltage "0" Level	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
	$V_{IN} = V_{DD}$ or 0	10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
V_{OH}	"1" Level	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
	$V_{IN} = 0$ or V_{DD}	10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
V_{IL}	Input Voltage* "0" Level									Vdc
	(V_O = 4.5 or 0.5 Vdc)	5.0	—	1.5	—	2.25	1.5	—	1.5	
	(V_O = 9.0 or 1.0 Vdc)	10	—	3.0	—	4.50	3.0	—	3.0	
	(V_O = 13.5 or 1.5 Vdc)	15	—	4.0	—	6.75	4.0	—	4.0	
V_{IH}	"1" Level									Vdc
	(V_O = 0.5 or 4.5 Vdc)	5.0	3.5	—	3.5	2.75	—	3.5	—	
	(V_O = 1.0 or 9.0 Vdc)	10	7.0	—	7.0	5.50	—	7.0	—	
	(V_O = 1.5 or 13.5 Vdc)	15	11.0	—	11.0	8.25	—	11.0	—	
	Pins 12, 15	5 to 15	0.75	—	0.8	2.0	—	0.85	—	
I_{OH}	Output Drive Current									mAdc
	(V_{OH} = 2.5) (Pin 7)	5	−0.62	—	−0.5	−1.5	—	−0.35	—	
	(V_{OH} = 9.5)	10	−0.62	—	−0.5	−1.0	—	−0.35	—	
	(V_{OH} = 13.5)	15	−1.8	—	−1.5	−3.6	—	−1.1	—	
I_{OL}	(V_{OL} = 0.4)	4.75	2.3	—	2.0	4.0	—	1.6	—	mAdc
	(V_{OL} = 0.5)	10	5.3	—	4.5	10	—	3.6	—	
	(V_{OL} = 1.5)	15	15	—	13	35	—	10	—	
I_{IN}	Input Current (Pin 15 = V_{DD})	—	—	—	—	—	±0.00001	±0.1	—	—	μAdc
I_P	Input Pull-up Resistor Source Current (Pin 15 = V_{SS}, V_{IN} = 2.4 Vdc) Pin 1,2,5,6,10,11,12,13,14	5	285	—	250	460	—	205	—	μAdc
C_{IN}	Input Capacitance	—	—	—	—	5.0	—	—	—	pF
I_T	Total Supply Current (Pin 15 = V_{DD})	5	—	4.5	—	1.1	4.0	—	3.5	mAdc
		10	—	13	—	4.0	12	—	11	
		15	—	27	—	8.0	25	—	23	
ACC	Modulator/Demodulator Frequency Accuracy (Excluding Crystal)	5 to 15	—	—	—	0.5	—	—	—	%
V_{2H}	Transmit Carrier Output 2nd Harmonic	5 to 10	—	—	−20	−26	—	—	—	dB
		10 to 15	—	—	−25	−32	—	—	—	
V_{OUT}	Transmit Carrier Output Voltage (R_L = 100 kΩ) (Pin 9)	5	—	—	0.2	0.30	—	—	—	V_{RMS}
		10	—	—	0.5	0.85	—	—	—	
		15	—	—	1.0	1.5	—	—	—	
t_{TLH}, t_{THL}	Receive Carrier Rise and Fall Times (Pin 1)	5	—	15	—	—	15	—	15	ns
		10	—	5.0	—	—	5.0	—	5.0	
		15	—	4.0	—	—	4.0	—	4.0	

*DC Noise Immunity (V_{IL},V_{IH}) is defined as the maximum voltage change from an ideal "0" or "1" input level, that the circuit will withstand before accepting an erroneous input.

**Note: Only 5-Volt specifications apply to XR-14412VP devices.

EQUIVALENT SCHEMATIC DIAGRAM



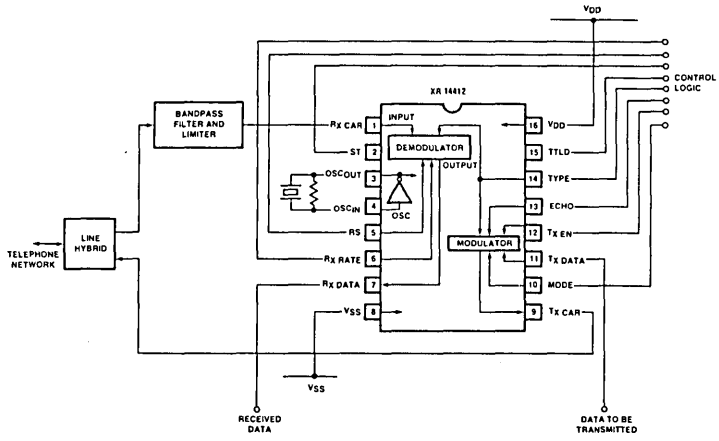


Figure 1. Typical Connection of the XR-14412 in a Complete Modem System

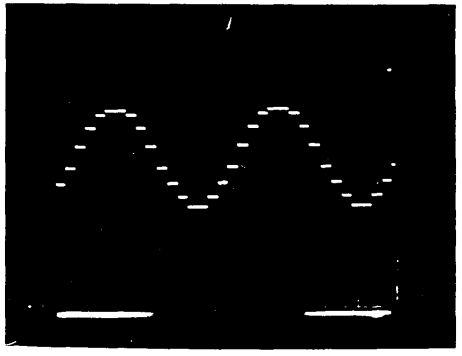


Figure 2. Transmit Carrier Sine Wave

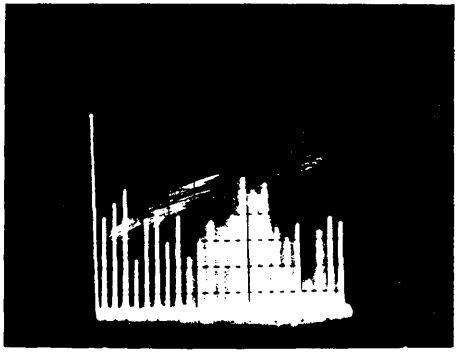


Figure 3. Typical Transmit Carrier Frequency Spectrum

PRINCIPLES OF OPERATION

Figure 1 shows the typical connection for the XR-14412 as a modem system. The system has four main component blocks. They are FSK modulator and demodulator, which are contained in the XR-14412, the bandpass filter, and the line hybrid. The function of each block is as follows:

Line Hybrid: This block acts to direct received FSK information to the bandpass filter and demodulator, while the FSK modulated carrier is directed to the telephone network.

Bandpass Filter and Limiter: Received FSK information is filtered by this block to remove extraneous signals received from the telephone network. The local transmitter carrier is also filtered out. The limiter stage is used to provide the XR-14412 with a TTL- or CMOS-compatible signal.

Modulator: This block, contained in the XR-14412, converts serial binary data into an FSK-encoded carrier signal. The carrier frequency is controlled by the mode and type inputs. Input data must be TTL- or CMOS-compatible. The output of the modulator is a digitally synthesized sine wave (see Fig. 2), with its harmonic content shown in Fig. 3.

Demodulator: This is used to convert an FSK-encoded carrier signal into serial data. The rate at which data can be received and decoded is controlled by the R_X rate and type control inputs.

Description of Control Inputs—Refer to Figure 1 and Table 1.

Type (Pin 14): This input is used to select either U.S. or CCITT operating frequencies.

Transmit Data ($T_{X\ DATA}$, Pin 11): This is the input for binary serial data.

Transmit Carrier ($T_{X\ CAR}$, Pin 9): This output provides a digitally synthesized sine wave derived from a 1 MHz crystal oscillator. The carrier frequency is controlled by the type and mode inputs.

Transmit Enable ($T_{X\ ENABLE}$, Pin 12): This pin is used to enable and disable the modulator, or $T_{X\ CAR}$, output.

Mode (Pin 10): In conjunction with the type input, the carrier frequencies are selected with this input.

Echo (Pin 13): This input is used to program the modulator to produce a 2100-Hz tone for disabling line echo suppressors.

Receive Data ($R_{X\ DATA}$, Pin 7): This is the binary data output resulting from demodulating the FSK-encoded receive carrier.

Receive Carrier ($R_{X\ CAR}$, Pin 1): The FSK-encoded receive carrier is fed into this input. The input signal must have either TTL or CMOS logic levels with a duty cycle of 50% ± 4%.

Receive Data Rate ($R_{X\ RATE}$, Pin 6): This input is used to adjust the demodulator for the incoming data rate.

Self-Test (ST, Pin 2): When a high level (ST = "1") is placed on this input, the demodulator is switched to the modulator frequency and demodulates the transmitted FSK signal.

Reset (R_S, Pin 5): This input can be used to disable the demodulator. With reset at logic "1", the demodulator output is forced high, logic "1". For normal operation, reset is tied low, logic "0".

Crystal (OSC_{IN}, OSC_{OUT}, Pin 4, Pin 3, respectively): A 1.0 MHz crystal is connected between these two pins for utilizing the on-chip oscillator. An external oscillator can also be used by feeding it into the OSC_{IN}, Pin 4, input. In the crystal mode, external parasitic capacitance, including crystal shunt capacitance, must be less than 9 picofarads at Pin 4.

TTL Pull-Up Disable (TTLD, Pin 15): All of the inputs to the XR-14412 have on-chip pull-up resistors. These pull-up resistors may be disabled when interfacing to CMOS logic by taking the TTLD input to a logic "1". For TTL logic interfacing, TTLD is tied to a logic "0".

APPLICATIONS

Figure 4 shows the XR-14412 connected as a 300-baud FSK modem. Amplifiers A_1 – A_3 are connected as bandpass filters to remove extraneous signals picked up from the phone line as well as local oscillator isolation. A_4 is connected as a comparator to provide limiting to the received carrier and provide the necessary square wave for Pin 1, $R_{X\ CAR}$, input. A_5 acts as a line hybrid. It provides amplification to the received carrier while attenuating the local oscillator, trying to go toward the bandpass filter. A_6 is simply used to buffer the $T_{X\ CAR}$, Pin 9, output of the XR-14412.

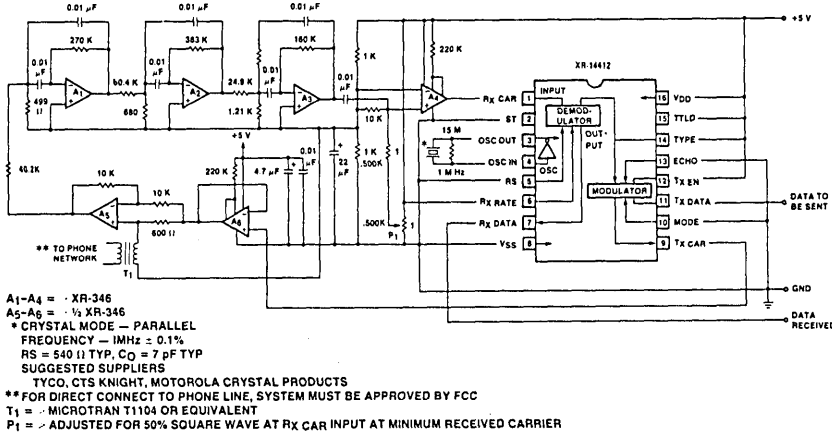
The configuration as shown is for answer mode, as the mode pin is at a logic "0". This circuit will work over a received carrier range of −10 dBm to −40 dBm.

Figure 5 shows a connection using the two spare amplifiers from the XR-346 to provide a carrier detect output. Here A_7 acts to amplify and peak detect the received carrier from the output of the bandpass filter. This voltage is then fed to A_8, connected as a comparator, to provide a logic output for carrier detect indication.

Table 1. Input/Output Controls

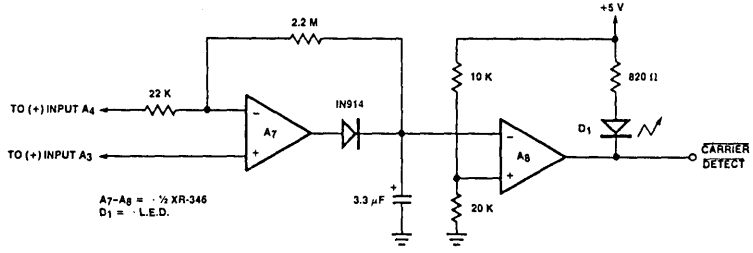
INPUTS					OUTPUTS				
TX ENABLE (12)	RX RATE (6)	MODE (10)	TYPE (14)	ECHO (13)	STANDARD	MODE	TX DATA	TX CARRIER	BAUD RATE
1	0	1	1	0	US	ORIGINATE	MARK 1	1270 Hz	600 bps
1	0	1	1	0	US	ORIGINATE	SPACE 0	1070 Hz	600 bps
1	0	0	1	0	US	ANSWER	MARK 1	2225 Hz	600 bps
1	0	0	1	0	US	ANSWER	SPACE 0	2025 Hz	600 bps
1	1	1	1	0	US	ORIGINATE	MARK 1	1270 Hz	300 bps
1	1	1	1	0	US	ORIGINATE	SPACE 0	1070 Hz	300 bps
1	1	0	1	0	US	ANSWER	MARK 1	2225 Hz	300 bps
1	1	0	1	0	US	ANSWER	SPACE 0	2025 Hz	300 bps
1	1	1	0	0	CCITT	CHANNEL 1	MARK 1	980 Hz	300 bps
1	1	1	0	0	CCITT	CHANNEL 1	SPACE 0	1180 Hz	300 bps
1	1	0	0	0	CCITT	CHANNEL 2	MARK 1	1650 Hz	300 bps
1	1	0	0	0	CCITT	CHANNEL 2	SPACE 0	1850 Hz	300 bps
1	X	0	0	1	CCITT	CHANNEL 2	— 1	2100 Hz	—
0	X	X	X	X	—	—	— —	NO OUTPUT	—

1 — Input or output is at a digital high, refer to Electrical Characteristics for exact value.
0 — Input or output is at a digital low, refer to Electrical Characteristics for exact value.
X — Can be either a 1 or a 0.



A1–A4 = · XR-346
A5–A6 = · ½ XR-346
* CRYSTAL MODE — PARALLEL
FREQUENCY — 1MHz ± 0.1%
RS = 540 Ω TYP, C_O = 7 pF TYP
SUGGESTED SUPPLIERS
TYCO, CTS KNIGHT, MOTOROLA CRYSTAL PRODUCTS
** FOR DIRECT CONNECT TO PHONE LINE, SYSTEM MUST BE APPROVED BY FCC
T1 = · MICROTRAN T1104 OR EQUIVALENT
P1 = ⌿ ADJUSTED FOR 50% SQUARE WAVE AT RX CAR INPUT AT MINIMUM RECEIVED CARRIER

Figure 4. Complete 300 Baud, Answer Mode, FSK Modem



A7–A8 = · ½ XR-346
D1 = · L.E.D.

Figure 5. Carrier Detect Circuit

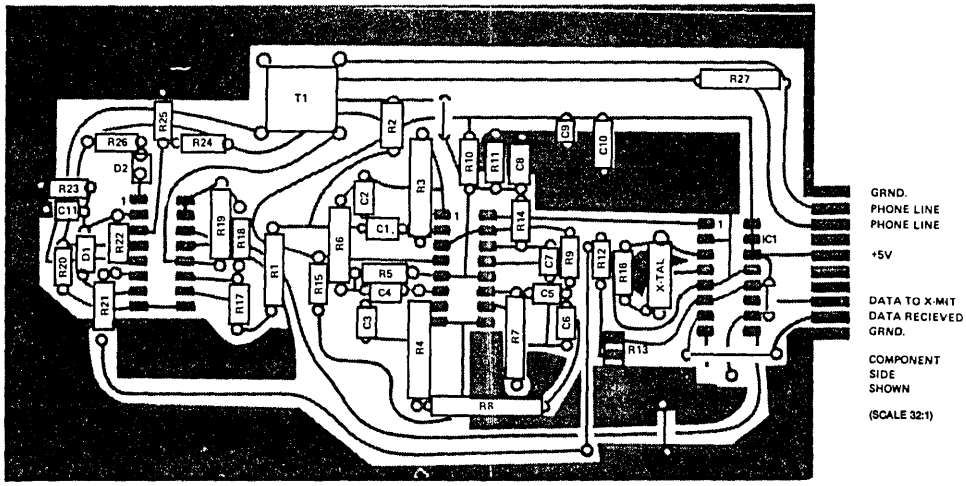


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Figure 6. Complete FSK Modem Printed Circuit Board Layout (Circuit Shown in Figure 4)

Table 2. Parts List for 300 Baud MODEM.

*1% tolerance; all other resistors are 1/4W, 10%; all capacitors are 10%.
Resistors are in ohms and capacitors are in μF.

	ANSWER	ORIGINATE		ANSWER	ORIGINATE
*R1	40.2K	47.5K	R24	20K	20K
*R2	499	191	R26	500	500
*R3	270K	357K	*R27	600	600
*R4	383K	270K			
*R5	680	160	C1–C6	.01	.01
*R6	60.4K	39.4K	C7	.1	.1
*R7	160K	160K	C8	22	22
*R8	24.9K	20K	C9	.01	.01
*R9	1.21K	360	C10	4.7	4.7
R10–R11	1K	1K	C11	3.3	3.3
R12	500K	500K			
R13	500K Pot	500K Pot	D1	IN914	IN914
R14	10K	10K	D2	LED	LED
R15	220K	220K			
R16	15M	15M	T1	Microtran	Microtran
R17–R18	10K	10K		T1104	T1104
*R19	600	600			
R20	220K	220K	CRYSTAL	1 MHz ± .1%	1 MHz ± .1%
R21	22K	22K			
R22	2.2M	2.2M	A1–A8	XR-346	XR-346
R23	3.0K	3.0K			
R24	20K	20K	MODEM IC_1	XR-14412VP	XR-14412VP
R25	30K	30K			