

# RF Modems — Part II

Part I provided an introduction to the subject of RF modems along with a description of useful ICs. Designs for single channel units were also presented. Part II covers various multiple channel (frequency agile) modem designs.

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## Multiple Channel (Frequency Agile) Modems

Frequency agile modems are described under two categories. "Fully frequency agile" and "paired channels." Either modem type can be programmed at will for operation on any one of many possible channels. The term "fully frequency agile" is being reserved for modems that are capable of having their transmitters and receivers programmed independent of each other. This allows the transmit/receive frequency separation or offset to be varied. The term "paired channels" is being used to describe modems whose transmit and receive frequencies have a built-in separation which remains constant as the modem is programmed to different channels (channel pairs).

## Fully Frequency Agile Modem

One implementation of a fully frequency agile modem is described by the block diagram in Figure 1 and the schematic diagram in Figure 2. Nominal performance data and other characteristics of the modem are given in Table 1 and various modem signal frequencies and synthe-

**Table 1**  
Summary of Characteristics for the Fully Frequency Agile RF Modem Described in Figures 1 and 2

Type:	<b>General</b> Fully frequency agile
Maximum Data Rate:	125 Kbps modem (limited by digital interface circuits to 50 Kbps)
Modulation:	FSK
Number of Channels:	Eleven as shown, but the limit is set by the transmit filter bandwidth employed. The number of channels can be extended to approximately 32 with an appropriate filter. The maximum useful bandwidth is dictated by the lowest injection frequency (10.2 MHz) to the transmit mixer.
Channel Spacing:	Three times deviation or 300 KHz
Transmitter Output Level:	-6 dBmv to +30 dBmv (adjustable)
RF Terminal Impedance:	75 ohms nominal (in band)
Transmit On/Off Ratio:	>80 dB
RTS Delay:	≤5 microseconds
Receiver IF Frequency:	10.7 MHz (center frequency)
Receiver IF Bandwidth:	±75 KHz nominal
DCD Delay:	≤5 microseconds
Power Requirements:	+5V <sub>DC</sub> , +12V <sub>DC</sub> , GND
D <sub>0</sub> — D <sub>7</sub> :	<b>Digital Interface Lines</b> Channel control data and address inputs for the transmit and receive PLL frequency synthesizers. Also, the ACIA data input and output.
A <sub>0</sub> , A <sub>4</sub> , SCS, E:	Address and clock input to the ACIA
A <sub>1</sub> , E, SCS:	Strobe input for the transmitter PLL
A <sub>2</sub> , E, SCS:	Strobe input for the receiver PLL
Q:	Transmit and receive clock input
Cart:	Interrupt request output to the computer
R/W:	Read/Write input into the ACIA from the computer

sizer programming information are summarized in Table 2. (Keep in mind that the transmitter and receiver can be programmed independent of each other i.e. one may choose to have the modem transmit on channel one and receive on channel five, etc.)

One may observe from Figures 1 and 2 that the modem consists of four major sections (not counting the MC6850 Asynchronous Communications Interface Adapter, ACIA, since it is common for this function to be considered as part of the digital interface system rather than the modem itself):

- Transmitter Phase-Locked-Loop (PLL) Frequency Synthesizer
- FSK Transmitter
- FSK Data Receiver
- Receiver PLL Frequency Synthesizer

The transmitter frequency synthesizer generates an error signal which is filtered and amplified by the loop filter and becomes a control voltage for the transmitter VCO. The error signal and thus the VCO's frequency is a function of the digital programming information provided to the MC145145 PLL IC. This information is under control of software and may be altered to fit particular application requirements. Since the 145145 is specified for operation to 15 MHz max. At 5V<sub>DC</sub> (-40°C to +85°C) a prescaler is used to reduce the VCO's frequency to acceptable values. Although smaller divide values could be used, the divide-by-20 MC3396 prescaler provides a good solution which is both low cost and in a compact eight pin package. The receiver frequency synthesizer is of like design and controls the receiver's VCO which provides the injection signal for the receiver mixer. Both the receiver oscillator and mixer are part of the MC3356 data receiver IC.

The transmitter and receiver synthesizers are independently programmed via their data (D<sub>0</sub>, D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub>) and address (A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>) input lines. These lines (and also the MC6850's data inputs) share a common data bus. The appropriate IC is selected by its strobe (ST) or chip select (CS2) input signal. Other single chip PLL synthesizer choices exist in the MC14145 family and could be used rather than the MC145145 devices. The other family members differ from the MC145145 primarily in the method used for channel programming. For example, the MC145155 or 57 employ a serial data stream and the MC145151 requires fourteen parallel data bits.

The transmitter section consists of the PLL controlled high frequency transmitter VCO and a lower frequency (nominally 10.2 MHz) oscillator. The transmit VCO determines the desired transmit channel and provides frequency stability since it is locked to the 10.24 MHz crystal refer-

**Table 2**  
**Signal Frequencies and Channel Programming**  
**Information for the Modem Described in Figures 1 and 2**

Channel Number	Channel Center (MHz)	Rcvr VCO Freq (MHz)	Trans VCO Freq (MHz)	Trans PLL ÷ N (Note 1)	Rcvr PLL ÷ N (Note 1)
0	42.5	53.2	52.7	527	532
1	42.8	53.5	53.0	530	535
2	43.1	53.8	53.3	533	538
3	43.4	54.1	53.6	536	541
4	43.7	54.4	53.9	539	544
5	44.0	54.7	54.2	542	547
6	44.3	55.0	54.5	545	550
7	44.6	55.3	54.8	548	553
8	44.9	55.6	55.1	551	556
9	45.2	55.9	55.4	554	559
10	45.5	56.2	55.7	557	562

Notes:

$$1. \text{Trans } \div N = \frac{\text{Trans VCO}}{(P)(f_R)}; \text{Rcvr } \div N = \frac{\text{Rcvr VCO}}{(P)(f_R)}$$

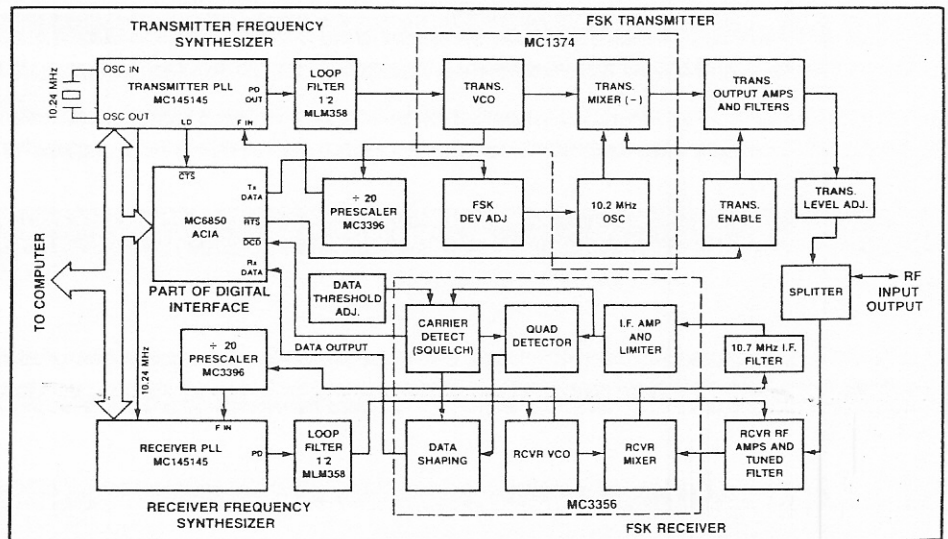
Where:

$$P = \text{PLL Prescaler Divide Value} = 20$$

$$f_R = \text{Phase Detector Comparison Freq} = \frac{10.24 \text{ MHz}}{\text{Ref Divider}} = \frac{10.24 \text{ MHz}}{2048} = 5 \text{ KHz}$$

$$2. \text{Trans VCO} = \text{Channel Freq} + 10.2 \text{ MHz}$$

$$3. \text{Rcvr VCO} = \text{Channel Freq} + \text{Rcvr IF} = \text{Channel Freq} + 10.7 \text{ MHz}$$



**FIGURE 1. Fully frequency agile RF modem block diagram.**

ence oscillator housed in the transmitter PLL IC. A ceramic resonator adds stability to the lower frequency oscillator yet allows it to be frequency shift keyed or modulated by the serial data bit stream (MC6850 T<sub>x</sub> data output). The two oscillator signals are applied to the transmitter mixer. The mixer's difference frequency product is allowed to pass through the transmitter's output filters/amplifiers and becomes the FSK transmit signal. Both oscillators and the mixer are

provided by the MC1374 IC. To minimize start-up time, both transmitter oscillators run continuously. The transmit output signal, however, is inhibited when desired by taking the RTS (Ready to Send) line high which causes the transmit mixer and output amplifiers to be biased off.

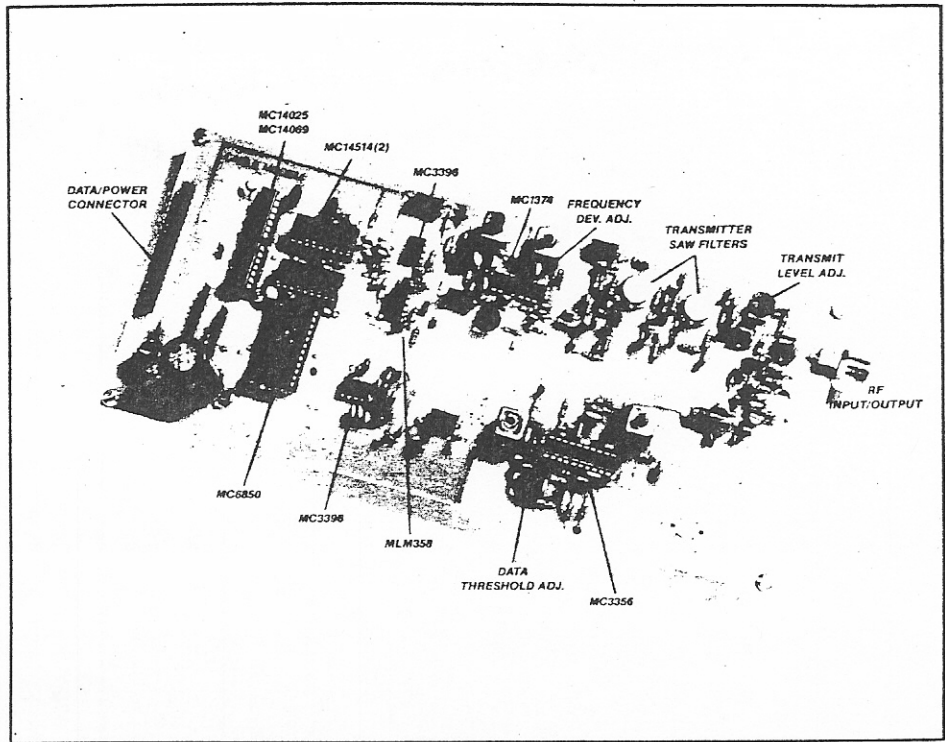
The band of channels the transmitter can be made to operate over is primarily dictated by its output filters. Standard 45 MHz TV IF SAW filters are being used and this unnecessarily restricts the trans-

mitter's total bandwidth to approximately 3 MHz.

The MC3356 data receiver IC preceded by a discrete RF amplifier and a varactor tuned filter stage make up the modem's receiver section. The filter is tuned by the same synthesizer error voltage that controls the receiver's VCO. The receiver's VCO is tuned such that only the incoming RF channel to be received is converted to the receiver's IF passband and allowed to pass through the 10.7 MHz IF filter. The IF filter used is a standard product manufactured for FM broadcast receiver applications. Other IF values and filters of various bandwidths can also be used with the 3356.

The modem just described can, within limits, be modified to serve different performance requirements. For example:

- Using a wider bandwidth filter for the receiver IF will allow the MC3356 to receive higher data rates. Higher data rates will, of course, also require the RF channel spacings to increase and thus the number of channels possible in a given system bandwidth allocation decreases.
- Using transmitter output filters having different passbands will allow other channel frequencies to be generated. Also, the use of wider bandwidth filters



Photograph of fully frequency agile RF modem employing the MC3356 data receiver IC and described in Figures 1 and 2.

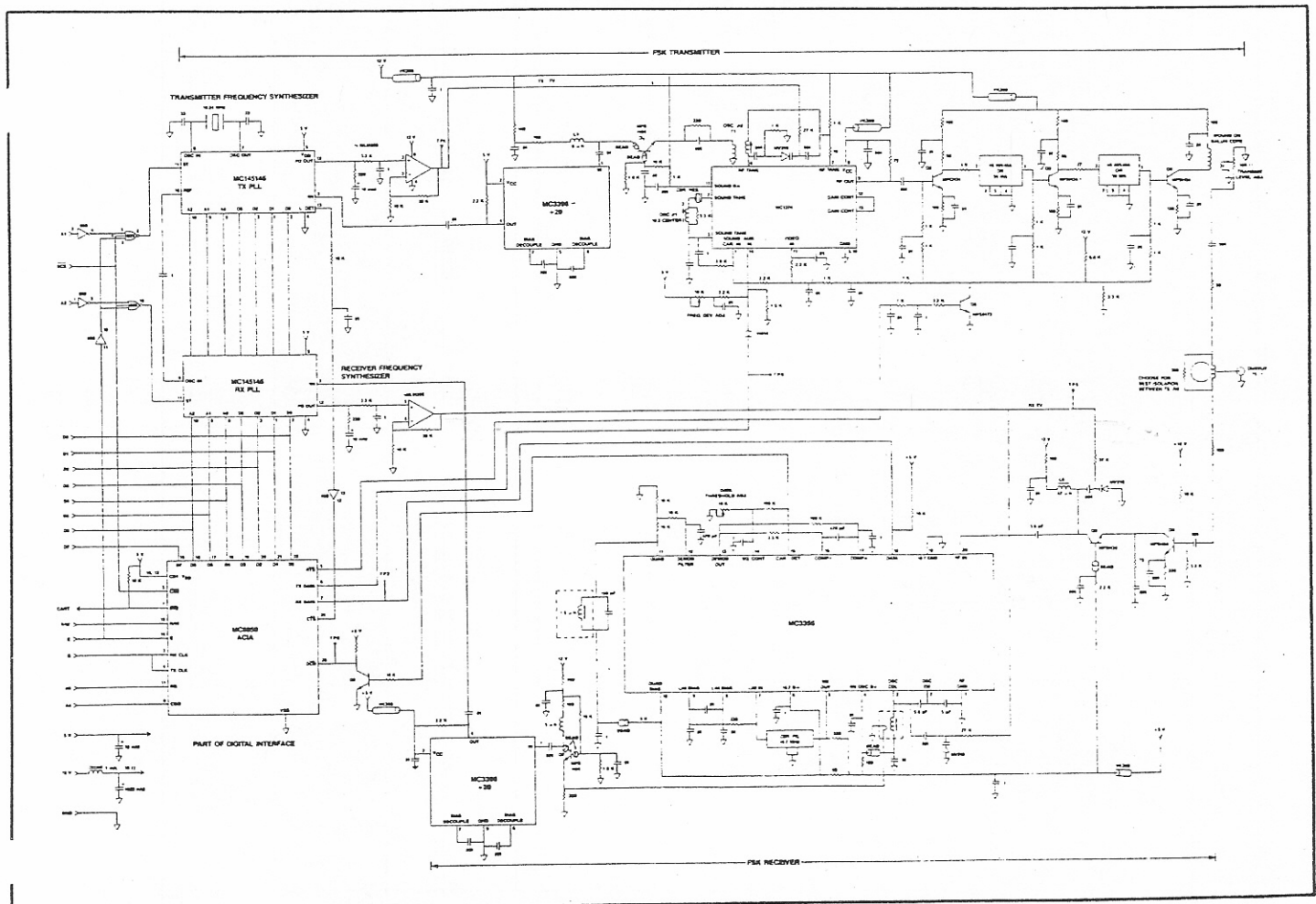


FIGURE 2. Fully frequency agile RF modem schematic.

