FM Packet Deviation Meter

Put your packet station on the money for 20 bucks.

by Steven R. Sampson N5OWK

There are a lot of "plug-and-play" amateurs today, and many are working FM packet. While many traditional amateurs can draw a Bessel function chart with their eyes closed, this new breed of ham is a lot less technical. Many have a hard time digesting the concepts of bandwidth and frequency drift, never mind deviation. This article will help. It shows how to build a useful instrument, explains exactly why it is needed, and challenges the less-than-technical ham to expand his or her electronic expertise.

Like most newcomers to VHF packet radio, I set my system up by connecting all the cables and getting on the air. It wasn't too long before I checked my audio levels. Unlike voice, there aren't a lot of people who complain if your packet audio is too hot or too weak. Actually, I don't think anyone locally listens to the packet tones because I was hotter than a two dollar pistol. First I set my receive audio level, and this was simply an increase in volume until the TNC Data Carrier Detect (DCD) light illuminated, followed by a squelch adjustment (some TNCs can operate without squelch, and this is the better way to go). You can make a pretty good judgement about setting the transmitter audio level by listening with another radio, but the correct method is to use a deviation meter. You won't find inexpensive deviation meters at any radio store, so you're going to have to build one. This article presents a deviation meter based on William Crowl N6MWS's design from the January 1990 issue of *73 Amateur Radio Today*. The circuit uses parts available at Radio Shack, and will run about $20. Bill's circuit featured many other useful functions which I deleted from this design to make it a simple one-evening project.

Figure 1 shows the schematic. This meter is based on simple AC voltmeter principles. It picks up the AC voltage from the receiver's FM detector, amplifies, rectifies, and drives the meter movement. The first stage takes the AC voltage from a scanner or your ham rig's discriminator output, blocks the DC, and amplifies it with a gain of three. The next two op amp stages form a clever full-wave rectifier function. The positive half of the input waveform passes around the second op amp to the third, while the negative half is inverted by the second stage,

Photo A. The FM Packet Deviation Meter makes this station complete.

causing a positive output to the third stage. Bill recommends that you not change the values of the second-stage resistors. The circuit is based on the LM-324 op amp chip. It draws about 1 mA total and will last forever on a 9 volt battery. It's very simple to put together on a perfboard. See Figure 1.

Calibration

I've really enjoyed watching all the signals as much as listening to them, and it took a bit of analysis to figure out the best way to use the meter. After several days of monitoring signals over the air, I found that the whole range of the meter is used by various

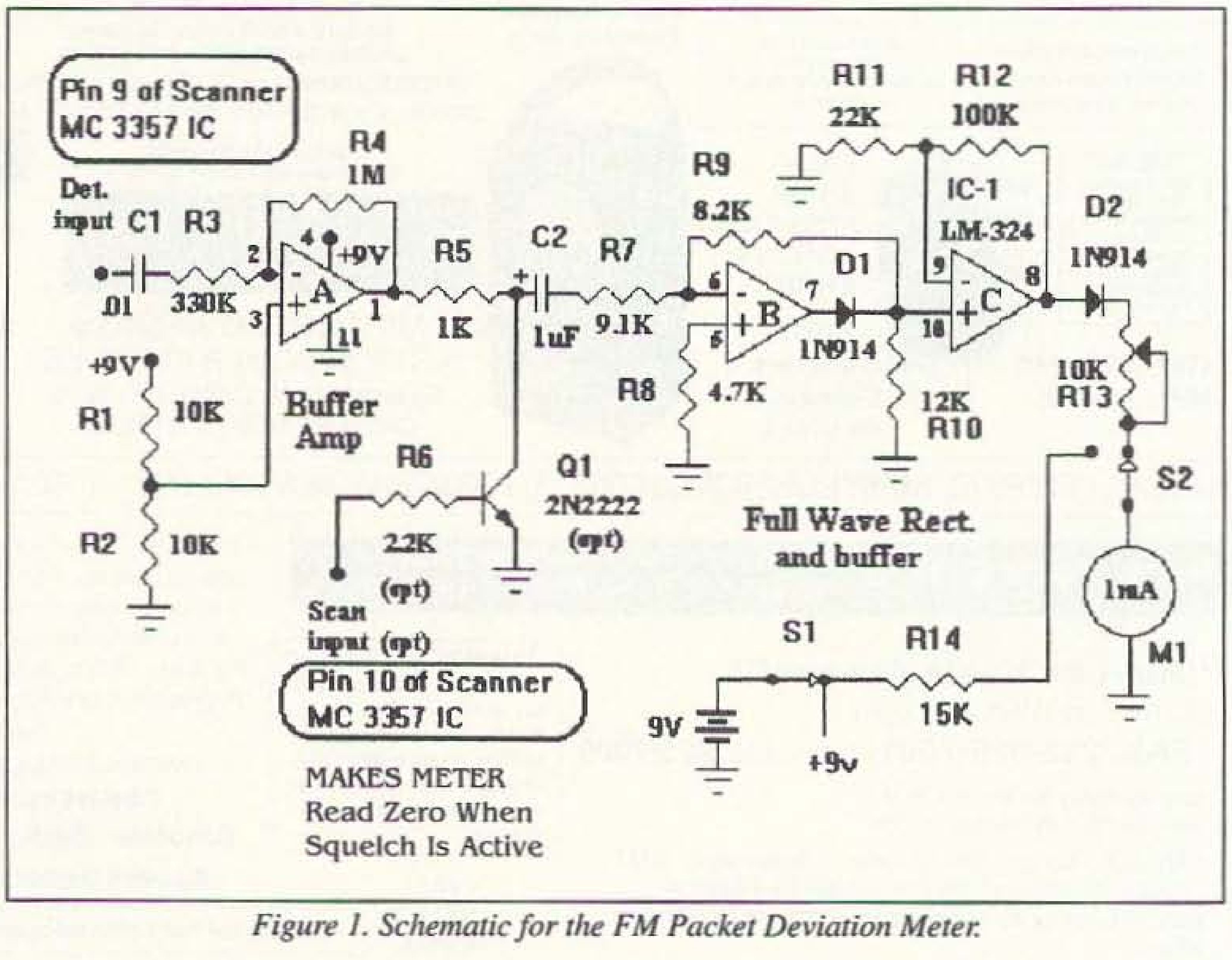

Figure 1. Schematic for the FM Packet Deviation Meter.

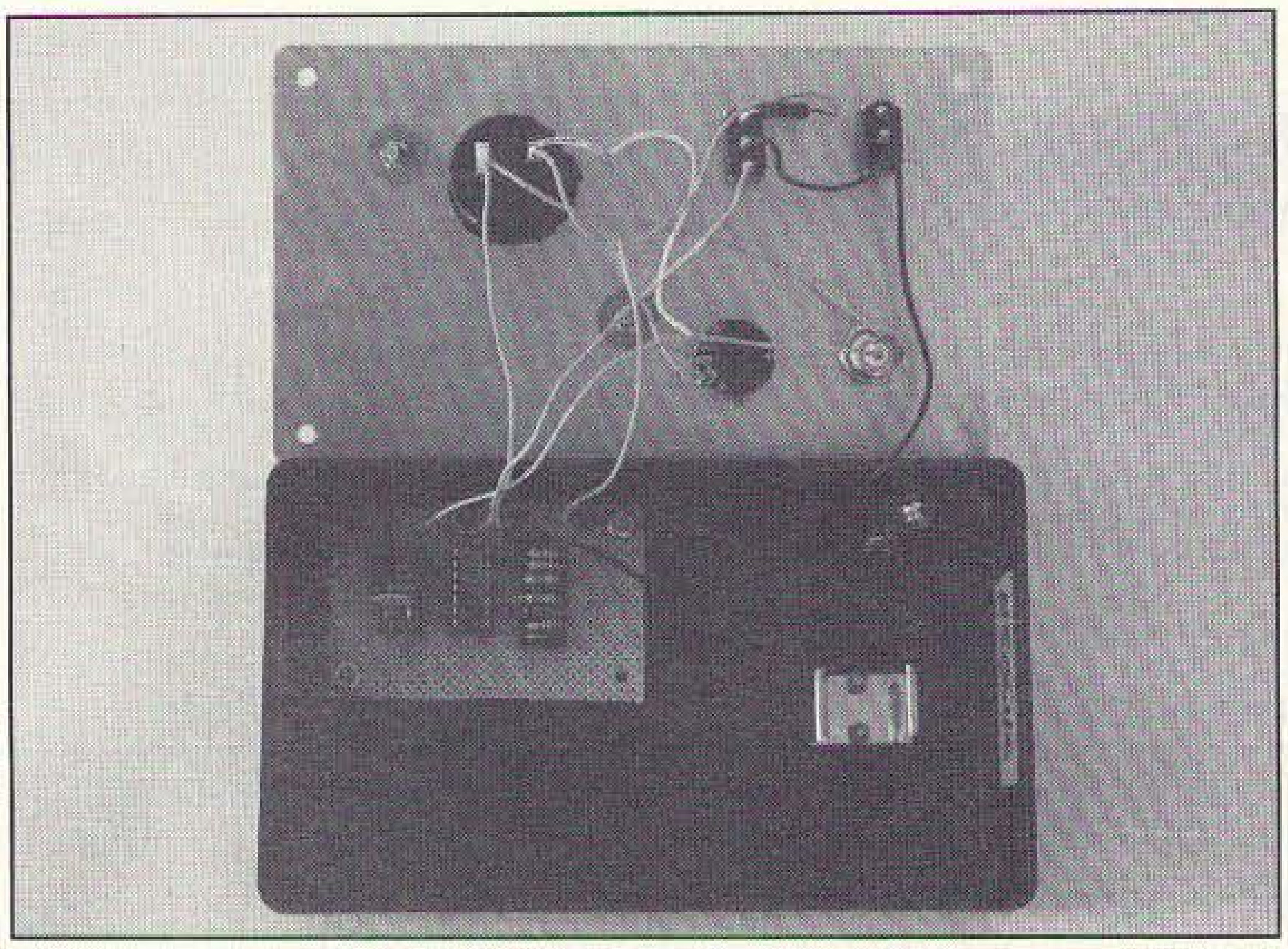

Photo B. The FM Packet Deviation Meter with cover removed.

Photo C. The finished product.

packet stations. The really poor ones drive the meter against the 15 reading (over deviation), while no audio of course, drops it down to 0. I chose the 2/3-scale 10 reading as the best calibration setting.

Without a signal present, the discriminator outputs a noise waveform, so the calibration pot on the meter is aligned to center about this 10 reading. Calibration needs to be performed each time the frequency is changed. I usually monitor the frequency for a minute to make sure there is no interference, and then recheck calibration. Any anomaly causes me to change frequency and recalibrate.

When a packet is received, the meter will deflect downward for the good guys and upwards for the bad guys. It's important that you only measure signals that are full-quieting, as noise will throw the reading off. I find it best to keep the circuit portable and take it to the transmitter for alignment. RF is bad news for consistent readings, however. You can avoid this by both removing the scanner antenna and placing a dummy load on the transmitter. If your TNC does not have a variable deviation adjustment (a design defect), the common method is to wire a 10k ohm potentiometer into the audio line to the transmitter. Don't depend on high or low jumpers to operate correctly—these are sucker settings.

After these initial steps, I usually command the TNC into the "calibrate" mode and send the high tone. Another good method is to command the TNC to the "converse" mode and hold down the "return" key. I then quickly adjust the audio pot to my calculated 3 kHz deviation reading (about 8.0 on my meter). Unless you calibrate your meter to a known source you are only guessing about what the readings mean, as each discriminator is different. If you can't find a calibration source, you can listen to signals on the air or tune your station by ear to get an initial estimate. After a couple of days you will quickly come to know what is good and what is bad by monitoring the performance of both your own and other packet stations. The object is to get a downward deflection.

Some radios produce a noticeable difference in the two AFSK packet tones. Here, you may want to do the alignment using the more critical high tone. As you might expect, any frequency error throws everything off, so make sure both the meter's receiver and the transmitter are tuned to the same frequency.

Deviation Basics

Whether an FM receiver has a discriminator, ratio detector, quadrature detector, or one of the modern phase detectors makes little difference as long as the output of the detector is proportional to the amplitude of the modulating tone. When a signal is fed to the FM modulator, it varies the frequency directly. The modulated FM signal is a variable set of sidebands whose total bandwidth depends both on the frequency of modulation and the amount of deviation. The limits set by the typical narrow band FM receiver IF stage is about 15 kHz.

The best method of determining the bandwidth of an FM signal is to use a Bessel function chart, as shown in Figure 3. You use this chart to find the number of sideband pairs and then compute the bandwidth. First you calculate the modulation index:

$$P = \frac{D}{m}$$

where P = modulation index,D = peak deviation, and m = modulating frequency.

Then you examine the chart to see how many sidebands there are on each side of the carrier. If the curve comes off the baseline a line-width or more, I include that sideband. The simple bandwidth formulas you find in textbooks are all different and can be considered unreliable. Use the chart. The worse case example is an FM signal that has been deviated 5 kHz with a modulating frequency of 3 kHz. The modulation index is 1.67, giving us four sideband pairs, or eight sidebands of 3 kHz, requiring an estimated 24 kHz bandwidth to contain it. This is quite acceptable for voice when it occurs only briefly. Packet uses a high tone of 2.2 kHz, and the predicted bandwidth using 5 kHz deviation is a steady 22 kHz. Transmitting a signal with this wide a bandwidth is certain to fail with distant packet stations, and likely even to fail across town. There are two reasons: First, most rigs will clip the audio to limit the deviation, which causes distortion. The second reason is crystal stability. One rig may be tuned 1.4 kHz higher in frequency, and the other 1.4 kHz lower, and still be within crystal tolerance on 145 MHz. This gives us about 12 kHz of worse-case usable receiver bandwidth.

Using 3 kHz deviation results in a modulation index of 1.36, and the chart shows about four sideband pairs, or 8 times 2.2 kHz for a 17.6 kHz bandwidth on the more

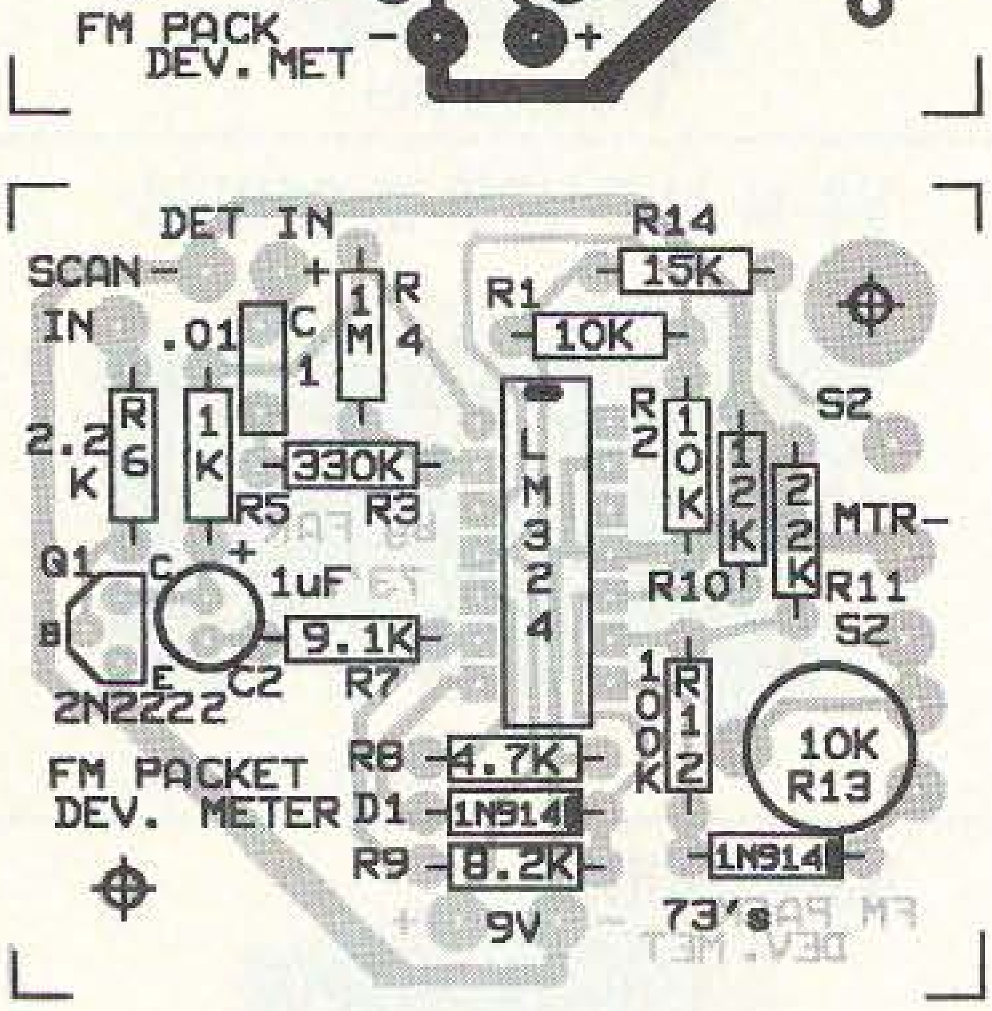

Figure 2. PC board pattern and parts placement diagram.

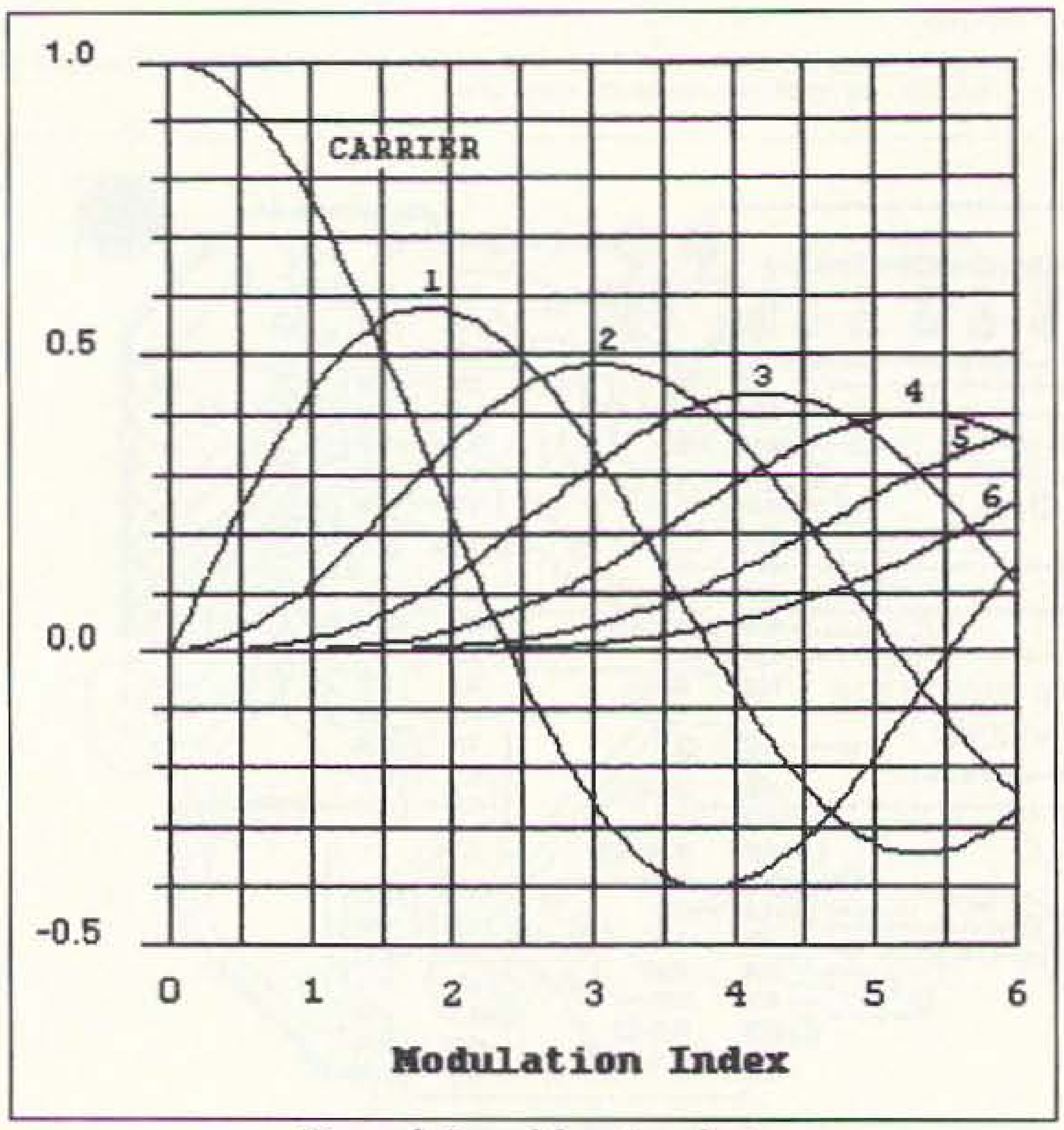

Figure 3. Bessel function chart..

Parts List

Case	Plastic	RS#270-627	
M1	1 mA meter	RS#270-1754	
J1	BNC jack	RS#278-105	
IC-1	LM-324	RS#276-1711	
Q1	2N2222	(Optional)	
D1,D	@1N914		
R1,R2	10k	All resistors 1/8 watt	
R3	330k		
R4	1 Meg		
R5	1k		
R6	2.2k	(Optional)	
R7	9.1k		
R8	4.7k		
R9	8.2k		
R10	12k		
R11	22k		
R12	100k		
R13	10k	Potentiometer	
R14	15k	Comes with RS meter	
C1	0.01 µF	Ceramic disc	
C2	1 uF	Electrolytic	

Drilled and etched PC boards are available from FAR Circuits, 18N640 Field Ct., Dundee IL 60118 for $4 plus $1.50 S&H.

critical high tone, and 12 kHz for the low tone. This reduced bandwidth is much less affected by the frequency drift between stations, and is not distorted by the transmitter deviation limiting circuits. By listening to the audio produced by 5 kHz deviation you will notice that it sounds raspy and terrible, while the 3 kHz sounds very pure.

Conclusion

The recommended setting for packet is 3 kHz deviation. With this meter you can quickly adjust your station, and others, to ensure that the transmitter hasn't gone into limiting, and that the bandwidth is optimized for the typical receiver. By spending a little time tuning up, you will benefit the entire local network system. I found that my station was able to connect with distant nodes that I thought were unreachable due to my power level or antenna height. Loan the meter out, and make sure everyone gets a chance to use it. Thanks go to William Crowl N6MWS for an excellent article and a repeatable circuit design, and to Joe Buswell K5JB who helped me first to calibrate the meter and then to understand FM modulation. 73