BY JOHN CLARKE AND LEO SIMPSON

Subcarrier Adapter For FM Tuners

This simple adapter circuit fits in your FM tuner and lets you tap into hidden FM transmissions

Although new to some countries, subcarrier transmissions on FM broadcasts have been made for years. They are referred to as Subsidiary Communications Authorized transmissions or SCA. They are based on a 67-kHz subcarrier that is placed on a station's main FM carrier. It's even possible to have multiple subcarriers, some carrying digital data and others carrying audio.

So you can receive such broadcasts, we present the SCA Adapter* that can be hooked into most FM tuners with a minimum of fuss. Low in cost, it uses just a few readily available integrated circuits.

Before we describe the Adapter circuit, let's briefly talk about FM-subcarrier transmissions. They have no effect on standard FM mono and stereo radios. Also, they are fully compatible with all existing FM radios, whether stereo or mono. In fact, unknown to the great mass of FM listeners, such transmissions have been going on for some time.

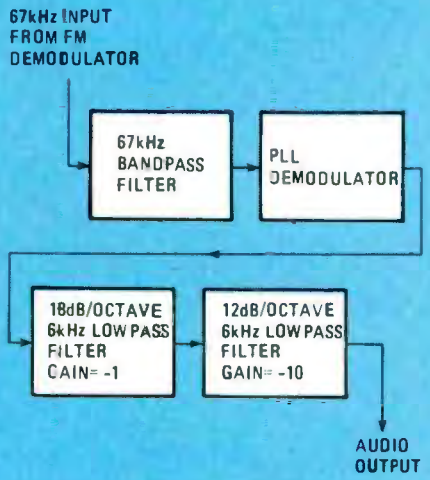

Fig. 1. This block diagram shows the four circuit functions of the SCA Adapter. The corresponding functions are also marked on the circuit diagram in Fig. 2.

But while all FM radios are presently unaffected, they are capable of picking up the subcarrier transmissions. With the addition of an adapter such as the one we'll describe here, they will be able to detect the hidden audio signals.

The SCA Adapter prototype was built on a compact printed-circuit board accommodating three low-cost op-amps, a phase-locked loop IC, a 3-terminal regulator, and a handful of resistors and capacitors.

How it Works. Figure 1 shows a block diagram of our circuit. The 67-kHz signal present at the output of the FM detecter (in the radio to be modified) is first fed to a 67-kHz bandpass filter, and then to a phase-locked loop (denoted PLL), which recovers the audio on the 67-kHz subcarrier.

The audio output of the PLL is then passed through a low-pass filter, which attenuates frequencies above 6 kHz at the rate of 18 dB/octave. Another 12-

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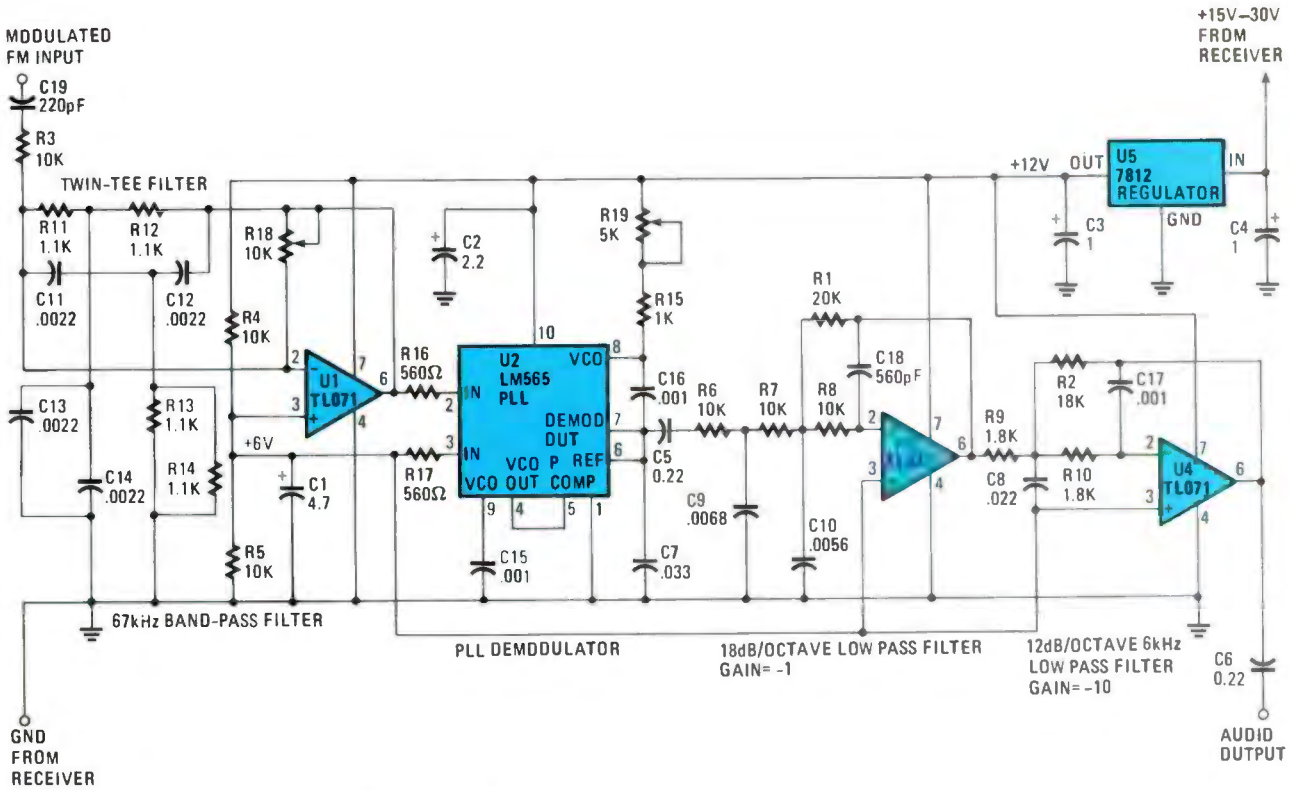


Fig. 2. The circuit for the SCA Adapter is basically a PLL with input and output filter stages.

dB/octave low-pass filter stage completes the conditioning of the signal before it is passed to an external audio amplifier.

Figure 2 shows the complete circuit. Op-amp U1 and its associated components comprise the 67-kHz bandpass filter. A twin-T network, comprised of four 1100-ohm resistors and four 0.0022-μF capacitors, is connected in the feedback network of the op-amp. That gives some gain at 67 kHz and heavy attenuation for frequencies above and below that frequency.

An additional passive filter at the input to the twin-T network (containing a 220-pF capacitor and a 10,000-ohm resistor) provides some additional roll-off for frequencies below 67 kHz.

In practice, the bandpass-filter action covers a frequency range of about 10 kHz above and below the 67-kHz center frequency. Resistor R18 sets the gain of the bandpass-filter stage.

Integrated-circuit U2 is a National LM565 phase-locked loop that demodulates the 67-kHz frequency-modulated (FM) signal from U1. The LM565 PLL consists of a voltage-controlled oscillator (VCO) set to 67 kHz, and a comparator that compares the incoming frequency-modulated 67-kHz signal at pin 2 with the VCO signal fed into pin 5.

The output of the comparator represents the phase difference between the incoming signal and the VCO signal, and is therefore the audio modulated by the subcarrier. Treble deemphasis of 150 μs is provided by a .033-μF capacitor (at pin 7).

The free-running VCO frequency is determined by the .001-μF capacitor at pin 9, and the resistance between the positive rail and pin 8 (100 ohms in series with R19). Variable-resistor R19 adjusts the oscillator frequency (also known as the "center frequency") so that the incoming signal is within the lock range of the PLL.

To minimize noise in the demodulated output, it is important to reduce the lock range of the PLL to a minimum. That is achieved by shorting pins 6 and 7 together. To a lesser extent, the lock range—and therefore the noise output—becomes smaller for lower input

PARTS LIST FOR THE SCA ADAPTER

SEMICONDUCTORS

U1, U3, U4—TL071 FET op-amp, integrated circuit
U2—LM565 phase-locked loop, integrated circuit
U5—7812 3-terminal 12-volt regulator, integrated circuit

CAPACITORS

C1—4.7-μF, 16-WVDC, electrolytic
C2—2.2-μF, 16-WVDC, electrolytic
C3—1-μF, 16-WVDC, electrolytic
C4—1-μF, 35WVDC, electrolytic
C5, C6—0.22-μF, metallized polyester
C7—.033-μF, metallized polyester
C8—.022-μF, metallized polyester
C9—.0068-μF, metallized polyester
C10—.0056-μF, metallized polyester
C11–C14—.0022-μF, metallized polyester
C15–C17—.001-μF, metallized polyester
C18—560-pF polystyrene
C19—220-pF ceramic

RESISTORS

(All resistors are ¼-watt, 5% precision units unless otherwise noted.)
R1—20,000-ohm, 2% precision
R2—18,000-ohm
R3–R8—10,000-ohm
R9, R10—1800-ohm
R11–R14—1100-ohm, 2% precision
R15—1000-ohm
R16, R17—560-ohm
R18—10,000-ohm, miniature vertical trimmer potentiometer
R19—5,000-ohm, miniature vertical trimmer potentiometer

ADDITIONAL PARTS AND MATERIALS

Printed-circuit board, hookup wire, audio leads, solder, etc.

signals, so we keep the input signal as low as possible without affecting the PLL's operation.

Following U2 is the 18-dB/octave filter containing U3, which has a gain of one for the desired signal frequencies. The filter is followed by the final stage, U4, which has a gain of 10.

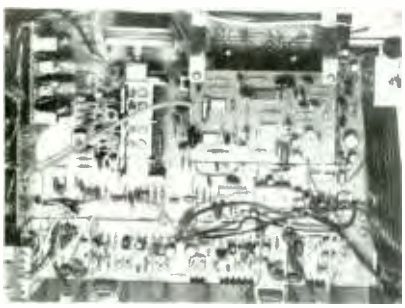
The adapter is ideally powered from the tuner or receiver it is built into, so we had to make its input-voltage requirements non-critical. The solution is to use a 12-volt, 3-terminal regulator that enables the circuit to be powered from any +15- to +30-volt supply.

The three op-amp IC's and the PLL are all biased to half the supply voltage by a voltage divider consisting of two 10,000-ohm resistors, which is decoupled by a 4.7-μF capacitor. The center of the voltage divider is connected to pin 3 of each op-amp and the PLL.

PCB Assembly. The printed-circuit board for the project (see Fig. 3) measures just 3-⅝ × 2-¼-inch and will help ease assembly if made. Point-to-point assembly can be used but will be a bit difficult to perform accurately.

No special points need to be watched when installing the parts on the board except that component polarities must be correct (see Fig. 4). Note also that U1 has a different orientation to U2, U3, and U4.

When assembly and soldering are finished, check your work carefully and then connect a DC supply of between 15 and 30 volts. Now check the voltage at the output of the 3-terminal regulator, at pin 7 of the TL071 op-amps, and at pin 10 of the PLL. In each case, the reading should be close to 12-volts. The voltage at pins 3 and 6 of each op-amp, and pin 3 of the PLL, should be close to 6-volts DC.



The photo shows the SCA Adapter installed in an older AM/FM stereo receiver, the Harman Kardon HK570I. Two brackets were used to suspend the Adapter above the tuner board.

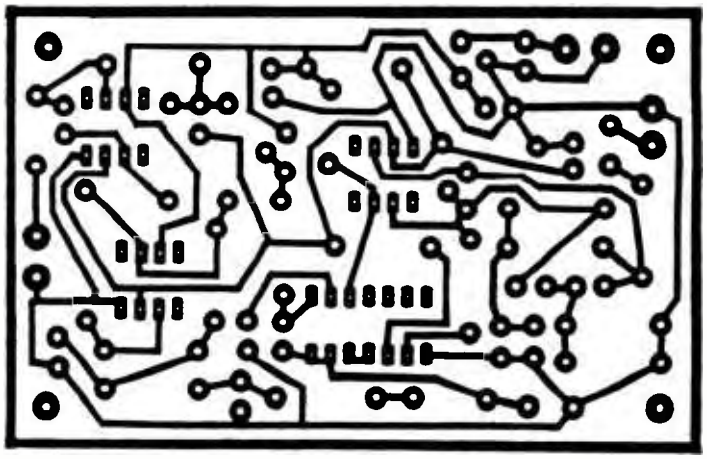


Fig. 3. Full-size PC artwork for the SCA Adapter. Its use is recommended.

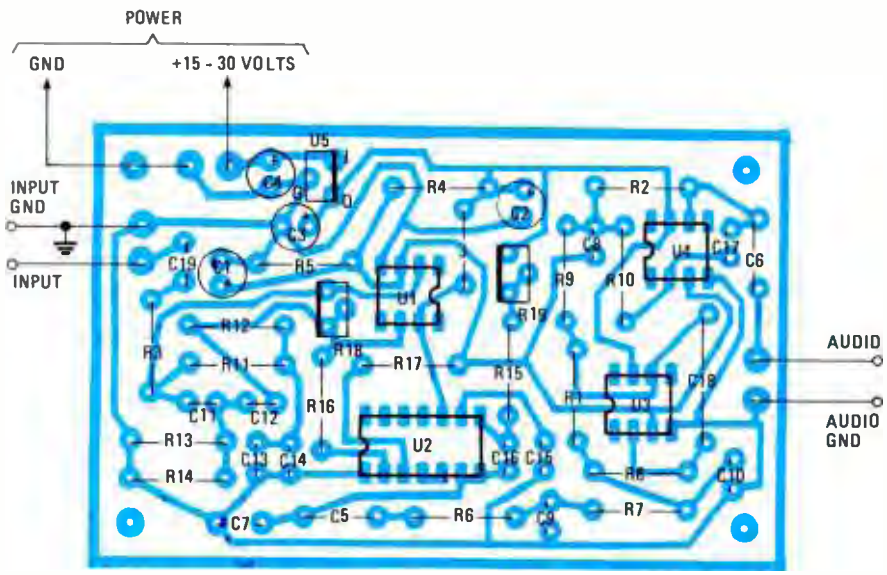


Fig. 4. Take care when assembling the board; U1 is oriented differently from U3 and U4.

If everything is okay, you are ready to install the Adapter in your FM tuner or stereo receiver.

Finding the Signal. Here comes the tricky part. Ideally, you need access to the circuit diagram of your tuner or receiver. Next, you need to identify a positive DC-supply rail of between +15 and +30 volts. Then, you need to find the output of the FM demodulator of your receiver or tuner.

In a stereo tuner, that comes before the multiplex decoder and treble de-emphasis networks. In a mono tuner, you must identify the demodulator output before de-emphasis. After de-emphasis, the 67-kHz signal will be non-existent.

Most medium-priced tuners use two IC's to do most FM-signal processing. They are the IF amp and detector IC, followed by a multiplex (MPX) decoder IC. The most convenient point to pick off the 67-kHz signal is at the input to the MPX decoder.

Setting Up. Having found the signal and made the necessary connections from the Adapter to your tuner, the set-up procedure is relatively simple. First, make sure that R18 is set so that its wiper is turned toward the LM565. That will provide maximum signal. Now adjust R19 so that there is an audio signal. Find the extreme settings of R19 where the audio signal drops out, then set R19 between the two extremes.

Resistor R18 is used to minimize noise from the audio signal when the FM-signal level is poor. Adjust the trimmer until the sound becomes distorted and then back off the adjustment until the distortion is no longer audible. If you have a strong FM signal, adjustment of R18 will have no effect on the noise level, and so it should be left at its maximum-resistance setting. ■