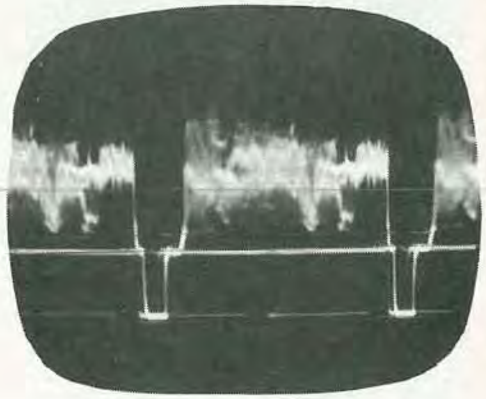
TV SIGNAL DESCRAMBLING



This month we show you how to build and align a gated-pulse decoder.

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Part 8 THIS MONTH, WE'LL look at a decoder for the outband system. Also, the PC board for January's gated sync descrambler is included in this month's PC Service.

Outband decoder

The outband system is used exclusively by cable-TV programmers. In it, the video signals, minus the horizontal sync pulses, are sent out over the assigned cable channel. The horizontal-sync is placed on another carrier, which can be located at just about any unused frequency within the cable system's bandwidth. The job of an outband decoder is to tune in the hidden carrier, extract the sync pulses, and recombine them with the video signal. In the following discussion, we will assume that the scrambled video has a center frequency of 150 MHz, and that the sync is located on a 100-MHz carrier.

If the circuit shown in Fig. 6 is to work properly, the cable must present a 75-ohm impedance and deliver a signal level of at least 1 millivolt. The cable lead is, of course, connected to the input, J1. A lowpass filter composed of C1, C2 and L1 passes the 100-MHz sync signal but blocks the 150-MHz video signal. Likewise, L2, C3, and C6 form a high pass filter that blocks the 100-MHz sync signal but allows the 150-MHz video signal to pass. We'll get to where that video signal goes in a moment. That circuitry allows only the sync information to reach IC1, an MC1350 IF amplifier. Note that while that IC is designed for 60-MHz operation, its performance is more than adequate at 100 MHz (gain is greater than 30 dB). The 100-MHz signal is fed to pin 4.

An amplified sync signal appears at pin 8 of IC1 and is coupled to pin 7 of IC2, an MC1330 video detector. That IC is tuned to 100 MHz by the C5-L4 network. Complementary outputs are available at pins 4 and 5. In our application, the detected signals available at those points consist of the sync pulses only. One output (pin 4) is used only as a test point.

Normally, a 30-millivolt input should produce an output on the order of one volt. But since the circuit is designed for 45-MHz operation, and we are using it at 100 MHz, the gain of the IC is somewhat reduced. In our experiments, we have seen outputs on the order of 300 millivolts. That is sufficient for our needs.

From IC2, the sync signal is fed to a differential amplifier made up of Q2 and Q3. The base of Q3 should be biased at 7 volts. If needed, the value of R7 can be changed to achieve that bias level.

Under normal conditions (no sync pulse received) Q3 is nearly cut off and Q2 is conducting heavily. That means that Q1 is also cut off and a DC current is flowing from the collector of Q2 through the L7-R9-D2-R12-L6 circuit to ground. The voltage at the collector of Q3 is practically zero, and very little current flows through the R8-R10-L5-D1 circuit. Therefore, D1 is cut off and the 150-MHz video signal from the L2-C3 network must flow through the R11-C16-R12 circuit. Since D2 is biased on, some of the 150-MHz energy is shunted to ground by R9. In essence, R9, R11, and R12 form a "T" pad, attenuating the signal by about 6 dB.

When a sync pulse is received, the voltage at pin 5 of IC2 rises. That cuts off Q2 and biases Q3 on, which in turn biases Q1 on (through R8). Transistor Q1 now conducts heavily, grounding the collector of Q2. At the same time, current flows through R10, L5, and D1, biasing it on, and grounds L6. Since D1 is now on, it offers a low-impedance path to the 150-MHz signal, allowing it to bypass the "T-" pad circuit previously described and to reach the output jack, J2, with relatively little attenuation. In essence, the 150-MHz signal is boosted during the sync intervals, restoring the proper sync-to-video relationship and decoding the signal.

Building the circuit

A parts-placement diagram of the circuit is shown in Fig. 7. The corresponding PC pattern can be found in PC Service. Note that the values of several of the capacitors and inductors will vary with different sync channel frequencies. Table 1 gives the appropriate values for two popu-

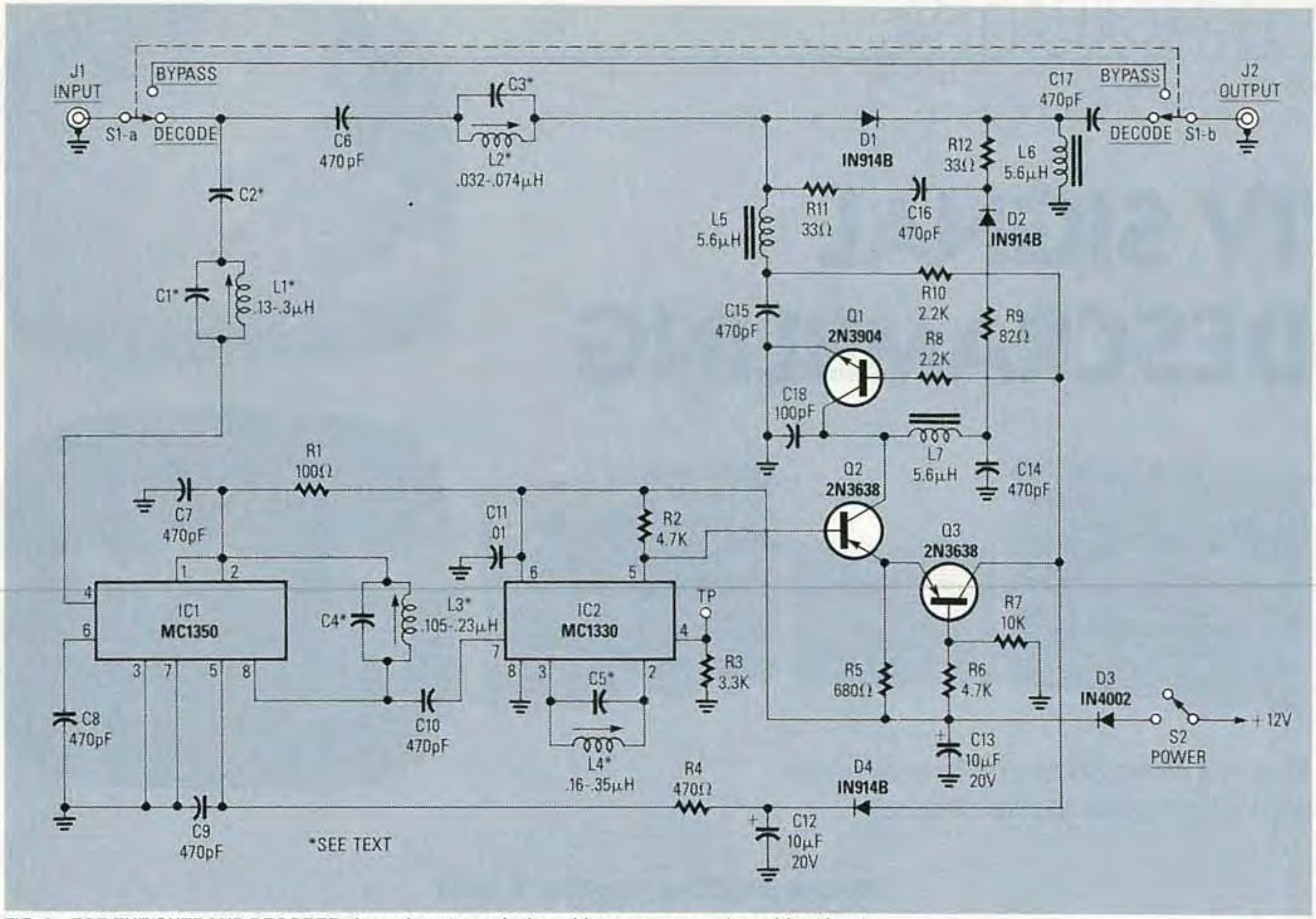

FIG. 6—FOR THE OUTBAND DECODER shown here to work, the cable company must provide at least a 1 millivolt signal. Values for C1–C5 and L1–L4 are found in Table 1.

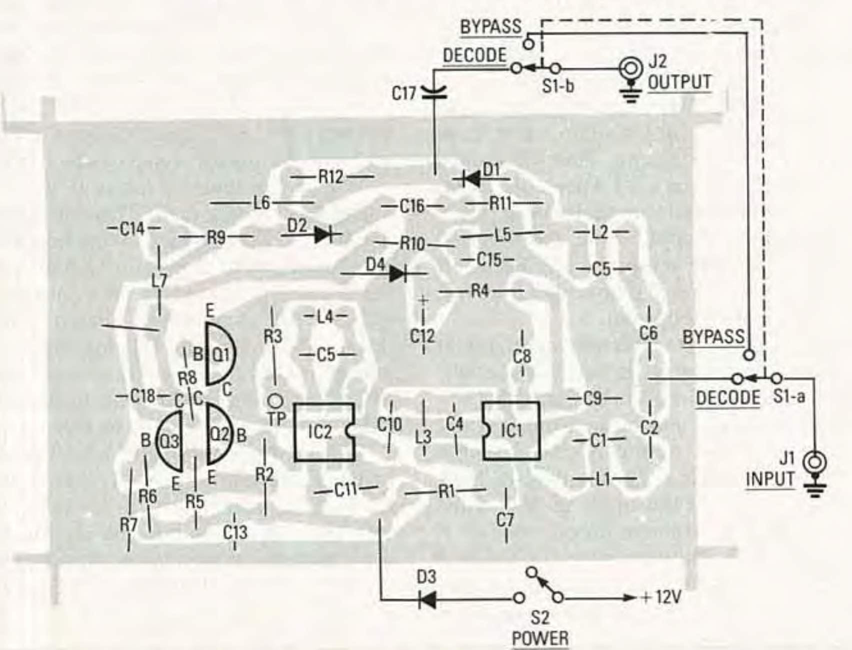

FIG. 7—IF YOU USE THE PC PATTERN shown in PC service, use this diagram when mounting the components.

lar sync-channel frequencies: 50 MHz and 90–114 MHz.

Also, if you do not order the kit from the supplier mentioned in the parts list, you will need to wind four of the inductors (L1–L4) yourself. All are wound using No. 22 enameled wire on an 8-32 screw. Coil L1 consists of 7½ turns, L2 consists of 2½ turns, L3 consists of 6½ turns, and L4 consists of 8½ turns. Once each coil is wound, remove the screw and replace it with an iron core. Cores can be salvaged from coils removed from an old TV or radio as previously discussed. Also, an appropriate core is manufactured by Midland-Ross, Cambion Division; its part number is 515-3225-06-21-00. If wound properly, the coils can be adjusted to the inductances indicated in Table 1.

Once the board is built, check your work for poor solder joints, solder bridges, proper component alignment, etc. Correct any errors you spot. A photograph of the completed outband decoder board is shown in Fig. 8.

TABLE 1—CAPACITOR AND COIL VALUES

	50 MHz	90–114 MHz
C1	5 pF	5 pF
C2	47 pF	12 pF
C3	200 pF	82 pF
C4	56 pF	12 pF
C5	56 pF	10 pF
L1	0.2 μH	0.2 μH
L2	0.05 μH	0.03 μH
L3	0.175 μH	0.2 μH
L4	0.175 μH	0.24 μH

PARTS LIST
OUTBAND DECODER

All resistors ¼ watt, 10% unless noted
R1—100 ohms
R2, R6—4700 ohms
R3—3300 ohms
R4—470 ohms
R5—680 ohms
R7—10,000 ohms
R8—22,000 ohms
R9—82 ohms
R10—2200 ohms
R11, R12—33 ohms
Capacitors
C1–C5—see text and Table 1, NPO
C6–C10, C14–C17—470 pF, ceramic disc
C11—0.01 µF, ceramic disc
C12, C13—10 µF, 16 volts, electrolytic
C18—100 pF, ceramic disc
Semiconductors
IC1—MC1350 video IF (Motorola)
IC2—MC1330 video detector (Motorola)
Q1—2N3904 NPN transistor
Q2, Q3—2N3638 PNP transistor
D1, D2, D4—1N914B diode
D3—1N4001 diode
Other components
L1–L4—see text and Table 1
L5–L7—5.6 µH, RF choke
S1—DPST switch, slide or toggle
S2—SPST switch, slide or toggle
J1, J2—phono jacks
Miscellaneous: PC board, wire, solder, etc

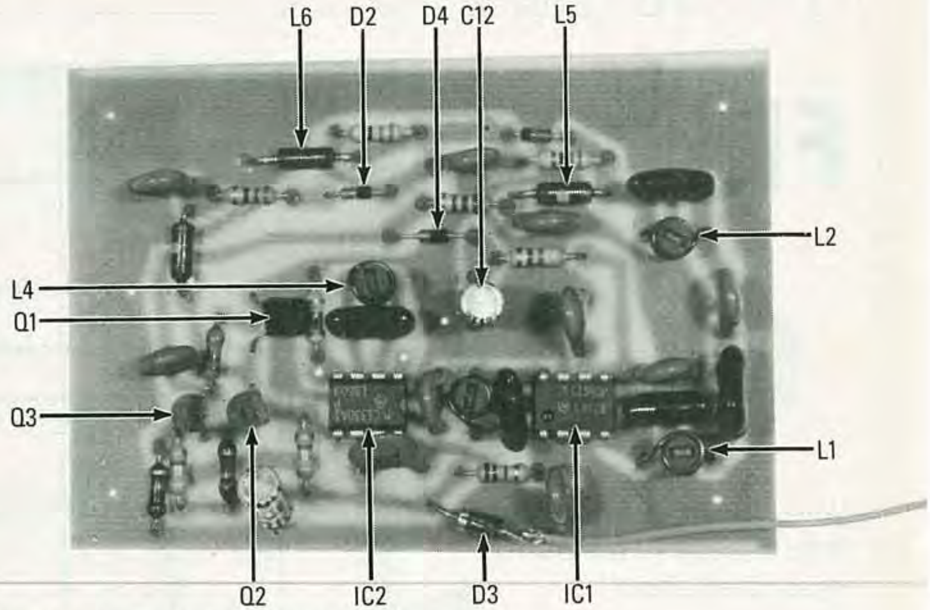

FIG. 8—THE FINISHED OUTBAND DECODER is shown here.

Aligning the unit

Begin by measuring the resistance between the power supply and ground rails. If it's less than a few hundred ohms, recheck IC1 and IC2 and the transistors for correct orientation. Once you've found and corrected the error, you can proceed.

Next, connect a VHF signal generator to the junction of C2 & C6 (input) and apply voltage to the power-supply rail. Connect a wideband (5 MHz), low-capacitance (1 megohm shunted by 10 pF, or less) scope between pin 4 of IC2 (use the convenient test point provided) and ground. Any modern TV-service scope should be able to meet those criteria.

Set the generator to the carrier frequency used for sync pulses on your cable system. Sometimes, an unused cable-channel frequency is used for that. If you find a channel that displays a clean white raster, you have likely found the sync channel. Otherwise, you'll need to ask your cable operator for that information when you request permission to use the circuit. **The circuit should never be used to decode cable signals without such permission**. For the purposes of our discussion, we will assume that the sync-channel frequency is 100 MHz. Modulate the generator's output 80% with a 10-millivolt, 1-kHz signal. Adjust L3 and L4 for maximum output. At that power level, some distortion is likely. If the output is reduced to 1 millivolt, it should be possible to obtain a 0.2–0.5-volt, 1-kHz sinewave. Note that if the cable company uses a frequency around 50 MHz for the sync channel, the gain will be higher.

Next attach a TV or FM-radio receiver to the output, J2, and adjust L2 so that the sync frequency is blocked. That is indicated on the TV by the white raster dissolving into snow or on an FM radio by a null in the signal. This adjustment is broad, and hence not critical.

Next, tune the generator to the center frequency of the scrambled channel (150 MHz in our case) and increase its output again to 10 millivolts, or more, until some response is seen at the test point. Adjust L1 for minimum response.

Now, connect the scope probe between the collector of Q3 and ground. With a 1-millivolt input, a 2-kHz squarewave should be seen. That indicates Q1, Q2, and Q3 are switching. If that squarewave is missing, check to be sure that there is 0.5–1 volt positive pulse at pin 5 of IC2. If everything else has checked out to this point and that pulse is missing, the IC is probably defective. Also check Q2, Q3 and their associated components. If you cannot locate any errors, try changing the value of R7 to 8.2K or 12K or replace the resistor with a 20K potentiometer.

Next, check R33 for a the presence of a pulse. It should be 0.1 volts, or more, indicating that sufficient current is flowing to bias D1 and D2 on.

If you have trouble getting the circuit to work, try experimenting with the values of R9, R11, and R12. If you find that the insertion loss caused by the circuit is excessive, try replacing D1 and D2 with Motorola MPN3404 PIN diodes.

That completes the alignment of the decoder. Obviously, not all cable systems will use our example frequencies; in fact it is likely that none will. However, it is a simple matter to adjust the circuit for operation for a particular frequency pair. Before performing those adjustments, however, **be sure to contact your cable-system operator and obtain authorization in writing. Using the outband decoder for unauthorized descrambling of a cable signal may be illegal. It is up to the user to determine what the requirements are for legal use and to meet them.** R-E