BUILD THIS TELEPHONE CALL SCREENER

Now you can keep unwanted phone calls from reaching you—only an authorized caller will be able to ring your phone!

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THE MODERN TELEPHONE SYSTEM IS a truly marvelous technological achievement. Never in history have so many people been able to communicate with so many others at such a low cost. But the price for being able to reach out and touch almost anyone also includes the opportunity for almost anyone to be touched, by anyone else with a phone. But the fact is, most people would rather not be called by strangers.

One system that appears to offer promise is "Caller ID," which provides the called party with a read-out of the caller's telephone number before the phone is answered. Customer response to this service is reportedly very good. The problem is, of course, that the system screens only telephones, not callers. If a call is made by an "authorized caller" from another telephone, the called party will not recognize the number and might reject the call. The cost for the service is about $100 to start, with a monthly service fee of around $6.

The real solution to the problem of screening unwanted telephone calls must be one that screens callers, not numbers. It must include a security system that no accidental access such as wrong numbers or sequentially dialed numbers can breach. And the user should be spared the intrusion of having to screen his or her own calls, which is the case with an answering machine or Caller ID. The real solution should intercept incoming calls and silently and automatically screen them. When a caller is cleared, then the phone rings.

The CallScreen does all of that and more. It's easy to use, easy to install, easy to build, and relatively inexpensive. What's more, the unit can also send fax or modem calls directly to specified device. If this no-nonsense approach to call screening appeals to you and seems worthwhile, then read on because the solution is here!

Operation

The CallScreen connects to the phone line at the point where the line enters the building, and the "slave" phones connect to the CallScreen. The unit features "Limited Screen" and "Full Screen" modes, which can be selected by toggling one of two pushbuttons on the cabinet; the other button toggles "Screen On"/"Screen Off." However, the easiest way to select screen modes is with the "*" and "#" keys on any phone connected to the CallScreen. Pressing the "*" key will alternately select Screen on/Screen Off.

Actually, one version of the CallScreen doesn't even have the pushbuttons—you must use a phone to change modes. Whenever a transition to Screen On is made, a momentary tone is heard through the handset. The "#" key selects Limited Screen/Full Screen, with the transition to Full Screen producing the tone. LED indicators on the cabinet indicate the current screening mode, regardless of which method is used for selection. Should a power failure occur, the CallScreen bypasses itself so that normal telephone service is provided. We'll now describe the operation of the CallScreen in Limited Screen mode.

When the unit detects ring current on the telephone line, the line is taken off-hook and a short tone burst is injected into the phone line, to signal the caller to enter a three-digit access code. The caller then has approximately seven seconds to enter a three-digit number sequence that must match either of two codes (a primary code and a secondary code) set by the user.

Each three-digit code is set via a set of DIP switches. Allowable codes include digits "1" to "9." The digit "0" is reserved for code-entry errors. If the caller enters incorrect digits; a zero may be entered causing the CallScreen to erase the previous digits and prepare for re-entry.

When a correctly entered primary code is detected, the CallScreen begins ringing any telephone connected to its output jack with a cadence of two short rings and a pause. The secondary code cadence is three short rings and a pause. The CallScreen owner now knows, by the type of ring, that the call has been screened and has some idea of the caller's identity (family or friends for instance). If neither code is entered, a standard ring is generated, which continues until any phone is picked up, or the caller hangs up. Should the unit be set in the Full Screen mode, the completion of the seven-second entry interval, with no proper code entered, results in the line going back on-hook, disconnecting the caller.

A call-routing adapter (CRA) allows operation with telephones and a choice of either an answering machine or a modem/facsimile machine. When the CRA is set for "ANS MACH," any unscreened calls will be routed to an output jack to which an answering machine may be connected. When the CRA is set for "COMP/FAX," all primary code calls and unscreened calls (or primary code calls only if the CallScreen is set for Full Screen) will be routed to the protected phone(s), while secondary code calls will be routed to the computer modem or facsimile machine.

If the user would rather substitute other telephones for the answering machine/modem/facsimile machine in order to control where in the building a phone will ring, full answer (off-hook) and connect recognition is provided even for telephones that are not ringing. That allows any protected phone to "answer" a ring even if the ring was being routed to another phone.

When the CRA is switched off, all processed calls are passed to both CRA output jacks. Outgoing calls are unaffected by the CRA regardless of its on/off status.

The CallScreen consists of five major circuits: Phone Line Interface, Decoder, Control and Reset Logic, Ringer, and Slave Telephone(s) Interface. We'll describe each section in detail.

Phone line interface

Figure 1 shows the schematic of the CallScreen. Incoming telephone calls are detected by IC7, a Texas Instruments TCM1520 ring detector IC, which, along with the other circuitry, is protected from over-voltages by surge suppressor R8. Capacitor C12 blocks DC voltage from entering IC7, and R11 limits ring current so that IC7 operates over a typical 40–150 volts RMS ring-voltage range. The incoming ring voltage charges C13 which brings pin 4 of IC7 high with respect to pin 3. After less than one full ring, the current from pin 4 turns on the LED inside IC10, which turns on the phototransistor. That, in turn, puts a low on pin 2 of NOR gate IC3-a.

Pin 1 of IC3-a is connected to the Master Reset line which is normally low, so when pin 2 goes low pin 3 goes high and pin 4 goes low. When the first ring interval has ended, the phototransistor in IC10 switches off. But, since IC3-b pin 4 is low and is connected through R19 back to pin 2, pin 3 remains latched high regardless of the state of IC10. As long as pin 3 is high, a forward bias current, limited by R22, flows through the base-emitter junction of Q1, turning Q1 on and energizing RY1, which takes the phone line off-hook. It takes about 100 milliseconds for RY1 to be activated after pin 3 of IC3-a latches high. That allows multiple CallScreen units connected to the same telephone line to latch before any of them actually "answer" the call. The time delay is generated by a ramp voltage across C18 following the latch up of IC3-a pin 3.

When RY1's contacts close, they provide a DC path across the telephone line through BR2 and R6. The resulting DC current through R6 signals an "off-hook" condition to the central office, which then removes the ring voltage and connects the calling party to the line. Bridge rectifier BR2 ensures that, regardless of the phone-line polarity, the end of R6 that's connected to C5 is always positive with respect to the other end. If, while the CallScreen is off-hook, any other telephone on the same line is lifted, the voltage across R6 will decrease due to the additional load placed across the line.

That voltage change is coupled through C5 as a negative pulse that appears on IC8 pin 2, momentarily illuminating the internal LED. The IC8 phototransistors then conduct, placing a brief low on pins 12 and 13 of IC27-d, which is part of the Control and Reset logic. That sends a reset pulse to pin 1 of IC27-a, which, with IC27-b, normally passes reset pulses to IC3-a pin 1, to release the off-hook latch. However, during the cue interval pin 2 of IC27-a receives a logic low, which disables the passage of reset pulses during this time. That allows any phone-line transients, that could trigger the off-hook detection circuit at the moment the CallScreen raises an off-hook, to delay before enabling the Master Reset line. The cue timer interval begins just before the CallScreen goes off-hook, and continues for approximately 1 second. Diode D3 protects the LED inside IC8 from any reverse voltage transients that may be on the telephone line.

The momentary negative-going pulse develops at IC27-d pins 12 and 13 whenever a remote phone is raised off-hook appears inverted (as a momentary high) at pin 1 of IC3-a. That pulse will unlatch IC3-a/IC3-b, releasing RY1, resetting the CallScreen, which goes back on-hook to await another call.

Audio is coupled to the phone line through transformer T2, which is AC-coupled to the line at all times via C11 so that signaling

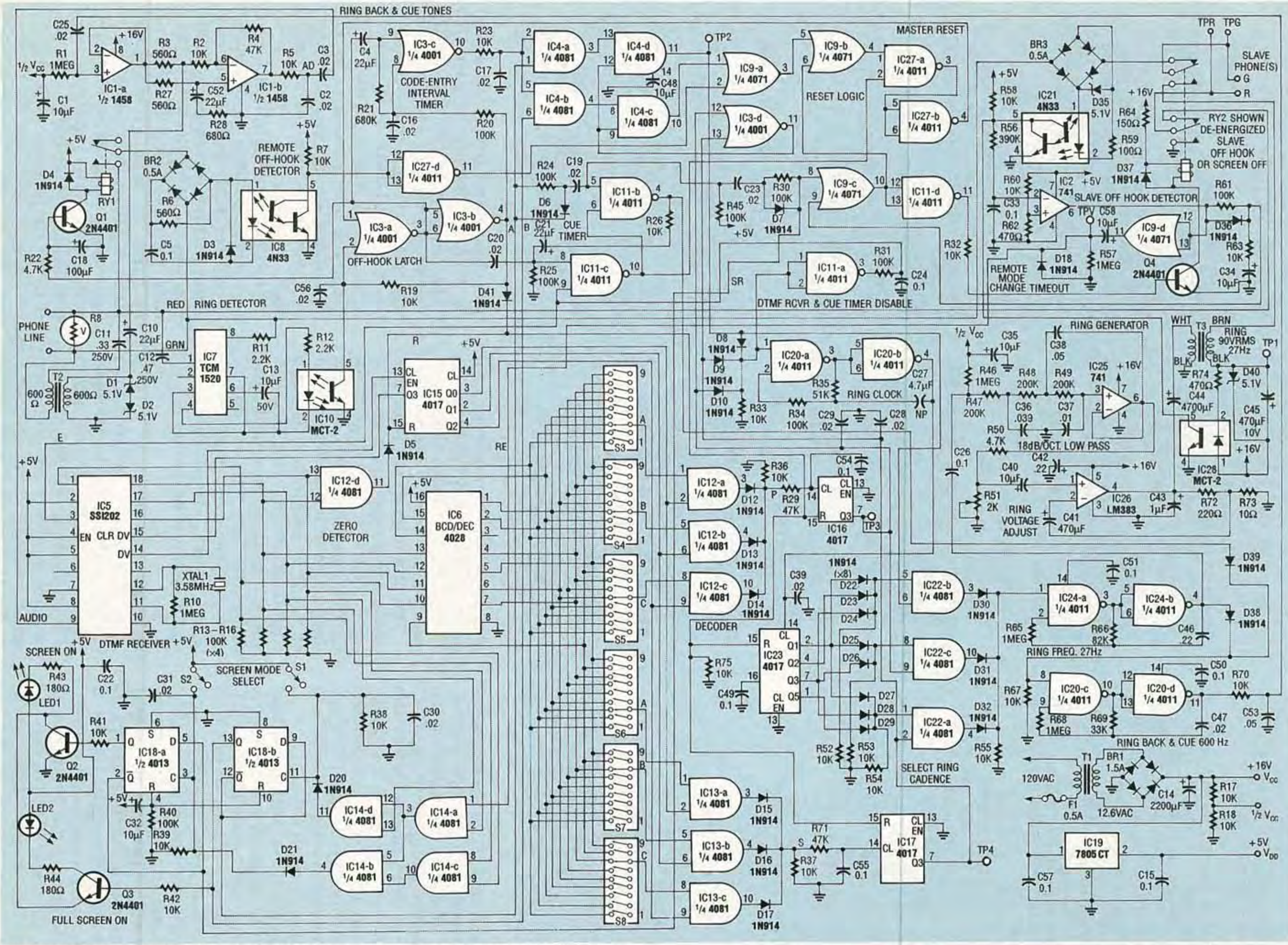

FIG. 1—SCHEMATIC OF THE CALLSCREEN. It can prevent unauthorized callers from wasting your time with "junk" calls.

CALLSCREEN PARTS

All resistors are ¼-watt, 5%, unless otherwise noted.

R1, R10, R46, R57, R65, R68—1 megohm
R2, R5, R7, R17–R19, R23, R26, R32, R33, R36–R42, R52–R55, R58, R60, R63, R67, R70, R75—10,000 ohms
R3, R27—560 ohms
R4, R29, R71—47,000 ohms
R6—560 ohms, ½-watt
R8—metal-oxide varistor surge-suppressor, 130 VRMS, 15 joules
R9—not used
R11, R12—2200 ohms
R13–R16, R20, R24, R25, R30, R31, R34, R45, R61—100,000 ohms
R21—680,000 ohms
R22, R50—4700 ohms
R28—680 ohms
R35—51,000 ohms
R43, R44—180 ohms
R47–R49—200,000 ohms
R51—2000 ohms, potentiometer
R56—390,000 ohms
R59—100 ohms
R62, R74—470 ohms
R64—150 ohms, ½-watt
R66—82,000 ohms, 1%
R69—33,000 ohms
R72—220 ohms
R73—10 ohms

Capacitors
C1, C32, C34, C35, C40, C48, C58—10 µF, 10 volts, radial electrolytic
C2, C3, C16, C17, C19, C20, C23, C25, C28–C31, C39, C47, C56—0.02 µF, 20 volts, ceramic disc
C4, C10, C21, C52—22 µF, 16 volts, radial electrolytic
C5, C15, C22, C24, C26, C33, C49, C50, C51, C54, C55, C57—0.1 µF, 20 volts, ceramic disc
C6–C9—not used
C11—0.33 µF, 250 volts, polypropylene
C12—0.47 µF, 250 volts, polypropylene
C13—10 µF, 50 volts, axial electrolytic
C14—2200 µF, 20 volts, radial electrolytic
C18—100 µF, 10 volts, radial electrolytic
C27—4.7 µF, 10 volts, non-polarized axial electrolytic
C36—0.039 µF, 20 volts, ceramic disc
C37—0.01 µF, 20 volts, ceramic disc
C38, C53—0.05 µF, 20 volts, ceramic disc
C41, C45—470 µF, 10 volts, radial electrolytic
C42, C46—0.22 µF, 50 volts, polyester
C43—1 µF, 35 volts, tantalum
C44—4700 µF, 16 volts, radial electrolytic

Semiconductors
IC1—LM1458 dual op-amp
IC2, IC25—LM741 op-amp
IC3—MC4001 quad NOR gate
IC4, IC12–IC14, IC22—MC4081 quad AND gate
IC5—SSI 202 DTMF receiver (Silicon Systems, Inc.)
IC6—MC4028 BCD-to-decimal converter
IC7—TCM1520 ring detector (Texas Instruments)
IC8, IC21—4N33 Darlington opto-coupler
IC9—MC4071 quad OR gate
IC10, IC28—MCT-2 transistor opto-coupler
IC11, IC20, IC24, IC27—MC4011 quad NAND gate
IC18—MC4013 dual D-type flip-flop
IC15–IC17, IC23—MC4017 decade counter
IC19—MC7805 5-volt regulator
IC26—LM383 7-watt power amplifier
D1, D2, D35, D40—IN5231 5.1-volt Zener diode
D3–D10, D12–D18, D20–D32 D36–D39, D41—1N914 diode
D11, D19, D33, D34—not used
LED1, LED2—red light-emitting diode
Q1–Q4—2N4401 NPN transistor
BR1—50-PIV 1.5-amp bridge rectifier
BR2, BR3—100-PIV, 0.5-amp bridge rectifier

Other components
T1—120/12VAC 950 mA power transformer
T2—600/600-ohm telephone line coupling transformer
T3—8/8K ohm 10-watt matching transformer (use 8-ohm and 0.625-watt taps on 70-volt line transformer)
XTAL1—3.58-MHz colorburst crystal
S1, S2—SPST momentary pushbutton switch
S3–S8—9-position DIP switch
RY1—SPST N.O. miniature relay, 5-volt, 70-ohm coil (or nearly any other 5-volt miniature relay)
RY2—DPDT miniature relay, 12-volt, 290-ohm coil (or with a coil between 260–400 ohms)

Miscellaneous: PC boards, cabinet, linecord, telephone wire, stranded wire, solder, hardware, etc.

to and from CallScreen can occur regardless of the hook status. That allows you to change screening modes using the "*" and "#" keys of slave phones while the CallScreen remains on-hook. Any voltages on T2's secondary are clamped by D1 and D2 to approximately 5 volts while audio is coupled through C10.

Op-amp IC1-a, which operates at unity gain, drives ring-back and cue-tone audio through R3. A coupling network to pin 5 of IC1, made up of R27, R28, and C52 approximately mirrors R3, C10, and the secondary impedance of T2. Therefore, the output signal from IC1-a appears equally across the differential inputs of IC1-b, producing very little output signal on pin 7. However, signals that are input from the phone line to pin 6 have a very small in-phase component appearing on the non-inverting input of IC1-b, so they appear at pin 7 amplified by a factor of approximately four, as set by R2 and R4.

The attenuation of phone-line input signals appearing on IC1-b pin 5 occurs by the voltage dividing of R3 and the very low output impedance of IC1-a. The output of IC1-b is connected through equalization network R5, C2, and C3 to dual-tone multi-frequency (DTMF) receiver IC5. Inputs to IC1 are biased to ½ of V_{CC} by R1, and C1 provides AC decoupling of the bias source.

Decoder

DTMF tones are coupled from the phone line to the audio input (pin 9) of DTMF receiver IC5, a Silicon Systems SSI 202 (or Sierra Semiconductor SS1202) chip set up for BCD output on pins 1, 16, 17, 18. The chip contains its own clock whose frequency is set by XTAL1. Normally, pin 15 (CLEAR DV—clear detection valid) is logic low and pin 3 (ENABLE) is logic high. Under those conditions, valid DTMF tone pairs, while being received from the telephone line, produce a BCD output and simultaneously raise the DV output (pin 14) to logic high.

The data outputs from IC5 are connected to BCD-to-decimal converter IC6. Pull-down resistors R13–R16 ensure a solid logic low at the inputs to IC6. Decade outputs from IC6 are connected to two sets of three nine-position DIP switches which are used to select two three-digit access codes. Both inputs of AND gate IC12-d bridge the BCD lines to detect the presence of digit "0." Likewise, IC14-a and IC14-c detect the "#" and "*" respectively.

When the CallScreen "answers" a call, the logic high from IC3-b pin 4, which holds the decoder circuitry inoperative until the CallScreen is off-hook, goes low and removes the reset from decade counters IC15, IC16, and IC17 through D41. At this time, IC15, IC16, and IC17 all have their Q0 outputs at logic high, and are enabled to begin counting. Because reset signals are diode-coupled, R75 is used to ensure a solid logic low on the decade counter reset line in the absence of reset logic levels. At all other times, the reset high to the decoder circuit prevents the tone-decoded ringing of slave phones, should the first three digits of a number dialed from a non-protected phone coincidentally contain a valid three-digit code.

ORDERING INFORMATION

Note: The following is available from Electronic Control Systems, R.D. 2 Box 3308, Wernersville, PA 19565. Set of two double-sided, plated-through PC boards, $39.95 (add $2.00 postage and handling); complete kit including PC boards and all parts except the cabinet, $158.000 (add $2.50 postage and handling). PA residents add 6% to all orders. Check or money order only.

For the following discussion of call decoding, we will assume a primary access code of 3-4-5, as shown by the DIP-switch settings on the schematic. Since IC15's Q0 output (pin 3) is high, primary and secondary code-enable gates IC12-a and IC13-a are enabled. The first DTMF tone pair received will be a three, and will appear as a logic high at switch position three of all DIP switches. Primary code switch digit "A" is in position three, so therefore the momentary logic high produced during the presence of DTMF-3 is passed through to IC12-a. When IC12-a is enabled, its output goes high and increments counter IC16 through D12, and 5-ms time-delay network R29-C54.

Meanwhile, when the DTMF receiver is detecting the valid tone pair representing the number 3, the DV line (IC5 pin 14) goes high. When the tones disappear, DV goes low, incrementing counter IC15 such that Q0 (pin 3) goes low and Q1 (pin 2) goes high to enable IC12-b and IC13-b for reception of the next digit.

The next digit will be a 4, and the logic high produced by it will pass through any DIP switches in position 4, incrementing counters IC16 and/or IC17 if the switch in position 4 is for digit B. In this example, IC16 will be incremented and two correct digits for the primary code will have been counted. Again, the transition of DV from logic high to low increments counter IC15 by one count, now enabling IC12-c and IC13-c. Next, a third DTMF tone pair is received representing a 5. It passes through IC12-c and D14 incrementing IC16 again, now producing a logic high on Q3 (pin 7) of IC16. As soon as three correct digits are counted by either counter, the ringer circuitry is activated to begin the ring.

Whenever the CallScreen rings the slave phones, pin 1 of IC20-a is at logic high through either D8, D9, or D10. The logic high is also coupled to IC11-a (which is connected as an inverter) whose output (pin 3) is then a logic low. Through R31, that low disables DTMF-receiver IC5 via pin 3 (ENABLE), making the CallScreen ignore any further DTMF input.

The detection of a correct code, by the Q3 output being high on either IC16 or IC17, is also coupled to the reset logic through NOR gate IC3-d pins 12 and 13. When either input to IC3-d goes high, its output goes low, disabling any control action resulting from the seven-second time-out of the code-entry interval timer IC3-c.

Counter IC15 accumulates the total number of digits input; when three have been entered, the Q3 output (pin 7) goes high. The Q3 high output is connected to IC5 pin 15 (CLEAR DV), freezing the counter at three by disabling the DV output on IC5. The only valid tone pair that the CallScreen can now recognize to use is digit "0." Tone pairs 1–9 are ignored since none of the gates are enabled. The "*" and "#" tones for remote mode-selection are also ignored because the remote-select gates are enabled only when one of the slave phones is off-hook.

If the caller enters "0" now, or at any time during the code dialing sequence, both inputs of IC12-d go high from IC5's BCD lines, and a logic high appears at pin 11 of IC12-d. That high is coupled through D5 to the reset (pin 15) of each of the decoding counters IC15, IC16, and IC17. Since the reset is blocked by reverse-biased D41, it does not affect any other circuitry, and the seven-second interval timer continues to run. Still, if the three digits counted by IC15 represent a valid code, then the entire DTMF receiver is shut down as discussed above, via IC5's ENABLE input.

Both flip-flop sections of IC18 are used for screen-mode selection latching. Local selection is made via push buttons S1 and S2. A momentary closure of S1 raises a momentary logic high on CLOCK pin 11 of IC18. That transfers the logic state of DATA pin 9 to the Q output pin 13. Since Q̄ (pin 12) is connected directly to pin 9, Q and Q̄ both change state and remain latched upon each momentary closure of S1. The Q and Q̄ outputs are used to control circuitry in the reset logic to place the CallScreen in either Full-Screen or Limited-Screen mode, so the mode changes occur in a toggle fashion using S1. When Q (pin 13) is high, the Full-Screen mode is active and Q3 is turned on lighting LED2.

The selection of Screen On/Screen Off is made independent of Full- or Limited-Screen selection. However, IC18-a is toggled by S2 in a similar manner as IC18-b. Screen-On status is indicated by LED1, where R43 and R44 are current-limiting resistors. Transistors Q2 and Q3 are connected in a series arrangement such that LED1 will be turned on any time the screen mode is "on." However, LED2 cannot be turned on by Q3 unless Q2 is also on.

Resistors R38 and R39 ensure a solid logic-low at the CLOCK inputs of IC18 in the absence of positive pulses. Capacitors C30 and C31 prevent the outputs of S1 and S2 from bouncing, which would produce multiple transfers of the flip-flops. The connection of reset pins 4 and 10 together through C32 to +5V and through R40 to ground causes both flip-flops to be reset whenever power is applied. That ensures that the operating mode will always initialize to Screen Off/Limited Screen in case of a power failure.

The MASTER RESET line is constantly held high by IC18-a from Q̄ (pin 2) through OR gates IC9-c and IC9-b whenever the CallScreen is in the Screen Off mode. Limited/Full Screen is controlled by IC18-b by enabling/disabling AND gates IC4-a and IC4-b in the reset logic.

Remote mode selection can be made through any Touch-Tone type telephone connected as a slave. The "*" and "#" BCD outputs from IC5 are detected by IC14. When IC5 receives a "*," D1, D2, and D8 (pins 1, 18, and 16) go high. That places a logic high on pins 8 and 9 of IC14-c and on pin 2 of IC14-a. Pin 1 of IC14-a is connected to remote mode-change timer IC9-d, which holds a logic high on pin 1 of IC14-a for 7 seconds after any slave phone goes off-hook. Such a combination of logic levels causes pins 3 and 10 to go high, causing pin 4 to go high, which toggles the state of IC18-a through D21. When IC5 receives a "#," D4 and D8 (pins 16 and 17) go high. That places a logic high on pin 2 of IC14-a and pin 13 of IC14-d. If pin 1 of IC14-a is also high from IC9-d, pin 3 of IC14-a will go high, toggling IC18-b through D20.

Control and reset logic

There are two reset conditions used by the CallScreen. One is a constant logic high on the MASTER RESET line which disables the off-hook latch (IC3-a and IC3-b), effectively shutting down the unit. The two signals that can hold the MASTER RESET line high are slave-off-hook (IC9-c pin 9) and screen off (IC9-c pin 8). The other reset condition occurs as an intermittent logic high delivered to the MASTER RESET line when the CallScreen is off-hook and is ending the process of screening a call. Any one of the following inputs will result in a momentary reset high:

a) Code-entry interval time-out when the CallScreen is in the Full-Screen mode and successful code entry is not made.

b) The calling telephone transitions to on-hook and local loop current momentarily drops.

c) Any other telephone on the CallScreen telephone line (local loop) transitions to off-hook.

During the one-second cue-tone interval that occurs while the CallScreen goes off-hook for an incoming call, pin 10 of IC11-c provides the enable gate (IC27-a and IC27-b) with a logic low on pin 2. That prevents any reset signals from reaching the off-hook latch during the off-hook time when line switching transients could trip the remote off-hook detector.

The code-entry interval timer (IC3-c) is initiated when pin 4 of IC3-b goes low. Pin 9 of IC3-c is normally low while pin 8 is normally high. When pin 5 of IC3-b goes high, pin 9 also goes high through C4. At the same time, pins 4 and 8 go low so that pin 10 remains low. Any transients that might disturb the transition of input states to IC3-c are filtered by R20 and C16.

As C4 charges, the voltage across R21 decreases; when it falls below approximately 1.5 volts, pin 9 sees a logic low and, since pin 8 is also low, pin 10 now goes high. That represents the end of the seven-second code-entry interval.

The output of IC3-c is coupled through RC filter R23-C17 to AND gates IC4-a (Limited-Screen logic) and IC4-b (Full-Screen logic). When the CallScreen is set to Limited Screen, IC4-a is enabled through pin 1 from pin 12 ($\overline{Q}$) of IC18-b. The IC4-a output is coupled to AND gate IC4-d. Gates IC4-c and IC4-d are normally enabled through IC3-d, whose inputs come from the number of correct digits that enter counters IC16 and IC17. When either a primary or secondary code entry is correct, either pin 12 or pin 13 of IC3-d will go high, placing pin 11 low and disabling both IC4-c and IC4-d. That prevents the generation of a standard ring, or the trigger of a master reset after a seven-second time-out, whenever a valid code is entered. If a valid code is not detected, the logic high produced by the seven-second time-out appears on pin 11 of IC4-d and is coupled to the ringer for generation of a standard ring to indicate an unscreened call.

If IC4-b is enabled for Full-Screen operation (pin 13 of IC18-b is high), the seven-second time-out produces a logic high on IC4-b pin 4. If a valid code has not been received, that high appears on pin 10 and is passed through IC9-a and IC9-b to the MASTER RESET line, releasing the off-hook latch.

The MASTER RESET is used only to enable or disable the off-hook latch. The MASTER RESET will also disconnect the CallScreen from the phone line whenever the remote off-hook detector (IC8 pin 5) couples a momentary low to IC27-d. That logic level is inverted by IC27-d, which then appears, through various gates, on the MASTER RESET line. Pin 2 of IC27-a receives a low from IC11-c pin 10 during the cue interval. That prevents the resetting of the off-hook latch during the cue interval when the CallScreen is going off-hook and the loop current is changing.

There are two conditions that will hold the MASTER RESET high indefinitely: pin 9 of IC9-c receives a continuous high whenever any slave phone is off-hook, and pin 8 receives a continuous high whenever the screen mode is off. Either of those conditions will hold the off-hook latch inoperative, disabling ring detection and the decoder. A high on pin 10 of IC9-c is inverted by IC11-d and coupled to the base of Q4; that causes relay RY2 to drop out, connecting the slave phone(s) directly to the telephone line, bypassing the CallScreen.

The cue timer one-shot, made up of IC11-b and IC11-c, operates as a monostable multivibrator, triggerable by either positively or negatively transitioning logic levels. The outputs of the cue timer perform two functions during the timing interval: first, to turn on the 600-Hz cue-tone oscillator and, second, to disable the MASTER RESET line. The first function is operated from IC11-b pin 4, which is normally low and goes high. The second is operated from IC11-c pin 10, which is normally high and goes low.

The cue timer one-shot monostable multivibrator is triggered by a high pulse through C20 to IC11-c pin 8 when the CallScreen goes off-hook; the other input to IC11-c is normally high. The cue timer is disabled by IC11-a whenever the ringer is enabled and the CallScreen is ringing the slave phones. RC network R31-C24 delays the re-enabling of the cue timer when the ring-enable signal returns to logic low. That delay allows any ring transients—that could develop should a slave phone transition off-hook at a moment when the instantaneous ring voltage is high—to decay before re-enabling the cue timer. The cue timer must be disabled during a CallScreen-generated ring, because of the high input impedance of the timer trigger circuits and their sensitivity to stray pickup from the high ring voltage.

There are two other input triggers to the cue timer. Each input is capacitively coupled so that either input can produce momentary low levels on pin 5 of IC11-b, which is normally held high through R45. These inputs come from the screen-mode select flip-flops of IC18. Whenever the mode transitions from Screen Off to Screen On, the reset level at pin 8 of IC9 goes low. Before pin 8 goes low, C23 has no charge on it.

The transition of pin 8 to low forward biases D7 allowing C23 to charge from the +5 volt supply through R45. The initial charging current causes a large momentary voltage drop across R45 effectively reducing the voltage at pin 5 of IC11-b to logic low, triggering the cue timer to inject a tone into the telephone line. At the same time, D6 is either momentarily reverse biased or has zero bias depending on the status of Limited/Full Screen selection. That effectively presents a high impedance (100K set by R24), preventing swamping of the logic low pulse developed by C23/D7.

When IC9-c pin 8 transitions high (screen mode is being set to off), C23 is fully charged to +5V, and D7 is reverse-biased. Resistor R30 discharges C23 by bringing both of its terminals to a +5V potential. The transition from Limited to Full Screen also triggers the cue timer in a manner similar to that described above, but uses R24, C19, D6 and R45.

With the cue timer enabled (pin 9 of IC11-c is high), and pin 8 normally low through R25, pin 10 is at logic high and therefore pin 6 of IC11-b is also high. Since pin 5 of IC11-b is normally high through R45, pin 4 is then low, which represents the quiescent state of the cue timer.

When the off-hook latch operates, a logic high differentiated by C20 to a momentary high appears at IC11-c pin 8. Since pin 9 is also high, pin 10 transitions low as does pin 6. With pin 6 low and pin 5 high, pin 4 now goes high. That high also appears at pin 8 through the charging action of C21 and, for the time being, the timer output (pin 4) remains latched high.

As C21 charges through R25 and R26, the voltage on pin 8 decreases. When the voltage diminishes to approximately 1.5V, IC11-c sees a logic low and pin 10 transitions high as does pin 6. With pins 5 and 6 both high, pin 4 goes low and the timing interval ends. The same timing action is triggered if a momentary logic low appears on pin 5 of IC11-b. This would occur upon operation of the screen-mode select logic as discussed earlier.

Ringer

The CallScreen ringer circuitry essentially takes a logic high on one of three inputs and produces one of three ring cadences which is delivered to the slave phone(s) as a 27-Hz, 90-volt RMS ringing voltage. The ringer also includes the 600-Hz cue oscillator which, along with cue timer functions, is keyed by the 27-Hz ring frequency oscillator to produce the "ring back" signal that the caller hears.

The three ringer input lines are coupled through diodes D8, D9 and D10 to ring clock NAND gate IC20-a pin 1. When any one of the lines goes high, indicating the need to ring the slave phone(s), IC20-a is enabled and the ring clock begins to run. An astable multivibrator, made up from IC20-a and IC20-b, produces gating pulses at pin 4 of IC20-b at 600 ms intervals when enabled by pin 1 of IC20-a being high. The repetition interval is determined

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SATELLITE TV

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so the viewer can choose a camera angle on sports events, interact with contestants on a game show, or determine the plot of an action series. TVN has an exclusive agreement with ACTV, a Canadian company that's developed a seamless way to switch between four video channels to provide interactive video.

Until digital compression became a reality, interactive TV made no sense, since few cable operators and no terrestrial broadcasters had the needed channel capacity. TVN Vice-President Stuart Jacob says his company hopes to offer sports fans interactive coverage of major sporting events like the Indianapolis 500, the 1992 Olympics and major-league hockey and baseball.

Does all this mean the large dish is dead? No way. The programmers who form the backbone of cable TV and today's satellite viewing—HBO, Showtime, CNN, ESPN, MTV and the rest—are committed to large-dish transmission through the year 2015. Over the next few months, they'll be joined by some 20 newcomers with everything from want ads and programs in Tamil, to sci-fi and American Lawyer (a 24-hour channel for Perry Mason addicts). What signal compression can do for small-dish DBS services, it can also do for large-dish owners. **R-E**

CALL SCREENER

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by C27 and R35, and R34 provides the feedback path to IC20-a. Gating pulses from pin 4 of IC20-b begin clocking decade counter IC23 whose ten outputs (they're not all shown) then begin sequencing, one at a time, to logic high. At a 600-ms clock rate, the counter will sequence through all ten outputs in 6 seconds, which is the standard ring cycle of the U.S. telephone systems. Steering diodes D22–D29 are connected from the Q outputs of the decade counter to assemble the three different ring cadences.

Diodes D22, D23, and D24 are connected to the Q1, Q2, and Q3 outputs of IC23. As soon as the ring clock is enabled, Q1 goes high for 600 ms, followed immediately in sequence by Q2 and Q3 for 600 ms each. The input of IC22-b (pin 5), therefore, sees a logic high for approximately 1.8 seconds (Q1 + Q2 + Q3) out of every 6 seconds, thus producing a standard telephone-company like ring if IC22-b is enabled by pin 6 being high. In a similar manner, IC22-c and IC22-a are supplied with logic levels corresponding to cadences as follows:

IC22-c—high 600 ms, low 600 ms, high 600 ms, low 4.25 seconds (two short rings and pause).

IC22-a—high 600 ms, low 600 ms, high 600 ms, low 600 ms, high 600 ms, low 3.5 seconds (three short rings and pause).

Each of the three ringer input lines is connected to one of the ring-cadence enable gates of IC22. Gate IC22-b is enabled via pin 6 from IC4-d pin 11 when the CallScreen is in the Limited Screen mode and the code-entry interval timer times out; this produces a "standard" ring, signaling an unscreened call. Gate IC22-c is enabled via pin 9 from IC16 pin 7 when the correct primary code is detected; this produces a double ring and pause. Gate IC22-a is enabled via pin 2 from IC17 pin 7 when the correct secondary code is detected; this produces a triple ring and pause.

The outputs of the ring-cadence enable gates are connected through diodes D30–D32 to the ring-frequency generator (pin 1 of IC24-a). Resistor R55 ensures a solid logic low in the absence of ring. Whenever pin 1 is high, the 27-Hz ring oscillator is running. Gates IC24-a and IC24-b are configured as an astable multivibrator producing approximately symmetrical square waves of logic-low and -high levels. The frequency is determined by C46 and R66, and R65 is a feedback resistor. Steering-diode D38 is used to enable the 600-Hz cue oscillator thus gating its output at 27 Hz. Resistor R67 ensures a solid logic low in the absence of enable signals.

The ringback and cue oscillator is an astable multivibrator consisting of IC20-c and IC20-d along with frequency-determining components C47 and R69, and feedback resistor R68. R70 and C53 form a low-pass filter which sets the 600-Hz output level correctly for input to IC1-a. Enabling of the oscillator occurs on IC20-c pin 8 through either D38 for ringback or D39 for cue signaling tones.

The output of the ring-frequency oscillator (IC24-b pin 4) is also coupled, through C26, to the input of op-amp IC25, which is configured as an active low-pass filter whose center frequency is set to 20 Hz. That setting provides a frequency-proportional attenuation of the 27-Hz square wave supplied from the ring-frequency oscillator at an 18dB/octave rolloff rate. The output of IC25 is very nearly a 27-Hz sine wave. Components R46 and C35 provide AC decoupling of ½ V_{CC} bias voltage to operate IC25 without a split power supply. Voltage divider R50 and potentiometer R51 set the input level to IC26 for a 90–95 volts RMS ringer output voltage.

The LM383 7-watt power amplifier (IC26) has its gain set by R72 and R73. Feedback for the inverting input is coupled through C41, while low-level ring voltage is connected to the non-inverting input via C40. Capacitors C42 and C43 stabilize IC26 against high-frequency oscillation. C44 couples high-current ring signals to the 8-ohm primary of T3. High ring voltages appear across the 8 kilohm secondary of T3. The ringer configuration is capable of reliably

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CALL ROUTING ADAPTER PARTS

All resistors are ¼-watt, 5%, unless otherwise noted.

R101—150 ohms, ½-watt
R102, R103—10,000 ohms
R104—330 ohms
R105—1000 ohms

Semiconductors

D101–D106—1N914 diode
Q101, Q102—2N4401 NPN transistor

Other components

RY101, RY102—SPDT miniature relay, 12-volt, 320-ohm (nominal) coil
S101, S102—SPDT miniature switch (or use single DPDT center-off switch)
J1, J2—modular phone jack

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ringing telephones with a combined ringer equivalence number (REN) of 5.0.

Slave phone interface

The primary function of the slave phone interface is to immediately detect when any slave phone is off-hook and to establish a MASTER RESET high, as long as the phone is off-hook. When the slave phone is placed back on-hook, the reset is removed.

Whenever the CallScreen is in the Screen-On mode, RY2 is energized, connecting the slave phones to the secondary of ringer transformer T3. The secondary of T3 provides the ring voltage when a ring is required from incoming calls processed through the CallScreen. The phone connection to T3 is made through the series connection of the +16V power supply, and the series/parallel combination of IC28, R74, D40, and C45.

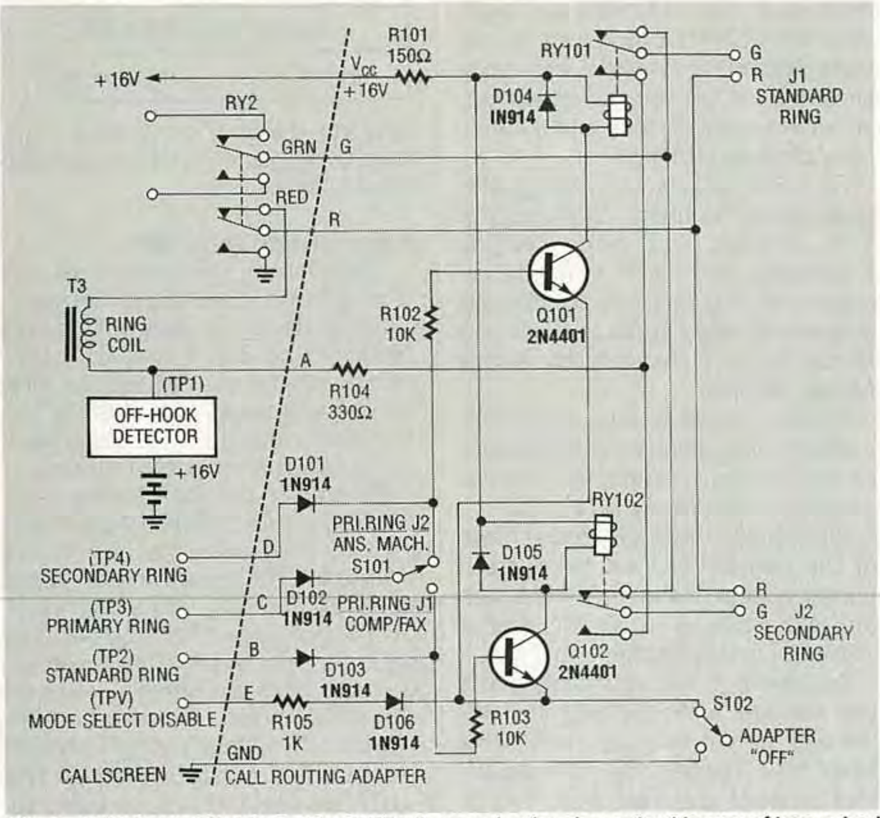

FIG. 2—THE CALL ROUTING ADAPTER allows selective ring output to one of two output jacks. While the circuit is optional, there is space for the components on the main PC board.

Standard telephones have their ringer devices coupled to the telephone line through very high DC resistances. In practice this coupling is usually capacitive, so that while on-hook, there is essentially no DC current path. When off-hook, a DC resistance of up to several hundred ohms is placed across the line. Any slave phone, when raised off-hook, causes DC to flow from the +16V power supply, forward biasing the IC28's internal LED, through R74 and the secondary of T3, through the DC resistance of the off-hook phone, and back to power supply ground. The forward-biased opto-coupler diode turns on the phototransistor whose collector is connected in parallel with the collector of the Darlington pair in IC21 and through R58 to +5V. When IC28 is turned on, the voltage at the lower end of R58 goes to nearly zero. That is coupled to pin 2 of comparator IC2 which causes IC2 pin 6 to go high.

The reference voltage for IC2 is developed by voltage-divider R60-R62; it is set to approximately 224 millivolts. When the voltage at pin 2 goes lower than 224 millivolts, the output of IC2 goes high. That output is coupled to pin 9 of IC9-c which, as part of the reset logic, sets a MASTER RESET high and also causes RY2 to release. A MASTER RESET high will unlatch the off-hook latch. The result of these actions is that the slave phones now bypass the CallScreen and are connected directly to the phone line, and the CallScreen is returned to on-hook. The output of IC2 is also connected to timer IC9-d which enables screen-mode changes for a period of approximately seven seconds after a slave phone is placed off-hook. That prevents screen-mode changes from inadvertently occurring during normal telephone calls in the event that the "*" and "#" keys are used.

Buffer IC9-d drives timing components R57 and C58. When any slave phone transitions off-hook, IC2 pin 6 goes high as does IC9-d pin 11. That high appears through C58 on IC14-a pin 1, which enables remote screen-mode changes. As C58 charges, the voltage across R57 decreases. When R57 reaches approximately 1.5 volts, pin 1 of IC14-a sees a logic low and remote screen mode changes are disabled.

As soon as IC2 pin 6 transitions high, C34 begins charging through D36 and R63; R63 limits the inrush current to C34 preventing a momentary voltage collapse at the cathode of D36. When RY2 drops, the slave phone connections are transferred from the CallScreen ringer transformer to the telephone line. When the transfer occurs, IC28 turns off and IC21 turns on. The LED inside IC21 is connected in series with the phone line through BR3 which ensures a correct polarity for forward bias regardless of actual phone line connections. Current for the LED comes from the telephone company central office.

Since the collector of the Darlington pair in IC21 is connected in parallel with IC28, the bottom of R58 remains low and the MASTER RESET remains high. At this time, the slave phone has been connected and the CallScreen is held reset and is effectively transparent on the line.

If a slave phone is raised off-hook to make an outgoing call, the process is the same as described above except that when the slave phone is transferred to the telephone line, there is a momentary interruption of the central office DC current from the time the central office detects a phone off-hook until a dial tone is returned superimposed on the restored DC current. During that interval, IC2 pin 6 transitions low, but the now-charged C34 maintains a high on pin 9 of IC9-c for approximately one second. That delay provides a ride-through capability that prevents RY2 from pulling in and eventually rocking the off-hook slave phone back and forth to and from the telephone line. The discharge of C34 takes place through R63, R61, and the low output impedance of IC2. Diode D36 is reversed biased during this interval. The arrangement of R61, R63, and D36 is designed to allow C34 to charge quickly, but to discharge slowly.

Resistor R59 limits current through IC21's LED while a forward-biased D35 eliminates any reverse voltages from appearing across the LED. When D35 is reversed biased, the voltage across the combination of R59 and

IC21's LED is limited to 5.1 volts, thus placing an absolute limit on the forward current through the LED. These precautions are necessary to protect IC21 in the presence of telephone-company ring voltage when the screen mode is off, and also to protect against electrical transients that appear on the phone line.

The detection of a slave phone off-hook while a ring voltage is being developed across the secondary of T3 requires that RC filtering be used to track the average DC voltage level on the collector of the phototransistor in IC28. While the ring voltage is present, IC28's LED will be forward biased during a portion of each half cycle of ring current. Zener-diode D40 protects the LED in the same manner as D35 protects IC21. Capacitor C45 bypasses a major portion of the AC ring current around the off-hook detection circuitry, but some short-duration pulsing of the IC28 collector to ground does occur. The combination of R56 and C33 act as a low-pass filter to reduce the ringing pulses to an average DC level across the input of IC2. The DC level is above the comparator reference voltage so that ring pulses will not trip the slave-phone off-hook detector. When the slave goes off-hook and the IC28 collector transitions to solid low, the comparator output goes high.

Call routing adapater

The call routing adapter (CRA), shown in Fig. 2, allows selective ring output to one of two output jacks. A switch (S101) on the CRA allows user selection of either answering machine or computer/facsimile machine operation. When S101 is in the "ANS MACH" position, all un-screened calls ring through J1, while all screened calls ring through J2. When S101 is in the "COMP/FAX" position, all secondary-code calls ring through J2, while all un-screened and primary-code calls ring through J1. Another switch (S102) allows the user to de-activate the feature permitting all CallScreen processed calls to be available on both CRA output jacks. The CRA derives all control signals and power from the base CallScreen unit.

With the CallScreen in a stand-by condition, both RY101 and RY102 are de-energized and both output jacks (J1 and J2) are connected in parallel through to the CallScreen output poles on RY2. This permits normal processing of outgoing calls generated by an off-hook condition on J1 or J2.

When an incoming call is determined to be un-screened, TP2 (in the main circuit) goes high simultaneously with the activation of the CallScreen ringer. When TP2 goes high, Q102 is turned on through D103 and R103, closing the contacts of RY102. The contacts on RY102 transfer the output on J2 from the CallScreen ringer directly to the CallScreen off-hook detector. That prevents CallScreen ring voltages from reaching any telephone(s) connected to J2. RY101, however, remains de-energized and the standard ring (for an un-screened call) is delivered to J1. Assuming that S101 is in the "ANS MACH" position, it is apparent that a logic high on either TP3 or TP4 will similarly energize RY101 preventing screened-call ring signals from reaching J1, while J2 receives screened-call rings. In this mode, the answering machine is connected to J1 and the telephones to J2.

When S101 is in the "COMP/FAX" position, the same ring lockout technique described above is used so that primary and un-screened call rings are prevented from reaching J2 and secondary rings do not reach J1. In that mode, the computer or facsimile machine is connected to J2 and the telephones to J1.

Resistor R101 reduces the 16-volt supply from the CallScreen to a nominal 12 volts for operation of the CRA relays. R102 and R103 are current limiting resistors while R104 protects the CallScreen off-hook detect circuit from excess current, should a short to ground occur across J1-J2. Diodes D101–D103 are steering diodes, while D104 and D105 act as back-EMF surge suppressors. When S102 is closed, a logic low is placed through D106 and R105 across the screen-mode select line which disables remote screen changes.

That's all we have room for this month. Next time we'll go over the assembly and provide parts-placement diagrams. **R-E**