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Dual-Band Smokey Detector

—Super Scooper does it all

The battle goes on.

The "Smokey Detector," described in the 1976 Holiday issue of *73*, has been the subject of much mail received at W1SNN. Many have asked if it could be used on the higher frequencies found with newer types of radars which have been designed to improve entrapment techniques and decrease confidence in Smokey Detectors.

The author has learned of new methods used to deploy obsolete police radar along highway ranges used for surveillance. Newer radar is used in conjunction with this method, which is known in police circles as "seeding." The older radar units are set up and left unattended so that they "illuminate" stretches of highway for many miles—depending on the number of "seeds" that are used. Most of those units operate on 10.525 GHz in X-band.

The newer radars, usually operated from a fixed position, are hand-held and triggered only when the device is pointed at a particular stream of traffic. The purpose of seeding is to keep the Smokey Detectors activated and, therefore, cause drivers to slow down. Confidence is soon decreased in the Smokey Detector, however, and the unsuspecting driver is trapped by the hand-held device. Yes, it works on X-band, too, but too late for a detector warning because the speeder has moved right into trigger range.

But that isn't the only technique used. How about this one: As before, seeding is used. Radar which has been designed to be used in vehicles while moving is employed. These units have a device that arithmetically removes the vehicle speed, allowing the officer to pursue and record the speed of the car being chased. Here again, the police car can depend upon the seeds to keep Smokey Detectors operating, and even when the police come into range of vehicles using detectors, they can follow without detection. The new radar operates in the K-band region. Most of the older radar detectors will not receive at this frequency range; again, confidence is lost.

These techniques are used by large municipalities and state agencies for the most part. They can afford to maintain the antiquated equipment for seeds. Others will be adopting them, however, because of newer seed equipment that is being manufactured by several companies at prices which can fit smaller budgets. The newer units are simply a small oscillator and battery supply. The oscillator will feed an antenna that floods an area with the oscillator's signal. They can be left unattended, fastened to street signs and stop-go signals. Other radar units that promise greater control for police agencies are in the works; the war is still on.

What can we do with our radar detectors? Well, we can update them to detect the newer frequencies and learn how to use the older ones to be sure that we are detecting an active radar and not a seed. It is not too hard to manufacture detectors that are sensitive enough to detect a seeding and radar entrapment, and thus provide a warning that both are being used, or to warn that just a higher-frequency moving radar is activated. Look at the block diagram of a dual warning system which accompanies this article.

A circularly-polarized horn coupled to a circular waveguide is coupled to a pair of crystal detectors. The detectors are mounted in cavities which support the frequencies of interest. The larger of the two cavities is tuned for the X-band frequency, 10.525 GHz, while the smaller one has a step ridge mounted into its E-plane coordinate. The step ridge performs as a tuning device that allows the smaller of the two cavities to work over the 16.5- to 26.5-GHz range. There are several frequencies used in this range for hand-held and moving-surveillance radar units.

Coupling to the circular waveguide is accomplished by careful placement of the two detectors which are mounted in rectangular waveguide to provide coupling to the circular mode.

Two preamplifiers, one for each waveguide-mounted detector, amplify the signal—which is the dc component of the detected signal. The amplified signal is passed through a CMOS switch which serves as a signal modulator.

Each of the switches has its own driving oscillator. An oscillator at 1 kHz modulates the X-band-detected signal, and another at 400 Hz serves as the K-band signal modulator.

The outputs of the two modulators are summed at the input of an audio amplifier that drives a loudspeaker.

The resulting warning signal will be two-toned when both X- and K-band radar units are detected. If just the X-band detector is activated, the higher-pitched tone of the 1-kHz oscillator will be heard. Likewise, the 400-Hz signal will be heard when a K-band signal is detected. When both are on, it is very likely that you are in an entrapment area which is well seeded. Beware when the higher-pitched tone stays on for long periods. If it is on for over 4,000 feet of driving, you are probably in a seeded area. If the signal continues, slow down and watch for your friend in blue.

The circuitry illustrated here is straightforward audio construction and can be built on a small board using flea clips or wire-wrap. No special attention is required. The completed board must be mounted so that the leads that connect to the detector outputs are short—that is, not over six inches long. Several adjustments to the electronics are required and will be described below.

The hardest part of the construction of the Super Scooper is its antenna and circular waveguide. In the original Smokey Detector article, instructions were given on how to construct the horn antenna. This was the subject of many inquiries both as to its beamwidth and gain and relative to variations from the given dimensions. First of all, the gain of the antenna is approximately 14 dB over a reference antenna that provided a 3-dB gain standard. The gain standard was determined in a laboratory using a section of circular guide terminated in a matching impedance to a standard signal generator. A similar antenna was used with a detector and spaced one meter from the generator gain standard and three meters above the ground. Once a level was determined by setting the signal generator attenuator to produce a full-scale deflection on the detector indicator, the new antenna used on the Super Scooper was substituted for the transmitting horn, and then the attenuator was readjusted to produce the same full-scale reading as with the reference antenna. The attenuator difference was 14 dB at 21 GHz and 17 dB at the X-band frequency.

Since most amateurs will not be able to duplicate these dimensions, a pattern shown in the drawings has been laid out so that it can be closely duplicated. Several antennas were constructed and measured, and variations from the values given were not worth mentioning. The dimensions were deformed

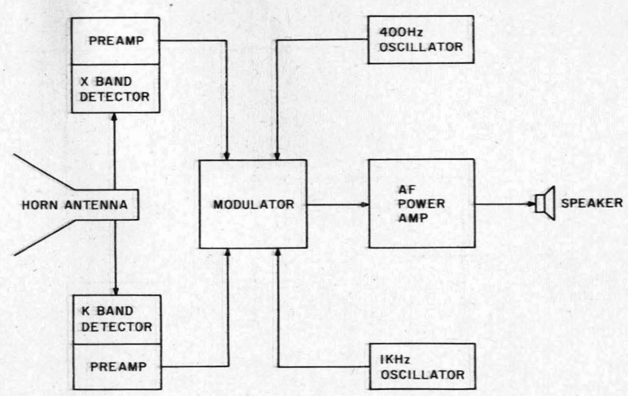

Fig. 1. Block diagram, Super Scooper Smokey Detector.

from true circular to a shape which occurs when the seam is soldered. Not a true circle, the variation in gain wasn't worth the trouble to measure. It is apparent that that would take quite a departure from a true funnel shape.

The beamwidth was measured, and it required a considerable amount of time to determine that it was a circular beam of 9 degrees. Variation from a true funnel shape does distort the beam considerably, so care in achieving the cone shape should be exercised. The beamwidth was measured on an antenna range at the same laboratory, using a quality of range equipment probably not available to most amateurs. A nine-degree beamwidth is very similar to that of most circular antennas used on police radars and should intercept most radiation from them.

To construct the antenna, it is necessary first to acquire a piece of copper flashing sold in most hardware stores. (Brass can be used but should be thin so that it is easily worked.) The sheet should be at least 10" x 6". With a compass, lay out a 9-5/16" circle and, from the same center, scribe the second ½" circle. (See the drawing.) Outside of the circle leave enough metal so that the tooth-like section can be cut and bent. Cut the sheet with tin shears and flatten out all bends and dents acquired in the cutting procedure. Make sure that the tooth-like cuts are bent at right angles to the sheet, and then lay it aside.

Next acquire a piece of construction paper with the same dimensions as the flashing sheet. Lay out the same dimensions as before, but forget the tooth-like part—just cut a smooth ½" half-circle. Cut out the complete sheet so that it can be glued at the seam tab. Now you should have a cone that has a mouth 3¾" in diameter and a length of 4-1/16". The opening at the rear should be about ½" in diameter.

Make up about two cups of plaster of paris that is nearly dry but easily molded, and fill the cone so that a substantial amount of it protrudes from the ½" hole. Shape the plaster so that the cone is as rounded as possible, and set it aside to completely harden. This form will serve as a mandrel for the metal horn when soldering its seam. Simply bend the metal around the form and hold it in place with rings placed at several points on the cone. Solder the seam. Shape the metal and set it aside until the circular guide is finished.

The circular waveguide is made from a section of ½" water pipe 3" long. Lay out the dimensions shown in the drawing. Measure up along the outside

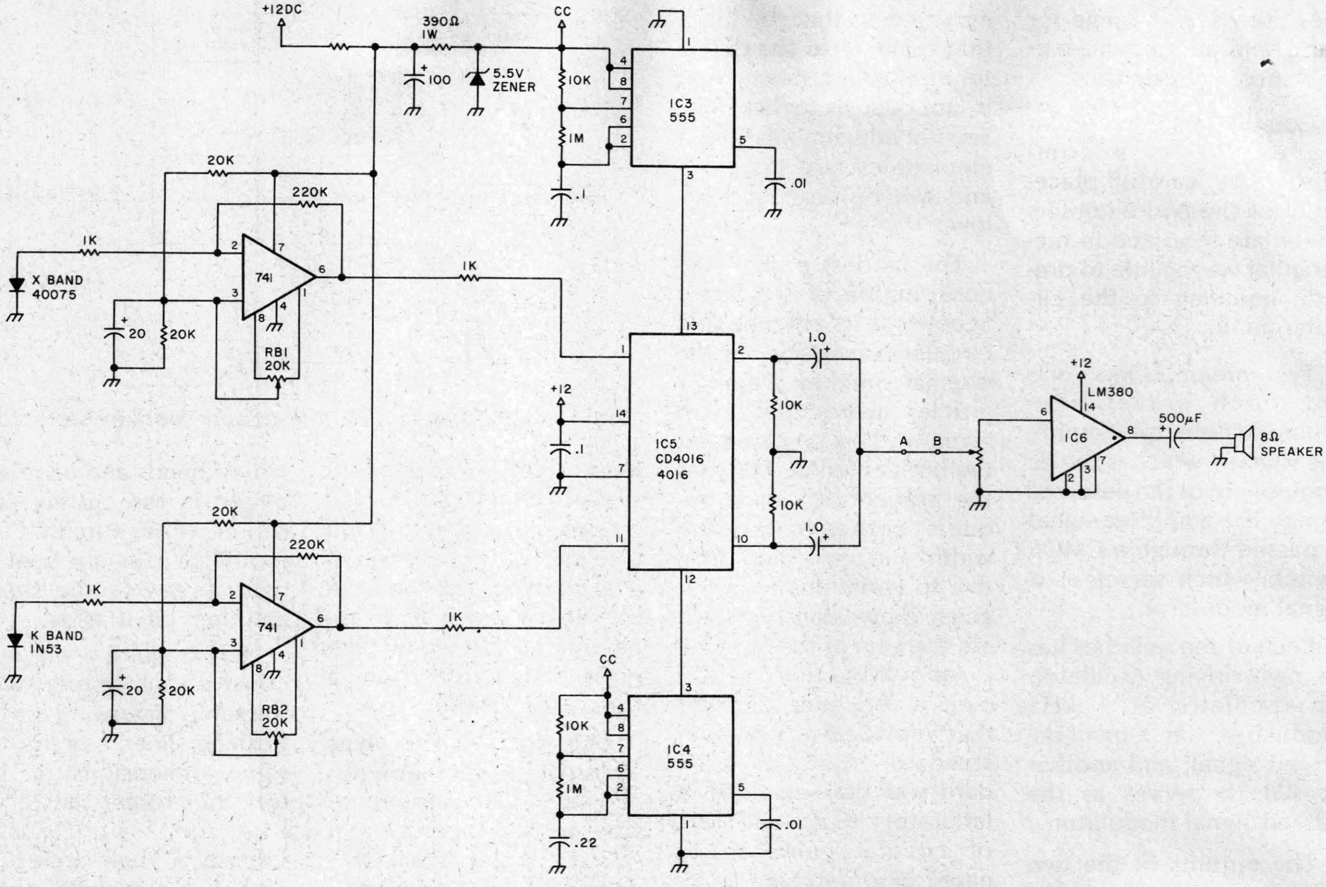

Fig. 2. Schematic, Super Scooper Smokey Detector.

of the pipe and make two marks to indicate the width of the cuts. They will be .250" wide and will support the K-band waveguide when soldered in place. Make this cut so that the .250" x .500" guide sits in place in such a way that edges of the guide mate with the H-plane walls of the K-band waveguide. Remove all burrs. (The cuts are easily made with a hacksaw, but can be better if done by a friendly machinist and a milling machine.)

No other cuts are needed in the circular waveguide, but its length is very important. The ends should be square and free of burrs. It also would be to your best advantage to clean the pipe inside and out with steel wool so that solder will easily tin the metal. Set the circular waveguide aside for now, and proceed to drill the holes in the E-plane dimension of each waveguide section.

Lay out the holes on the X-band guide as shown in the drawing. The crystal detector mounting for the 40075 X-band detector should be a 3/16" drilled hole on the centerline of the E-plane. Mark a point 11/16" from the smoothed end of the guide. Carefully centerpunch a point for the drill and drill through both walls of the guide. Open one hole to 5/16 of an inch. Place a section of 3/16" pipe or tube, 3/16" long, into the other hole.

(This pipe is found in most model shops; it is brass tubing used in model construction. If you try to buy it at a metal dealer you will pay for a lot more than you need since there it will be a one-foot section you will have to purchase.)

Solder this small piece in place so that it is just even with the inside wall of the X-band guide. This serves as a connection for the small end of the X-band diode. Now lay out the other two holes in line with the 5/16" diameter hole, drill them, and tap for 4-40 threads. Next, drill holes located 3/4" from the B tuning hole through both walls. Use a #36 drill. On the same side of the guide wall as the detector holes, open the #36 hole to a 5/8" diameter. Tap the remaining #36 hole for 6-32 threads. Deburr the hole inside and out. This hole is used to couple the circular guide to the X-band detector. Mount two 4-40x½" brass screws in the holes marked B and C and use nuts as locks for these screws. A ½" brass 6-32 screw and nut is used for the same purpose at point A.

Next, lay out the hole required on the K-band waveguide. This hole must be on the centerline of the E-plane side of the waveguide. Very carefully centerpunch a point 5/16" from a smoothed end of the guide, and at this point drill a .187"-diameter hole through one wall of the guide. Deburr on each side of the hole, as on the X-band guide. Mount a ¼" long piece of copper tube .250" in diameter. The ends should be deburred inside and out. This piece of copper serves as the outer part of a capacitor and choke for the K-band 1N53 detector diode. The copper tube and the diode are coaxially mounted, so it is necessary for the tubing to be aligned so that the hole in the guide is exactly in the center.

The next step is to lay out the 1/8" thick piece of brass which will serve as the step ridge for the K-band waveguide. Lay out the steps, cut with a hacksaw, and smooth with a file. The steps are set so that the bandwidth of the K-band cavity is quite broad and will cover many of the frequencies used by K-band radar. Departure from the dimensions given will decrease the sensitivi-ty of the Super Scooper, s try to stay as close as possible.

Next, in the middle of the second step from the top of the structure, drill a hole with a number 60 drill. This hole must be on the centerline of the step, and fall 5/16″ from the end of the structure so that it will align with the hole in the waveguide when the structure is in place. Remove the center conductor from a BNC chassis jack (UG-1094/U). Cut off the solder section so that the pin is .250″ long, and file it smooth. Insert the cut end into the number 60 hole and carefully solder into place. (Take care that solder does not fill the flutes on the opposite end.) This pin serves as the connection to the center conductor of the 1N53 diode—a coaxial diode that has a pin connection.

Slide the step ridge section into the waveguide so that the pin is in the center of the .187″-diameter hole. This ridge section must lie on the center line of the inside (E-plane) of the guide. (It may be held in place by wood wedges while it is soldered on the bottom to the waveguide wall.)

Now solder the X-band and K-band detector mounts in place. The 2″ circular waveguide should be inserted into the 5/8″ hole drilled into the X-band guide. The pipe should be just through the waveguide so that it is parallel with the inside wall of the guide. Solder in place. Also solder a ½″ x 1″ cover plate on the open end of the guide. Install the K-band detector mount and solder in place. Add a cover plate to the open end of this mount, also.

Now slide the horn over he end of the pipe and ress down the tooth-like 'aps so that they lie flat on ie pipe. Match up the end f the horn with the end of e pipe and solder the ps to the pipe. Use solder sparingly on the inside joint and make it smooth and clean, but build up the solder on the outside to strengthen the joint. Gussets may be added to the outside of the horn and pipe, if desired.

Install the X-band diode by first slipping over the diode a ¼″ solder lug and a ¼″ shoulder washer. The shoulder should face the small end of the diode. Install a 1N53 diode in the K-band mount by first wrapping the diode outer sleeve with one wrap of Saran Wrap, which serves as the dielectric for the choke capacitor. (For the purist: Use a single wrap of 1 mil mylar™.) When this diode is installed, it should be pushed into the mounting hole carefully so that the insulation is not scored. The center pin of the diode should engage in the hole of the pin jack mounted on the ridge. A diode clip should be used to connect to the shank of this diode where it protrudes from the copper tube. Use a razor blade to cut away excess Saran Wrap or mylar™ so that the clip can make contact with the outer diode sleeve.

The diodes may now be connected to the points indicated on the schematic diagram. Care must be used in making these connections. Be sure that there is no power in the circuitry. Do not solder to the diodes; solder to the lug—and then only briefly for the X-band detector diode—and do not solder at all on the K-band diode. Use a diode clip or make a small clamp that contacts the diode sleeve.

Assuming that all of the electronics has been constructed as shown in the schematic diagram, it is now time to test individual circuits.

The input circuits to the LM380 audio amplifier can be used as an audio circuit tracer by disconnecting the jumper marked AB at the input of the volume control. Connect a .01 capacitor to this point and use it as a probe to detect the 1-kHz tone at the output of IC3, pin 3. Be sure the audio volume control is half open, as the tone should be present at this point. Also, you should be able to detect a 400-Hz tone at pin 3 of IC4. If this test checks out OK, reconnect the jumper at AB. Now, probably, you will hear both tones. If so, disconnect pin 3 of IC4 and adjust balance pot RB1 so that the tone nulls out. Reconnect pin 3 of IC4 and then adjust balance pot RB2 until the other tone disappears. This completes the electronic adjustments.

The rf adjustments require the use of two signal generators, or your friendly police car. Apply a signal to a horn, or other radiator, from an X-band signal generator, point the Super Scooper antenna toward the generator, and use a fairly strong signal from the generator. Adjust tuning with screws B and C alternately for the strongest tone from the speaker. To use an indicator, connect an ac voltmeter across the speaker leads and adjust the screws for the greatest output. Now turn off the X-band signal generator and radiate a signal from a K-band generator at 24.5 GHz toward the Super Scooper. Adjust screw A for the strongest signal.

The adjustments are now complete, and so off to the highway! You may find that radar used at airports and military bases will be detectable. These units are putting out very strong signals and will saturate your Super Scooper. It will take only a very short time to learn how the Super Scooper works.

No description of the packaging of this device is given here. It is sufficient

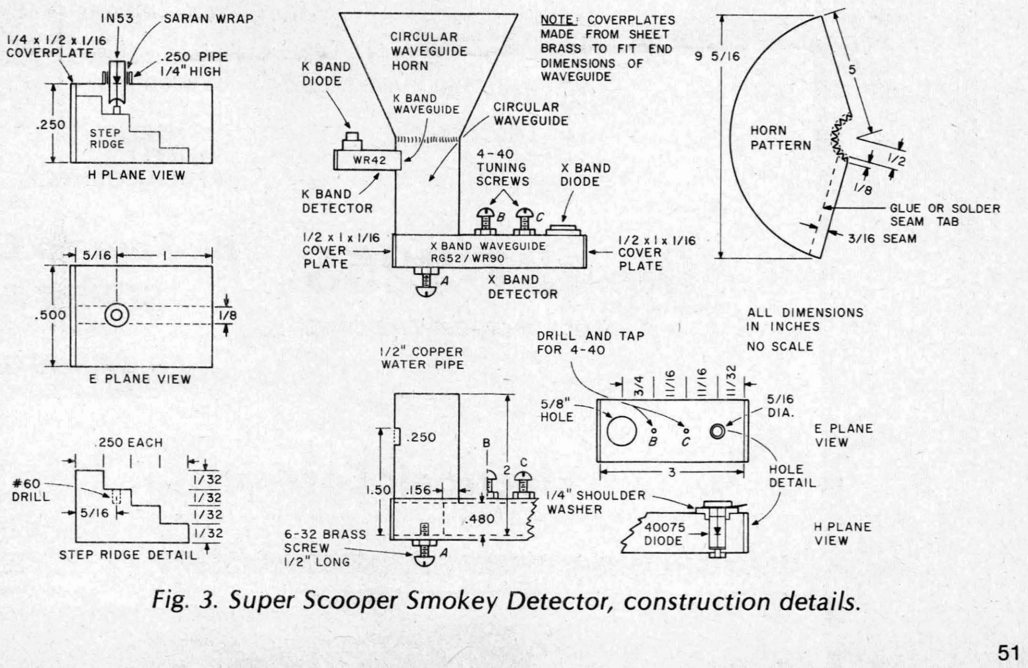

Fig. 3. Super Scooper Smokey Detector, construction details.