ICARC TDOA Antenna Switch

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User Manual for ICARC Antenna Switch. TDOA Time Difference of Arrival DTOA Differential Time of Arrival It is a work-in-progress right now.

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1 The Boards

A tool that makes your handy-talkie more useful for foxhunting!



Figure 1: First Prototype

Surface mount only for the RF section, all the rest is thru-hole. Boards provided to club members with the surface mount mount parts installed.



Figure 2: Second Prototype

Functions the same as figure 1, but it is all surface mount (faster to build!). Surface mount parts are less expensive than thru-hole parts.

Both versions of the board mount in the same project box, a Hammond series 1599B plastic housing. The newer board is slightly smaller, as can be seen by comparing the location of the mounting holes.



Figure 3: Third Prototype

These are the incarnations of a simple PIN Diode switching circuit that inserts an audio tone (of fixed frequency) when the attached antenna array is not *normal* to the transmitter.

The *normal* line from the antenna array is the line perpendicular to the line that connectes the two antennas of the array.

So, what we're up to here, is to have a circuit that makes direction finding a bit easier when using a hand-held FM receiver. To make a direction sensitive antenna array, let us use a pair of simple monopole antennas seperated by no more than a half wavelength.



Figure 4: IMGP3324_50.png

When the antennas array (i.e. the two antennas) are oriented *normal* to the transmitter, they will be equidistant from the transmitter. Being equidistant, the two antennas of the array will see more-or-less identical signals. In particular the two antennas will see the received signals having the same phase. Nothing special happens in this case, the radio operates as you would expect; you hear the fox transmitter.

When we switch between the two antennas, the signal from the antennas are in-phase so the receiver does not notice.

As the antenna array moves away from *normal*, the antenna switching will introduce a phase error into the received signal presented to the receiver. An FM system will see this phase shift as a frequency change and introduce a discontinuity into the demodulated audio. You will hear this as a squeal at the antenna switching rate.

2 Theory of Operation

This is the section where I try to convince you that I know how this works.

This should be good for a laugh...

2.1 The PIN Diode

This shows the basic structure of a PIN diode, where the acronym is **Positive-Intrinsic-Negative**. There is a region between the anode and cathode that can form a large-ish insulation area when properly biased.

When the device is reverse-biased the *intrinsic* region effectively isolates the two side of the device, acting as an RF switch in the OFF state. The RF loss through the diode is relatively high.

When the device is forward-biased the *intrinsic* region is conductive and we depend on the carrier liufetime to be much shorter than period of the VHF carrier.

Although the RF carrier might tend to excite the PIN Diode to act as a rectifier, the diode is much slower than the RF carrier so when forward biased, it doesn't come out of conduction when the carrier would reverse-bias the device.

In our receive-only application, we could get by with a simple silicone diode as our bias voltage overwhelms the receive signal, in a T/R switch the RF field strength during transmit would demand

the use of a real PIN diode. Using a PIN diode shows lower parasitic capacitance when reversebiased so it achieves a bit more isolation between the two receive antennas.

2.2 Revision -A

The -A revision uses a simple 555 timer and a simpler bias drive scheme.



Figure 5: Basic PIN Diode



Figure 6: Revision A Schematic

This is the original circuit using a 555 timer to generate the bias control for the PIN diode.

In this circuit, the bias drive is applied to the common pin of the PIN diode array. The other two pins of the PIN diode array are (DC) grounded through R6/L2 and R7/L3.

The reverse bias voltage available here is about half of what we see on the newer 102-73170-20 circuit. The higher reverse bias slightly improves the isolation by increasing the RF isolation of one of the two PIN diodes.

The forward current available is slightly less due to the reduced forward voltage available to drive the forward biased PIN diode.

2.2.1 RF Switching

The basic antenna switch consists of the same PIN diode that will be used in the -20 boards. As mentioned above, we supply the drive to the common pin of the PIN diode array. When this node is positive one of the PIN diodes conducts and when this node is negative the other PIN diodes conducts.

Figure 7: OLD_-switch.png

The drive for this version of the circuit is far simpler.

We couple the anode-cathode junction of the PIN diode to the bias drive signal and provide a DC path to ground at either end of the PIN diode.

Inductors L1, L2 and L3 provide the RF isolation. Resistors R5 R6 and R7 limit the current through the individual diodes of D1 when forward biased.

C3 is the RF shunt to keep RF out of the 555 timer.

2.2.2 Diode Bias Circuit

Again, working our way back through the circuit to the diode bias.

Figure 8: OLD_-bias.png

We DC isolate the drive signal with the C2/C2A capacitors.

The L1A/L1 inductor present a high impedance to the RF signal running to the receiver.

Finally, the C3 capacitor shorts RF energy to ground to keep it out of the driving circuit. This cap also keep digital noise from the drive circuit out of the receiver.

2.2.3 Clock & Drive Circuit

The timing control elements for the 555 timer are a bit more involved.

Figure 9: OLD_-clock.png

The charge and discharge path for the timing componants are seperated to allow the duty cycle to be trimmed.

The prototype unit was provisioned with trim pots to set the modulation frequency. The values measured and then updated to use fixed parts to reduce cost.

2.3 Revision -20

The second revision, the all surface mount edition...

Figure 10: Revision_20_Schematic

With this revision, we move to entirely surface mount. This reduces component costs and make replacing parts a bit easier.

This revision makes use of a somewhat simpler clock in the CD4047. The timing parts are one capacitor and one resistor. The internal divider (in the CD4047) always results in an output duty cycle of 50%.

We also improve the drive to the PIN diode to improve RF isolation a bit.

2.3.1 RF Switching

The core of the antenna switch is the PIN diode (D1) switch that is used to switch between the two elements of the antenna array. This is the same part used on the **-A** revision.

A PIN diode, when forward biased and conducting, looks like a closed switch to the RF signal. The PIN diode takes a relatively long time to stop conducting (on the order of tens of nanoseconds), so RF (even transmit levels) doesn't bring the PIN diode out of RF conduction.

The PIN diode, when reverse biased, looks like an open switch to the RF signal. The PIN diode takes a relatively long time to start conducting, as well. Therefor the RF signal will not forward bias the PIN diode long enough to drive it into conduction.

Figure 11: RF Switch

We drive a control voltage through the **LEFT_BIAS** and the **RIGHT_BIAS** nets that are the opposite polarity of the **RADIO_BIAS** net. This causes the one diode of D1 to be forward biased and other diode to be reverse biased.

When the diode is forward biased, the RF impedance of the diode is low, on the order of one to two ohms. When the diode is reverse biased, the RF impedance of the diode is quite high, in the order of hundreds of thousands ohms.

By altenating the on diode (the diode that is forward biased), we switch antennas. The loss through the reverse biased diode is quite high and through the forward biased one quite low. The diode switching time is relatively slow, so the RF signal has no effect on the RF impedance of the PIN diode.

The connectors on the schematic show a large number of ground points. These parts on the circuit board will accommodate either a BNC style connecter or an SMA style connecter.

R12 is installed when necessary to keep the DC level to the hand held radio at ground. It may be omitted if the radio already keeps the antenna input near ground.

This is a rather simple circuit; it must be, it all fits on one page. Text in red is function descriptive, not describing the topology of the circuit.

Net connections that carry over to the circuit board are green.

Parts on the schematic correspond, of course, with those on the circuit board.

2.3.2 Diode Bias Circuit

Working our way back through the circuit, we next see the PIN diode bias control circuit. There is something providing a square wave further to the left (we'll get there next).

Figure 12: TDOA_-bias.png

We DC isolate the drive signals with the C20..C25 capacitors.

The L1A..L1C inductors present a high impedance to the RF signal from the antenna array, isolating the control circuit from the receiver.

Finally, the C3A..C3C capacitors shorts RF energy to ground to keep it out of the driving circuit. These caps also keep digital noise from the drive circuit out of the receiver. The PIN diode (D1) is kept near ground by R4A, R4B, and R4C. Since **LEFT_BIAS** polarity matches **RIGHT_BIAS** polarity, both being opposite **RADIO_BIAS** polarity, current flows in only one of the diodes of D1 at any time. We will see shortly that the control signals are a square wave (see figure 13, do we alternately turn on of the the diodes in D1 and then the other.

2.3.3 Drive Circuit

Our bias drive circuit is relatively simple, consisting of a hex 4000 series CMOS buffer (**not** 74HC!).

Figure 13: PIN diode switching drive

The top four gates are all in-phase and provide drive to the individual anode and cathode pins of the PIN diode (D1-1 and D1-2). The drive level is controlled by the battery voltage.

The bottom two gates are driven out-of-phase provding the drive for the common pin of the PIN diode (D1-3).

The gates are doubled for two reasons. One being to slightly improve the drive and switching time. The other being that the 4049 has six gates, and the gates would otherwise go unused.

2.3.4 Clock Circuit

We will end the -20 revision description with the clock circuit which makes use of a CD4047 multivibrator (**must** be 4000 series CMOS). The 4047 is a bit easier to deal with than the venerable LMC555 timer as the timing parts for the oscillator are fewer and easier to calculate. We also end up with a 50% duty cycle square wave out of the CD4047 with the output appearing in both true and inverted form.

AUDIO FREQUENCY (

Figure 14: TDOA_-clock.png

The CD4047 has a configurable multivibrator and a divide-by-2. We strap the device to operate as an astable multivibrator that produces our base clock. This is passed through a divide-by-2 which serves to produce a nice square wave with very close to 50% duty cycle.

The true and inverted output are exactly what we need tto drive the PIN diode switch in figure 11.

Setting the frequency is rather simple and straightforward, requiring an external resistor and capacitor. The R3/R2 parts are not populated on production boards as they were only used on the prototype to verify the value used for R8.

2.4 Revision -61

The third revision adds a synchronous detector and an analog meter emulation. The goal being to provide a visual indicaton of where the antenna array is pointed.

The synchronous detector compares the average audio level from the attached radio when the antenna switching occurs. We expect to see a more-or-less positive glitch in the audio when one antenna is selected and a more-or-less negative glitch in the audio when the other antenna is selected.

We integrate the audio for 10% of the cycle during the antenna switch (to the other antenna) and again for another 10% of the cycle during during the antenna switch (back to the first antenna). We compare these two *glitches* and drive a meter to suggest a direction.

2.4.1 The Synchronous Detector

Figure 15: Revision_62_Clock_Generation

We form a simple oscillator using a CD4093 (U1), a Schmitt Trigger inverting gate, to generate approximately a 10KHz clock to driver a decade counter. The decade counter (U3), in turn, controls two analog switches that gate the audio signal from the attached radio to a pair of simple integrators.

The decade counter, a CD4017, presents 10 clock pulses that we use to gate the audio signal, and an overflow that is then used to drive the antenna switch. The **carry out** (**DRIVE**) from the CD4017 happens to be a square wave, which is exactly what we want to drive the antenna switch.

The switch (U4) integrates the audio activity when the output of the decade counter is high. Normal audio would integrate to the average level set by R18 and R15 (about 2.5V).

We are expecting the audio glitch from antenna switching to correspond in polarity, to the phase error in the received carrier introduced by the switching action.

R10 enables **SLOT1** during the time we switch from J2 to J3, while R5 enables **SLOT2** during the time we switch back from J3 to J2. The switching description for J2/J3 may be backwards.

The integrated audio, stored on C51 and C61, is buffered by U5 so as not to load these capacitors. U5 is configured as a simple follower.

The output of these 2 op-amps is routed through JP2 to allow the buffered **INTEG1** and **IN-TEG2** signals to be swapped. This allows the input to U6 to be set to force U6 to produce a positive output.

U6 is set-up as a differential amplifier such that the difference between **INTEG1** and **INTEG2** is output as a positive voltage.

This is then passed on to U6. This op-amp provide gain and offset. The output of this op-amp may be used to drive an analog voltmeter (0V to 5V). Attenuation at the input of U8 is provided by a simple resistor divider as U8 inputs are limited to 2.5V. The input to U8 is further protected against reverse voltage using a diode to ground.

When connecting to the speaker jack of the radio, this would normally mute the radios speaker. There is a small on-board speaker to allow the audio to be heard as you hunt for the hidden transmitter. The J9 connector provides a connection for a larger speaker, if desired.

The H.T. volume control operates, in effect, as a sensitivity adjustment. The integrators (U4/C51 and U7/C61) simply store the audio amplitude from the H.T, so increasing the H.T. volume will increase the charge stored on C51 and C61.

Negative bias generator (charge pump).

The two op-amps in U6 are powered directly from the battery (positive rail) and a negative bias voltage. The negative voltage is provided by U8, a switched-capacitor voltage inverter.

The schematic symbol give some insight into the operation of the device. It switches a flying capacitor from its input pins (VCC and GND) to the output pins (GND and OUT).

2.4.2 The Same Antenna Switch

Figure 16: Revision_62_Antenna_Switching

We can now move on to the antenna switching logic.

It is, in essence, the 102-73170-20 switching circuit. See the discussion in section 2.3.1 on page 9.

We receive the **DRIVE** signal from the previous schematic. The **DRIVE** signal is slightly delayed through U1, moving the antenna switch slightly into the sampling window. The **DRIVE** signal drives nine CMOS buffers. Rather than inverting the drive signal through the CD4093 inverter, we make use of one inverting buffer and one non-inverting buffer to minimize propagation delays (the difference in delays through the CD4049 and CD4050 is less than 20nS, rather than the 50-100nS through the CD4093). The **DRIVE** signal, un-inverted (by U13), is fed to the radio port. The **DRIVE** signal, inverted (by U2), is fed to the two antenna ports. One of the diodes in D1 is, therefore, always forward biased (with a forward drop of about 850mV) while the other diode is reversed biased (typically at more than 10 volts).

Compare this with the circuit in figure 10 on page 8.

The digital parts on the board are all 4000-series CMOS that will run at or above 10 volts. Substitution of 74HC series logic exceeds the *Absolute Maximum Rating* of these devices. The opamps and analog switch will all operate above 10 volts. This eliminates the need for a regulator for the TDOA section, we simply run the antenna switching logic directly off of the 9V battery.

There is a small fuse to deal with any attempt to install the battery backwards. It requires soldering skill (and good mignification) to replace, so don't reverse the battery!

2.4.3 Analog Meter Emulation

Figure 17: Revision_62_Meter_Emulation

When searching for an analog meter, I have run into a bit of a wall. Although Ebay and Amazon all show analog meters, in both mechanical and digital form, there seems to be little documentation available. For a simple 5V meter, this shouldn't be a problem, but almost none provide mechanical drawings that would indicated the depth required to mount the meter.

The one digital meter that would mechanically fit had a prioce tag of \$35.00. Keeping in mind that we don't really need much resoution, the approach is to implement a 9-level meter using LEDs and a SOC processor (ZiLog Z8F1680).

The processor is a simple Z8 derivative in a 28-pin package. The chosen processor is the ZiLog Z8F1680 providing 16KB of program flash and 2K or 3K bytes of data RAM. The processor simply takes the analog readings from the detector circuit and illuminates one of 9 LEDs indicating what the processor sees.

We should be able to eliminate the diff-amp and level shifter (all in U6) and the negative bias supply (U8) along with their supporting parts. The eZ8 Encore then takes of the job of calculating the difference between the integrated level on the **INTEG1** and **INTEG2** nets.

The processor is split into multiple symbols on the schematic. One for the power and programming pins, and then one symbol for each of the ports provided by the device. U9\$0 presents the power pins, crystal oscillator pins, and programming pins. J7 provides access for the standard ZiLog programming devices. The programming protocol is simple enough to implement with a simple serial program which is what is used by the author. This programmer consists of an FTDIchip USB serial chip and a few open drain gates.

U9\$A has the serial port pins that are used for debugging the Z8F1680 software. They are otherwise unused.

The center LED is driven from the PA3 pin.

PA6 may be used by the software to jam the CD4017 into a reset state. This will select one of the antennas for a few milliseconds.

PA7 routes to a pad. This pad me be hat wired to the clock input of the CD4017 to allow the Z8F1680 to provide the 10 KHz clock.

U10 combines all the reset inputs. R40/C32/D3 implement the power-on-reset function.

For the debug serial port, there is a 3.5mm connector that is pinout compatible with an FT-DIchip cable, **TTL-232R-3V3-AJ**. The port is buffered with a simple non-inverting gate.

U9\$B are the analog inputs. Although the Z8F1680 has dedicated power pins for the analog section, this implementation simply connects the analog section directly to the digital power pins.

An external voltage reference, U12, provides a stable 2.5V reference for the analog section.

U9\$C drives the remaining 8 LEDs. The order of connection was determined by the board layout. It is expected that a table lookup would be employed to provide the port patterns to drive the LEDs.

3 Construction

The -A revision has part of the board as through-hole parts. Resistors and capacitors are predominantly thru-hole.

The RF section is surface mount.

The -20 and -62 revisions are predominantly surface mount to keep costs down and, in the case of the -20 board, to fit on the smaller board.

Install low-profile parts first.

Ceramic capacitors and resistors.

PIN diodes.

Install tantalum capacitors and large diodes.

The battery connector can be installed at this point. Note the pads toward the bottom of the board that may be used to capture the battery leads and provide strain relief.

Install active devices.

Integrated circuits.

Install connectors and switches.

Recheck battery polarity. The revision -20 boards have a narrow trace in the battery net that should be damaged if you install the battery backwards.

I haven't done this intentionally, so I don't have advice other than check before you solder the battery connector.

Always switch the unit off when connecting the battery!

3.1 Prototyping: 102-73170-20

You may, if the mood strikes you, install R2 and R3 to allow changing the pitch of the audio squeal heard in the radio.

R8 must be removed for this to work.

R3 can be installed as a 10-turn pot (Bourns **3296Z-1-104LF**) that would require a tiny screwdriver to adjust (and a plump wallet). R3 can also be fitted with a Bourns **PTV09A-2020F-A104** or **PTV09A-2020F-B104** (about \$1.00) with a shaft that will protrude well past the edge of the housing.

3.2 Prototyping: 102-73170-A

Similar audio fun & games may be had on this revision hardware.

R1/R1B and R3/R3B may be installed and R2/R8 shorted to experiment with audio. The same Bourns **3296Z-1-104LF** or a Bourns **3296Z-1-503LF** may be installed in the R1B/R3B positions (and you now have a skinny wallet) or a Bourns **3310-001-503L**.

Both of the these parts are in the \$3 to \$5 range.

3.3 Parts List -62

, ,	2024-08-23T13:57 Package	73170_62.sch , Value	derived from A102_ Part (Ref Des)	$\left(\begin{array}{c} 73170 ight) \ \mathrm{Qty} \end{array} ight)$	102- Idx
3	SM0603	.01UF	C1 C11 C12 C15 C20 C21 C26 C3	23	6
			C33 C34 C36 C37		
			C38 C39 C4 C40		
			C41 C43 C5 C6		
	01.0000	1100	C65 C7 C8	-	-
5	SM0603	. 1 UF	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	7	7
,	SMOGOS	1000 D E	C27 C35 C40 C17 C5A C5P	9	0
) 2	SM0003 SM0603	1000FF 10PF	C17 C3A C3D C30 C31	ა ე	0
, ,	SM0005 SM0805	101F/16V	C10 $C18$ $C2$ $C22$	2 8	10
,	5140005	1001/107	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0	10
)	SMP1210	 10UF	C28 C29 C44 C73	4	11
)	SM0805	$1 \mathrm{UF}$	C14 $C42$ $C51$ $C61$	5	12
			C9		
3	SM0603	47PF	C3A C3B C3C	3	13
3	SOD123	1N4148	D2	1	14
3	SOT23-3	-1SV267	D1		15
3	SOD123	BAS100	D4 D5	2	16
3	SOT23-3	BAV199	D3	1	17
)	DO-201-AD	ER502	D10	1	18
Ľ	ENCLOSURE	1599EBKBAT	ENCLI	1	19
5 -	SM0603	500MA	F1		21
3	HDR_1X3	0705430002	J5 J9	2	23
3	$HDR_{50}-57-9403$	0705530002	J4	1	24
3	COAX_SMA_BNC	5414373 - 1	J2 J3	2	25
3	HDR_2X3	75869 - 131 LF	J7	1	26
)	HDR_2X2/JMP	PBC02DAAN	JP2	1	27
1	JMP03N	PBC03SAAN	JP1	1	28
)	COAX_SMA_BNC	RF2-49B	J1	1	29
ľ	SJ-352X	SJ-3524	J6 J8	2	30
2	AIAC-1812	100nH	L1A L1B L1C	3	31
2	$LED_T1-3/4C$	LTL-4213	LD1 LD9	2	32
2	$LED_T1-3/4C$	LTL-4223	LD2 LD8	2	33
3	$LED_T1-3/4C$	LTL-4233	LD5	1	34
]	$LED_T1-3/4C$	LTL-4253	LD4 LD6	2	35
2	$LED_T1-3/4C$	LTL-4293	LD3 LD7	2	36
3	SM0603 - 3	0	R38	1	41

Listing 1: A102_73170_62.packing.txt

41	1	R38	0	SM0603-3
42	2	R23 R24	 1.0K	SM0603
43	1	R26	100K	SM0603
44	20	R14 R15 R17 R19	10K	SM0603
		R20 R21 R22 R27		
		R40 R43 R44 R45		
		R46 R47 R48 R49		
		R50 R51 R52 R57		
45	2	R10 R5	10	SM0603
46	2	R41 R42	10	SMR0603-41
47	3	R5A R5B R5C	2.00 K	SM0603
48	1	R28	200K	PTV09–A4
49	2	R32 R35	270	SM0603
50	1	R39	3.3K	SM0603
51	1	R56	4.7 K	SM0603
52	7	R29 R30 R31 R33	470	SM0603
		R34 R36 R37		
53	1	R25	5K	PTV09–A4
54	1	R16	82.5K	SM0603
55	6	R11 R13 R18 R4A	825K	SM0603
		R4B R4C		
56	8	R1 R2 R3 R4 R6	N/A 10	SM0603
		R7 R8 R9	,	
57	1		 N/A 20K	
58	3	R53 R54 R55	N/A	SM0603
59	1	SP1	CVS-1508	CVS-1508
60	1	SW2	ET01MD1ABE	SW ET A
61	1	SW1	KMR221	SW_KMB2
62	1	U10	74LVC1G11	SOT23-6
63	1	U11	74LVC2G17	SOT23-6
64	1	U3	CD4017	SO16
65	1	U2	CD4049	SO16
66	1	U13	CD4050	SO16
68	1	— — — — — — — — — — — — — — — — — — —		
60	1		MAX1791	SOT22 6
09 70	1	U0 1119	MAX1121 MAX6109	SOT23-0 SOT22 2
70	1		MAA0102 MCC200072	50125-5
71	2		NUS20072	5U8 COTT02 F
(2	Z	04 07	1512A4514	50123-5
73	1	U9	Z8F1680	SO28
76	1	VR3	R-78K5.0-0.5	$TO220-3/VX78_REV$
77	1	VR2	ZLDO1117-3.3	SOT223
78	1	X1	ECS-200-20-4X	HC49U
			<u></u> .	

Line Items 64

3.4 Parts List -20

dx Qty	Part (Ref Des)	Value	Package
6 2	C2 C72	.01UF	SM0603
7 2	C13 C14	.1UF	SM0805
8 1	C4	$1000 \mathrm{PF}$	SM0805
9 1	C73	$10 \mathrm{UF}$	SMP1210
10 6	C20 C21 C22 C23 C24 C25	4.7UF	SM0805
11 3	C1 C5A C5B	470PF	SM0603
12 3	C3A C3B C3C	$47\mathrm{PF}$	SM0603
13 1	D1	1SV267	SOT23-3
14 1	D10	ER502	DO-201-AD
15 1	ENCL1	1599BBAT	ENCLOSURE
18 1	GND	— — — — — — —	PAD0062
19 2	J2 J3	DNI	COAX_SMA_BNC
20 1	J4	DNI	$HDR_{50}-57-9403$
21 1	J1	RF2-49B	COAX_SMA_BNC
22 3	L1A L1B L1C	$100 \mathrm{nH}$	AIAC-1812
23 1	PCB1	102 - 73170 - 20	HAMMOND_1599BSHC
26 2	PAD1 PAD2	N/A	PAD0062
27 3	R5A R5B R5C	2.00 K	SM0805
28 1	$\mathbf{R8}$	220K	SM0805
29 3	R4A R4B R4C	820K	SM0603
30 1		DNI	PTV09–A2
31 1	R2	DNI	SM0805
32 1	R12	N/A 820K	SM0603
33 1	SW2	200USP1T1A1M6RE	SW_ET_A
34 1	U3	CD4047	SO14
$\frac{-}{35}$ 1	 U2	CD4049	SO16

Listing 2: A102_73170_20_PROD.packing.txt

Line Items 26

3.5 Parts List -A

Packing List PROD iCARC FOX HUNT ICARC DTOA DIRECTION FINDER							
(102- Idx	$\begin{array}{c} 73170 \ \mathrm{Qty} \end{array}$	derived from A10 Part (Ref Des)	2_73170_A.sch , Value	Package			
6	3	C4 C5 C72	0.01UF	AXX150			
7	1	C13	0.1UF	AXX150			
8	2	C2 $C2A$	10UF/CERAMIC	SM1210			
9	1	C73	10UF	SMP1210			
13	2	C1 C3	470PF	SM0805			
15	1	D1	BAR63-04	SOT23–3			
16	1	 D10	N/A 1N4001	 DO-201-AD			
17	1	ENCL1	1599BBAT	ENCLOSURE			
23	1	HW5	232	HARDWARE_BATTERY			
29	3	J1	RF2-49B	COAX_SMA_BNC			
30	3	L1A L2A L3A	$100 \mathrm{nH}$	AIAC-1812			
33	1	PCB1	 102-73170	HAMMOND_1599BBAT			
37	1	R5	100	SM0805			
38	1	R8	27K	CF0.400			
39	2		330	SM0805			
40	1	R2	59K	CF0.400			
43	1	R4	N/A 100K	SM0805			
44	1		200USP1T1A1M6RE	SW ET A			
46	1	U3	TLC555	DIL08			

Listing 3: A102_73170_A_PROD.packing.txt OD iCARC FOX HUNT ICARC DTOA DIRECTION FINDER

Line Items 37

3.6 Antenna Base 102-73170-31

A mounting base for the antenna elements.

Figure 18: 102-73170-31

The coax connector, on the left side of the image, fits both a SMA style connector and a BNC style connector.

The SMA connector is a common right angle SMA connector. Many mechanically compatible parts may be used.

The number from *Adam Tech* for a low cost connector **RF2-49B-T-00-50-G-HDW**. Digi-Key number is **2057-RF2-49B-T-00-50-G-HDW-ND**.

A BNC part may also be fitted using a part from *TE Connectivity AMP Connectors*. The part number is **5414373-1** available from Digi-Key using their part number **A32274-ND**.

The board has six mounting holes available all 0.125" diameter. The two adjacent to the connector are bonded to ground should there be a need to bond to a metal chassis.

The 4 holes adjacent to the large pad have the copper relieved.

For most applications a nylon or other similar spacer is suggested along with an insulating washer.

The prototype antenna array, shown in figure 4 on page 2 used #4 pan head sheet metal screws and 0.250" nylon spacers from Digi-Key to attach the antenna base board to the rather crude antenna spacer (a pair of yardsticks glued together).

3.7 A Box to live in

Both boards are made to fit in a Hammond project box, part number 1599B.

Several variants are offered by Hammond and the board will fit in any of them. A battery access door is convenient, but you will find that battery life is rather long and opening the box to replace batteries is not particularly time consuming.

One variation of these boxes are a bit more expensive due to the use of thread inserts to fasten the halves together. The other having self tapping screws.

The antenna connector locations match on all revisions of the boards. Once you correctly locate the connectors, you can switch boards without having to relocate these holes.

The power switch, on the other hand, was moved on the new board revision to deal with the smaller board. This should be obvious when looking at the image in figures 1 and 2 starting on page 1.

4 Testing

The

4.1 Using Oscilloscope

The

4.2 -20 Revision

There is a test pad near the big diode labelled "FRQ". That net should have a square wave that is close to 2 KHz. Actual frequency is not critical.

Using a 'scope on the $_BIAS$ nets, you should see waveforms approximating what is shown on the schematic.

4.3 -A Revision

U3-3, the output pin of the 555 timer, should have a square wave at near 1000Hz. Dutycycle should be close to 50

Looking at either side of L1 you should see a square wave (duty cycle will match U3-3) that has a 0V DC value. It should be above and below ground roughly the same amount.

Seeing the signal all above ground or all below ground indicates a bad diode in D1.

5 Operation

Be aware that SMA connectors have a limit to the number of mate/demate cycles that is relatively small (typically 500 cycles). Don't *play* with the antenna on your handie-talkie! For example, don't remate the rubber-ducky to the radio until you're ready to use it. Similarly, don't attach the DTOA cable until ready to use it and don't detach it when you're done; wait until you need to use it!

5.1 Hints

Don't leave the battery on when you're done. (duh!!!, but it happens)

Having the antenna array attached with the switch electronics powered off will also give you an indication of where the transmitter is located. If your antenna array is close to $1/2 \lambda$ wide, pointing the antenna array along its length toward the transmitter will severely attenuate the signal received by the handie-talkie. One antenna element will see the incoming signal almost 180° out of phase with the other; viola! attenuation!

The PIN diode, when unbiased, shows a resistance of around 500 Ω to 1K Ω , not satisfactory for transmitting, but we're not transmitting.