Amateur Radio Communications Technology®

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ARCT Model AP-4800©
Repeater Controller

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Welcome

Congratulations!! You've purchased another fine ARCT product.

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ARCT would like to thank you for purchasing the Model AP-4800 repeater controller. Please read all instructions prior to installation.

INTRODUCTION

Welcome to the exciting world of FM repeaters, you've joined the ranks of one of the fastest growing modes in Amateur Radio. Your ARCT AP-4800 repeater controller connects between your transmitter, receiver and phone line. The ARCT AP-4800 does all the "magic" between your mobile or hand held to your phone line. The Model AP-4800 is a full duplex or cross band repeater controller with a telephone-auto patch that is controlled by DTMF tones from your radio. It uses the INTEL™ 8750 micro controller (MPU) (INTEL is a trademark of the INTEL corporation). A complete VHF / UHF repeater (any frequency) can be made by connecting a receiver, transmitter, antenna system, 12 volt power supply and a phone line. The antenna system can be to separate antennas or one antenna with a duplexer. "No other add on boards or test equipment are needed". The AP-4800 repeater controller was designed to be a low cost repeater controller with a telephone auto-patch all on one board. It was designed for one receiver one transmitter and one phone line (HOWEVER) other Hi-tech customers have added more receivers, transmitters and additional circuitry. You could have 3 receivers, 3 transmitters (2m, 70cm, 1.25m Weather radio ect) Linking operations, remote base, simplex telephone patch operations all controlled by one controller but that's up to you!

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(WARNING)

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IF YOU DO NOT FOLLOW THE SET UP INSTRUCTIONS STEP BY STEP YOU CAN DAMAGE YOUR UNIT OR CAUSE INTERFERANCE WITH OTHER ELECTRONIC DEVICES.

Notice: This equipment generates and uses radio frequency energy. If it is not installed properly, that is, in strict accordance with ARCT's instructions, it will cause interference to radio, telephone and television reception. And will DISTROY the AP-4800 repeater controller your warranty will be void.

USE SHIELDED CABLE FOR ALL CONECTIONS THIS SHOULD ELIMINATE MOST IF NOT ALL EMI / RFI PROBLEMS.

PROCESS IMPROVMENT

As part of ARCT's continuing program for product improvement, we encourage you to contact us in the development of our products. If you have made a modification or addition to this product we would like you to share it with us, so we can include it as part of this manual.

IN CASE OF TROUBLE

Please attempt to solve problems locally, using other hams or a technician in the area of the trouble before contacting ARCT. Products are sent to us for repair that are perfectly in good condition when we receive them. Please perform whatever steps that are applicable from the information on installation.

WARRANTY

ARCT products are under warranty for 90 days from the date of purchase. If it fails under <u>normal</u> operation and do to faulty parts it will be repaired or replaced. If you let the smoke out of any component (exceed limits / burn it up) you pay for repairs, replacement and shipping. If lighting hits your repeater you pay for repairs or replacement. I have seen all of the above happen to this controller and I've burned some of them up (not paying attention), so I can tell what happened to it!!! ARCT will reserve the right to determine if repair or replace of equipment is required.

Internal Connections via the (16) mini screw terminals:

1. Power Ground
2. Power + 11 to 15 volts regulated 250ma max. (130ma at idle) (170ma with auto-patch active)
3. Receive Audio Ground
4. receive Audio + (2.2 volts Peak to Peak or .77 volts RMS)
5. Receive COS (pulls low when receiving)
6. Transmitter Ground
7. Transmitter Audio (mic Level)
8. Transmitter PTT (open collector output goes low for TX)
9. Phone Line (if phone does not dial reverse polarity)
10. Phone Line
11. Control Output 1 (open collector low active)
12. Control Output 2 (open collector low active)
13. Control Output 3 (open collector low active)
14. Control Output 4 (open collector low active)
15. Ground for control outputs
16. Not Used (may be used - goes low during CWID)

The board is high quality Glass Epoxy double sided with plated through holes, solder mask on both sides, parts legend on top side and wave soldered.

Software upgrades will be available for $25.00 + shipping. Notices of upgrades will be sent out to everyone that bought a AP-4800. The Upgrade will be a new MPU plug in chip and a list of new commands.

OPERATION

Any one of four control lines can be connected to the courtesy tone input select and long distance call reject input. When control DTMF codes are received, two beeps are sent for acknowledgment. When the auto-patch is turned on a dial tone is sent for acknowledgment, then the phone number is entered through your DTMF pad. When the call is complete press the "#" key, and the repeater will go back to normal operation.

TIME OUT

Time out of the repeater is acknowledged by two low tones when the user unkeys (similar to the tones heard on video games for "game over" or on a game show for the "wrong answer").
Time out of the auto-patch is acknowledged by the normal courtesy tone of the repeater.
Long distance calls are rejected by detecting the first digit of the phone number. If it is a "1" and the reject input is high then the call will be rejected.

CWID SETUP:

Your call sign is programmed into the controller by a set of dip switches. An "R" is sent after your callsign to indicate (repeater). Each dip switch has six switches
Note: See Jumper J1 Setup (your CWID tone will sound real good)

Letter Switch	1	2	3	4	5	6
A	OFF	ON	ON	ON	ON	ON
B	ON	OFF	ON	ON	ON	ON
C	OFF	OFF	ON	ON	ON	ON
D	ON	ON	OFF	ON	ON	ON
E	OFF	ON	OFF	ON	ON	ON
F	ON	OFF	OFF	ON	ON	ON
G	OFF	OFF	OFF	ON	ON	ON
H	ON	ON	ON	OFF	ON	ON
I	OFF	ON	ON	OFF	ON	ON
J	ON	OFF	ON	OFF	ON	ON
K	OFF	OFF	ON	OFF	ON	ON
L	ON	ON	OFF	OFF	ON	ON
M	OFF	ON	OFF	OFF	ON	ON
N	ON	OFF	OFF	OFF	ON	ON
O	OFF	OFF	OFF	OFF	ON	ON
P	ON	ON	ON	ON	OFF	ON
Q	OFF	ON	ON	ON	OFF	ON
R	ON	OFF	ON	ON	OFF	ON
S	OFF	OFF	ON	ON	OFF	ON
T	ON	ON	OFF	ON	OFF	ON
U	OFF	ON	OFF	ON	OFF	ON
V	ON	OFF	OFF	ON	OFF	ON
W	OFF	OFF	OFF	ON	OFF	ON
X	ON	ON	ON	OFF	OFF	ON
Y	OFF	ON	ON	OFF	OFF	ON
Z	ON	OFF	ON	OFF	OFF	ON
1	OFF	OFF	ON	OFF	OFF	ON
2	ON	ON	OFF	OFF	OFF	ON
3	OFF	ON	OFF	OFF	OFF	ON
4	ON	OFF	OFF	OFF	OFF	ON
5	OFF	OFF	OFF	OFF	OFF	ON
6	ON	ON	ON	ON	ON	OFF
7	OFF	ON	ON	ON	ON	OFF
8	ON	OFF	ON	ON	ON	OFF
9	OFF	OFF	ON	ON	ON	OFF
0	ON	ON	OFF	ON	ON	OFF
BLANK	ON	ON	ON	ON	ON	ON

NOTE: On some switches ON=CLOSED and OFF= Open

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Example: Call Sign is KD6UOI

	K	D	6	U	O	I
	SW1	SW2	SW3	SW4	SW5	SW6
1	OFF	ON	ON	OFF	OFF	OFF
2	OFF	ON	ON	ON	OFF	ON
3	ON	OFF	ON	OFF	OFF	ON
4	OFF	ON	ON	ON	OFF	OFF
5	ON	ON	ON	OFF	OFF	ON
6	ON	ON	OFF	ON	ON	ON

IF YOU ONLY HAVE 5 LETTER'S IN YOUR CALL LEAVE (SW1) **BLANK** .

Answers to Frequently Asked Questions

1. The CWID sends the call sign set on the dip switches and adds (/R) your right the /R is for repeater. KD6UOI/R is what is looks like if your running Morse on your modem.
2. The Autopatch does not regenerate the DTMF digits for the phone number, the tones from your radio goes directly to the phone line. NO PULSE TONES WILL WORK, TOUCH TONE PHONES ONLY!
3. The autopatch doesn't have a ring detector and won't reverse autopatch call's.
4. The CWID waits for you to un-key for up to 60 seconds.
5. The CWID is not sent during idle times. The CWID is sent after the first key-up and then every 8-9 minutes after un-key

CRASH RESET:
Hold any DTMF key down for 10 Seconds = MPU RESET (same as Power on reset). This SECRET code should not be used unless nothing else works.

POWER ON RESET:
When Power is first turned on the repeater controller sends the CWID and then goes to it's idle mode and waits for a signal from the receiver. All of the open collector outputs will be off (high). When you first power up ENSURE ALL CONECTIONS ARE MADE FIRST. If you power up and more then the power light comes on and stays on, your board was fried from the wrong connections. Read your owners manual for you receiver and transmitter for the proper connections!!!!!

What Is a "open Collector Output"
An open Collector Output is like a set of solid state relay contacts with one contact connected to ground and the other contact is output. In the inactive state (off) the contacts are open (not connected) and in the active state (on) the contacts are closed (connected). The active state (on) grounds whatever is connected to the output as long as it is within the voltage and current limits of the outputs on this board are 30+ volts max and +40ma max. Negative voltages and currents will blow the output, and so will over voltage or over current.

VOX
This board has a built in VOX circuit for receivers that don't have COS (carrier Operated Signal) output. The VOX circuit triggers on about .3 volts of audio and has about a one second delay. To use the VOX circuit connect a wire from the hole in the circuit board marked VOX to the Receive

COS, connector number 5 on the screw terminal block. Connect the receive audio to connectors 3 (ground) and 4 (audio in). Note: some receivers or set up don't need the ground on terminal 3 try it without the ground.

Level Setup
First the audio from the receiver should be set to zero dbm while receiving a signal the is 100% modulated. Zero dbm is about .77 volts RMS or if you are using a scope about 2.2 volts peak to peak. When the receiver is set to this level all the other radio levels will be correct (CWID, courtesy tone and autopatch). There is one pot output to set the audio level going into the mic input of the transmitter. This can be set by listening to the input and output frequencies of the repeater, and adjusting this pot until both levels are the same.

COS inputs and Open collector outputs
The COS (Carrier Operated signal) input and open Collector Outputs like PTT (push to talk) and the control outputs are standardized by making them active low. The means that the COS input must be pulled to ground when the receiver receives a signal and that the open collector outputs will go low (to ground) when turned on. When connecting a relay to a open collector output the relay coil should be 12 volt unit with a minimum resistance of 350 ohms. Radio shack relays 275-248 10 amp SPDT, or 275-233 1 amp SPST will work fine. Connect one end of the relay coil to your + 12 or 13.8 power supply and the other end of the coil to the open collector output. You also need to put a diode (1N4001) across the relay coil to remove the inductive kick from the coil. If you leave the diode out you will smoke the 74LS06. (BE CAREFUL)

JUMPERS J1 and J2
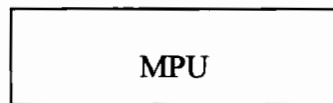
```
┌─────────────────────┐
│                     │
│        MPU          │
│                     │
└─────────────────────┘

  J1  O      O  J2 - Input
      O      O     - Ground
```

AP - 4800

J1 Open (One or High) = Courtesy tone 1
J1 Shorted to Ground (Zero or Low) + Courtesy tone 2

J2 Open (One or High) = Long distance Calls Locked out.
J2 Shorted to ground (Zero or Low) = Long distance calls OK

J1 is the left two pads. The top one is the input and the bottom on is the ground
J2 is the right to pads. The top one is the Input and the bottom one is ground.

Both inputs have pullup resistors to + 5 volts. They can be connected to any of the open collector control outputs. The voltage at the inputs must not exceed +5 volts or go below zero volts. These inputs are N-MOS and are static sensitive

If you are running on batteries
If your battery chargers connected to the batteries through a diode you can connect J1 input to the charger side of the diode through a resistor voltage divider consisting of a 2.2K resistor from the charger to J1 and a 1K resistor from J1 to ground. The resistor divider limits the voltage to J1

to about 4.5 volts. When the charger has power you will hear courtesy tone one and when the power goes out and you are running on batteries only you will hear courtesy tone 2.

Long distance reject
Is done by detecting a "1" as the first telephone number and disconnecting if it is.

Using an HT for a Transmitter
Connect a shielded cable (RG-174) with the shield connected to terminal 6 (ground) and the center to terminal 7 (tx audio). Connect a 2.7K ¼ resistor from terminal 7 (tx audio) to terminal 8 (PTT) at the terminal strip. The other end of the coax goes to the mic input of your HT. Heat is a problem with HT's. In repeater operation the transmitter will be on during both sides of the conversation and my overheat. Use low power settings to avoid this problem.

Phone line Autopatch Connections
Simply connect the phone line to terminals 9 and 10. The levels are set to FCC phone standards. If you can hear the dial tone but can't dial, change the polarity of your phone line.

MPU Reset
If Lighting strikes near your repeater it may crash the MPU. When this happens the controller wont respond to DTMF tones. To recover from this you can switch the power to the controller off for about 30 seconds and back on to reset the MPU. This operation may be inconvenient if the repeater is on a mountain top, and the road to the top is closed because it is covered by snow. To solve this problem I added a remote MPU reset feature. To reset the MPU press and hold any DTMF key down for 10 seconds. This is the same as a power reset. The repeater will send it's CWID and will be ready to operate. All settings will be "default".

De-sense Problems
The transmitter, Receiver and Controller should be in separate cases. All wiring including power NEED to be shielded wire (coax). The receiver, transmitter and antenna coax that go to the duplexer MUST be double shielded and be separated from each other as far apart as possible. All signals like COS, PTT and audio must be shielded with both ends of every cable GROUNDED to the unit it is connected to. Separate power supply filters for the receiver, transmitter and controller consisting of a RF choke and filter capacitor for each unit will help. Sometimes you may have a problem that sounds like de-sense but in fact it is audio oscillation problem. This oscillation problem can be cured with ground straps between the receiver, transmitter and controller and/or audio isolation transformers in the audio lines. The ferrite Toroid type filters may also help.

How to invert COS
You will need two 4.7K ¼ watt resistors and a 2N2222 or a PN2222 transistor. Connect the resistor in series with one end going to ground and the other end to your upside-down COS. Connect the BASE of the transistor to the mid point between the two 4.7K resistors. Connect the EMITTER to ground. The COLLECTOR is your output and goes to screw terminal 5 on your AP-4800 controller board. For additional RF protection add two 0.001MF disk capacitors, one from the BASE to ground and one from the COLLECTOR to ground.

DTMF CODES
Version 2.0 control codes   1 Jan 2000

X=7 on reset or power up.

All of the codes start with "X". The default value of "X" is "7". The default values are used when the controller is first powered up or reset is entered (see reset command). The command X00 is 700 on power up or reset. After entering 700 "X" is 0.
Most commands are acknowledged by 2 beeps. The 2 beeps are different tones. A Low-High beep (ascending) indicates you turned something on. And a High-Low (descending) indicates you turned something off. Some commands don't have the beeps because they have there own indicators like when you turn the autopatch on you hear a dial tone.

Main Commands

X80   REPEATER OFF
X81   REPEATER ON < DEFAULT
X82   LOCK DTMF
X83   UNLOCK DTMF
X84   TEST TAIL TONE TWO
X85   FORCE CWID
X86   RESET
X87   CWID OFF
X88   CWID ON < DEFAULT
X89   AUTOPATCH ON
X8A   911 REJECT
X8B   911 OK < DEFAULT
X8C   SET CWID TIME TO 8 MIN < DEFAULT
X8D   SET CWID TIME TO 9 MIN

CONTROL COMMANDS

X90   RESERVED FOR FUTURE COMMAND
X91   CONTROL OUTPUT 1 OFF (HIGH) < DEFAULT
X92   CONTROL OUTPUT 1 ON   (LOW)
X93   CONTROL OUTPUT 2 OFF (HIGH) < DEFAULT
X94   CONTROL OUTPUT 2 ON   (LOW)
X95   CONTROL OUTPUT 3 OFF (HIGH) < DEFAULT
X96   CONTROL OUTPUT 3 ON   (LOW)
X97   CONTROL OUTPUT 4 OFF   (HIGH) < DEFAULT
X98   CONTROL OUTPUT 4 ON   (LOW)
X99   CONTROL STATUS REPORT
X9A   OPERATOR CALLS REJECT
X9B   OPERATOR CALLS OK < DEFAULT
X9C   SET CANCEL TO "#" < DEFAULT
X9D   SET CANCEL TO "D"

= AUTOPATCH OFF OR CANCEL COMMAND

Setting "X"
X0D   SETS "X" TO "D"
X01   SETS "X" TO "1"

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X02   SETS "X" TO "2"
X03   SETS "X" TO "3"
X04   SETS "X" TO "4"
X05   SETS "X" TO "5"
X06   SETS "X" TO "6"
X07   SETS "X" TO "7"
X08   SETS "X" TO "8"
X09   SETS "X" TO "9"
X0*   SETS "X" TO "*"
X0#   SETS "X" TO "#"
X0A   SETS "X" TO "A"
X0B   SETS "X" TO "B"
X0C   SETS "X" TO "C"
```

CWID

X1D	FASTEST		
X11			
X12			
X13			
X14			
X15			
X16			
X17			
X18			
X19			
X10			
X1*			
X1#			
X1A			
X1B			
X1C	SLOWEST < DEFAULT		

CW TONE (ALSO AFFECTS THE SPEED)

X2D	HIGHEST
X21	
X22	
X23	
X24	
X25	< DEFAULT
X26	
X27	
X28	
X29	
X20	
X2*	
X2#	
X2A	
X2B	
X2C	LOWEST

AUTOPATCH TIMEOUT

X3D	NO TIMEOUT
X31	2.3 MIN
X32	4.7 MIN
X33	7.0 MIN
X34	9.4 MIN
X35	11.7 MIN < DEFAULT
X36	14.0 MIN
X37	16.4 MIN
X38	18.7 MIN
X39	21.1 MIN
X30	NO TIME OUT
X3*	25.8 MIN
X3#	28.1 MIN
X3A	30.5 MIN
X3B	32.8 MIN
X3C	35.2 MIN

REPEATER TIMEOUT

X4D	NO TIME OUT
X41	35 SEC OR .58 MIN
X42	70 SEC OR 1.2 MIN < DEFAULT
X43	105 SEC OR 1.8 MIN
X44	141 SEC OR 2.4 MIN
X45	176 SEC OR 2.9 MIN
X46	211 SEC OR 3.5 MIN
X47	246 SEC OR 4.1 MIN
X48	281 SEC OR 4.7 MIN
X49	316 SEC OR 5.3 MIN
X40	NO TIME OUT
X4*	387 OR 6.5 MIN
X4#	422 SEC OR 7.O MIN
X4A	457 SEC OR 7.6 MIN
X4B	492 SEC OR 8.2 MIN
X4C	527 SEC OR 8.8 MIN

HANG TIME

X5D	NO HANG TIME
X51	0.33SEC
X52	0.66 SEC
X53	1.00 SEC
X54	1.33 SEC < DEFAULT
X55	1.66 SEC
X56	2.00 SEC
X57	2.33 SEC
X58	2.66 SEC
X59	3.00 SEC
X50	NO HANG TIME
X5*	3.66 SEC
X5#	4.00 SEC
X5A	4.33 SEC
X5B	4.66 SEC
X5C	5.00 SEC

TAIL TONE ONE SECTION (JUMPER J1 OPEN)

X6D	3 DESCENDING PROGRAMMABLE DUAL TONES
X61	3 ASCENDING SINGLE TONES < DEFAULT
X62	2 DESCENDING SINGLE TONES
X63	THE CW LETTER "K" AT THE CWID ID SPEED AND TONE
X64	3 ASCENDING DUAL TONES
X65	3 DESCENDING DUAL TONES
X66	2 ASCENDING DUAL TONES WITH SPACE
X67	2 DESCENDING DUAL TONES WITH SPACE
X68	1 PROGRAMABLE DUAL TONE
X69	2 ASCENDING PROGRAMABLE DUAL TONES.
X60	NO TONE
X6*	THE CW LETTER "E" AT THE CWID SPEED AND TONE
X6#	1 PROGRAMABLE DUAL TONE
X6C	2 PROGRAMABLE DUAL TONES.

TAIL TONE TWO SELECTION (JUMPER J1 GROUNDED)

X7D	3 DESCENDING PROGRAMABLE DUAL TONES
X71	3 ASCENDING SINGLE TONES < DEFAULT
X72	2 DESCENDING SINGLE TONES
X73	THE CW ID LETTER "K" AT THE CWID SPEED AND TONE
X74	3 ASCENDING DUAL TONES
X75	3 DESCENDING DUAL TONES
X76	2 ASCENDING DUAL TONES WITH SPACE
X77	2 DESCENDING DUAL TONES WITH SPACE
X78	1 PROGRMABLE DUAL TONE
X79	2 ASCENDING PROGRAMABLE DUAL TONES
X70	NO TONE
X7*	THE CW ID LETTER "E" AT THE CWID SPEED AND TONE
X7#	1 DUAL TONE
X7A	3 ASCENDING PROGRAMABLE TONES
X7B	1 PROGRAMABLE TONE

X7C   2 DESCENDING PROGRAMABLE DUAL TONES

FREUENCY FOR PROGRAMABLE TAIL TONES	**DURATION FOR PROGRAMABLE TAIL TONES**
XAD IS THE HIGHEST PITCH	XBD IS THE SHORTEST IN DURATION
XA1	XB1
XA2	XB2
XA3 < DEFAULT	XB3 < DEFAULT
XA4	XB4
XA5	XB5
XA6	XB6
XA7	XB7
XA8	XB8
XA9	XB9
XA0	XB0
XA*	XB*
XA#	XB#
XAA	XBA
XAB	XBB
XAC IS THE LOWEST PITCH	XAC IS THE LONGEST IN DURATION