WAG-AERO FLY-BY-NIGHT RECEIVER, REV A: INSTALLATION, OPERATION, AND MAINTENANCE

GENERAL INFORMATION.

Functional Description.

The Wag-Aero Fly-by-Night Receiver is a tough, commercial-grade receiver with very good sensitivity and selectivity. It is designed for operation at small airports to facilitate pilot control of lighting.

The Receiver is tunable over a range of 118-137 MHz in 25kHz increments. It uses triple-tuned circuits in the front end and ceramic filters in the i-f with steep skirts for good adjacent channel selectivity.

The Receiver has one microcontroller which is responsible for watching the squelch to determine what is happening on the air. It can be programmed to perform several different tasks in response. The primary task for this application is Pilot-control of runway lights.

- Runway lights may be activated by keying the aircraft radio microphone several times, typically three times in five seconds.
- If the airport is equipped with variable intensity lighting, the pilot can select intensities by keying the microphone 3, 5, or 7 times in a 5-second period.
- Lights remain on for a programmable period of time, usually 15 minutes.
- Various programming options allow for change in intensity after initial turn-on and flashing lights to warn of turnoff during last minute.
- Front panel red LED indicates when lights have been activated at any intensity.
- A green LED indicates when the squelch is closed.

INSTALLATION.

General.

Following are general instructions for installation of the receiver. For proper operation and to prevent damage to the unit, it is recommended that a qualified two-way radio technician do the installation.

Mounting.

The receiver enclosure can be mounted against any vertical surface with screws through the mounting flanges. If you want to use the whip antenna for localized operation, mounting the unit with the connectors down will allow you to simply attach a whip antenna to the connector. Because the antenna is long and flexible, mounting with the antenna hanging down is preferable.

Selecting a location for the receiver depends on several factors. It should be near the electrical circuit for the runway lights so the relay to switch the lights is close to the receiver. It should also be near an ac outlet to provide power for the receiver.

If you want to use the whip antenna, you want to select a location which allows the antenna to pick up transmissions well and not be near sources of interference such as motors or fluorescent lights. Normally, the higher the antenna, the better, and it should not be in an area enclosed by metal siding, which could restrict the range. If you cannot find a location which provides interference free reception with an indoor antenna, you may want to use a roof mounted antenna of some sort. A simple scanner radio antenna from Radio Shack should do the job nicely.

Cover Removal.

If you need to remove the cover for any reason, remove the four screws on the ***side*** of the cover, and slide it off. Do not remove screws from bottom.

Relay Mounting.

The relay should be mounted in an electrical cabinet for safety, and it should be mounted on a metal surface for proper heatsinking. As shown in the derating curve in figure 3, the relay may be operated with a load up to 4Amp at room temperature with no heatsink.

For operation at elevated temperatures or for load currents over 4 Amp, the relay needs to be heat sunk to a large metal surface, and a good size metal electrical cabinet should provide ample surface for that.

To provide heatsinking for the relay, it must be mounted on a bare metal surface. If necessary, an aluminum plate can be installed in the cabinet to provide bare metal for heatsinking. Before screwing the relay to the heatsink surface, spread a very thin layer of heatsink compound on the metal relay base to transfer the heat to the heatsink. The heatsink compound and a toothpick for applying it are provided in a small plastic bag in the box for the relay for shipping.

CAUTION: Installer is responsible to ensure that proper heatsinking is provided. Warranty does not cover damage to relay which might result from improper installation.

Table 1. Quick Reference

Frequency range: 118-137 MHz
Channel spacing: 25 kHz. Frequency set with dip switch; (repeaking coils required for freq change more than 2 MHz - use A28 tool)
Squelch sensitivity: adjustable 2-35 µV
12dB sinad: 2.5µV
Adjacent channel selectivity: 60 dB
Image rejection: 40dB (at +900kHz)
Other spurious rejection: 50 dB
Temp stability: ±10ppm +20 to +30° C; ±20ppm -30 to +50deg C.
Control outputs: three separately controlled open-collector switching transistors able to sink up to 50 mA to ground on circuits up to 15Vdc. External relays can be controlled for high current loads.
Antenna connector: UHF jack on cabinet.
Power and control connections: 9 pin D-sub jack on cabinet
Size: 7 in wide, 8 in deep, 2 in high.
Operating Power: +13.6Vdc +-10% at approx. 45mA.

ELECTRICAL CONNECTIONS.

The antenna connection is made with a coaxial connector. The power and relay connections are made with a DB9 connector. Table 2 identifies the terminals used for these connections. Figure 1 shows the terminals on the DB9 connector.

Antenna Connections.

For normal operation, the whip antenna supplied with the unit should be sufficient to provide useful range. It should be plugged into the coaxial connector and the wire antenna unfolded to full length.

In the event that you need to use an outside antenna, it should be connected with good, low-loss 50 ohm coaxial cable plugged into the antenna connector with a suitable UHF (PL-259) plug.

Power Connections.

The receiver operates on +13.6 Vdc at about 200 mA peak with full audio.
An ac power adapter is provided; so all you need to do is plug it into a source of 115Vac once the installation is completed.

If you want to operate the receiver on some other source of power, be sure to use a regulated and filtered 12Vdc power supply and observe polarity when connecting the power supply in place of the ac adapter supplied with the unit. Operating with reverse

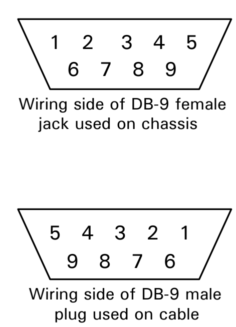


Figure 1. Connector Pinout.

Table 2. Power, Audio, and Control Connections		
Function	**Module Pin**	**DB9 Pin**
Ground	screws	6
+12Vdc	E3	1&2
Output A	E4	3
Output B	E5	4
Output C	E6	5

polarity will damage the unit.

Control Outputs.

The FBN Receiver has three output transistors used to control relays for operating the runway lights with three, five, or seven clicks of the microphone push-to-talk button. Each transistor can sink as much as 50mA at voltages up to +15Vdc. In other words, the transistors switch ground on and off and can be used to ground one end of a circuit. The common use is to ground one side of a relay input to energize a relay.

With the standard unit, one solid state relay is provided to simply turn runway lights on with three microphone clicks. The input side of the relay should be connected as shown in figure 2A, with the red wire connected to the positive input, terminal 3, and the blue wire connected to the negative input, terminal 4. Be careful not to reverse polarity.

Should it be necessary to use a conventional relay, connect as per figure 2B. Be sure to use a diode across the relay coil to prevent damage to the receiver from transients generated when the coil is de-energized. Be sure that the relay coil does not require more than 50mA. (Using the solid state relay, as explained above, avoids these problems.)

NOTE: The unit is wired at the factory so that the relay responds to 3 clicks. If you want it to respond to 5 or 7 clicks, you must rewire the plug which connects to the receiver box as shown in Table 2. The output normally is wired to pin 3, and it must be rewired to pin 4 or 5 depending on how many clicks you would rather have it respond to.

Runway Light Connections.

The solid state relay provided will control runway lights of either 115 Vac or 230 Vac with a load current up to 10 Amp if proper heatsinking is provided. Connect the output or load side of the relay in series with the hot ac line to the runway lights as shown in figure 2A. The load terminals of the relay are not polarity sensitive; so terminals 1 and 2 are interchangeable.

OPERATION.

General.

The receiver has one microcontroller which is responsible for watching the squelch to determine what is happening on the air. It can be programmed to perform several different tasks in response.

Squelch Setting.

The squelch control, which is the small trim pot on the pc board, sets the threshold at which signals will be detected. The green LED, on the left, indicates when a signal is detected. It normally is lit when waiting for a signal (squelch closed) and it is extinguished when a signal is detected. The proper way to set the squelch threshold is to turn the pot ccw until the LED goes out and then turn it cw just past the point where the LED comes on again. Of course, do this when no one is transmitting. *Note: the squelch control is preset at the factory and should not be adjusted unless there is a problem.*

There may be installations where the default setting is too sensitive. If you get false triggering of the relay, try setting the squelch control a little more clockwise. Since aircraft normally have line of sight communications with the airport, often times a receiver does not need maximum sensitivity.

Mode Switch.

The red LED, on the right, is used to indicate various conditions detected as explained for each mode below.

Seven position dip switch S2 is used to program the microcontroller which provides special features. In the discussion below, "1" indicates that a particular switch is ON or closed and "0" indicates that a switch is OFF or open.

Positions 1 and 2 set the mode of operation. The four possible modes are as follows:

0 0 = not used
0 1 = test mode
1 0 = not used
1 1 = PCL mode (normal setting)

Position 3 is set to allow changes to be made by the pilot after initially turning on lights.

Position 4 is an optional setting for the PCL mode. It controls how the output responds during the last minute runway lights are on. If switch position 4 is turned on, the runway lights will flash during the last minute they are on to warn pilots that the lights are about to go out. If the switch is off, no flashing will occur; lights will simply turn off at the end of the timer period.

Positions 5 through 7 set the time delay for ELT and PCL modes in 5 minute increments. The switches set a four digit binary number which, multiplied by 5, is the time delay in minutes. Following are example settings:

000 = 1 min	100 = 20 min
001 = 5 min	101 = 25 min
010 = 10 min	110 = 30 min
011 = 15 min	111 = 35 min

Note that 000 sets it for one minute, an exception, handy for testing.

Test Mode.

Turning on switch section 2 with section 1 turned off sets the microcontroller for a special test mode in which the red LED blinks on and off one cycle every two seconds. This allows a technician to check the controller clock accuracy, as there should be about 30 flashes per minute. Note that the controller clock is not as precise as a regular clock; so there may be a small variation in timing. This is normal. The purpose of the test is simply to see if the controller is running properly and that the clock is roughly accurate. The blinking will stop if the squelch is opened.

Pilot Control of Lighting.

In the PCL mode, if a pilot clicks his push-to-talk button three, five, or seven times within five seconds, runway lights can be activated with Outputs A, B, and C, respectively. Depending on wiring, this can turn on runway lights at up to 3 intensity levels.

Programming the dip switch for PCL mode requires that switch sections 1 and 2 both be turned on. Switch position 3 allows for the option of letting the pilot make a change in settings once the lights are initially activated. Once the lights are activated, they will stay on for the length of time programmed with switch sections 5 through 7. Note that the timing system isn't precise; so if the time is too short, simply increase the set-

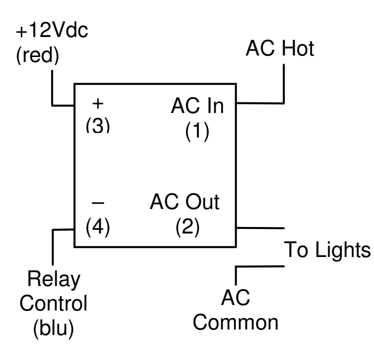


Figure 2A. Solid State Relay Wiring.

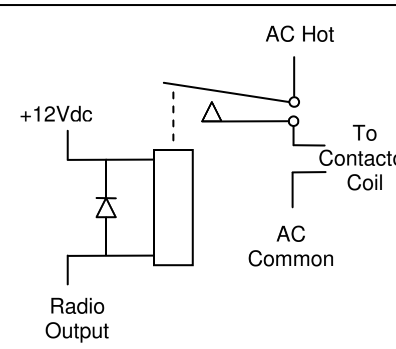


Figure 2B. Small Relay Switching Power Contactor.

ting until you get the about the length of time you want. Position 4 controls whether or not the lights flash during the final minute as a warning that they are about to go out.

When you install the system, carefully plan how you want the lights to respond to any possible condition. With the proper combination of programming and wiring the outputs to relays, you can make the lighting system operate smoothly and safely. Following are factors to be considered.

The receiver has the option of allowing changes to the command after an initial command is executed. If the switch is on, subsequent commands will be carried out, otherwise, they will be ignored until the time delay is completed for turning off the lights. If you do not allow changes and someone, even unintentionally, sends a command, they cannot carry out another command for 15 minutes or whatever the time delay is set for.

Red LED (D6) on the front of the receiver will illuminate anytime a command is in effect, that is, whenever one of the outputs is activated.

If you need to turn off the lights manually, you can use a reset switch, as explained in the Installation section. Resetting the controller effectively starts everything from scratch with the lights off.

If you have problems turning on lights.

A few users have commented that they have trouble turning on lights sometimes or that the lights turn off early. Here are a few things to consider.

The number of clicks is important. You must send exactly the correct number of clicks within 5 seconds. If you accidentally send more or fewer clicks, it won't turn on. Requiring 5 or 7 clicks is a bit harder to send accurately than 3 clicks; so most airports use 3 clicks.

The receiver responds to 3, 5, or 7 clicks. Just because you only wire one output to your relay does not mean the receiver won't respond to the other two commands. There are three outputs, one for each correct command. If someone sends one of the other commands, the receiver responds, but your relay does not turn on because it is not wired to that output.

Dip switch position 3 is turned on to allow changes to be made by the pilot after initially turning on lights. If this switch is off, the receiver accepts only the first valid command until the timer expires, e.g. 15 minutes. If this switch is on, the receiver will accept a new command while the timer is running, either another intensity or extending the current intensity.

Note that when one output turns on, the others turn off. For example, if you have your lights turn on with 3 clicks and someone sends 5 clicks after your lights are on, if you have dip switch 3 turned on to allow changes, the 5 click output will turn on and your 3 click output will turn off. This is so to allow the receiver to operate three different intensities of lighting, which is a scheme used at some airports.

The receiver may also pick up signals a pilot is sending to a nearby airport if they use the same frequency you do. So always consider that a command might be coming from someone other than a pilot using your airport. It is good to use a unique channel frequency for your receiver. Most of our customers order receivers for 122.800 or 122.900MHz. So if you use one of these channels for your receiver, so may another nearby airport.

If you are picking up signals from pilots far away, it may be that your receiver is too sensitive. Because aircraft have line of sight to the airport, signals can be received over a great range. Your antenna may be too effective (if you use a big antenna), or you may need to adjust the squelch sensitivity in the receiver to prevent weaker signals from activating the receiver. Refer to the section on Squelch Setting above.

FREQUENCY ADJUSTMENTS.

Opening Case.

To access the dip switches on the pc board, remove the four screws on the ***side*** of the cabinet, and lift off the cover.

General Procedure.

The channel frequency is determined by frequency synthesizer circuits, which use dip switch S1 in conjunction with programming in microcontroller U1 to set the channel. The microcontroller reads the dip switch information and does mathematics, applying serial data to the synthesizer ic whenever power is applied. Following is a discussion of how to set the dip switch to the desired channel frequency.

☞ **NOTE:** *If the frequency is changed more than about 1 MHz, a complete alignment of the receiver should be performed, as described in later text. Optimum operation only occurs if the synthesizer is adjusted to match the frequency switch setting and all the tuned amplifier circuits are peaked for the desired frequency.*

To determine what channel frequency to use, the microcontroller adds the frequency information from the dip switch to the 118 MHz "base" frequency.

Dip switch settings are binary, which means each switch section has a different weighting, twice as great as the next lower section. Sections have weights such as 25 kHz, 50 kHz, etc., all the way up to 12.800 MHz. *(See Table 3 or the schematic diagram for switch values. Also see the shortcuts and tricks which follow this discussion.)*

The system sounds cumbersome, but it really is fairly simple, and you don't need to do this frequently. (Also, see shortcut after this discussion.) A piece of paper or a small calculator is handy to aid in determining which sections of the switch to turn on. When done, you might want to record the switch settings in table 4 for future reference.

Begin by subtracting the base frequency, 118.000, from the desired frequency to determine the total value of all the switch sections required to be turned on.

If the difference is greater than 12.800 MHz, turn on switch #1, and subtract 12.800 from the difference frequency to determine the remainder. Otherwise, turn off switch #1.

Do the same for each of the other sections, from highest to lowest weighting, in sequence. Each time you consider the remainder, turn on the switch section with the highest weighting which will fit within the remainder without exceeding it. Each time it is found necessary to turn on a switch section, subtract the value of that section from the remainder to get the new remainder.

As an example, let us consider how to set the receiver for 127.325 MHz. The following discussion is broken down into steps so you can visualize the process easier.

a. 127.325 - 118.000 base freq. = 9.325 MHz remainder. Turn on switch #2, which represents the largest increment to fit remainder. Turn off switch #1 because its value is larger than 9.325.

b. 9.325 - 6.400 value of switch #2 = 2.925 MHz. Turn off switch #3, which is too large a value. Turn on #4, which is 1.600 MHz, the largest increment to fit the remainder.

c. 2.925 - 1.600 = 1.325 MHz remainder. Turn on switch #5, which has a value of 0.800 MHz (800 kHz).

d. 1.325 - 0.800 = 0.525 MHz (525 kHz) remainder. Turn on switch #6, which has a value of 400 kHz.

e. 525 - 400 = 125 kHz remainder. Now it is easy. Looking at the weightings of the switches, you can see that turning on switches 8 and 10 gives 125 kHz. Turn off switches 7 and 9, which are not needed.

f. When we finished, we had turned on switch sections 2, 4, 5, 6, 8, and 10. We

Table 3. Frequency Settings

Device	Frequency Weight
Switch #1	12.800 MHz
Switch #2	6.400 MHz
Switch #3	3.200 MHz
Switch #4	1.600 MHz
Switch #5	800 kHz
Switch #6	400 kHz
Switch #7	200 kHz
Switch #8	100 kHz
Switch #9	50 kHz
Switch #10	25 kHz

turned off all the others. This can also be expressed as the binary number 0101110101.

Note: Dip switch information is read by the synthesizer only when power is first applied. If switch settings are changed, turn the power off and on again.

Shortcut.

If you have access to the internet, our website has a long table of numbers which gives the equivalent binary number settings for every possible frequency. We couldn't print it here because it takes many printed pages of space. Surf to our website at www.hamtronics.com and look for Dip Switch Programming for R121/R122 Aviation Receiver under Reference Info. The complete url is hamtronics.com/dipswitch_r122.htm.

Look up the frequency, and it will give you all the binary switch settings. The address is case sensitive, and you must enter the address carefully, exactly as shown.

Also, here are settings for two common frequencies:

122.800 MHz = 0011000000

122.900 MHz = 0011000100

Note that it is easy to do frequencies just above 122.800 just by adding the least significant digits on the right. See that for 122.900, we just add the setting to increase the frequency 100 kHz above 122.800.

MAINTENANCE.

Complete electrical specs, diagrams, and alignment and troubleshooting information is available on our website . Go to www.hamtronics.com and download the manual for the R122 Receiver, which is the module in the enclosure.

PARTS LIST.

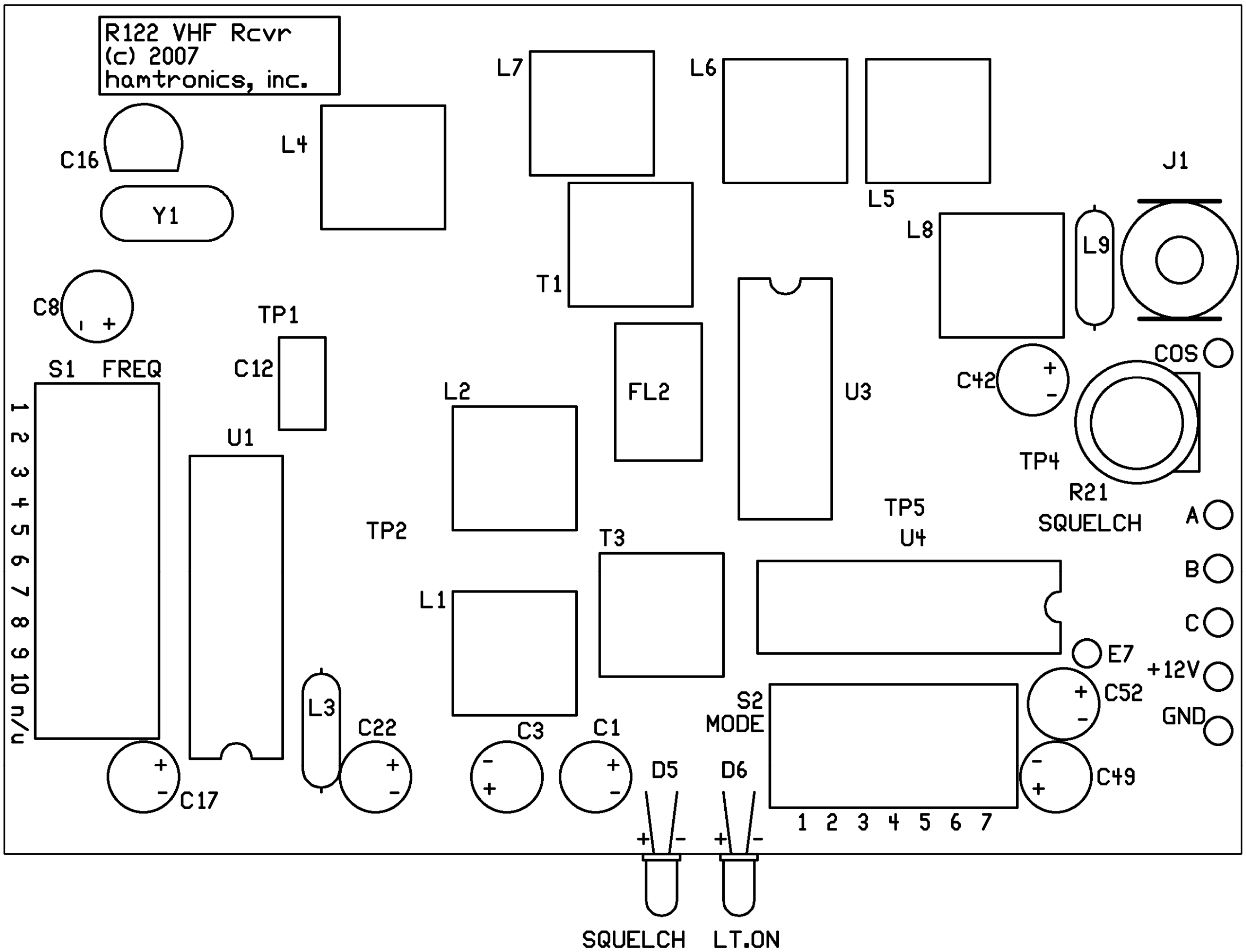
Following are notes specific to certain parts.

❶ R40 is installed under board in parallel with LED D5 (tack solder to pads for LED).

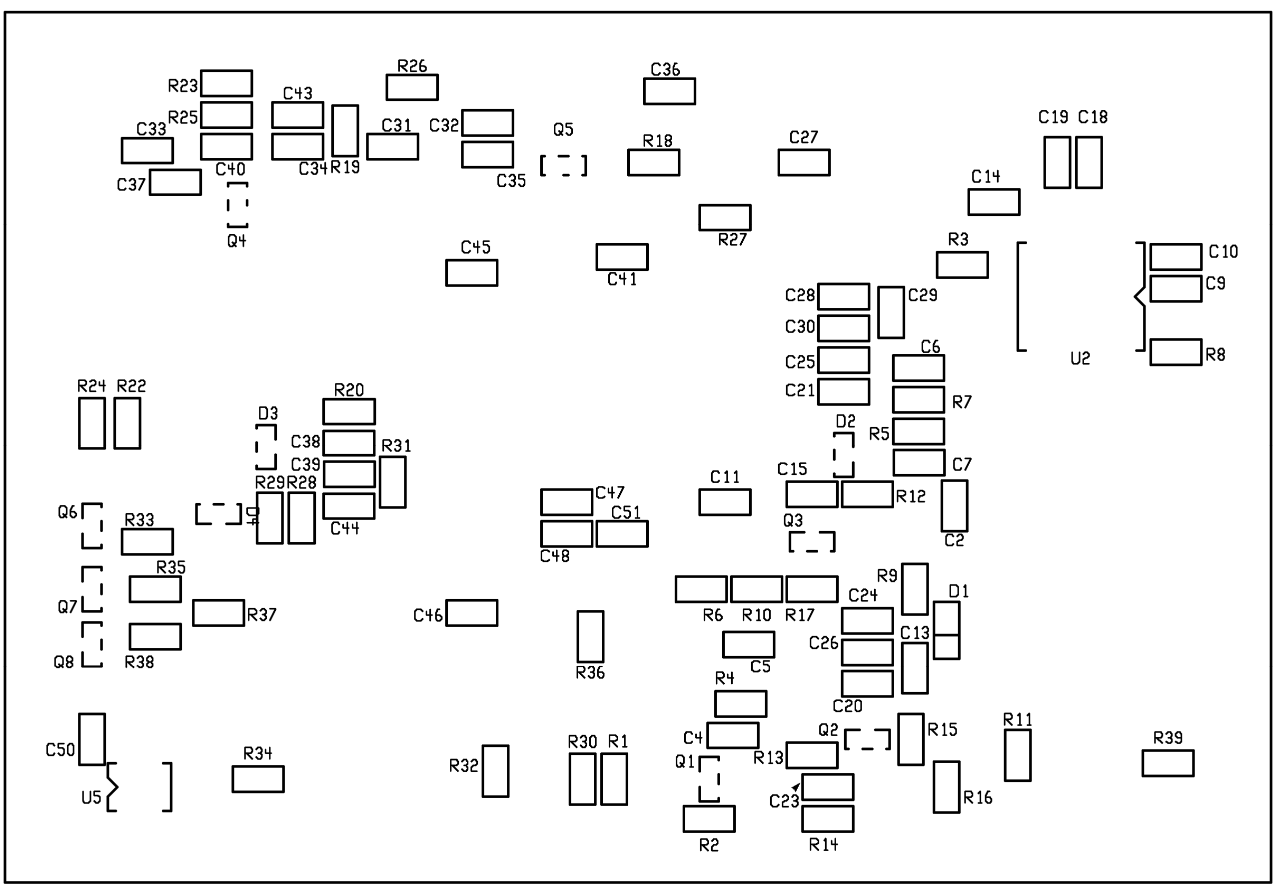
❷ Microcontrollers must be factory programmed for each application, and they are not interchangeable.

Caution: Ic's and fet's are static sensitive. Use appropriate handling precautions to avoid damage.

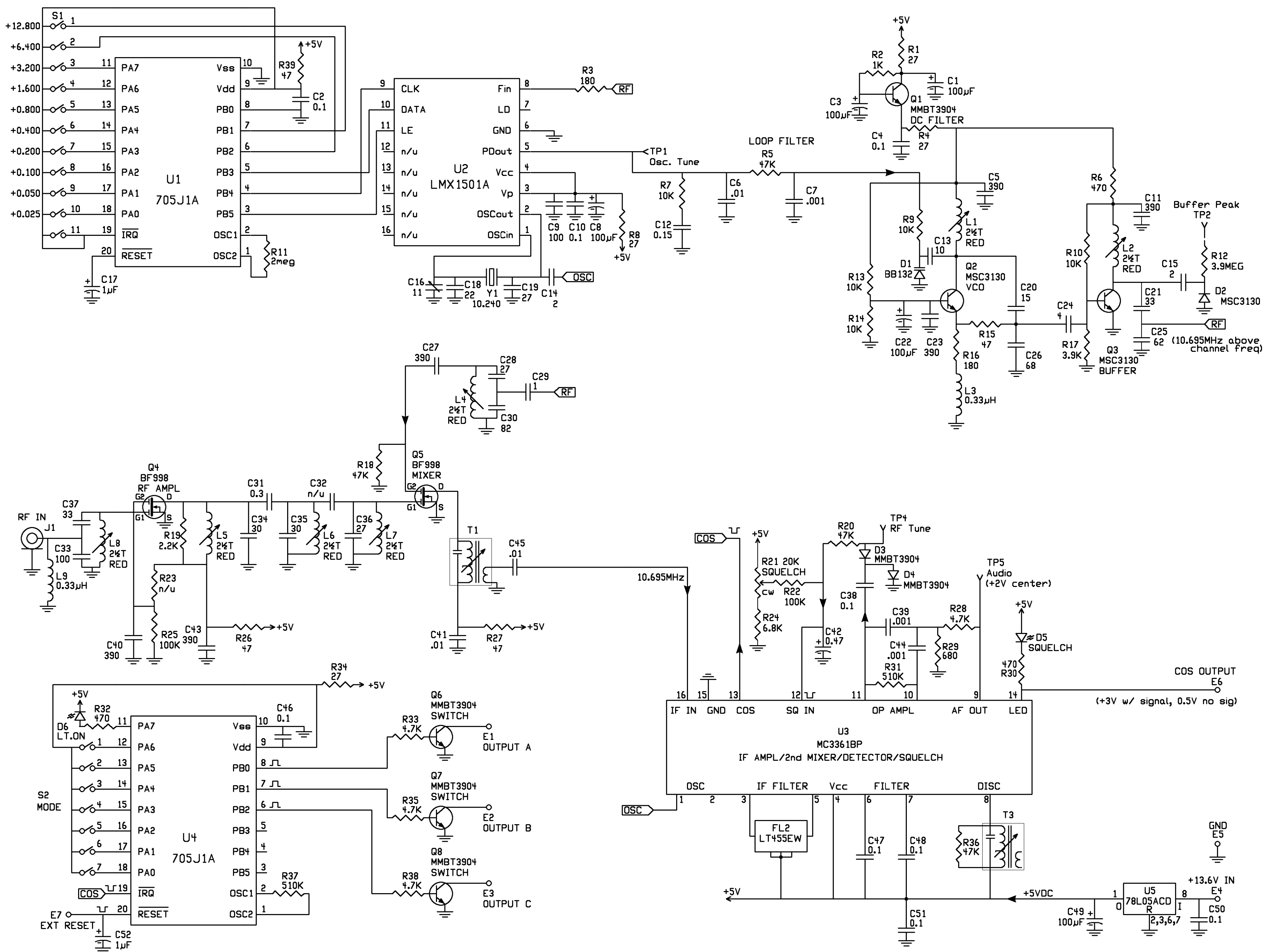
Ref Desig	Description (marking)
C1	100µf electrolytic
C2	0.1µf
C3	100µf electrolytic
C4	0.1µf
C5	390pf
C6	.01µf
C7	.001µf
C8	100µf electrolytic
C9	100pf
C10	0.1µf
C11	390pf
C12	0.15µf mylar (red)
C13	10pf
C14-C15	2pf
C16	20pf var cap
C17	1µf electrolytic
C18	15pf
C19	27pf
C20	15pf
C21	39pf
C22	100µf electrolytic
C23	390pf
C24	4pf
C25	62pf
C26	68pf
C27	390pf
C28	27pf
C29	1pf
C30	82pf
C31	0.3pf
C32	n/u
C33	100pf
C34-C35	30pf
C36	27pf
C37	39pf
C38	0.1µf
C39	.001µf
C40	390pf
C41	.01µf
C42	0.47µf electrolytic
C43	390pf
C44	.001µf
C45	.01µf
C46-C48	0.1µf
C49	100µf electrolytic
C50-C51	0.1µf
C52	1µf electrolytic
D1	BB132 varactor diode
D2	MSC3130 used as diode
D3-D4	MMBT3904 used as diode
D5	Green T1 LED
D6	Red T1 LED
FL2	455kHz ceramic filter, type "LT-455-D"
J1	RCA jack
L1-L2	2½ turn slug-tuned coil
L3	0.33µH RF choke (red-sil-orn-orn)
L4-L8	2½ turn slug-tuned coil
L9	0.33µH RF choke (red-sil-orn-orn)
Q1	MMBT3904
Q2-Q3	MSC3130
Q4-Q5	BF998 MOS FET
Q6-Q8	MMBT3904
R1	27Ω
R2	1K
R3	180Ω
R4	27Ω
R5	47K
R6	470Ω
R7	10K
R8	27Ω
R9-R10	10K
R11	2meg
R12	3.9meg
R13-R14	10K
R15	47Ω
R16	180Ω
R17	3.9K
R18	47K
R19	2.2K
R20	47K
R21	20K trim pot.
R22	100K
R23	100K
R24	6.8K
R25	3.9K
R26-R27	47Ω
R28	4.7K
R29	680Ω
R30	470Ω
R31	510K
R32	470Ω
R33	4.7K
R34	27Ω
R35	4.7K
R36	47K
R37	1 meg
R38	4.7K
R39	47Ω
R40 ❶	47K
S1	10 pos. dip switch
S2	7 pos. dip switch
T1	10.7MHz IF xfmr T1005
T3	455kHz IF xfmr T1003
U1 ❷	MC68HC705J1A µC *
U2	LMX1501A synthesizer
U3	MC3361P
U4	MC68HC705J1A µC *
U5	78L05ACD regulator
Y1	10.240 MHz crystal



R122 VHF Rcvr
(c) 2007
hamtronics, inc.
C16
Y1
L4
L7
L6
L5
J1
L8
L9
T1
C8
TP1
S1 FREQ
C12
U1
L2
FL2
U3
C42
COS
TP4
R21
SQUELCH
TP5
U4
TP2
T3
L1
A
B
C
E7
+12V
C52
GND
S2
MODE
L3
C22
C3
C1
D5
D6
C49
C17
1 2 3 4 5 6 7 8 9 10 n/u
1 2 3 4 5 6 7
SQUELCH
LT.ON



R23
R25
C33
C37
C40
Q4
C43
C34
R19
R26
C31
C32
C35
Q5
C36
R18
C27
R27
C14
C19 C18
C45
C41
R3
C10
C9
R8
U2
C28
C29
C30
C25
C21
C6
R7
R5
C7
D2
C15
R12
C2
Q3
C11
R24 R22
R20
D3
C38
C39
R31
R29 R28
C44
D4
C47
C51
C48
Q6
R33
R35
Q7
R37
Q8
R38
C46
R36
R6 R10 R17
R9
C24
D1
C13
C26
C5
R4
C20
C4
Q2
R15
R11
R39
Q1
R13
C23
R16
R14
R2
R30 R1
R32
R34
C50
U5



R122 VHF Receiver, Schematic Diagram.