Air Conditioner
Kit Build Instructions
Revised April 2012

This is a very straightforward project. The only caveat is the requirement for the correct sequence in the assembly of the various major components.

Radiator PEM Nuts

This project originally required the installation of PEM nuts. These have proved difficult to install due to some tight clearances and dimensional tolerance variations in the radiators. In lieu of the PEM nuts I have gone to using #8 x1/4" Pan head sheet metal screws. They will thread into the 0.135' holes in the radiator frame.

Fan mount

The brushless DC fan is attached to the radiator with 4 each #8 sheet metal screws. Note the airflow direction arrows molded into the fan frame. Additionally, two semicircular notches have been cut into one face of the fan frame in order to clear the input and output plumbing fittings.

Drill Template

Print out the case mounting and drill template. Attach the template to the left side of the cooler case with tape or spray glue. Drill 4 each 1/16" holes in the exterior surface of the case. Do not drill deep. A 1/16" penetration to break the surface of the blow-molded case is all that is required. You will want to maximize the grip of the attaching #4 x ½" sheet metal screws that go into the foam case wall filler. Also drill two pilot holes thru the case wall for the water ports. Enlarge these two holes with a ½" diameter spade bit. Drill a ¼" thru hole for the water pump cable.

Plumbing

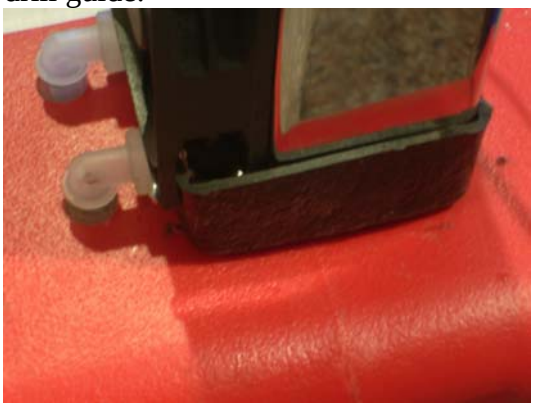
Use Teflon plumber tape when installing the nylon right angle hose bibs on the radiator and orient the barb ends parallel to the radiator frame. Cut a 5" length of the ¼" ID Tygon tubing and attach it to the lower hose barb. The remaining length is attached to the upper hose barb. This must be done prior to mounting the fan. Mount the fan to the radiator with #8 screws.

Back view

Remove the paper drill template and install the two black ABS plastic L bracket mounts on the left side of the cooler case using 4 each #4 x ½" sheet metal screws. Note orientation. There are upper front topside and the bottom front L bracket. Each has a slotted 1/8' hole on the front facing end.. The cooler case wall has a 1-degree draft angle. In addition to the sheet metal screws, I would recommend application of some ABS /PVC pipe dope between mount and the case wall just prior to tighten the screws.

L Brackets Note Upper & Lower

Guide the Tygon tubing thru the holes in the case and align the radiator in its mount. Insert the top front #8 screw thru the L bracket and into the top radiator mount hole. Insert the lower #8 screw in the slot on the lower L bracket and into the radiator lower mount hole. Do not cinch yet. Place the cooler case on a level surface and pivot the radiator body until it is level with case bottom, then tighten both screws. Turn the assembly around square the radiator face parallel to the front face of the cooler and transfer drill the back ends of the L mounting brackets with 1/8" holes using the rear fan mounting holes as the drill guide.



ABS L bracket mount goes inside fan flange and over the front lip of the radiator.

Check to see that the radiator is square to the cooler in the roll and yaw axis before drilling. Use two ea #8 sheet metal screws to secure the mount to the rear face of the radiator.

Pump Mount

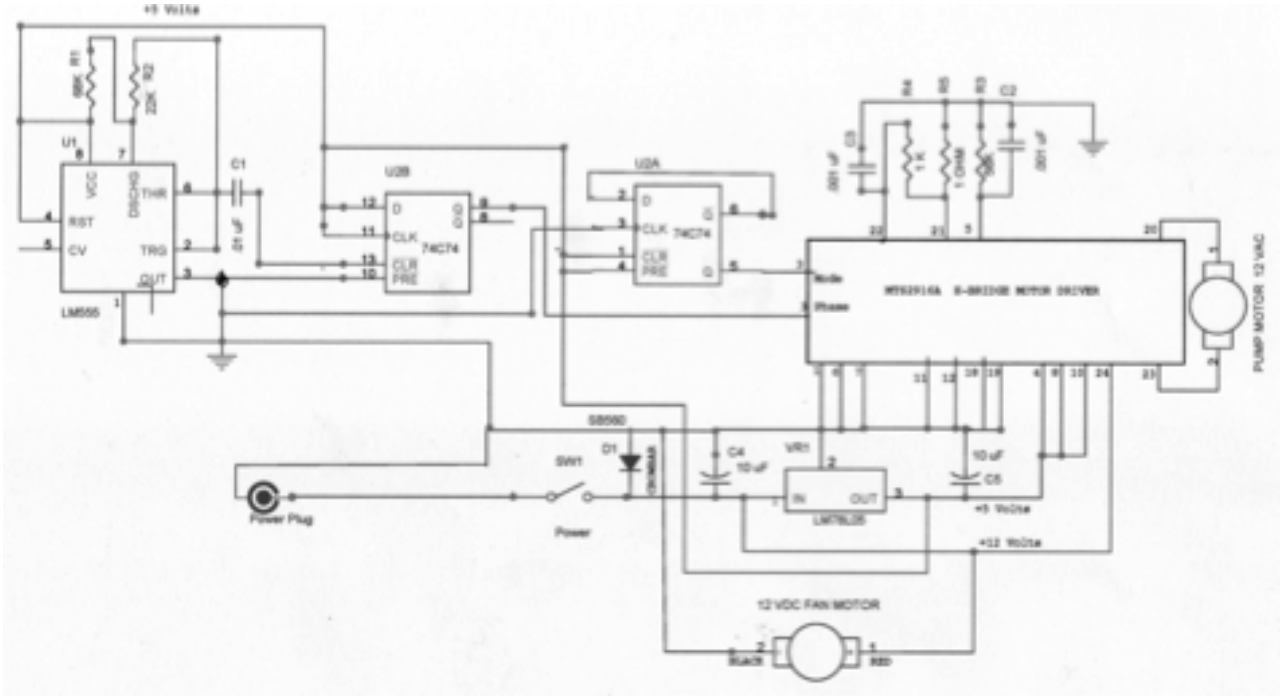
Fit the lower Tygon hose on to the water pump output stub and the apply cement (RTV or Goop) to the bottom of the suction cup feet on the water pump and position it on the floor of the cooler near the back wall. Use some weight and block to hold the pump in position until the glue cures. Route the pump power cord thru the case sidewall. Apply RTV glue generously around the tubing /wall and pump power cord /wall interface to make it watertight.

Position and glue the ABS 2x4" sheet on top of the radiator. Note: Switch mounts in rear two holes .

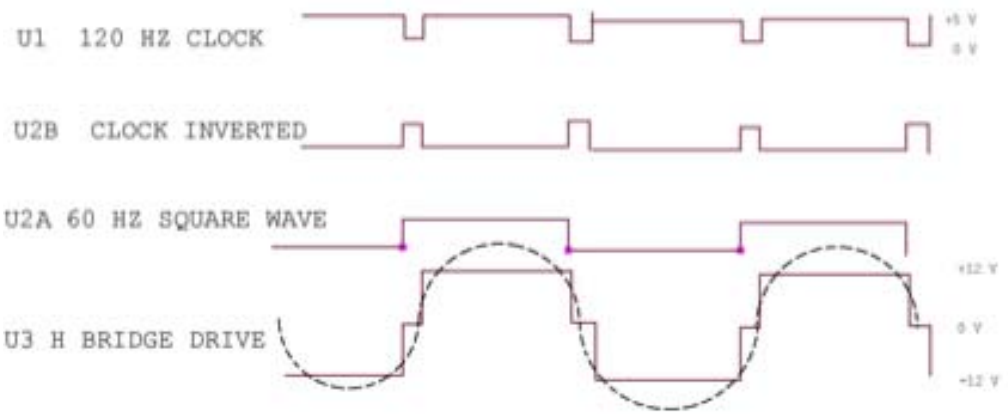
12 volt DC to 12 volt AC Inverter

Inverter drive electronics for pump

This circuit uses an LM555 timer to create a 120 Hz clock pulse. Next a 74HC74 dual flip-flop inverts the clock pulse and performs a divide by 2function



to generate a symmetrical 60 Hz square wave. The MTS2916A is a single chip stepper motor controller and a dual H-bridge stepper motor drive. These devices are typically used to run printer motors. One of its various mode-control options permits summing the inverted clock pulse with square wave input to create a synthetic quasi-sine wave suitable for running the circulation pump motor.

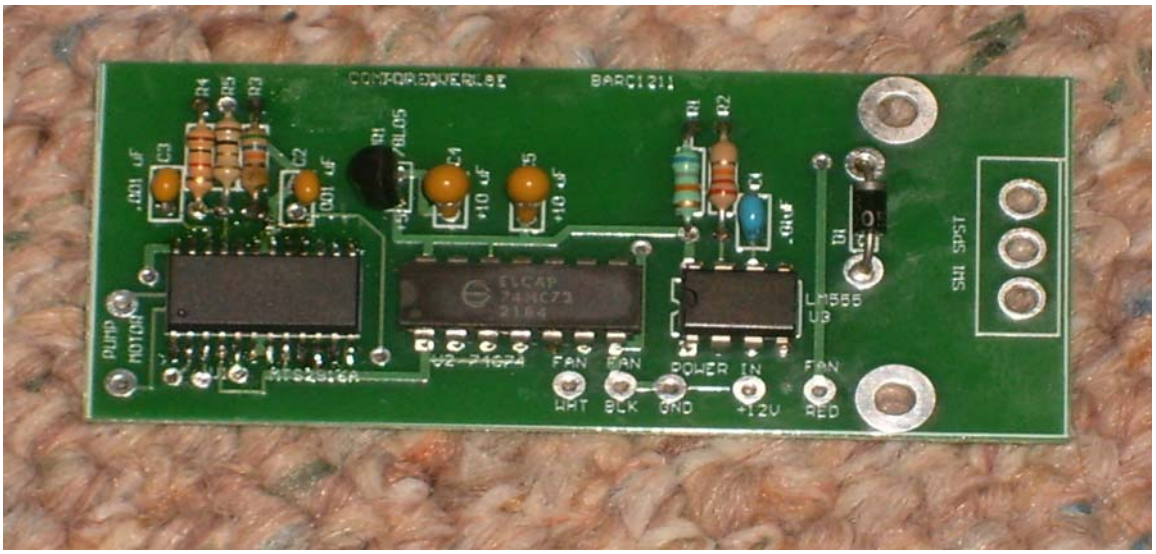


Inverter Quasi-sine Waveforms

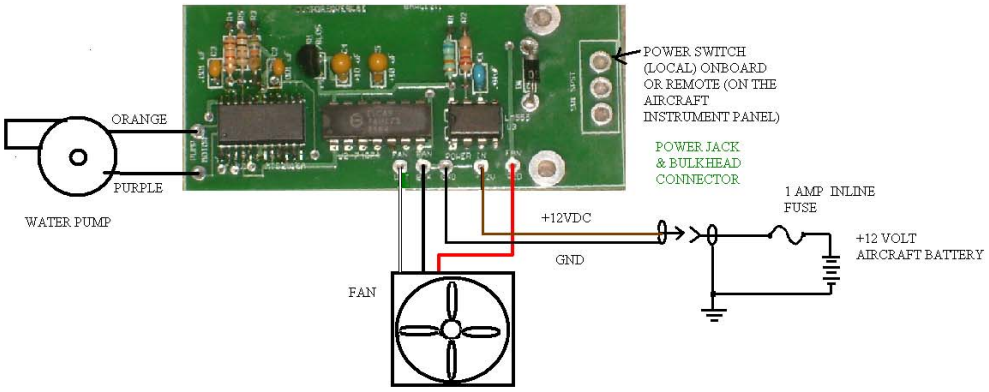
PC board Assembly

The MTS 2916A is an SOP-24 type of surface mount chip. I normally try to avoid using high-density surface mount lead format Integrated Circuit chip for these “Do-It-Yourself” projects. The very tight 0.050” lead spacing for surface mount parts can be a bit of a learning curve for “first-timers” soldering very tiny stuff. But in this case there were no other viable part options. So, use 0.032” diameter solder and a very fine needlepoint-soldering tip. Also, have a roll of solder wick braid handy (available at Radio Shack) to extract solder in case of a solder bridge between adjacent legs on the MTS 2916A part. Tin the corner pads on the PC board U1 part location. Orient and position the IC on the PC board pads and then re-flow solder onto diagonal corner legs to secure the IC before soldering the rest of the legs. Place the soldering iron tip on each leg and apply very small 032” diameter wire solder to each pad and allow the solder to flow between the PC board pad and the IC foot. The U2 and U3 chips are standard thru-hole mounting devices and have the larger 0.1” lead spacing making then easier to work with. (A visor-mounted set of magnifiers is strongly encouraged for this job.) Be sure to note correct orientation for all integrated circuits (Dot is pin#1) and the polarity orientation for the 10uF capacitors. Mount the PC board to the ABS floor plate glued to the top surface of the radiator .Use 2 ea. #4 sheet metal screws. Wire up the pump, fan and power cord as shown in the above illustration. Depending on your aircraft, the location of the bulkhead female power connector is left up to you. I do encourage you to fuse the connector as close to its supply bus as possible. Solder the 12 DC volt power cord to the PC board input terminal pads (Red striped wire is for the connector sleeve or Ground and the white wire is the center +12 Volt line) Don't’ ask me why? This wire color coding is backwards from normal convention! (Ah! The inscrutable Chinese mind)

Note: There is a layout error on the PC board . The offending trace has been cut and a jumper wire added. between pin 10 and pin 3 of the 74HC74. The jumper wire has been installed under the 74HC74 and is not readily visible. Leave this jumper wire in place when installing and soldering the components.



Circuit Board with Components Installed



PUMP DRIVER BOARD HOOKUP TO FAN AND PUMP

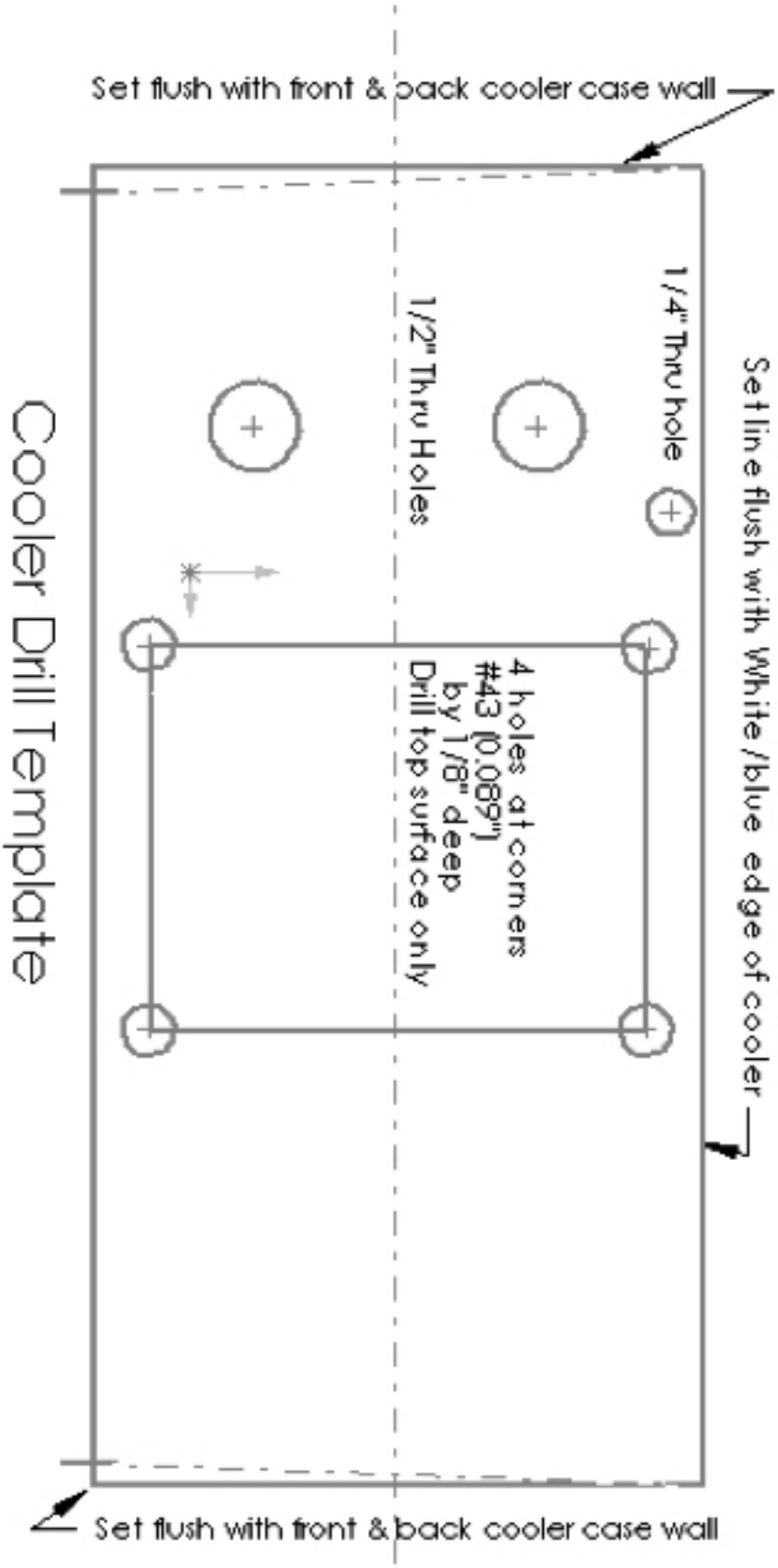
I installed the mating miniature Power jack in the rear of my cabin and wired the jack directly to the aircraft bus with an inline fuse located right at the battery /master relay. This is philosophically similar to the fusing of the aircraft clock and master relay power switch. (If a short should occur, the fuse interrupts power right at the battery.) Bundle the wires to exit the slot in the top ABS board cover. I recommend securing the top board cover in two to four spots with some hot glue. (This permits easy removal if necessary) Do this <u>after</u> you power up for testing.

Test

For the initial power up test I recommend using a 12 Volt bench power supply that is current limited to ~ 1 amp. This will help preclude damage in case something got assembled wrong. Upon power up you should feel a small vibration in the pump that will let you know it is running. Check the fan airflow thru the radiator. Add enough water to submerge the pump to check the system flow and for leaks.. Please note there is a flow rate lever adjustment on the side of the pump. This should be kept in the wide-open position. In fact, a dab of RTV glue on the lever is advisable.

Application and Use

Load the cooler with ice cubes and add ~ 1" of chilled water to submerge the pump. Mount the AC unit in the rear of your plane (hat shelf or the baggage clothes hook) Connect to aircraft 12-volt power and turn it on. The pump will circulate cold water thru the radiator and return it back over the ice. The fan provides that welcome stream of cold air. Operating time is of course, temperature dependent, but you can expect up to an hour or more of cool air before melting all of the ice. Ice takes 80 calories per gram to convert from 0°C ice to 0°C melt water (32°F). This energy /adsorption or release is called the heat of fusion. Each additional degree of temperature change requires only 1 calorie per gram per degree. Thus the bulk of the cooling capacity is stored in the melting phase transition of the ice. I have found that filling the cooler case with ice cubes has been sufficient for my type of flying. It has been most comforting in getting me from the hangar, down the taxiway, and a climb to cooler altitudes. I have usually had sufficient remaining ice for the decent back into the hotter air near Earth. On longer trips in the more hot and humid environments of the Deep South or Texas, you may want to add a drain tube and bring along an ice refill.


Set flush with front & back cooler case wall
Cooler Drill Template
1/4" Thru hole
1/2" Thru Holes
4 holes at corners
#43 (0.089")
by 1/8" deep
Drill top surface only
Set line flush with White/blue edge of cooler
Set flush with front & back cooler case wall