Midea Air Conditioner Timer

A fun little project to turn the AC unit on in my office before I get to work in the morning.

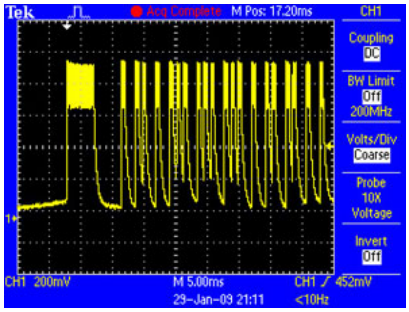
OVERVIEW

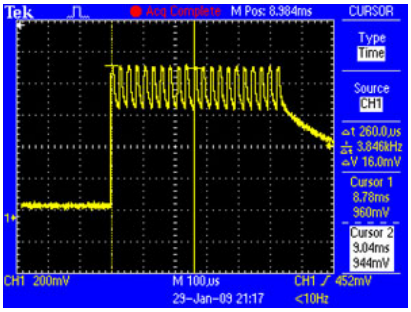
Here in China there is no central air, so my office is heated/cooled by a room air conditioner. Because of this, it's cold when I arrive at work in the winter, and hot in the summer, and it takes until about noon for the little room a/c unit to get the room to a remotely comfortable temperature. So an idea was born to create a small, battery powered, IR emitter that would issue the same "ON" command the AC's remote control does, but does it an hour or so before I get to work in the morning. The end result should be a nice warm office in the winter and a cool one in the summer!

I originally envisioned this as having an elaborate real time clock and entering the current time and a turn-on time via a serial interface. I finally decided just to turn the unit on at 5:00pm before going home and have it just count 14.5 hours to start up at 7:30am. I'll have it re-issue the start command every 10 minutes or so between 7:30 and my arrival at 8:30 just in case someone sees the AC running in an unoccupied office and turns the AC unit off.

DISCOVERY

To determine the carrier frequency of the remote control, I used an IR LED as a photodiode. I hooked the diode up to my oscilloscope and transmitted the start code from the AC remote to determine the pulse timing and carrier frequency.

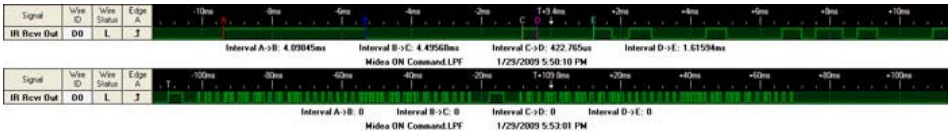




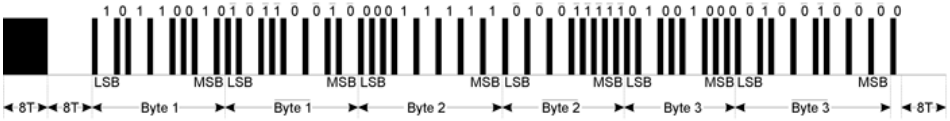
The Midea IR signal uses pulse distance encoding. Each pulse (one "time" unit or 1T) is 21 cycles of a 38KHz carrier burst (about 550µs long). A logic "1" is a 1T pulse followed by a 3T space and takes 2.25ms to transmit. A logic "0" is a 1T pulse followed by a 1T space and takes 1.125ms. The AGC burst consists of a 4.5ms burst followed by 4.5ms space (8T pulse + 8T space). This is very close to the RCA infrared standard.

I then hooked up a IR receiver module of the correct carrier frequency to a logic analyzer to determine the actual data transmitted by pressing the "ON" button. The Midea remote command signal consists of 3 bytes of information.

Each byte was first transmitted normal and then inverted for a total of 48 bits of data. This was followed by what appeared to be a single "0" stop bit followed by 4.5ms space (8T). This entire command including the AGC pulse and stop pulse was then immediately transmitted again.



Here's the Midea remote control output partially deciphered:



It was observed that *Byte 1* appears to be a constant and does not change with any control inputs. The actual determination of what each bit does is left as a exercise for the reader. It was enough for me to just record the code and regurgitate it.

THEORY OF OPERATION

Timing will be handled by using the watchdog interrupt. The watchdog will fire every 8 seconds (450 ticks per hour). If we set up a 24 hour counter, then the counter should roll over every 10,800 ticks. If we start our IR emitter at 5:00pm we should initialize the timer counter to 7,650. We want the IR emitter to send the "ON" command to the AC unit at 7:30am (3,375 ticks), then again every 10 minutes (75 ticks) until 8:30am (3,825 ticks).

The internal RC clock is not very accurate. We can minimize the error from this by turning the unit off and back on every day at 5:00pm to reset it. We can also measure the actual length of our 8 second timer tick at the µC/temperature/supply voltage/clock frequency we will operate at and adjust the target tick points accordingly. The IR carrier frequency we generate is also dependant on the internal RC clock so we will also need to measure the actual carrier frequency generated and adjust it as well.

The device needs to transmit one command for heating during the winter, and a different command for cooling during the summer. To keep from having to reprogram the chip for each season, and to minimize the user interface on the device, a simple season select is implemented using the power switch.

Seasons are denoted by the color of the heartbeat LED. Red for winter (heating mode) and green for Summer (cooling). If the device is switched off during the first 8 seconds, it will start back up in the next "season". If the startup season is correct and the device is allowed to run longer than 8 seconds, then the next startup will be the same as the current season.

Season information is stored in non-volatile EEPROM. Assuming the device is started twice per day (worst case when changing seasons), then four EEPROM writes occur per day. With a life of 100,000 write/erase cycles, that gives us a 70 year life span for the EEPROM memory.

Season mode changing is a little tricky because of sleeping in power-down mode. The processor is using very little power so there is enough power stored in the filter capacitors to execute a few cycles after waking even if the power was switched off long ago. Therefore, when changing modes, be sure to leave the power off at least 8 seconds (1 timer tick). That way, the processor will awaken and then attempt to flash the heartbeat LED effectively draining the stored energy, and preventing the mode toggle from executing unexpectedly. Be sure to enable Brown Out Detection in the fuses to get reliable shutdowns.

Much more in the source code comments!

APPLICABILITY

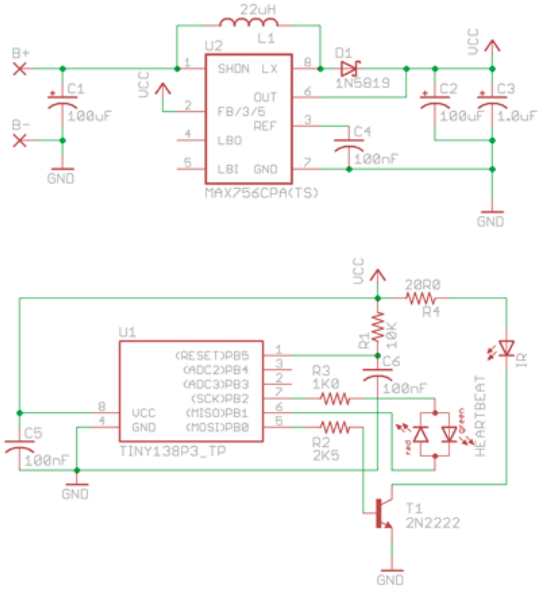
Unless you have a Midea air conditioner in your office, this project will probably not help you very much. However, there are a few building blocks here that can be re-purposed to do many useful things. The DC-DC voltage converter can be used to drive many 3.3V or 5V low power devices from a single 1.2V rechargeable AA cell. The packaging in a 2-AA cell battery case might give you some ideas for your own projects. The ATTiny13 controlled IR emitter circuit might be used to control many other IR devices, and the well-commented source code is a great learning tool in and of itself.

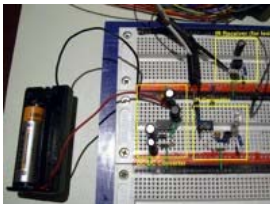
CONSTRUCTION

The circuit consists of two parts; the DC-DC converter and the IR signal generator and emitter. The Maxim MAX756 DC-DC Converter is supplied with a single AA battery. You can use either a 1.2V rechargeable, or a regular 1.5V Alkaline cell. The '756 converts this to 3.3V to supply the Atmel ATTiny13A which handles the control logic and signal generation.

The µController portion is very simple. A bypass cap and weak pullup are attached to the chip reset line to prevent inadvertent resets from occurring. The IR LED operates at 100ma - too high to run directly from one of the Tiny's output pins, so we use a common 2N2222 transistor to buffer the current. The "heartbeat" LED is a 3mm bi-color 2-lead red/green LED. If we pull I/O pin PB1 low, and set PB2 high, we get green light. Pulling PB2 low and setting PB1 high generates red light. That's it for the hardware, other than a two cell AA battery case with an integral on-off switch which we house everything in.

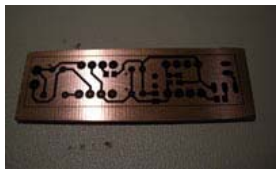
The circuit was breadboarded to work out the bugs and create the software before the layout and creation of a printed circuit board. You





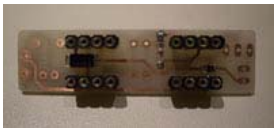
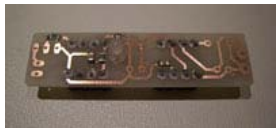
could probably wire this up "dead-bug" point-to-point style, but as easy as PCBs are to create using the toner-transfer method, it almost as fast and far more professional just to go ahead and make one.

It's a little bit more trouble to make a double-sided PCB using toner-transfer, but certainly doable. Briefly, here's how: Clean one side of the board, iron on the image. Apply clear packing tape to the other side to protect it in the etch tank and go ahead and etch the first side. After etching, remove the packing tape then pre-drill two of the holes in the board slightly larger than a straight pin. Clean the other side of the board, and using pins to align the artwork, iron-on the second side. Apply tape to cover the already etched first side, and then etch the second side. Remove the tape after etching, then drill and trim the board.


Laying out a double-sided board for making at home is a little more involved since you don't have plated-through holes. It helps to use a mixture of through-hole and SMD components to reduce the number of vias required. You also need to remember that not all through-hole components can be soldered on both sides (i.e. electrolytic caps, LEDs, etc.). I decided to socket the µC and DC-DC converter so it would be easy to salvage the chips later. I like to use turned pin sockets for this since both sides can be easily soldered. Using these techniques, this board was made without any vias.

Start by installing the lowest components first, usually the SMD devices. Then work your way up to the tallest items. Think about what needs to be soldered on each part, especially on the top of the board, to make sure you don't put something in the way of soldering a connection later. I like to clean the flux of the board a couple of times as I go since the top gets pretty hard to clean as the taller components start going on.


THE FINISHED PRODUCT

And here's the completed device. Before I leave work for the day, I switch it on, make sure it's in the right mode, and set it on my desk pointing at the AC unit. Next morning I arrive to a wonderfully comfortable office!

DISCLAIMER AND LICENSE

It worked for me so it should work for you, but no guarantees. Feel free to use the schematics and information on this page as you see fit, but a little attribution would be appreciated.

PROJECT SOURCES

- AVR Studio GCC Source (25K .zip)
- Cadsoft Eagle Files (71K .zip)

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