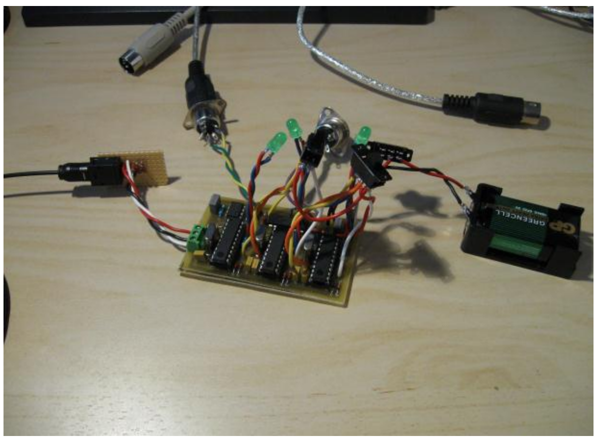
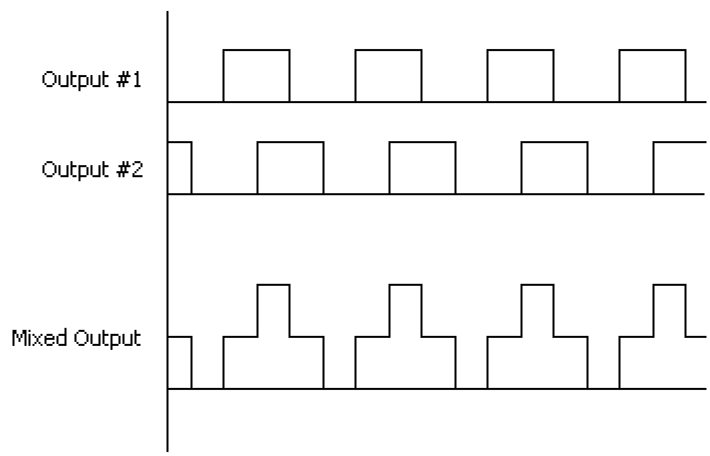
POLYPHONIC TESLA COIL MIDI INTERRUPTER

The Polyphonic Tesla Coil MIDI Interrupter, quite a mouth-full isn't it? This device is basically a modular MIDI player, which can be used as a Tesla coil interrupter or synthesizer. For those who aren't familiar with MIDI, it's a music standard used largely by keyboards and drum pads, in which simple commands are sent serially, such as note on and off information and intensity, but not actual music. That job is left to the synthesizer, which is simply told when a note is on or off, and must create the corresponding sounds (frequency, waveform, etc) itself in order to make audible music. So no matter what the original song is supposed to sound like, the MIDI signals simply tell us when a key is on or off (and a lot of other information, but nothing that's interesting for this project). This is perfect for Tesla coil modulation, as every SSTC or DRSSTC can be interrupted, and by interrupting the coil at the same frequency as the note being played, we can create music!

This project has evolved from a monophonic MIDI player using a single ATmega32, to a multi-channel, multi-note (polyphonic) MIDI player using cascaded ATtiny2313s. Each ATtiny2313 can play two notes at once, using Timer1 and the two Compare Match modules. The AVRs are organized so they all receive the same input, but only start playing notes once an enable input (PD5) is set high. Once an AVR has used both it's compare match modules to play notes, ie is full, an output pin (PB0) goes high. This way they can cooperate, and in theory play and infinite number of notes at once. The MIDI channel that the AVRs listen on is set using the four most significant bits on PORTB. I've made a small example circuit where three ATtiny2313s are chained together, and can either play 6 notes on one channel, 4 notes on channel 1 and two on channel 3, or two notes on channels 1,2 and 3. All depending on the position of two switches. The firmware was made using WinAVR (AVR-GCC). Firmware, schematic, a command-line program for determining the compare match values AND PCB files (w00t!) can be found here. -> TC MIDI Interrupter.zip



For anyone else who wishes to tread down the path of MIDI and AVRs, I recommend you read this article by Paul Maddox. It was a reference I used throughout the entire process, and saved me a lot of headaches. (not to say I still didn't encounter enough of them.) Also, if you wish to mix several notes together you need to keep the duty cycle low (~5%). This is obvious once it's been pointed out (thanks Steve Ward), because you can only send one bit of data down the line, and mixing two square waves results in areas at V/2 - which would require 2 bits of data to describe. Keeping the duty cycle low reduces the chance of an overlap. And the more square waves you mix the more bits are required. It's easy to see graphically if my explanation is poor.



The firmware itself is interrupt-driven. MIDI bytes are processed as soon as they are received, and once a full MIDI packet has been received a note is either turned on or off.

When a note is turned on the correct off-time and on-time values are looked up and stored for quick access, and interrupts are enabled for one of the compare modules. If both compare modules are now busy an output pin is set high to alert any other AVRs in the chain that it's full. Once a compare module generates an interrupt, an output pin is toggled and the time until the next interrupt is determined depending on whether it's in a high or low state (to get an asymmetric waveform (less than 50% duty cycle)). When a note off event occurs the AVR first checks that it's actually playing the note before stopping one of the compare modules. The main program loop is used to indicate when notes are being played, to check what channel to listen on and to enable or disable the next AVR in the cascade.

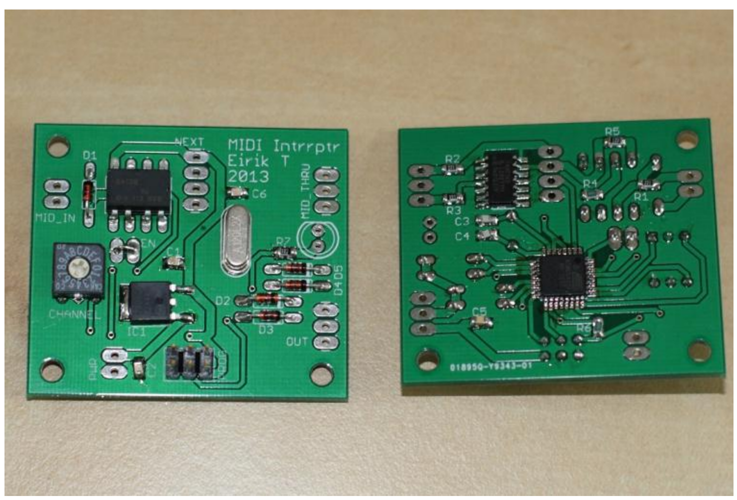
Energy Labs used this design to create a PIC based version, for those more inclined to Microchip.

DRSSTC edition

I've recently built a DRSSTC, and in order to use the MIDI interrupter with it I had to make some alterations. Most importantly, the maximum on-time had to be limited (this applies to low frequency notes) and the range of frequencies had to be truncated. My DRSSTC would only respond to notes below middle C, anything else would simply result in no output. I suspect this is the case with most DRSSTCs, due to the time it takes the tank current to ring up.

To counter this, I had the MIDI interrupter shift all received notes down one octave, and at the same time ignore notes above a defined key. The duty cycle in the provided firmware was set to 1,88%, or 3,75% with both notes playing at once, and with the maximum on-time limited to 250us per note.

The compare notes generator was rewritten in Golang, which is Google's "spiritual successor" to C. A version of the code is provided which will run directly on the Golang site's servers, so no installation is even needed. What this code does is automatically generate the correct timer values needed in the firmware, if you wish to alter the duty cycle or on-time limit. A new circuit layout and microcontroller is used, which I have made a PCB layout for. All required design files can be found here. Like the version above, the layout here assumes you will be using your own TLL compatible fiber optic unit, or any other Tesla coil interface of your choosing.



Source: http://uzzors2k.4hv.org/index.php?page=midiinterrupter