555 Timer based Music Box Player by Francis Bauer

Project description:

This project was inspired upon hearing about the 555 Timer contest and having recently seen some videos on YouTube regarding do-it-yourself music box kits. The video that I first looked at was Möbius Strip Music Box Experiment which had me looking for music box kits that use paper strips to play music. I found some at TinToyArcade.com and made an order. Upon receiving the music box kit and playing around with it, I decided to make an electronic version using 555 Timers for the contest and for the fun of it.

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Quick links to documentation sections:

The project consisted of two major parts:

1. A paper strip reader suitable to interfacing with electronics.
2. Electronics capable of producing a 2 octave musical scale (15 notes).

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Paper Strip Reader Assembly/Construction:

The first challenge was creating a mechanism for electronically reading the paper strips similar to the ones the mechanical music box kits used. The original music box strips have a .08" vertical distance between each of the 15 musical notes (2 octaves). I ended up having to digitize the paper strips and use Photoshop to increase the vertical distance to .1" (a 125% vertical increase). This allowed me to utilize normal .1" spaced electronic devices and protoboards. The included hole-punch in the music box kit made it relatively easy to punch the new enlarged paper strips. I had some 3mm Phototransistors in my electronics stash, which after some grinding their edges with a dremel tool I was able to have the Phototransistors spaced .1" apart. The Phototransistors I used sense visible to infra-red light so I was able to use some high intensity Red T1¾ LEDs as the light source to shine through the paper strip holes. Using the T1¾ sized LEDs allowed me to use one LED per every 2 Phototransistors, since the LEDs had a 20° viewing angle. Using 2 protoboards I wired up the LEDs on one board and the Phototransistors on the other along with their pull-up resistor networks. I made aluminum panels to hold the 2 protoboards an appropriate distance apart. **Figure 1** shows a close-up of the completed assembly.

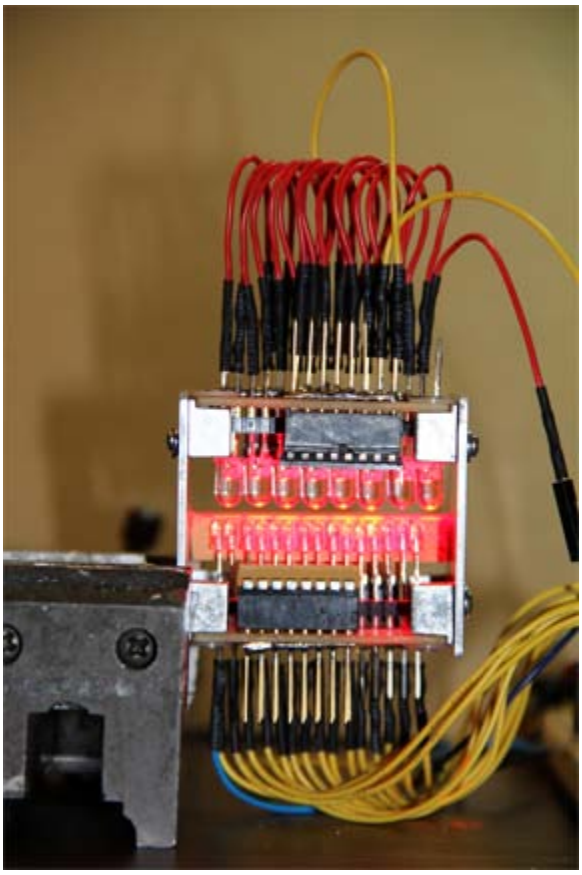

Figure 1

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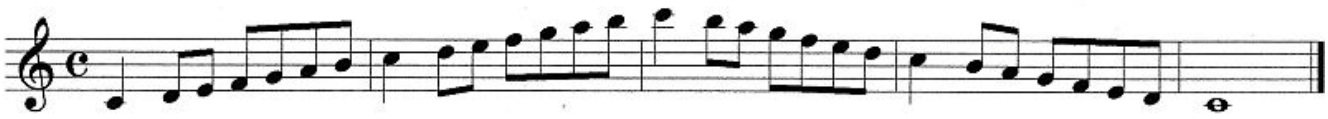
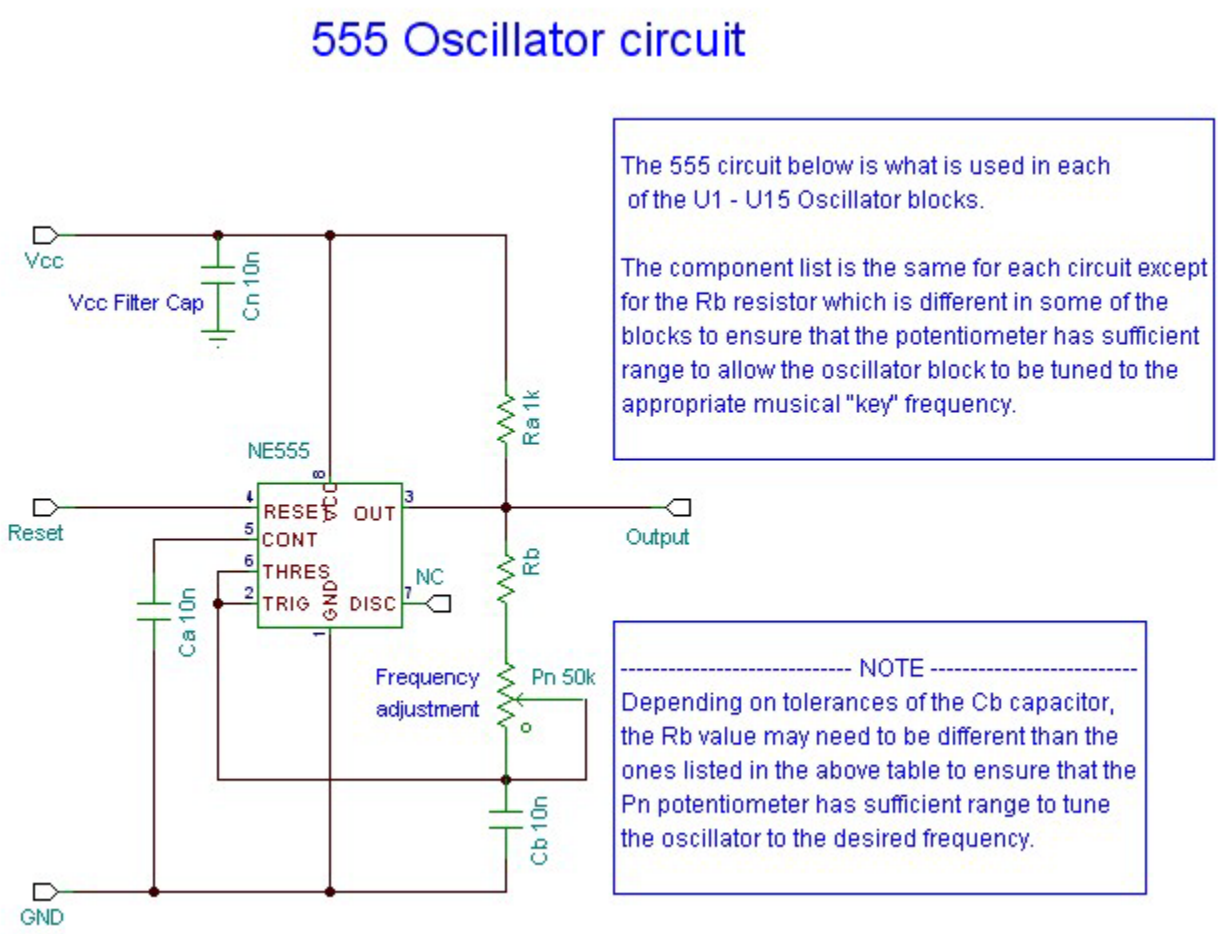
Music Box player electronic circuit:

Since the project was for the 555 Timer contest, the plan was to use 555 Timers to produce the needed musical tones. Since time was short I decided to just be satisfied with a simple 50% duty cycle square wave tone output from the 555 Timers. The following shows the basic 555 astable oscillator circuit I used for each of the 15 musical tones and the *Rb* resistor value that was used.



555 Timer IC designation	Music Key	Frequency (*Hz*)	*Rb* resistor Value (*Ohms*)
U1	C6	1046.502	62*k*
U2	B5	987.767	62*k*
U3	A5	880.000	62*k*
U4	G5	783.991	62*k*
U5	F5	698.456	100*k*
U6	E5	659.255	100*k*
U7	D5	587.330	100*k*
U8	C5	523.251	120*k*
U9	B4	493.883	120*k*
U10	A4	440.000	150*k*
U11	G4	391.995	180*k*
U12	F4	349.228	220*k*
U13	E4	329.628	220*k*
U14	D4	293.665	220*k*
U15	C4	261.626	270*k*



Schematic 1

Each of the 15 musical tones has a circuit similar to the one shown in **Schematic 1**. The only differences between each of the circuits is the total resistance used to charge the 555 Timer timing capacitor.

The *Reset* input on each 555 is used to turn on and off the musical tone and is connected to a phototransistor/transistor pair. So when a "hole" is detected on the paper strip the appropriate musical tone circuit is enabled.

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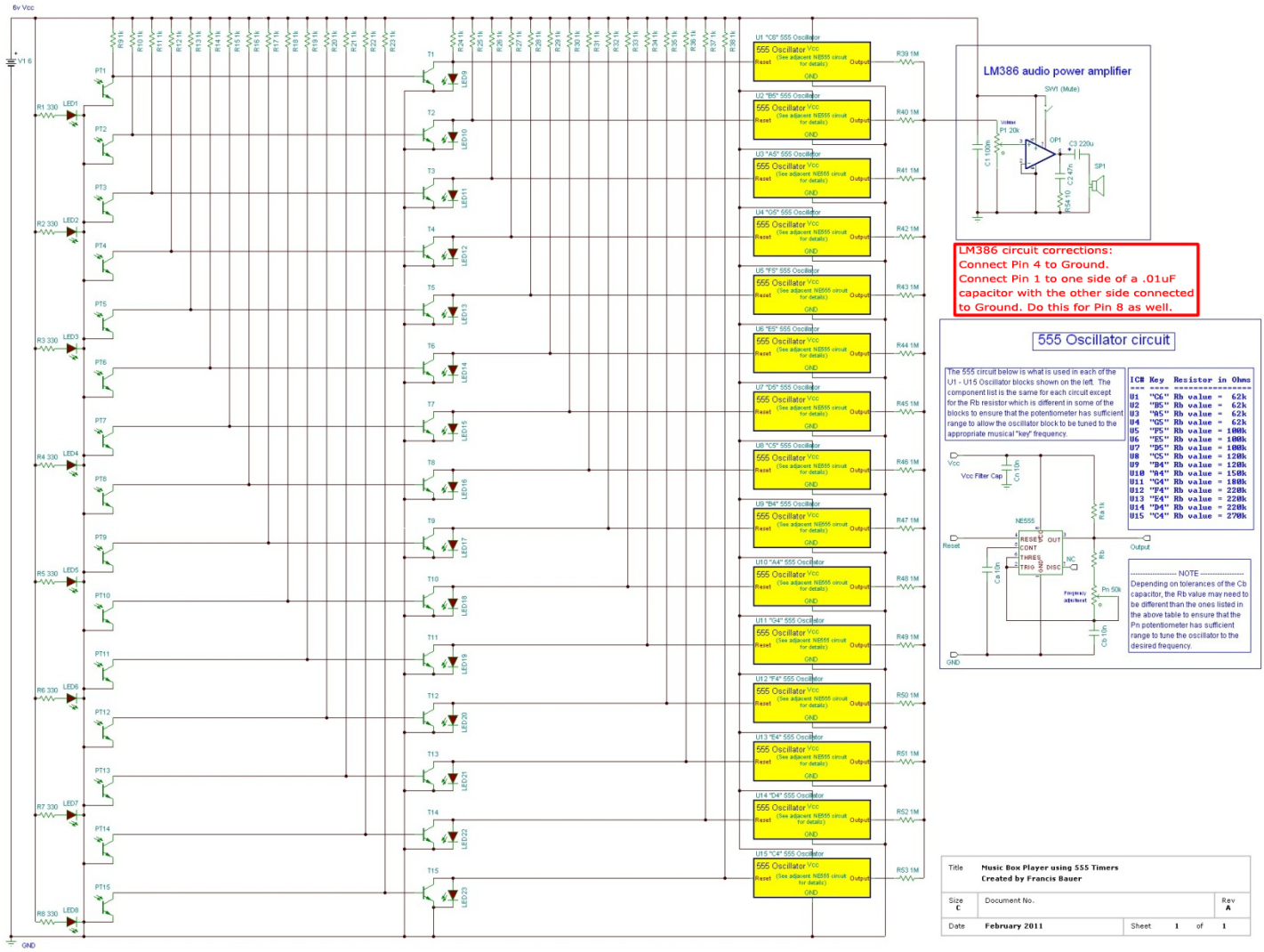
Here is the overall Music Box Player schematic, which you can click on to see a larger version:



Schematic 2

Component list

Quantity	Designation(s)	Value	Description
1	C1	.1μF	Audio amp. Vcc filter capacitor
1	C2	.047μF	Audio amp. Filter capacitor
1	C3	220μF	Audio amp. output filter capacitor
15	Ca	.01μF	U1-U15 (pin 5) control voltage
15	Cb	.01μF	U1-U15 timing capacitors (with good tolerance & temperature specs)
15	Cn	.01μF	Vcc filter capacitor (1 per U1-U15)
Note: The working voltage of the capacitors are not critical, 2x Vcc or larger should be fine.			
8	LED1-LED8	Red	Any T1¾ high intensity LED will work as long as their wavelength is within the (PT) phototransistor's spectral range and they have at least a 20° viewing angle.
15	LED9-LED23	Red	Any LED will work and are only needed if you want to see each musical note triggered/played.
1	OP1	LM386	Audio Power Amplifier IC
1	P1	20$k\Omega$ ¼ w	Trim potentiometer
15	Pn	50$k\Omega$ ¼ w	Trim potentiometer (U1-U15 timing capacitor charge resistor)
15	PT1-PT15	PT202C (Everlight)	3mm NPN phototransistors (400-1200nm spectral range) (visible to infra-red)
Note: Pretty much any 3mm phototransistor could be used, just ensure that your LED's output is within the spectral range of the phototransistors.			

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Quantity	Designation(s)	Value	Description
8	R1-R8	330Ω ¼ w	LED current limiting (Discrete resistors or DIP/SIP network resistors could be used.)
30	R9-R38	1*k*Ω ¼ w	Transistor collector pull-up (Discrete resistors or DIP/SIP network resistors could be used.)
15	R39-R53	1*M*Ω ¼ w	U1-U15 output summing (Discrete resistors or DIP/SIP network resistors could be used.)
1	R54	10Ω ½ w	Audio Amp. filter resistor
15	Ra	1*k*Ω ¼ w	U1-U15 output pull-up
15	Rb	(see table)	U1-U15 timing capacitor charge resistor
1	SP1	8Ω	Any speaker of 1w or greater
1	SW1	SPST	Audio Amp. mute switch
15	T1-T15	2N2222	NPN transistors
15	U1-U15	NE555	555 timers IC (Or use 8 556 dual timers)

Additional items:

Depending on how you put the circuit together you may need 8 or 16 pin IC sockets for the NE555 timers and/or DIP resistor networks.

I used 16 pin wire-wrap sockets and SIP sockets when constructing the LED/Phototransistor assembly. This allowed me to easily insert the LEDs and Phototransistors as well as the DIP resistor networks I used.

Image of MusicBoxPlayer Breadboard

(Click image for High Res. Version)

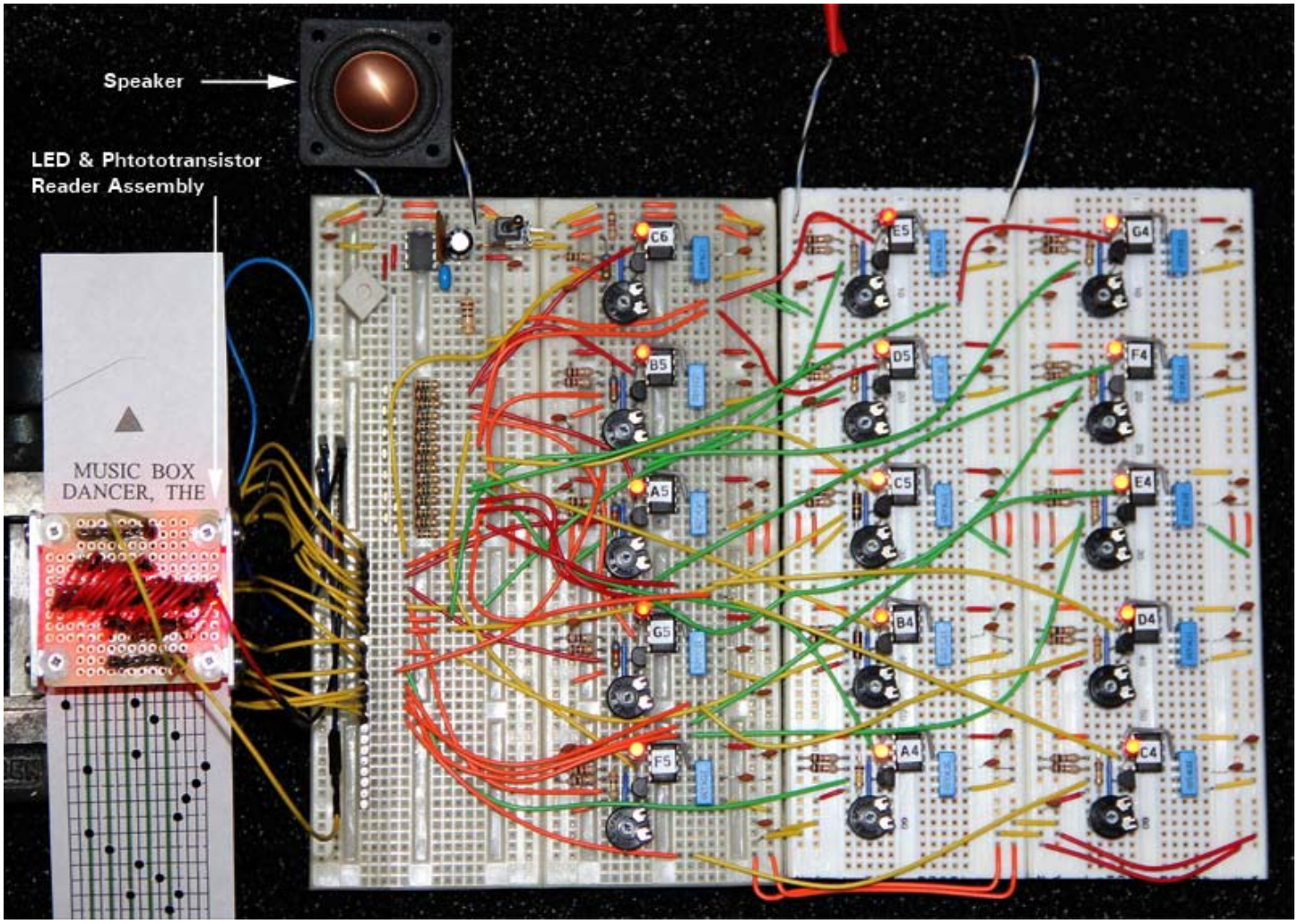

Figure 2

Circuit Adjustments/Calibration:

I used a frequency counter to measure and adjust the frequency of each circuit to be as close as possible to the desired musical tone frequency. Of course as temperature changes, the frequency output of each of the circuits change so over time there are some changes in the musical tones. I imagine the original mechanical music box has an advantage in that its metal based tuning fork mechanism is much less sensitive to temperature changes so its musical tones don't change as much.

Future Enhancements:

Currently the Music Box Player requires someone to manually pull the paper music strip through the paper strip reader. I ran out of time to add a 555 circuit to control a motor and create a motor drive assembly to automatically feed the paper music strips. I envision adding an additional phototransistor to the strip reader that will detect a start/stop "hole" punched into the paper music strip. This additional "hole" could also be used as a master on/off music output control so that the musical tones are only generated when a paper music strip is inserted into the Music Box Player.

Other enhancements could include the addition of some active or passive filters on the output of each of the oscillators to convert the square wave into something more sinusoidal.

Conclusion:

The prototype breadboard of the Music Box Player worked reasonably well and will eventually get built using a custom printed circuit board or at least using a hand soldered vector board.

With 15 musical tones you can create many different songs to be played on the Music Box Player of almost any length by using longer and longer paper music strips. You could even connect the paper music strips ends together for continuous playback or even make a paper music strip version of the unique physical media winding method used in old 8-Track audio tapes.

Anyone up for making a Music Box Player covering all 88 Piano keys/tones using 555 Timers ☺