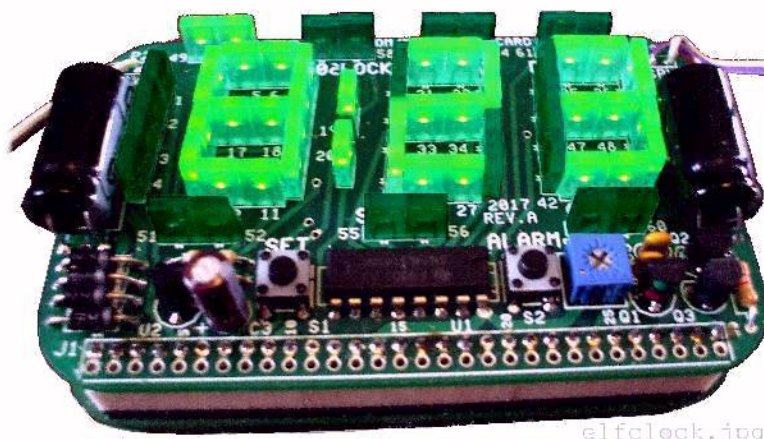


A Clock for the 1802 Elf

A TMSI ElectroniKit (tm)

<http://www.sunrise-ev.com/membershipcard.htm#clock>



Here is a fun project to put your RCA 1802 microprocessor to work. The **ElfClock** is an accessory board for the **1802 Membership Card** to turn it into a digital alarm clock. It also works with any other computers based on the original 1976 Popular Electronics COSMAC Elf articles.

Yes, you could build a digital clock with dozens of logic ICs, or buy one ready-made that uses some dedicated clock chip. But this project demonstrates the real power of a microcomputer: It replaces dozens of ICs with just a few, while adding lots more features. Moreover, **YOU** can control how it looks and works!

In fact, a clock was the first project I built with my resurrected "Elf" back in 2012. It all started because my son loves Minecraft, and is very hard to get out of bed in the morning. So how about an alarm clock that is truly "alarming"?

Minecraft has a character called the "Creeper". He's like a suicide bomber -- he sneaks up on you, and then **EXPLODES!** I decided to build a Creeper alarm clock. Most of the time, it's simply a digital clock, showing the time through the eye holes. But when it reaches the alarm time, it starts ticking like approaching footsteps. Louder and louder, closer and closer, until a big **KABOOM** explosion sound at the end. He'd better get up and shut it off when he hears the footsteps... or ELSE!

There was a lot of interest in my one-off original, so I made this kit version. It's a real "retro" project, with big pads, big traces, and through-hole 1970's vintage parts (no surface mount). You can build it from plans on the web, or buy a bare board and populate it yourself, or a complete kit.

An 1802 Membership Card is needed to run it (any revision). The Front Panel Card is not used. An AC "wall wart" transformer provides power and a 60 Hz timing reference so the clock keeps good time. If you add a battery, it will keep time and the alarm still works if the power fails.

The LEDs are individually programmable, and source code is available, so you can change the display and sounds to anything you like. Ready? Let's begin!

If you bought a kit, find each part, and check it off in the space provided. If you bought a bare board, this is your "shopping list". Sources for the parts are shown (in parentheses).

Parts List

<u>Quantity</u>	<u>Identifier</u>	<u>Description</u>	
<input type="checkbox"/>	2	C1, C2	Capacitor, 1200uF 10vdc electrolytic (jameco.com 607363)
<input type="checkbox"/>	1	C3	Capacitor, 4.7uF 16v tantalum (jameco.com 94035)
<input type="checkbox"/>	2	C4, C5	Capacitor, 0.1uF 50v ceramic (jameco.com 544868)
<input type="checkbox"/>	4	D1-D4	Diode, 100v 1a 1N4002 (jameco.com 76961)
<input type="checkbox"/>	62	1-62	LED, 3mm round or 5x2mm, red yellow or green (jameco.com 790356)
<input type="checkbox"/>	3	J1abc	30-pin (or three 10-pin) socket (3 pieces Mouser 538-22-18-2101)
<input type="checkbox"/>		P2	Transformer, 5-8vac (not supplied; jameco.com 2230651 or equivalent)
<input type="checkbox"/>		P3	Loudspeaker, 8 ohms (not supplied; jameco.com 1950972 or equivalent)
<input type="checkbox"/>	1	Q1	Transistor, 2N3904 NPN small signal (jameco.com 38359)
<input type="checkbox"/>	1	Q2	Transistor, 2N4401 NPN general purpose (jameco.com 38421)
<input type="checkbox"/>	1	Q3	Transistor, 2N4403 PNP general purpose (jameco.com 38447)
<input type="checkbox"/>	1	R1	Resistor 100K 5% 1/4w, brown-black-yellow-gold (jameco.com 691340)
<input type="checkbox"/>	1	R2	Resistor 2.7K 5% 1/4w, red-violet-red-gold (jameco.com 690961)
<input type="checkbox"/>	1	R3	Resistor 300 ohm 5% 1/4w orange-black-brown-gold (jameco.com 690734)
<input type="checkbox"/>	1	R4	Trimpot 1K, Bourns 3362P or Vishay/Spectrol 76P (jameco.com 253982)
<input type="checkbox"/>	2	S1, S2	Pushbutton switch 4-pin 0.25" square (jameco.com 149948)
<input type="checkbox"/>	1	U1	74LS145 1-of-10 BCD-decimal decoder/driver (jameco.com 46666)
<input type="checkbox"/>	1	U2	LM317LZ adjustable voltage regulator (jameco.com 23552)
<input type="checkbox"/>	1	PCB	"180¢LOCK" printed circuit board (from me :-)
<input type="checkbox"/>	1	*U2*	27C64 EPROM (marked MCCLOCK) * = goes on the Membership Card

Assembly

If you've built any electronic projects before, assembly is pretty straightforward. You'll need a soldering gun or iron, rosin-core electronics solder (please; no acid-core plumbing solder!), and wire cutters.

In the grand old Heathkit style, step-by-step instructions start on the next page. I like to put the lowest height parts in first, and work up to the tallest ones last. This means resistors first, then the diodes, IC, transistors, capacitors, LEDs, and finally the electrolytic capacitors. Hints:

- Do the steps in order, then mark the box (X) so you know you did it.
- All parts go on the **front** side of the board, marked "180¢LOCK".
- Insert each part, then bend a couple of its pins or wire leads slightly to hold it in place.
- Then turn the board over, and solder all the part's connections.
- Finally, cut off any excess wire length (so they don't short to anything on the 1802 board).

Resistors are "dogbone" shaped tubes with colored rings to indicate their resistance, and a wire on each end. Bend the wires at a right angle, and insert them into the holes on the board.

- R1: 100K (tan body, with brown-black-yellow-gold rings).
- R2: 2.7K (tan body, with red-violet-red-gold rings).
- R3: 300 ohms (tan body, with orange-black-brown-gold rings).
- R4: 1K trimpot (square blue body with 3 pins)

Diodes are reddish glass tubes with a wire on each end. Diodes must be installed the right way! The end with the black band must match the end with the band printed on the board. Ignore the white paint on one wire. You can either stand the diodes on end, or scrape off the white paint so the diode can lay flat on the board.

- Diode D1 (marked 1N4002).
- Diode D2 (marked 1N4002).
- Diode D3 (marked 1N4002).
- Diode D4 (marked 1N4002).

Integrated Circuit U1 looks like a black “caterpillar”. Bend the pins inward slightly, and insert it on the board. ICs must face the right way! The end with the notch must match the notch shown on the board. Note: The text printed on the IC will be **upside down** when it is installed correctly!

- U1: 74LS145 (marked SN74LS145N).

Transistors and U2 are little black tubes with three wires and a flat side (looks like a D shape from above). The flat side must match the one printed on the board. Bend the wires to fit into the corresponding holes inside the D-shape on the board. Push the part down close to the board so it is no more than about 1/4” high.

- U2: LM317LZ (marked LM317LZ).
- Q1: 2N3904 (marked 2N3904).
- Q2: 2N4401 (marked 4401).
- Q3: 2N4403 (marked 4403).

Capacitors have two wires coming out the same side.

- C3: 4.7uF (yellow body, marked 4.7-16). The wire with the “+” sign next to it is positive, and goes in the hole marked “+”.
- C4: 0.1uF (yellow body, marked 104).
- C5: 0.1uF (yellow body, marked 104).

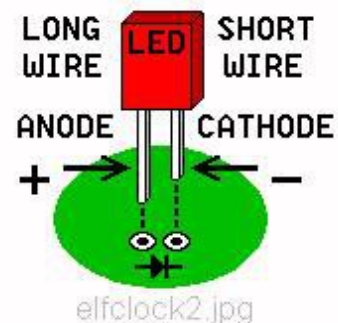
Switches S1 and S1 are square and have 4 pins. Place them on the board as shown.

- S1: pushbutton switch.
- S2: pushbutton switch.

LEDs are next. This is the fun part. You can use round or rectangular LEDs, in any color you like. I have lots of red LEDs, so that's what comes with the kit. Red was also the only color you could get back in the 1970's; so it is period-correct.

LEDs are polarity sensitive, and **must** be installed the right way! The **LONG** wire is positive (anode) on the LEDs supplied with the kit... and with most (but not all!) others that you may find. It goes in the hole with the **arrow-head** printed on the board, as shown in the illustration at the right.

For best appearance, install a few LEDs at a time. Lay the board face-down, so the table holds all the LEDs at the same height. Solder **ONE** wire of each one. Flip the board over, and wiggle them a bit so they line up nicely. Then solder the remaining wire.



Capacitors C1 and C2 are the tallest parts, so they get installed last. They are polarity sensitive. The negative wire has a big stripe with “-” signs on it. Put it in the hole marked “-” on the board. Lay C1 and C2 flat to minimize their height. Note that there are TWO sets of holes; one set for capacitors with both wires on the same end, and one for capacitors with wires on opposite ends.

- () C1: 1200uF 10vdc electrolytic capacitor.
- () C2: 1200uF 10vdc electrolytic capacitor.

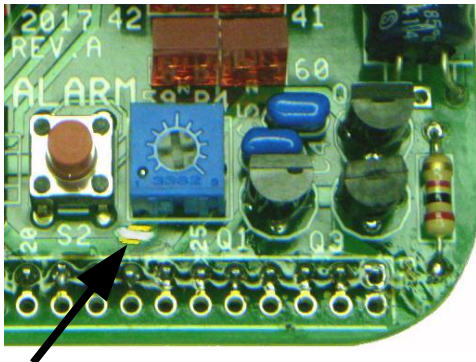
Connector J1 mounts on the **BOTTOM** of the board. It plugs into the pin header on your 1802 Membership Card. I couldn't get a 30-pin part, so the kit has three 10-pin parts (J1a, b and c). Install them with their pins in the **INSIDE** rows of holes for J1, and solder them on the top side.

- () J1a: 10-pin female socket.
- () J1b: 10-pin female socket.
- () J1c: 10-pin female socket.

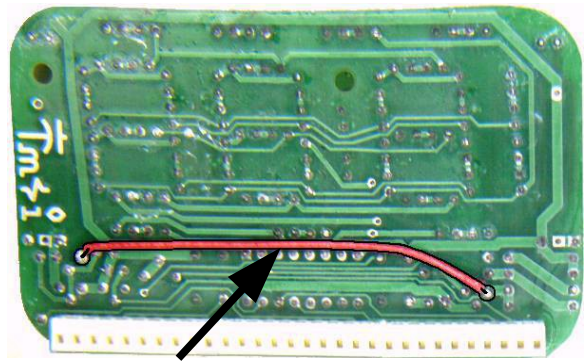
That's it! All the parts should now be installed. Check your work carefully for unsoldered connections, bad solder joints, parts in backwards, or in the wrong places.

Cut-n-Patches

The ElfClock rev.A board needs one trace cut, and one patch wire added.



- () Cut the trace shown on the top side of the board to disconnect VCC from the collector of Q2.



- () Add a patch wire on the back side of the board as shown to connect the collector of Q2 to VIN.

Testing

You will need a source of AC power. A small “wall wart” transformer, or old-school 6.3vac filament transformer will do. It must provide 5 to 8 volts AC (not DC) at about 50ma.

Note that the PC board says “6-9vac”. Small transformers deliver significantly more than their rated voltage with such a light load. So, pick a transformer with a lower rated voltage, so it won't be too high. For example, the transformer in the parts list is rated “5vac 500ma”, but it actually delivers 6vac with a 50ma load. You need to stay under 9vac right at the board, or the rectified voltage on C1 will exceed its 10vdc rating and regulator U2 will overheat.

- () Solder wires from your transformer to the two holes labeled “P2”.
(You can add a connector, if you like).

You will also need an 8 ohm loudspeaker. It can be any size; but a tiny speaker makes tiny sound. If you want an “alarming” clock, use a larger more efficient speaker (mine is about 5”).

() Solder wires from your loudspeaker to the two holes labeled “P3”. (Or use a connector).

Now for the “smoke test”! Do not plug the ElfClock card into your Membership Card yet.

1. Plug in the transformer.
2. Measure the AC voltage at P2. It should be 6 to 9 volts AC.
3. Measure the voltage across C1. It should be 7 to 10 volts DC.
4. Measure the voltage from J1 pin 1 (negative, which is at the left end of J1) to J1 pin 14 (positive, which is one pin left of the one labeled “15”). It should be between 1.2v and 5.2 volts DC.
5. Adjust trimpot R4 to set the voltage in step 4 to about 5 volts. This is VCC; the regulated power supply for the Membership Card, and also sets LED brightness.
6. Connect a jumper wire from J1 pin 12 (the “Q” signal) to either wire at P2. You should hear a loud “HUM” from the speaker.

If all is well, now you can configure your 1802 Membership Card to work with the ElfClock. Any revision can be used (* but see below for ancient rev.A cards).

- () Set the clock speed to 1.8 MHz. This will let the clock keep time even on battery power. If it's an older version that does not have the 1.8 MHz resonator, then adjust the speed with the trimpot on the Membership Card to about 1.8 MHz.
- () Remove the memory chip from the socket at U2. Replace it with the 27C64 EPROM (marked MCCLOCK) provided.
- () Set the jumpers at P2 and P3 for a 27C64 EPROM.
 - a. At P2, short pins 2-3.
 - b. At P3, short pins 1-3 and 4-5.
- () If you have a rev.G or later Membership Card, check to make sure there are foil traces (or jumpers) connecting U2-LO and U8-HI. (You don't need a RAM installed at U8; but if it's already soldered in, it won't hurt, either.)
- () Plug the ElfClock onto the Membership Card. Check to be sure no parts or wires on the back of the ElfClock are touching anything on the Membership Card (short circuits)!
- () Now for the arc-n-spark show: Plug in your transformer! You should be rewarded with a working clock display! :-) Adjust R4 for a comfortable brightness, and it's ready to use!

* 1802 Membership Card rev.A used port 5 instead of 4 for its I/O ports. To use a rev.A card,

- a. Change the program. Replace all the OUT4 instructions with OUT5, reassemble it, and burn a new EPROM.
- b. Or, change the board. Cut the trace to 1802 pin 19, and add a jumper wire from U4 pin 1 to pin 2. This changes the input and output port number from 5 to 4.

Operation

The ElfClock displays 12:01 AM when first powered up. The colon between the digits will toggle on/off every second.

To set the time, press and hold the left SET button. You will hear a “tick-tick-tick” as the time counts up (one minute per second). After 64 seconds, it zeros the minutes, and the time counts up one hour per second. Hold down the SET button until the hours and AM/PM get to the desired time. Release the SET button; then press it again to set the minutes to the desired time.

The alarm is initially set to 12:00 AM. When it matches the time, you will hear a “step-step-step” once per second. After one minute of this, the alarm sounds and you will hear a continuous “explosion” sound. To stop the alarm, press the right ALARM button.

The right ALARM button toggles the alarm on/off. When on, the bottom right ALARM indicator is on. When the alarm is off, this LED is off. To set the alarm, hold down the right ALARM button, and then press the left SET button to set the alarm time, exactly as you did to set the time.

If you put the ElfClock in a box (such as a Creeper head), you can connect a second pair of pushbuttons so they are more convenient to use.

Battery Backup

You can add a battery, so the clock keeps time even if the AC power goes off. You will need:

- Four AA cells
- 4-cell battery holder
- 1N4002 diode (the diode is not critical; almost **any** diode will work).

- () Connect the negative wire from the battery holder to the second negative hole (-) of C1.
- () Connect the diode cathode (the end with the band) to the second positive hole (+) of C2.
- () Connect the diode anode (the end away from the band) to battery holder positive (+).

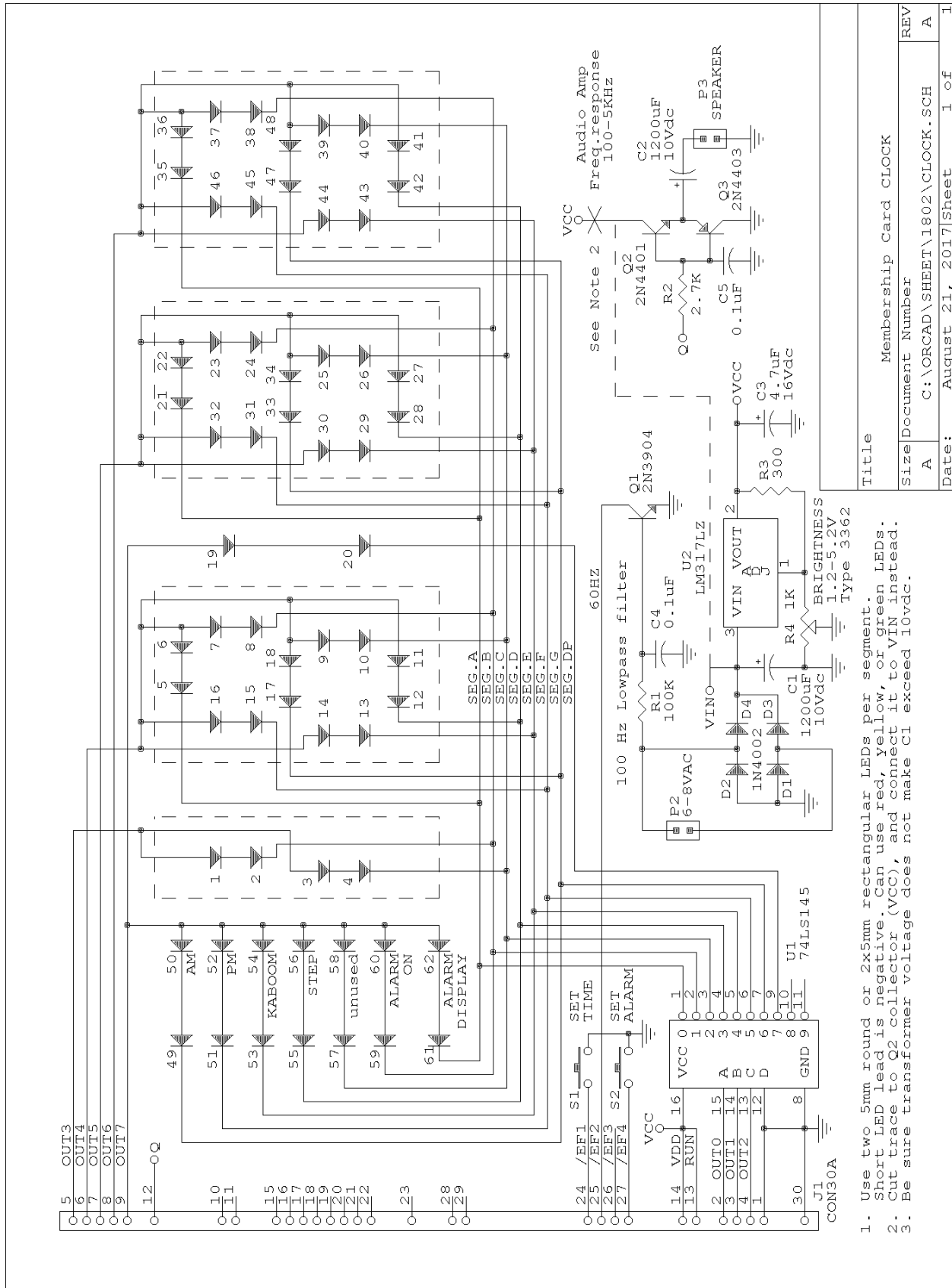
This setup works with NON-rechargeable batteries. Normal AA alkaline cells will run the clock for a few days. The diode insures that the batteries do not supply **any** power when running on AC, so they will last for many years.

If you want to use RECHARGEABLE batteries, add a resistor across the diode. The value of the resistor depends on the type and amphour capacity of your cells, and the voltage of your transformer. For example:

- You have nicad cells, and want to charge them at 1.5v at 10ma.
- $1.5v \times 4 = 6v$.
- Your transformer produces 8 volts DC on capacitor C1.
- So resistor $R = (8v-6v) / 10ma = 200$ ohms.

Credits

A project like this depends on the inspiration and support from many people. In particular, I want to thank to Josh Bensadon for his brilliantly clever program, and Chuck Yakym for modifying it to run on this updated circuit board. I couldn't have done it without you, guys!



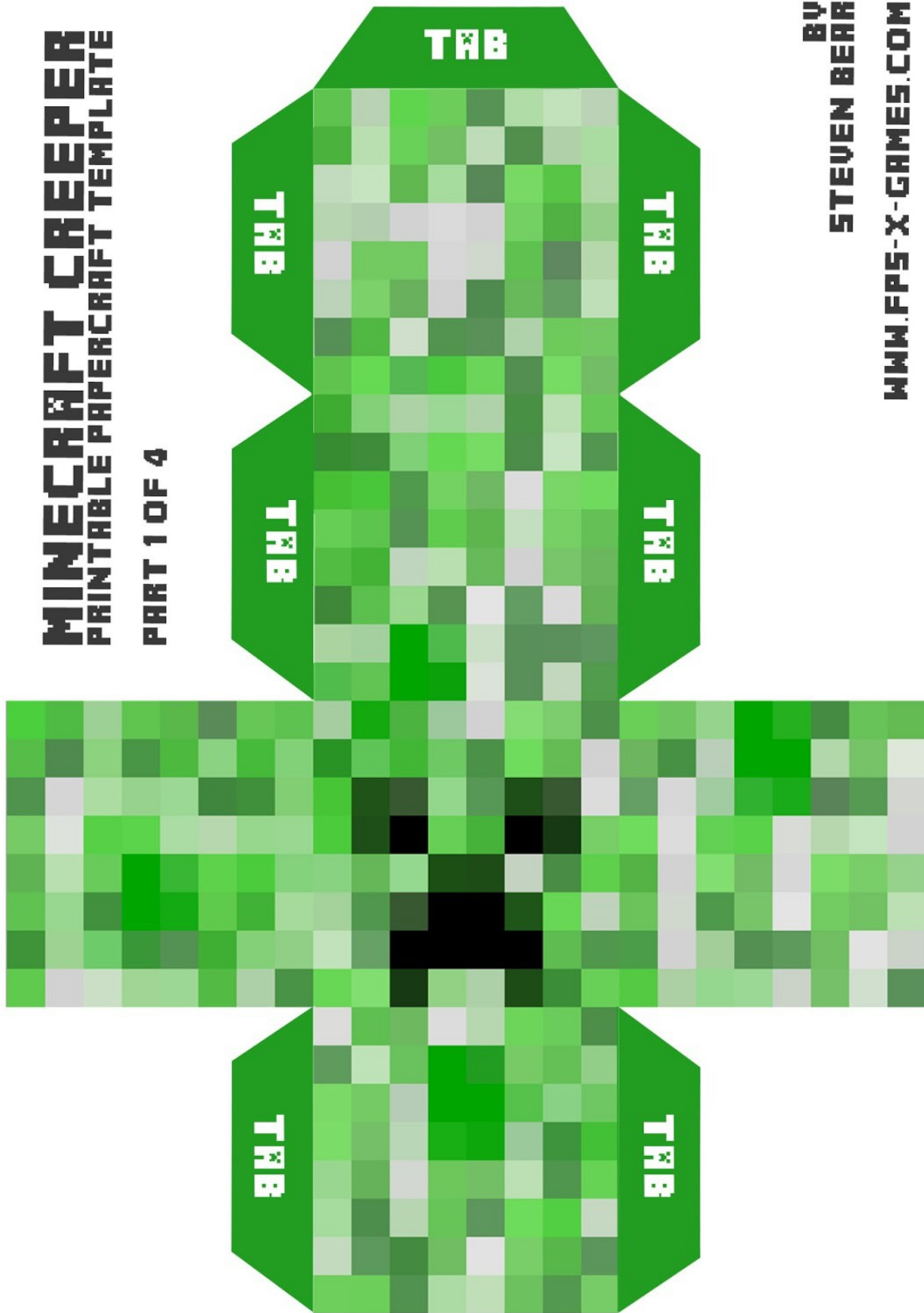
I hope you enjoy this little project as much as I did. Please let me know how you like it, or if you come up with any improvements or enhancements. Th-th-that's all, folks!

by Lee Hart, 814 8th Ave N, Sartell MN 56377, leehart@earthlink.net

Title		Membership Card CLOCK
Size	Document Number	C:\ORCAD\sheet\1802\CLOCK.SCH
REV	A	A
Date:	August 21, 2017	Sheet 1 of 1

MINECRAFT CREEPER PRINTABLE PAPERCRAFT TEMPLATE

PART 1 OF 4



BY
STEVEN BEAR
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Here is a pattern to make your own Creeper case for the Elflock. I enlarged it to about 5" on a side, printed it, and glued it to the sides of a wooden box that doubled as the speaker cabinet.