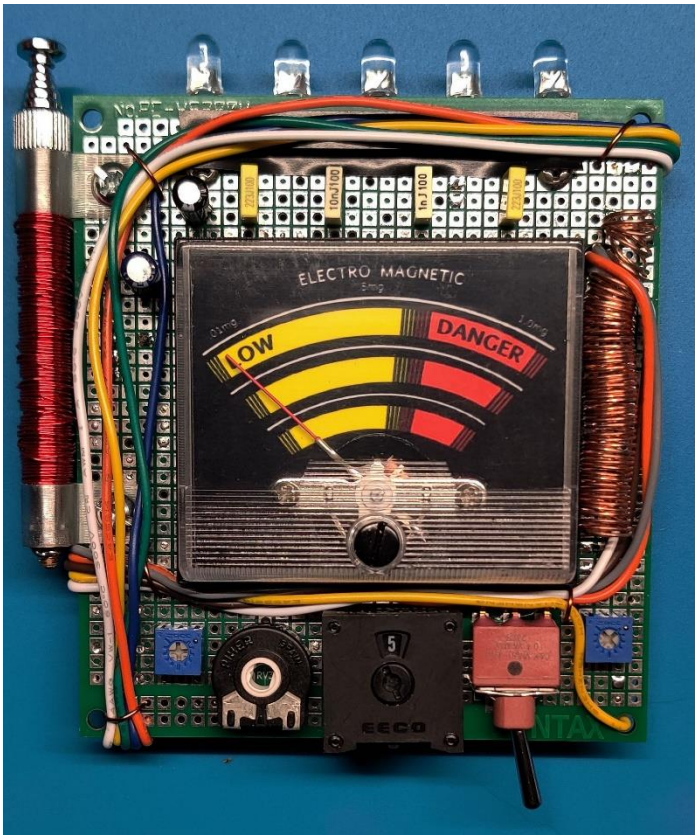
EMF Meter Build (r2)

Contents

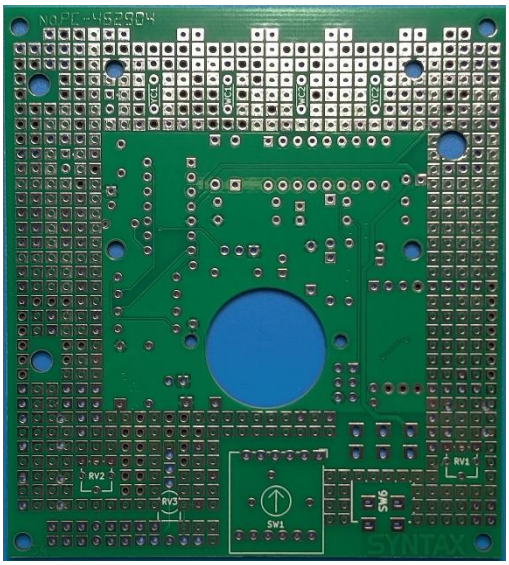
Description



Assembled EMF Meter (6v Battery)

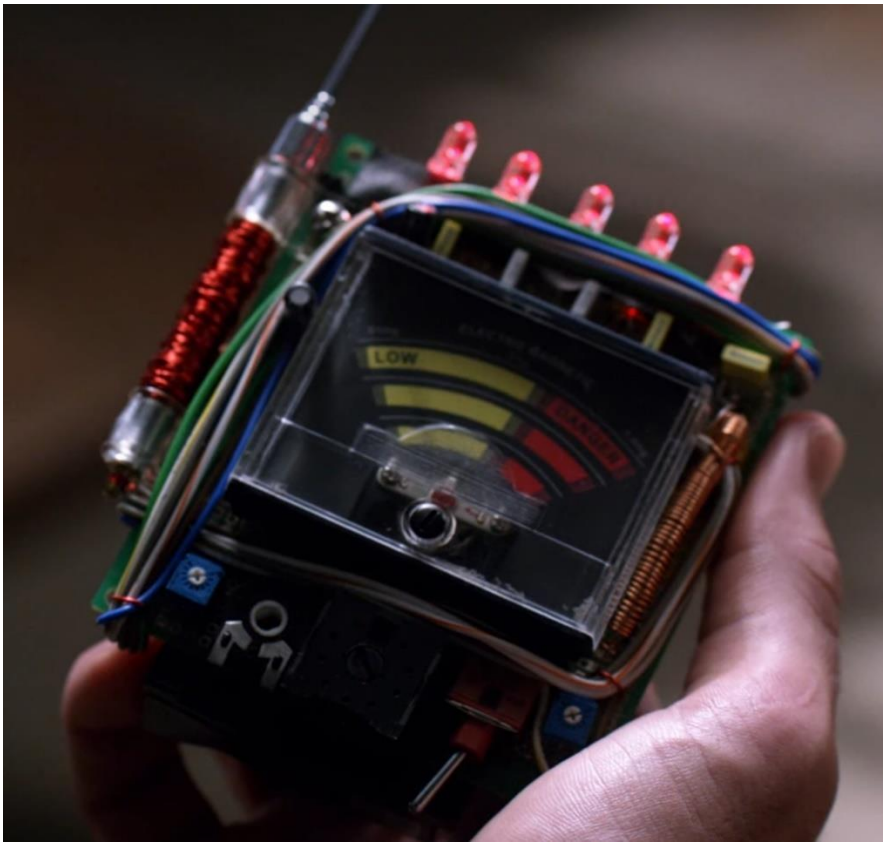
Printed Circuit Board

Front



Back

This document describes the assembly of the EMF Meter which was made to be a replica of the one used in the Supernatural TV series. I based my initial version on Sam's EMF Meter from S4 E13 (and seen in a few other seasons).



SAM's EMF Meter with 5 Capacitors (S4 E13 25:10)

This is a functional EMF meter that can detect both Electric and Magnetic fields. It can also be built as a simple prop by not populating the analog components. The meter was designed to replicate a variety of the meter configurations used in the TV series. Great prop or cosplay item.

The meter can be powered by 6v or 9v batteries:

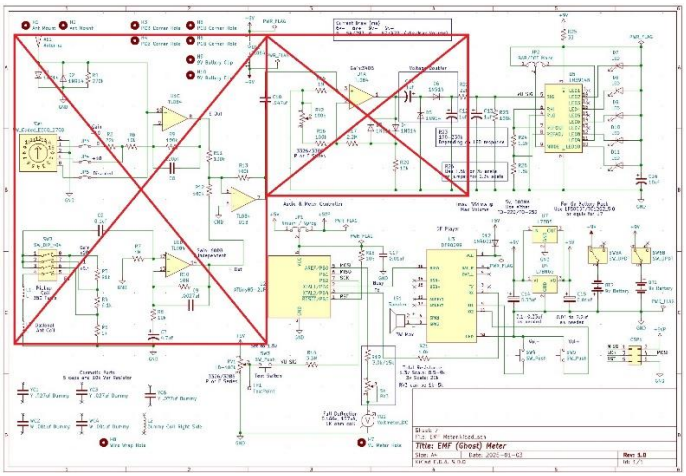
- Using two 9-volt batteries to provide +/- 9 volts
- Using 4 AA batteries to provide 6v with a 6v negative voltage buck converter

The board was designed to support a number of different part selections for the components:

- Optional 5th yellow capacitor
- Supports 3326, 3362, or 3386 F and P series blue potentiometers
- Supports PT10 or PT15 black potentiometer
- Uses a functional EECO switch to select gain for the E-Field detector and can support a number of different EECO switches. Specifically, EECO 2700 series -02, -19, -31, -33, -41, -44 will work as is and others can be adapted to work. The PCB footprint supports 6 and 12 pin switches.
- Flexible wiring options.

An ATTiny85 is used to control the DF Player sound board. Programming for the ATTiny85 can be accomplished using an In-Circuit Serial Programming (ICSP) port to program the mounted part on the board. There is a jumper option (JP5) to select to use the ICSP port for programming power if you want to program the part before batteries are connected. I also have available a soft touch programming cable for programming this part. There are many YouTube videos on Arduino programming options.

If you only want to make the prop version (No real EMF detection) then do not populate IC1 (TL084) and associated components and switches. See crossed out sections to remove.



Board Details

- Dimensions: 86 x 95 mm
- Parts Supported:
  - RV1/2: 3326,3362,3386 Bourns blue F or P series potentiometer
  - RV3: PT15 or PT10 series black potentiometer
  - EECO Switch: 27xx02/19/31/33/41/44 for E-Field gain
  - Piano DIP or 4 position rotary switch for H-Field gain
  - 5-volt regulator. A 5v 500 ma regulator is needed, the PCB layout supports TO-252-3 and DPAK packages. If using a 6v supply a Low Drop Out (LDO) regulator should be used. The LF50 and TC1262-5.0 are both good options. The TC1262 can only be used for the 6v battery supply.
  - Option for 5th yellow top capacitor (Cosmetic use only)
- Programming using an ICSP port.
- LED can display in BAR or DOT mode.
- Detects E-Field and H-Field signals (Electric and Magnetic Fields) with 3 gain settings for each (-10, 0, +10). No guaranteed accuracy of the meter.
  - Telescopic antenna can be used to detect E-Field (Electric) signals.
  - The wire wrap coil around antenna can be used to detect H-Field (Magnetic) signals.
  - An additional inductive coil is used to detect H-Fields on a different axis.
- 6 or 9 volt operation
- Assembly requires a small number of surface mounted components.

Parts List

See the EMF Board BOM for a detailed list of parts and part suppliers.

What's new for Rev 2?

- All modifications for r1 now included in this revised PCB layout
- Remembers volume level between power cycles
- Can use a 4-position rotary switch in place of the piano dip switch for H-field gain
- Now supports 6v or 9v battery operation with either a SPDT or DPDT switch
- Updated AA battery pack holder with cut outs for -6v buck converter and speaker
- Updated VU Meter base. Thicker base that can now be screwed in to secure
- Cleaned up front PCB layout to fill in pad gaps

Assembly Guide

Caution: Electrostatic discharge (ESD) is a sudden and momentary flow of electric current between two differently-charged objects when brought close together or when the dielectric between them breaks down, often creating a visible spark associated with the static electricity between the objects. [1]

This type of shock can cause damage to ESD sensitive parts such as those used in this build especially U1,2,3,5. Proper ESD protection and soldering equipment should be used to prevent damage to parts during assembly and implementation into your project.

Assembly Planning

This assembly uses a mix of through hole and surface mount parts. A medium to fine tip soldering iron is useful along with 0.034" and smaller flux core solder for surface mounted parts. Extra flux can be helpful to have on hand. See the references section for a YouTube video link on assembling this board.

Selecting a power source

This meter can use 9v or AA batteries for power so what's the difference? The meter will function the same with either power source but consider these points for determining your selection.

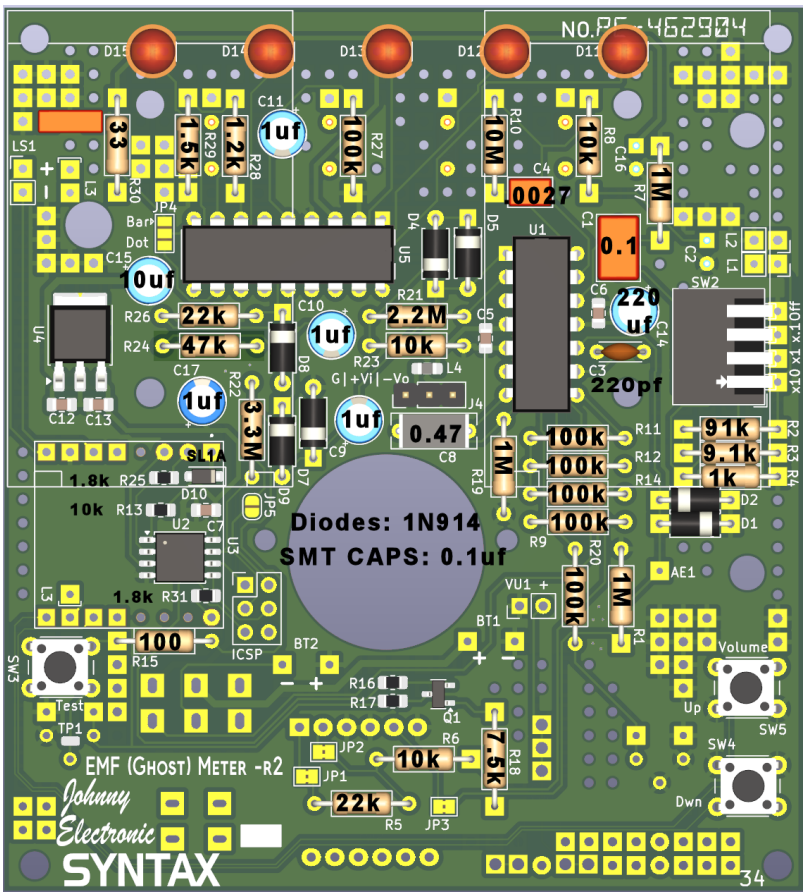
9V: This is the easiest solution since a -6v buck converter is not needed. A larger DPDT switch is used for SW6 which is a bit more expensive but that cost is a wash since a buck converter, inductor (L4) and capacitor (C14) are not needed. The life of the 9V battery is not as long so a Lithium cell is suggested for BT1. BT2 is very low current so a standard cell can be used. There is also an option for the TL084 U1-D to change the H-Field detection response. This provides a broader range of detection and would otherwise also detect the buck converter if installed.

6V: This option is only slightly more difficult because it requires a -6v power source and added filtering (Buck converter, L4,C14) to prevent triggering the E-Field detection circuit. The AA batteries hold up pretty well with normal use but lithium cells can also be used. Only needs the smaller SPDT switch and more closely matches the TV series versions. You cannot modify U1-D as it would then detect the buck converter oscillation frequency.

PCB Assembly

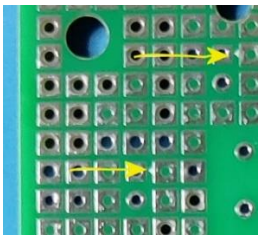
- PCB assembly can be completed in any order except with U3. See assembly notes below.
- You will want a good set of wire cutters that can cut flush to the PCB surface. The area under the meter should be as flat and level as possible. Also, any components soldered under L2 should not have leads through to the top surface as they may be shorted by the coil. Cut the leads as short as possible before soldering. Hot glue can be used to insulate any connection shorts after assembly.
- The majority of components will be installed on the back of the PCB. The board was designed to hide most of the components under the VU Meter. You can use this placement guide to help in assembly.

[1] Definition provided by From Wikipedia, the free encyclopedia. For more information on ESD see https://en.wikipedia.org/wiki/Electrostatic_discharge

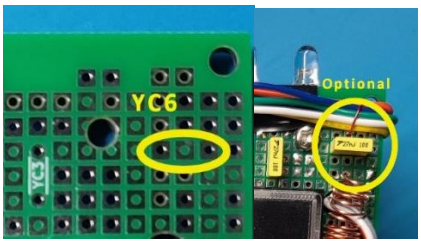


PCB Component Placement Guide

- My recommendation is to complete the back of the board first starting with mounting all the surface mount parts.
    - Surface mounted parts include: U2, D10, R13,25,31, C7 (All under U3). C5, 6 (U1 filters). U4, C12,13 (Regulator). R16,17, Do not mount Q1-See modifications section for mounting options (Meter driver).
    - If using a buck converter then install L4 (-6v Buck Converter Filter if using 6v battery supply)
- I'd then suggest to mount all the remaining IC's starting with U1 and U5.
    - NOTE: U2, D10, R13,25,31, C7 must be installed before U3. Once installed then U3 can be placed on top of those parts.
    - U2 can be programmed any time after being installed. Use JP5 for programming without a battery connection. Programming code is available in Github. The link is in the references section at the end of this document.
- You can apply solder to jumper JP4 (Bar/Dot mode) now or later but do not forget to do so.
- Install the resistors, capacitors, and diodes next.
    - If using a buck converter then C14 will be used otherwise it is a no load.
    - NOTE: All capacitors should be mounted as flat as possible against the PCB so there will be clearance for the battery pack latter in the assembly. **Specifically, C15** should be flat to allow clearance for the speaker. Standoffs with a minimum length of 10-12mm are suggested. See assembly images at the end of this document.
    - NOTE: C2, C16, YCx, WCx will all be installed on the top of the PCB. C2 (Blue Sleeve) and C16 (Black Sleeve) mounting locations are shown on the bottom of the board. Both of these are polarized parts so look for the small "+" on top of the board for proper placement. You also have the option of installing a 5th yellow capacitor and it's mounting location is shown on the bottom of the PCB but it mounts on the top.



Cap Polarity Marks



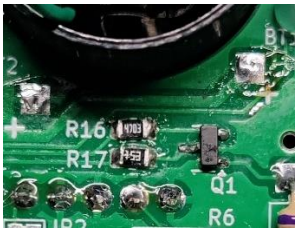
YC6 – 5th Yellow Capacitor

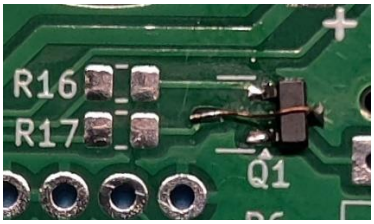
- Next install SW2 to SW5
    - SW2 now has the option of using a 4-position piano or rotary switch.
- The LEDs can be installed either on the bottom or the top. Looking at images from the TV series they have done it both ways so it's your choice. Mounting on the bottom lets you use some hot glue to better secure the LEDs to the PCB.
- This completes the bottom assembly

- Continue to the top of the PCB and mount the power switch SW6 and EECO switch SW1
    - If using 9v power then install a DPDT switch for SW6 otherwise use a SPDT.
- If you did not mount the capacitors C2, C16, YCx, WCx then mount them now.
- Mount the potentiometers RV1-3
- This completes the PCB assembly. Continue to the mounting of the antenna and coils for the next step for this assembly.

Modifications

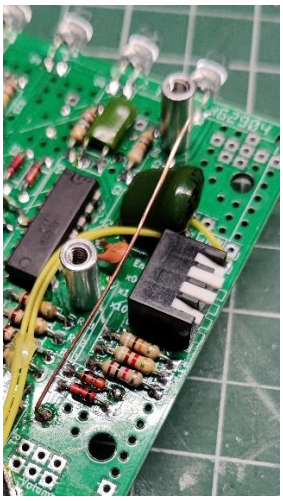
1. Pad for Q1 has an incorrect layout. Mount Q1 upside down to correct. You can also rotate Q1 180°, solder the base and emitter pins and add a wire to connect the collector.



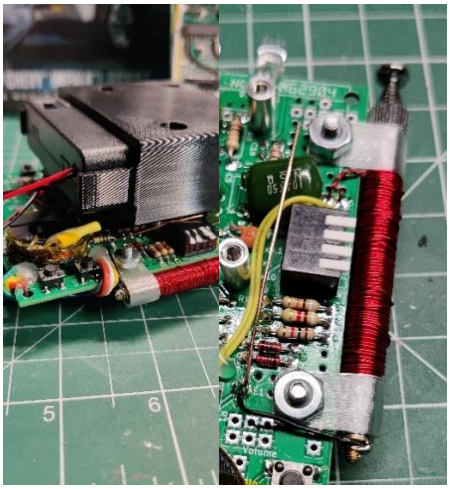


Antenna, Coil Assembly and Mounting

- Main Antenna. An antenna is used to detect electric (E) fields. The telescopic antenna can be used for added sensitivity or you can use a short piece of wire about 1 ½ - 2" (You can use the same 22 AWG solid copper wire used for coil L3). For the copper wire antenna make a right-angle bend at one end and solder that short section to pad AE1. To connect the telescopic antenna, use a short piece of solid wire. Strip one end and wrap around the base of the antenna. If possible, solder the wire to secure it. Connect the other end to pad AE1. Both antennas can also be connected together.



Short Wire Antenna



Telescopic and Short Wire Connected

- There are three coils that can be mounted with two of them functional and one cosmetic only.
- Coil L3 is mounted to the right side of the meter and is cosmetic only. The mounting holes are marked on the bottom of the meter. The coil was made using 22 ga. plain copper wire around a wire wrap tool (I used a #2 Craftsman Philips screwdriver shaft to get a 6.4mm diameter coil). The coil should be the length of the meter or about 1 ¾".

L3 Pad Locations

L3 Coil Wrap

There are two upper pads and one lower pad for mounting L3 so you can stretch the coil or make it longer if desired. Note that the lower pad for L3 is under U3 thus this pad will need to be soldered from the top. Make sure the wire does not short against any part of U3.

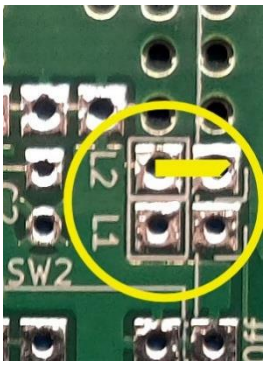
Note: If you have any wires that poke though and touch the coil body you can add a small bit of hot glue to the coil bottom to both secure it and isolate it from shorting out parts.

- Coil L1 and L2
  - Coil L1 is a 350 turn of 36 AWG enameled wire that is hot glued to the bottom of the PCB at either the lower left or right side. See the available video of making the coil and 3D files are available for printing the core.
  - As a substitute for handmaking the coil a 10 – 33mH wire wound inductor can be used instead.

25mm Coil Mounted

10-33mH Inductors

- Coil L2 is the coil around the antenna and it can be included in the circuit to pick up magnetic fields. I used 26 AWG red enameled wire to wrap around the antenna. Before wrapping the antenna with wire, you will want to attach the p-clips with 6-32 3/8" screws with nuts. Align the screws/p-clips with the PCB mounting holes but do not mount it to the board. Once you have the p-clips aligned tighten the nuts so the clips do not move. You can now start wrapping the enameled wire between the two p-clips. If you will be using the coil in the circuit you will need to start and end the coil toward the top of the antenna so it can be attached to the circuit board.
- Make the first layer wrap tight and uniform around the antenna. On the second pass feel free to add multiple layers and give it a non-uniform look much like a free-handed wire wrap.
    - Mount the antenna/coil using P-Clips. 3D files are also available for printing these.



L2 Pad Locations

NOTE: If you do not use the coil in the circuit then a small jumper wire will be needed to jump the L2 connection.

Completed L2 Coil Wrap

- Coil sensitivity is based on form size and number of windings. Increasing windings will make the magnetic field detection more sensitive. A few coil forms are available (20mm and 25mm)

Mounting Meter

- Review the available video for options for making the meter. I've provided a 3D print file for the meter base I used and it will also align with the battery pack mounting screws.
- Before mounting the meter use four 4-40 or M3 x 6mm screws to attached four 10-12mm standoffs. The screws will go through the top of the PCB and the standoffs will be mounted to the bottom.
- If you used a MF-110A meter as your meter element then you can use two of the small screws form the MF-110 to mount the meter base. Otherwise use a small dot of hot glue in each corner of the meter and mount the meter to the front of the PCB placing it through the hole provided. Use more hot glue on the back of the PCB around the area where the meter goes through the PCB. This will add additional hold for the meter.
- Connect the meter wires to VU1 following the proper polarity.

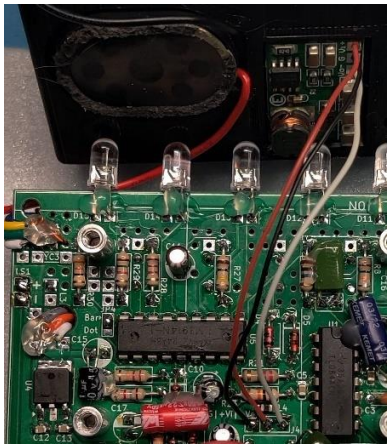
VU Meter Screw Mounted

Mounting Speaker and Battery Holders

- Place a protective pad over the VU meter bezel to prevent scratches for this next step.
- Using hot glue attach the speaker to the bottom of the battery/pack holder.
    - If you are using the 3D printed AA battery holder (6v) a cut out is provided on the bottom for a 20x30mm speaker. There is a notch to one side for the speaker wires.
    - For 9v you will hot glue the speaker to the bottom of the left holder (closest to the LS1 pads).
    - Make sure you have enough speaker wire length to attach to the PCB once the battery holder is attached.
- For 6v connect the 4-AA battery pack to BT1. If using the additional EMF circuit (ie: TL084) then connect a buck converter such as a DD0315NA configured for ***-6v.*** The PCB has mounting pads for the +Vi, -Vo and G wires. You can use hot glue to mount the buck converter on the underside of the battery holder which has a cutout provided.
- For 9v connect two battery clips to BT1 and BT2 following the correct polarity, Red +, Black -.
- Use four 4-40 or M3 x 6mm screws to mount the battery/pack holder(s) to the standoffs. I've provided some 3D files for 9-volt and 4-AA battery pack holders so they can be mounted to this board.
- Connect the speaker to the LS1 pads following the marked polarity.

Buck Converter Front

Buck Converter Back

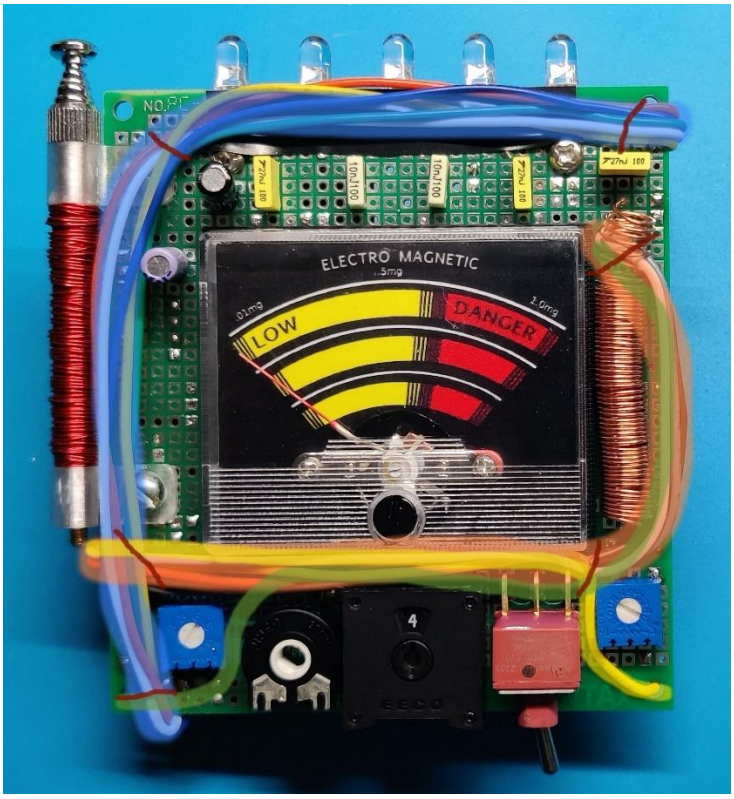


Speaker and Buck Converter Connection

Adding Cosmetic Wires

- This board was designed to support various wiring options. The wires can be either hot glued to the back of the PCB or in some cases soldered to available pads.
- From various references wire gauge is either 28 AWG or 24 AWG. My preference was 24 AWG based on the various images from the TV series. I've noted some of the wire combinations seen in the series in the table below.
- Available wire clamp locations are also shown in the image below (Marked in RED). 22 AWG wire seems to be what was used in the show versions.
- Feel free to pick your own wire colors and routes.

Series/Episode Shown	Upper Harness	Lower Harness	Option 1A	Option 1B
General Prop Analysis	2-3 Grn, Blu, Wht/Brn, Wht/Org	Wht/Brn, Grn		
Rainbow Prop Analysis	Wht, Org, Yell, Blu, Grn, Red			
Westaby Rainbow (28awg)	Grn, Blu, Purp, Gry, Wht	Brn, Red, Org, Yell, Blk		Brn, Yell, Blk
S2 E18 8:54 - Dean's, 4 caps	Brn, Wht, Blu,Grn, Gry?, Yell	Brn, Grn, Yell	Yell	
S11 E23 14:30 - Dean's 4 caps, no blue pots	Red, Org, Blu, Yell, Wht, Grn	Wht, Purp, ??? Different routing		
S3 E14 17:08 - Sam's 4 cap	Wht, Blu, Yell, Grn,	Yell, Grn, Blu, Brn?	Yell, Brn?	
S4 E13 25:10 - Sams 5 cap	Grn, Blu, Wht/Org, Wht/Yell, Gry?	Wht/Org, Gry,	Wht/Yell	
S7 E4 3:40 - Sam's 5 cap	Grn, Blu, Wht/Org, Wht/Yell, 5th Clr	Wht/Org, Wht/Yell, Gry,	Wht/Yell	
S11 E16 8:08 - Sam's 5 cap, no blue pots	2-3 Grn, Blu, Wht/Org, Wht/Yell,	Wht/Org, Wht/Yell, Gry,	Wht/Yell	
My Selection	Grn, Blu, Yell, Org, Wht	Brn, Wht, Gry Org	Yell	



Various Wire Routes and Clamp locations in RED

Board Options/Configuration

This section should be reviewed for those that are assembling the board themselves or purchased a pre-assembled version.

ICSP Power

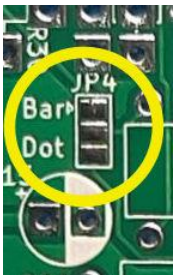
Sorting JP5 will connect U2 (ATTiny85) to the ICSP power connection for programming. This is useful when the battery packs are not connected. This jumper should be removed when using the battery packs for programming.

Jumper Options

JP5	ICSP 5v

Bar/Dot LED Display Mode

Using the table below determine which display method will be used for the LEDS. Selecting JP4, 1 & 2 will provide a BAR display mode. Using JP4, 2 & 3 will provide a DOT display mode and also helps conserve battery power.



Jumper Options

JP4	1-2 – BAR Mode 2-3 – DOT Mode

Selecting display mode option, ► marks pin 1

Making a solder bridge

You can make your connection by selecting which half of the bridge to connect but make sure you do not connect both parts. The center pad will connect to either the upper or lower pad, ie pad 1-2 or 2-3. Once you determine the pads to connect add some solder to each pad then continue to heat both pads adding more solder if needed until the two pads are connected. The images below show some examples:

Step 1
Example bridging pad 1 & 2

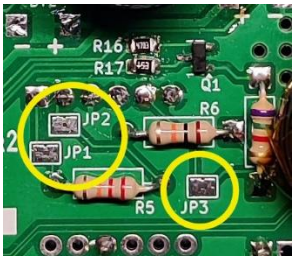
Step 2
Completed Bridge

Bad Solder Bridge
All pads connected

Switch Settings

SW1
EECO Series 2700 Switch
The rotary EECO switch is used to control the gain and operation of the E field circuit. The operation of the switch will depend on the type of switch used. The tables below show a number of switch types and their associated setting. This allows adjustment of the E-fields sensitivity or the ability to disable the E-Field and just check for H-fields.

Most of the pre-assembled boards will have a 271131M installed and use the last chart below. If you need to use another type of switch or want to rewire an existing one you can use JP1-3. These bridged jumpers can be cut in the center so that the connection is broken. Wires can then be added to attach to different terminals.



27xx -02, Table B02 (Terms 1,2,8)
BCH 1-pole, 10 position
27xx -33/34, Table B07 (Terms 1,4,8)
BCH 1-pole, 16 position (Orange and Blue Section)

Dial	1	2	4	8	Function	
Truth Table					B02	B07
0					Gain 0	Gain -10
1	●				Gain -10	Gain 0
2		●			Gain +10	Gain -10
3	●	●			Gain +10	Gain 0
4			●		Gain 0	Gain +10
5	●		●		Gain -10	Gain +10
6		●	●		Gain +10	Gain +10
7	●	●	●		Gain +10	Gain +10
8				●	Disabled	Disabled
9	●			●	Disabled	Disabled
10		●		●		Disabled
11	●	●		●		Disabled
12			●	●		Disabled
13	●		●	●		Disabled
14		●	●	●		Disabled
15	●	●	●	●		Disabled

-19, Table C13 (Terms 1,2,8)
BCH 1-pole, 10 position

Dial	1	2	4	8	Function	
Truth Table					C13	
0	●			●	Disabled	
1				●	Disabled	
2	●	●	●		Gain +10	
3		●	●		Gain +10	
4	●		●		Gain 0	
5			●		Gain -10	
6	●	●			Gain +10	
7		●			Gain +10	
8	●				Gain 0	
9					Gain -10	

27xx -31/41, Table C16 (Terms 1,4,8)
BCH 1-pole, 16 position

Dial	1	2	4	8	Function	
Truth Table					C16	

0	●	●	●	●	Disabled	
1		●	●	●	Disabled	
2	●		●	●	Disabled	
3			●	●	Disabled	
4	●	●		●	Disabled	
5		●		●	Disabled	
6	●			●	Disabled	
7				●	Disabled	
8	●	●	●		Gain +10	
9		●	●		Gain +10	
10	●		●		Gain +10	
11			●		Gain +10	
12	●	●			Gain 0	
13		●			Gain -10	
14	●				Gain 0	
15					Gain -10	

SW2

Piano DIP/Rotary Switch

The switch is used to control the gain and operation of the H-field circuit. The table below shows the setting for each switch position.

Note when using the Piano switch:

For normal operation one of the switch positions (1-4) must always be enabled.

Piano	Rotary	Gain Setting
1	**4**	**Gain x10** – Provides a gain setting of 10
2	**3**	**Gain x1** – Provides a gain setting of 1
3	**2**	**Gain x0.1** – Provides a gain setting of 0.1
4	**1**	**Disable** – Disables checking for H-fields

Sound Files (MP3)

The sound files are stored in a folder named /mp3 on the SD card. Six files are available but only five are used in the program for the EMF meter. This table lists the files, functionality, and associated code define. The sound files are available in Github. The link is in the references section at the end of this document.

If you wish to change the files, they must be in the mp3 folder and start with the same 4-digit numbers.
Ie: 0001_emf start.mp3 could change to 0001 my custom sound.mp3
Keeping the file duration to the same length is suggested but not required.

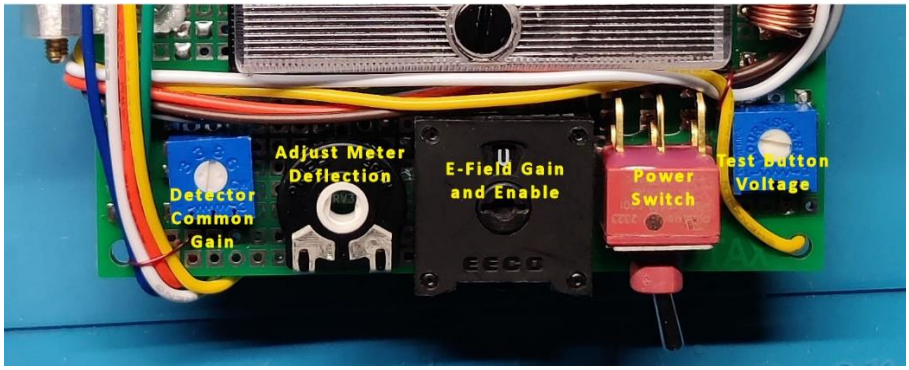
File Name	Define Name	Function
0001_emf start.mp3	EMF_TONE_START	Initial startup when a signal is detected or test button pressed, 0.238s
0002_emf low short.mp3	EMF_TONE_LOW	Used for mid-point signals that are neither high or low, 0.238s
0003_emf steady short.mp3	EMF_TONE_STEADY	Short high tone - Not used

0004_emf steady long.mp3	EMF_TONE_STEADYL	Long high tone when signal reaches maximum, 1.435s
0005_emf steady end.mp3	EMF_TONE_END	Signal going back down to off, 0.282s
0006_emf power up.mp3	EMF_POWER_UP	Used for initial setup/power on (5 LED)
0007_emf power up.mp3	EMF_CHARGE_UP	Used for initial setup/power on (10 LED)

EMF Meter Adjustments and Power Up

1. Before powering up the meter check for any shorts by doing an ohm measurement across the +/- battery connector(s).
2. Adjust all three potentiometers to their mid points.
3. Enable the maximum gain switch of SW2 (x10).
4. Set SW1 (EECO Switch) to one of the enabled maximum gain settings.
5. Insert the SD card with audio files into the DFPlayer slot.
6. Connect or install batteries and flip the power switch(s) on.
7. With in a second you should see the meter briefly deflect and a sound from the speaker.
8. Press SW3 (Test Button) and you should see the LEDS and VU Meter deflect and some sound effects. While pressing SW3 adjust RV1 until all 5 LEDS are on.
9. Again, press and hold SW3 and adjust RV3 for full meter deflection.
10. RV2 (Detector common gain) see meter adjustments below.
11. To test the E-field circuit touch the antenna with your finger, you may need to extend the telescopic antenna some. The meter should react.
12. To test the H-field circuit move the meter toward a wall transformer or electrical appliance.
13. Removing the AA battery pack from the holder is easiest by firmly pulling battery pack straight out from the battery holder. To insert slide the battery pack in so the power switch is facing out and the clasps are at the edges of the pack. Slide in until it locks into place.

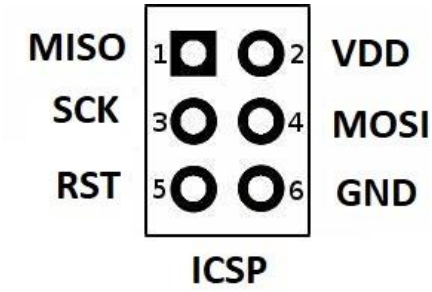
    For 9V battery just use your figure to push the battery out of the back. To insert just slide it back in.



Meter Adjustments

RV1	Test button voltage – CCW increases level
RV2	Detector Common Gain – CW decreases gain. Reduce gain if the H/E-Field is too sensitive or increase for more sensitivity.
RV3	Meter Deflection – CW increases deflection

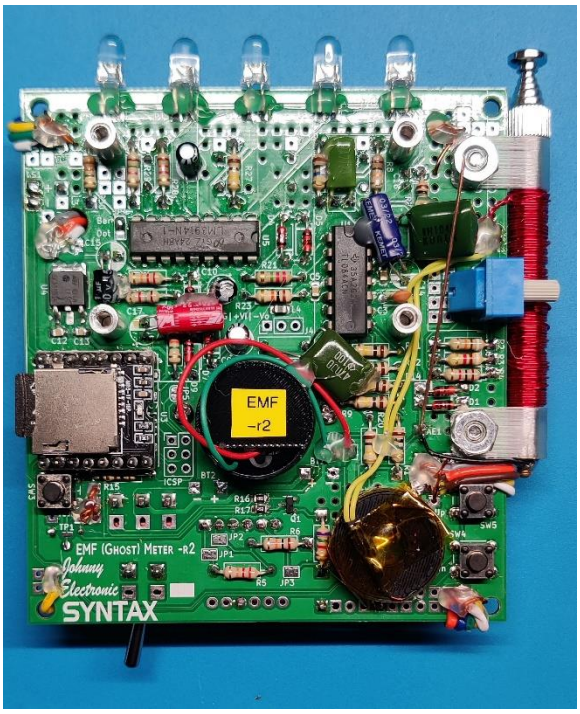
ICSP Header



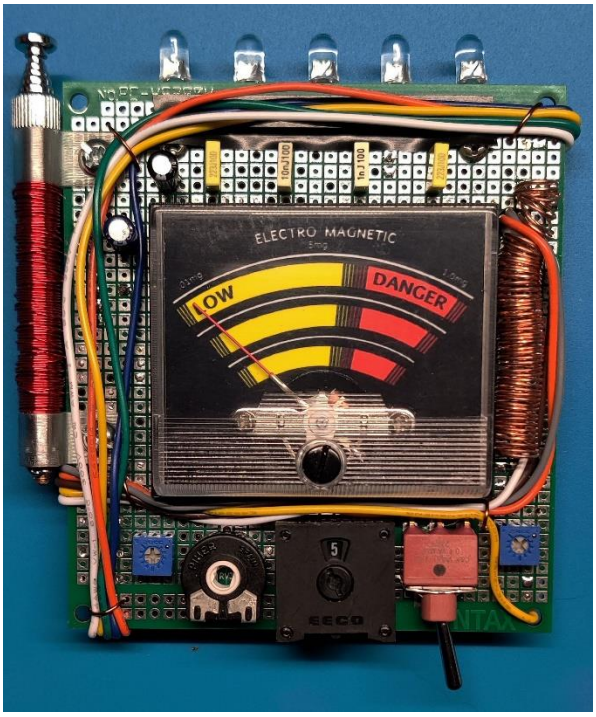
An In Circuit Serial Programming (ICSP) port is provided for reprograming the ATTiny part.The ICSP connector follows this layout which is the same used for Arduino boards. There are a number of YouTube videos showing various methods for programming including using UNO or Nano boards as an AVR In System Programmer using the ArduinoISP sketch.

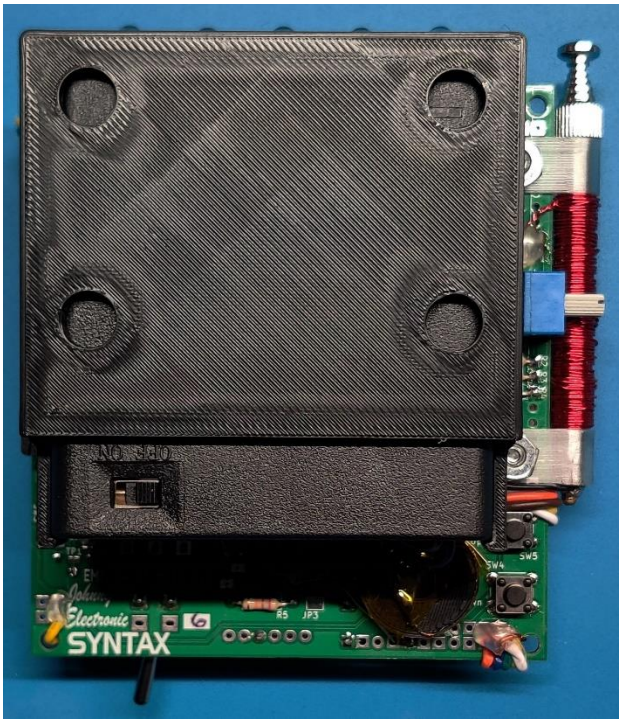
I also offer a soft touch programming cable to eliminate the ICSP header and connect directly to the board.

Assembly Images

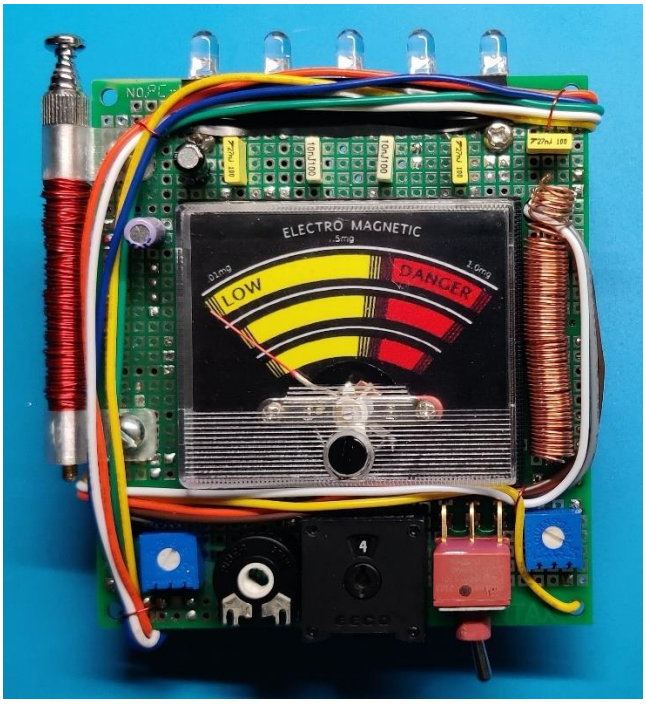


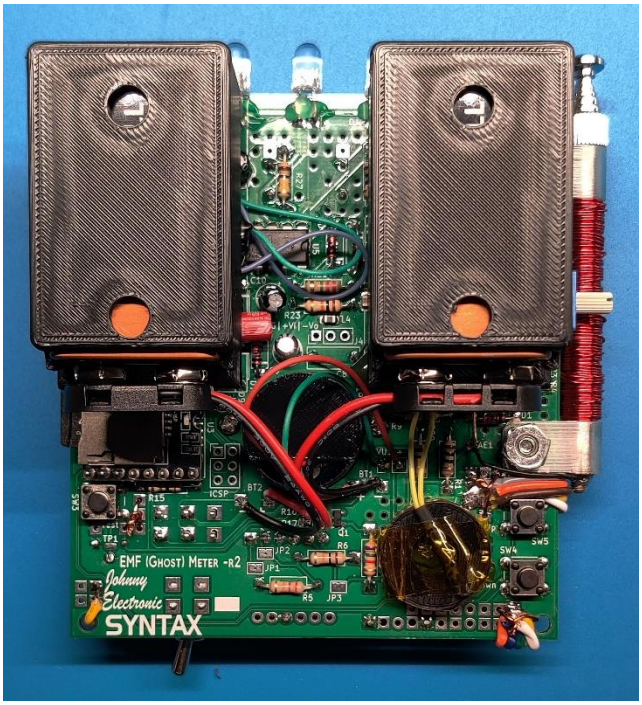
Partial Assembly Images





EMF Meter with 4 Capacitors, Smaller 3326 Blue Potentiometers, 6v 4-AA Battery Pack





EMF Meter with 5 Capacitors, Larger 3386 Blue Potentiometers, 9v Battery Pack

References

- **Github: Development board documentation, schematics, and related files.**
  - **https://github.com/JohnnyElectronic/EMF_Meters/**
- **YouTube: Board assembly and project videos that are related to this project.**
  - **https://www.youtube.com/@Johnny_Electronic**

Revisions

R1.1	First board release, First document release
R1.2	Added EMF User Guide section
R1.3	Added PCB modification descriptions to align with the 1.1 version of the schematic.
R1.4	Corrected RV2 Detector Common Gain to CW for decreased gain. Added new images for antenna connection and modified buck converter.
R2.0	Updated for new PCB release r2

Disclaimer

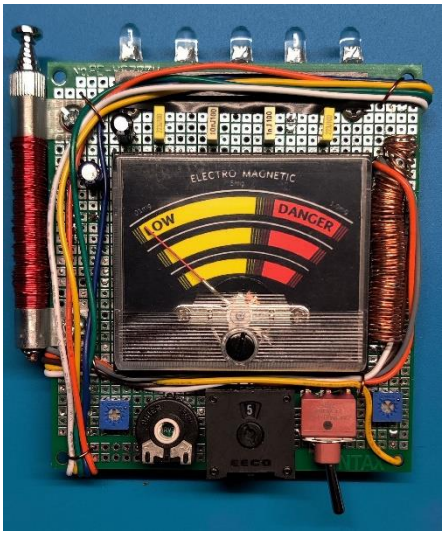
This information is provided “as-is” with no representation or warranty of any kind whether express or implied. However, I’ve tried to make this document (as well as the supporting videos) as useful and accurate as possible. If you find something that is incorrect or confusing, please let me know as I would like to make the correction so others will not have the same issue.

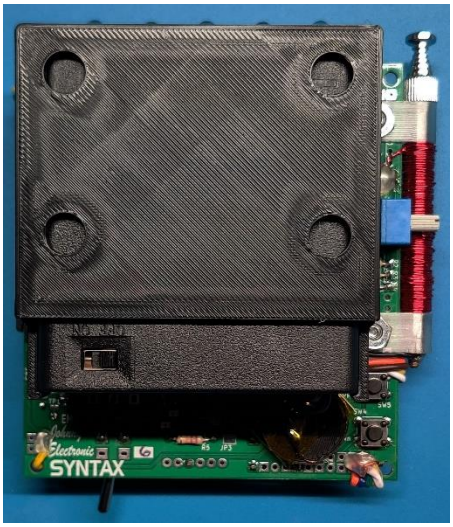
This meter is for entertainment purposes only and there is no representation as to the accuracy of the meter readings.

Feel free to email me any time for issues you may have with this build.
johnnyelectronic1@gmail.com

Legal note

EMF Meter User Guide





This EMF Meter was made to be a replica of the one used in the Supernatural TV series. I based my initial version on Sam's EMF Meter from S4 E13 (and seen in a few other seasons).

This is a functional EMF meter that can detect both Electric and Magnetic fields. The meter was designed to be able to replicate a variety of the meter configurations used in the TV series. It's a great prop or cosplay item.

Meter Details (Pre-Assembled Boards)

Due to the availability of certain parts, the pre-assembled meters may vary. The listing for any pre-assembled meter will show the specific items used for that build.

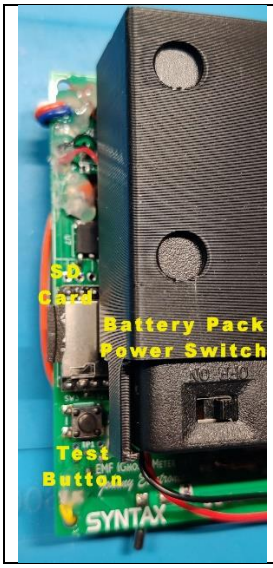
- Dimensions: 86 x 95 mm
- Powered by a 6v AA power pack, 4 AA batteries
- Configured for 4 or 5 top capacitors. (If you ordered a 4-cap version the 5th will be included separately)
    - An effort will be made to have the correct capacitor value of 22n for yellow and 10n for white.
- 5 LED BAR display mode
- ATTiny85 to control the MP3 sound effects
    - Re-programming possible using an ICSP port.
- SD card with sound files (sound files can be changed if needed)
- Detects E-Field and H-Field signals (Electric and Magnetic Fields) with 3 gain settings for each (-10, 0, +10). No guaranteed accuracy of the meter.
    - Functional EECO rotary switch for E-Field gain (will vary based on availability)
    - Rotary 4-position switch for H-Field gain
- 3326/3362 Series blue potentiometers (Smaller version)
- PT15 black potentiometer
- Antenna will vary based on availability. If the ATT 5100 6mm is available it will be used.

Meter Operation

If you purchased an assembled unit then all adjustments have already been made and a programmed SD card has been installed. Otherwise review the EMF Meter Adjustments and Power Up section in the build guide.

- Install the batteries in the battery pack if you have not already done so.
    - To remove the battery pack just pull it straight out from the holder (AA) or use your finger to push the battery out of the holder (9v).
    - To insert slide the battery pack in so the power switch is facing out and the clasps are at the edges of the pack. Slide in until it locks into place (AA). For 9v just slide the cell back in to the holder.
- Check that the SD card is inserted properly.
- For AA batteries check that the power switch is in the ON position.
- Flip the front power switch to the ON position, left.
- You should see the meter deflect briefly and the EMF detected sound played.
- Use the Test button to force an EMF event otherwise you can move around and see if any Electric or Magnetic fields can be detected.
- There is a VOLUME UP and DOWN switch to control the meter sound. It is easiest to adjust the sound volume while pressing the test switch. The sound volume level will be saved every 5 seconds.
- Hold the meter on the right side so you do not block E-field reception. For greater E-field detection extend the telescopic antenna.
- Review the remaining sections for gain adjustments of the meter.
- This meter was designed as a novelty item and no calibration of field strengths was performed.

Meter Settings

	**Left Back Side of Meter** Battery Pack Power – Main power switch SD Card – Contains sound files for meter operation. If you do not hear any sound check that the SD card is inserted properly. Press in to release and insert. You should hear a click when inserting. Test Button – This button can be pressed to simulate an EMF event.

Right Back Side of Meter

Piano DIP/Rotary Switch (SW2) – Used to control the H-Field gain as well as enable and disable of H-Field detection.

Piano Switch: The lever DIP switch is used to control the gain and operation of the H field circuit. The table below shows the setting for each switch position.
Rotary Switch: Turn the selection dial to the desired setting.

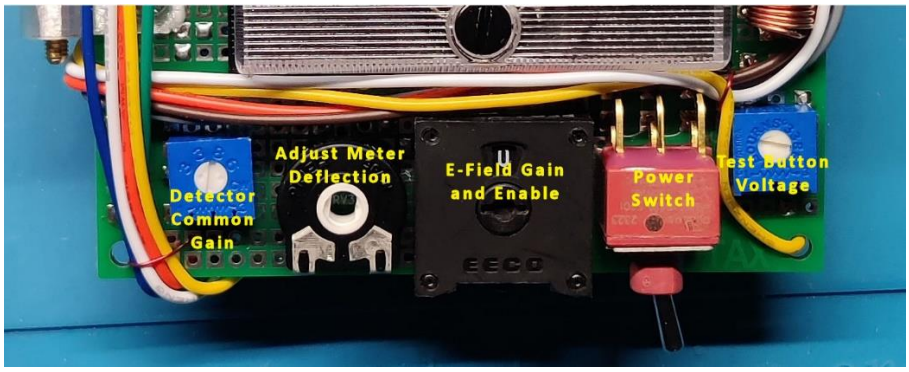
Piano	Rotary	Gain Setting
1	4	**Gain x10:** Provides a gain setting of 10
2	3	**Gain x1:** Provides a gain setting of 1
3	2	**Gain x0.1:** Provides a gain setting of 0.1
4	1	**Disable:** Disables the checking for H-fields.

For normal operation with the piano switch there must always be one selection enabled.

Volume Control

Up/Down – Used to control the volume level of the meter sound

Meter Adjustments



RV1	Test button voltage – CCW increases level
RV2	Detector Common Gain – CW decreases gain. Reduce gain if the H/E-Field is too sensitive or increase for more sensitivity.
RV3	Meter Deflection – CW increases deflection

EECO Switch (SW1) – E-Field Gain and Enable/Disable

The EECO switch installed in this meter is a 271131M and the table below will show the various E-Field gain settings based on the switch position.

Dial	Function
0-7	Disabled
8-11	Gain +10
12	Gain 0
13	Gain -10
14	Gain 0
15	Gain -10

SD Card (Sound Files, MP3)

The sound files are stored in a folder named /mp3 on the SD card. Six files are available but only five are used in the program for the EMF meter. This table lists the files, functionality, and associated code define. The sound files are available in Github. The link is in the references section at the end of this document.

If you wish to change the files, they must be in the mp3 folder and start with the same 4-digit number.
Ie: 0001_emf start.mp3 could change to 0001 my custom sound.mp3
Keeping the file duration to the same length is suggested but not required.

File Name	Function/Duration
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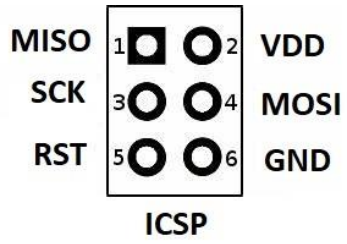
0007_emf power up.mp3	Used for initial setup/power on (10 LED)

Reprogramming the ATTiny85

ICSP Header



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