

# Model T











## Ford Arduino Coil Tester (FACT)

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**DRAFT 6/8/2021**

## Ordering Coil Hardware

(Also see [reference 3.](#)) (Prices from summer 2019, use as a reference.)

Image	Description	Price/Quantity	Purpose
	Brass Hex Nut, 10-32 Thread Size, 3/8" nut <a href="https://www.mcmaster.com/92671A195">https://www.mcmaster.com/92671A195</a>	\$8.72/100	Adjustment nut
	Brass Hex Nut, 10-32 Thread Size, 5/16" nut <a href="https://www.mcmaster.com/95130A160">https://www.mcmaster.com/95130A160</a>	\$9.78/100	Lock nut for above
	Machine Tool Plug Chamfer Tap for Through-Hole Threading, 12-32 Thread Size <a href="https://www.mcmaster.com/25705A57">https://www.mcmaster.com/25705A57</a>	\$29.80/each	Use with nuts above for 4 nuts on mounting studs
	#12-32 Jam Nut 0.312" (7.92mm) 5/16" Stainless Steel, Gold Plating <a href="https://www.mcmaster.com/1-328690-2-ND">1-328690-2-ND</a>	\$2,940.00/2000	For 4 nuts on mounting studs <small>*Note: These are rare to find</small>
	5007N Nut Set For Coils, Brass <a href="https://www.chaffinsgarage.com/catalog.pdf">https://www.chaffinsgarage.com/catalog.pdf</a>	\$1.50/one set	
	5 mm flat washer .043 thousands thick		
	Cadmium-Plated Steel Mil. Spec. Washer for Number 10 Screw Size, 0.365" OD, MS-27183-47 <a href="https://www.mcmaster.com/98032A466">https://www.mcmaster.com/98032A466</a>	\$2.40/100	Shim spacers on compressed wood
	Aluminum Unthreaded Spacer, 3/8" OD, 7/16" Long, for Number 12 Screw Size <a href="https://www.mcmaster.com/92510A278">https://www.mcmaster.com/92510A278</a>	\$1.15/each	Spacer for contacts
	Fiber washer for spring		
	spring		
	Brass Pan Head Slotted Screws, 4-40 Thread Size, 3/16" Long <a href="https://www.mcmaster.com/92443A076">https://www.mcmaster.com/92443A076</a>	\$5.89/100	Cushen spring rivet replacement
	Brass Hex Nut, 4-40 Thread Size <a href="https://www.mcmaster.com/92671A005">https://www.mcmaster.com/92671A005</a>	\$4.65/100	Lock nut for screw above
	Extra-Long Life Machine Tool Tap, 4-40 Thread Size <a href="https://www.mcmaster.com/2568A33">https://www.mcmaster.com/2568A33</a>	\$13.10/each	Tap for above

## Basic Electrical Tests

Perform the following tests to diagnose and fix issues detected. Capacitance can be verified by using a multimeter on the high resistance setting and watching reading move slowly then reversing leads to see the same or a capacitance tester. It may be desirable to do Basic Mechanical Adjustments (i.e. remove/replace points) before completing these tests.

### Ford Model T Coils - 1913-1927

#### Connections/ Ohm Readings

A-B:  $\infty \Omega$  (w/points open)

A-C:  $0 \Omega$

A-E:  $0.295 \Omega$  (w/points closed)

B-E:  $0.295 \Omega$

C-D:  $3300 \Omega$

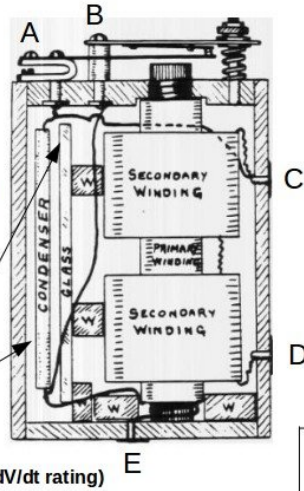
Note: Connections at A and B are sometimes reversed (more common on K-W coils).

#### Condenser

0.40-0.45  $\mu F$

replacement capacitor spec:

0.47  $\mu F$ , >400VDC, >600V/ $\mu sec$  (dV/dt rating)

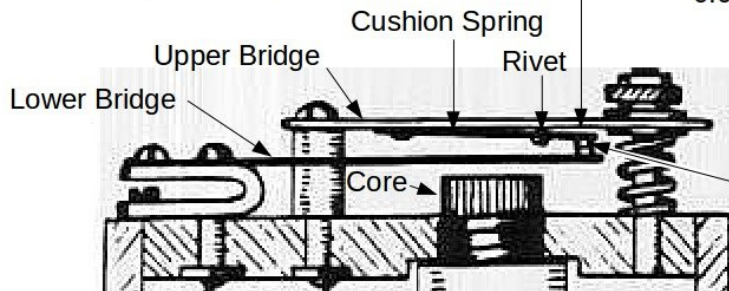


#### Problem Causes - Symptoms

- **Condenser Open** – heavy blue arc on points but no spark (A-B  $\infty \Omega$  w/ points open)
- **Condenser Shorted** – no arc on points, no spark and irregular current draw (A-B  $0 \Omega$  w/ points open)
- **Secondary Coil Open** – points vibrate and no spark (C-D  $\infty \Omega$ )
- **Secondary Coil Shorted** – points vibrate but irregular spark (C-D  $0 \Omega$ )
- **Primary Coil Shorted** – points don't vibrate and irregular current draw (B-E  $0 \Omega$ )
- **Primary Coil Open** – points don't vibrate, no current draw and points are clean/adjusted (B-E  $\infty \Omega$ )

#### Cushion Spring Gap:

(cushion spring touching rivet head with very light pressure, make all four coils the same gap) 0.003-0.005"



#### Point Gap:

1/32" or 0.029-0.031" (with lower bridge pulled down to core)

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**Results:** To record multiple coils use a table in the appendix. (Figure above [drawn by John Carter.](#))

Test	Desired	Results	Comment
A-B (w/Points open)	$\infty \Omega$		
A-C	$0 \Omega$		
A-E (w/Points closed)	$0.295 \Omega$		
B-E	$0.295 \Omega$		
C-D	3300 $\Omega$ (Ford) 2100 $\Omega$ (some KW)		
Point Gap	1/32"		
Spring Cushion	0.005		
Condenser	.47 $\mu F$		
Current Draw	1.3 Amp		

**Comments:**

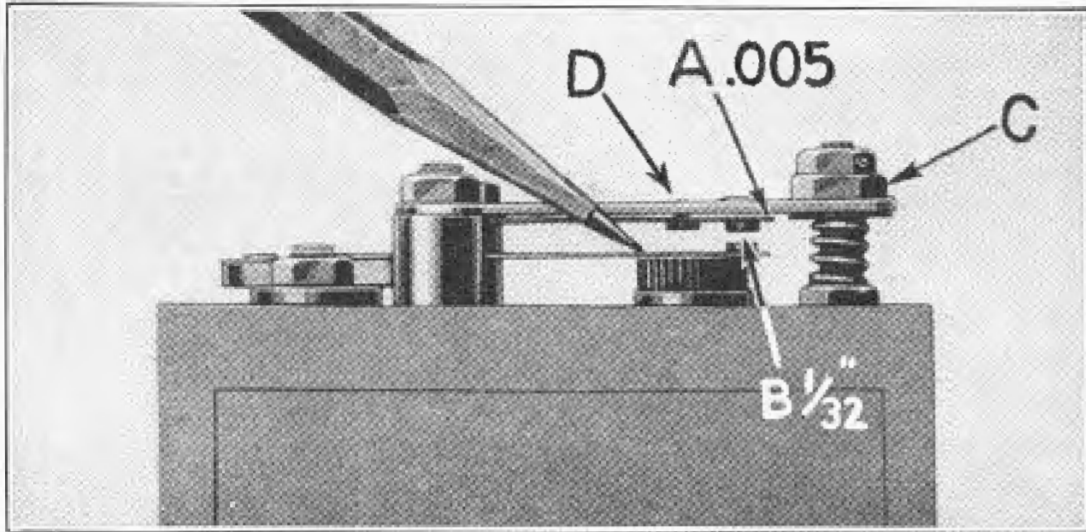
## Basic Mechanical Adjustments

The following are the basic mechanical adjustments needed for a coil. It is a good idea to electrically test coils to verify that you have a rebuildable coil before proceeding.

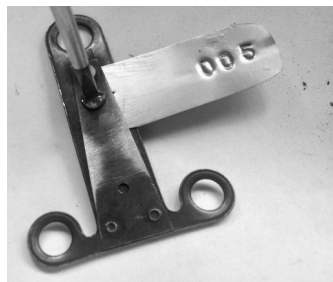
### 1. Disassembly

- Clean all bolts with a wire brush/wheel to remove rust and dirt.
- Add favorite oil to threads and allow to set overnight.
- Gently loosen nuts. Use care to not turn studs as they are electrically connected internally. If nuts are too stubborn they can be carefully ground/cut off.
- Clean all studs, nuts and determine usable hardware.
- Before moving forward, this would be a good time to test/replace electrical components including the capacitor. See Basic Electrical Adjustment section.

### 2. Cushion Spring Gap



- Set Cushion Spring Gap
  - Ford recommended .005" clearance for the full length of the spring.
  - See [Ref 13](#) for more details from Original Ford service manual.
  - Many new points have .020" travel.
  - If cushion spring is not the correct clearance the following two methods can be to remedy the problem.
    1. **Gently smash down rivet**
      - a. Using either modified vice grips (see [Ref 2](#)) or a small hammer gently smash down the rivet.
      - b. The issue with this method is if you go too far
    2. **Replace rivet with screw** (see [Ref 1](#) for image of this)
      - a. If the rivet is over smashed it may be removed and replaced with a 4-40 screw.



- b. Screw is put in place using a tap and lock nut.



### 3. Polish Points

- Use a wet stone or wet/dry sandpaper to clean/polish points.
- If deep peaks and valleys use coarse then go down to 1000 grit.



### 4. Instal Points

- Add shims under points if hardware has sunk into wood.
- Points should come together flat, as seen in image on step 2. If not, shims (washers) can help.



### 5. Replace Capacitor

- Coils with original capacitors can be found with 0.1 to 5  $\mu\text{F}$ .
- It is recommended to replace original capacitors.
- Replacement of capacitors is an involved process that requires caution in carefully removing tar, soldering wires with replacement capacitors and repotting with tar.
- Because of the work involved it is attractive to have a set of coils refurbished by a skilled rebuilder for a couple hundred dollars, but then that would make most of the recommendations here not relevant.

### 6. Set Point Gap

- Ford recommended that points be set to  $1/32"$  (.031") gap when the coil spring is pulled down.
- This can be done with a feeler gauge or use a small paper clip (of correct diameter).

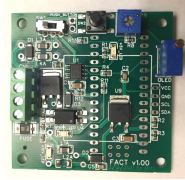
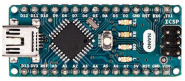



### 7. Set Spring Tension

- It is recommended that the current be set to 1.3 A @ 6 Volts by adjusting tension.
- Tension can be set by gently prying and hammering on the lower bridge.

## Dynamic Coil Adjustments

To fully test a coil it must be dynamically tested. Traditionally the Hand Crank Coil Tester (HCCT) was used. Recently, a few alternatives were made available (i.e. Strobo-Spark, [ECCT](#), and now the [Ford Arduino Coil Tester](#)). Ultimately the goal is to create four *matched* coils that produce sparks with similar dwell and spark intensity over a wide range of engine speeds. All of these products have been used successfully. The following is how to build/use the FACT.

### Purchasing Parts to Build the FACT

Image	Description	Price
	<b>FACT PCB</b> Order from <a href="http://jlcpcb.com">jlcpcb.com</a> using files above.	\$5-10 (depending on quantity)
	<b>Arduino Nano</b>	<\$5 (For generic.)
	<b>.96" OLED Display</b> <b>Important must have all the following</b> <ul style="list-style-type: none"> <li>Pin order must match the image: VCC, GND, SCL, SDA.</li> <li>128 × 64 dot matrix display (Yellow/Blue recommended)</li> <li>I2C IIC serial communications</li> </ul> Larger 1.3" should be compatible.	<\$5 (For generic.)
	<b>Push Button (Quantity 2)</b> Any single pole single throw (spst) momentary push buttons can be used. Recommended two different colors.	~\$2
	<b>Toggle Switch</b> Optional, but very desirable to turn on and off power and/or to select from different voltages. Double pole double throw (dpdt) recommended.	~\$1
	<b>Hook-Up Wire</b> Note: Use 16 - 18 AWG to work properly. Four color silicon wire with fine strands is recommended.	
	<b>Alligator clips</b> - Four colors recommended.	
	<b>Electronics Box</b> to hold electronics and test coil.	
	<b>Tuning Tools</b>	

## How to Order FACT PCB

Go to [jlcpcb.com](http://jlcpcb.com) and upload/order pcb using the following files

1. BOM- Bill of Materials:

[BOM\\_PCB\\_FACT\\_3\\_12\\_21\\_2021-03-29.7z](#)

2. Gerber files:

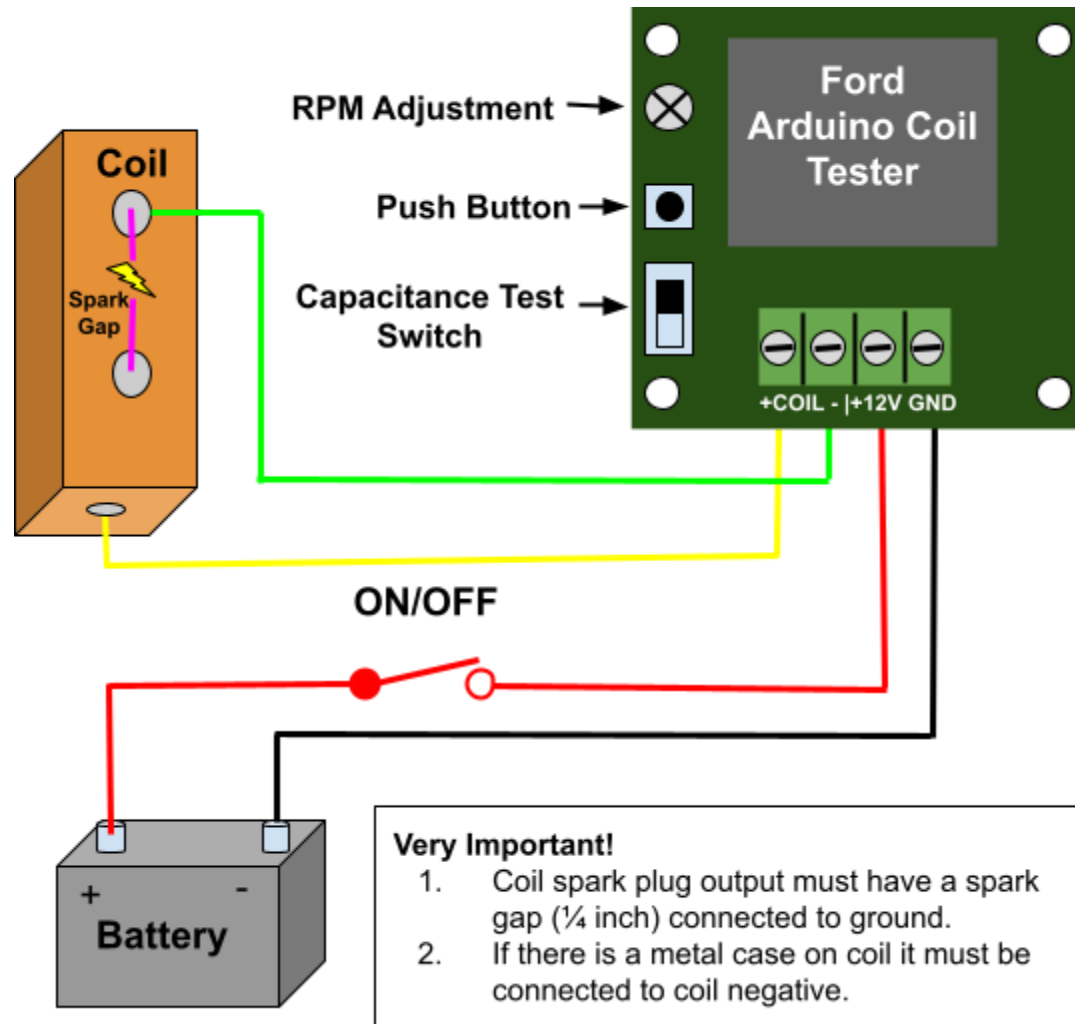
[Gerber\\_PCB\\_FACT\\_3\\_12\\_21\\_2021-03-28.zip](#)

3. Pick and Place file:

[PickAndPlace\\_PCB\\_FACT\\_3\\_12\\_21\\_2021-03-28.7z](#)

## FACT Coil Tester

Please refer to the following pictorial diagram for connecting the Ford Arduino Coil Tester:



Simply put the FACT coil tester is an oscilloscope that graphically displays the time to fire and current consumed by the coil. The FACT does this by sending an electronic pulse for 50 ms. There are four test modes:

- Single fire
- Multiple fire (50 times)
- Continuous firing
- Capacitance test

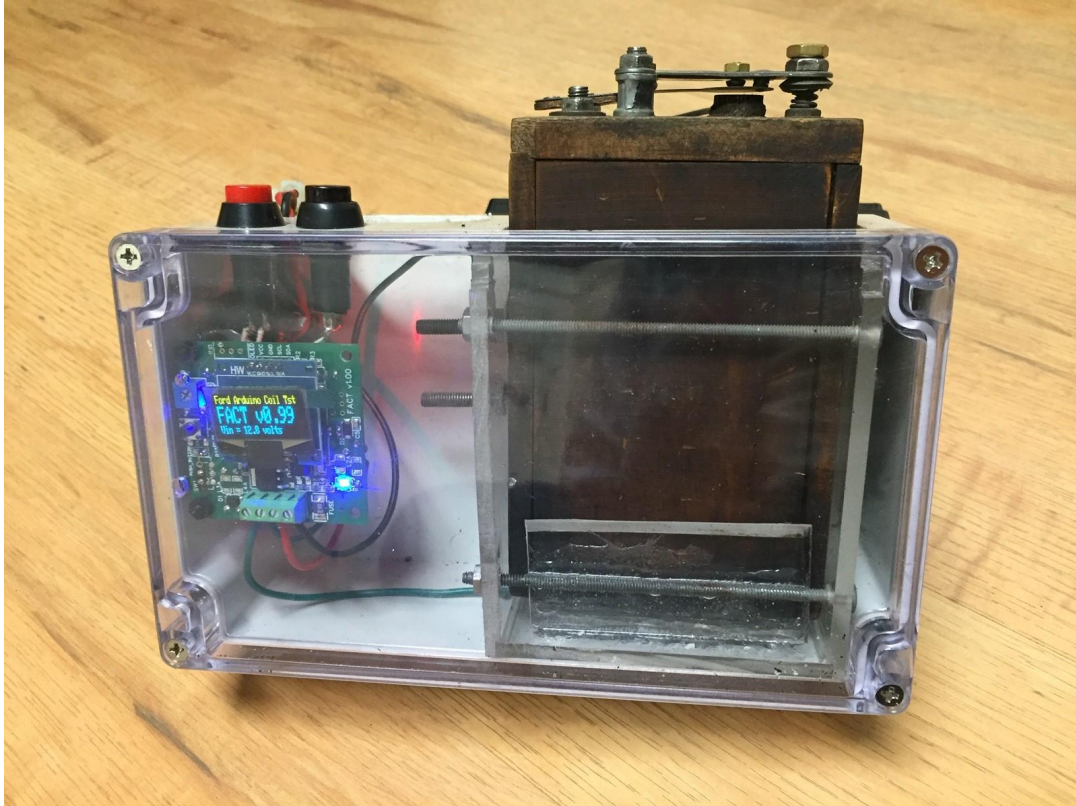
Each test (except for the capacitor) gives the time to fire and current.



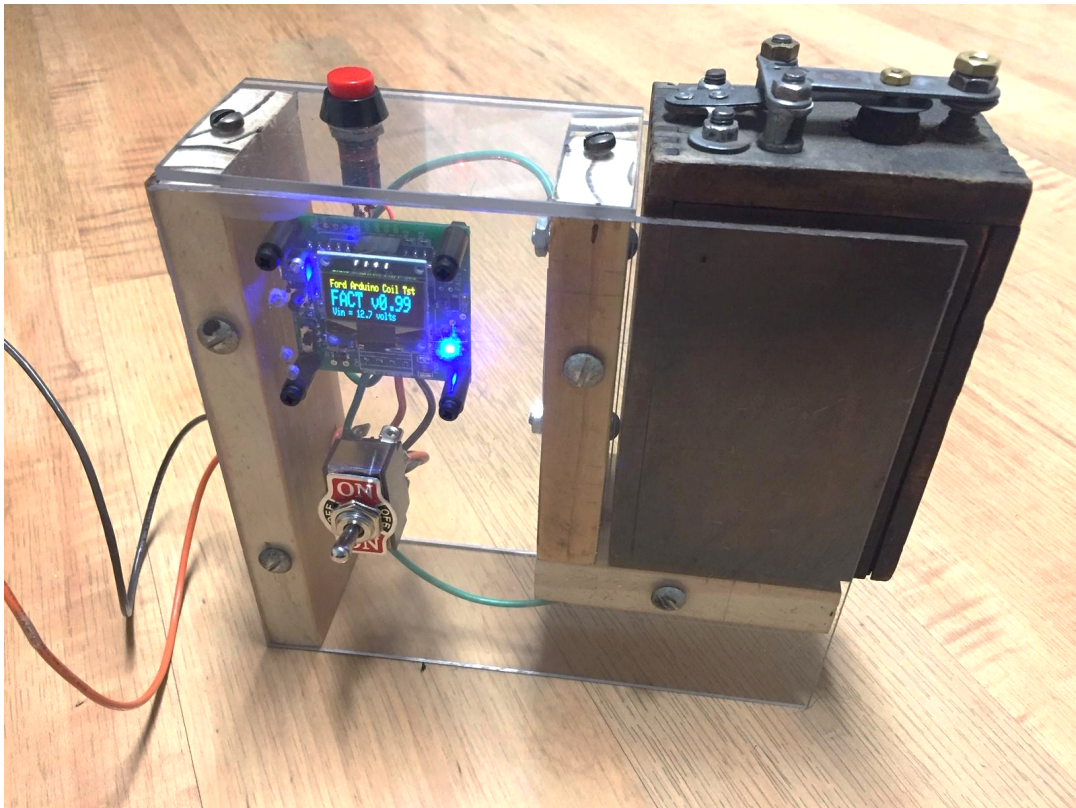
## Example Test Fixtures

There are many options for building test fixtures. Here are two.

### Premade Electronics Box






### DIY Box



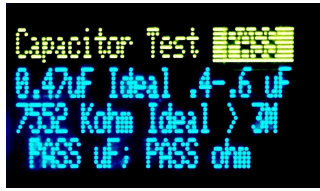

## Testing with the FACT

The following is a simple dynamic test using a Motor Crank Coil Tester (MCCT).

1. Turn on power to FACT.
2. Place coil in tester.
3. **Capacitance Test Test**
  - a. Move switch on PCB to Capacitor Test Mode.
  - b. Hold points with a piece of paper.
  - c. Press the pushbutton.
  - d. Review graphical analysis:

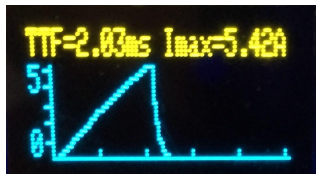
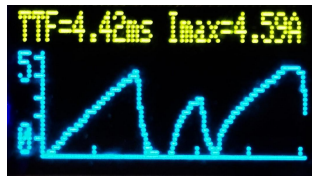
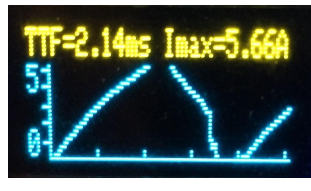
		
<b>Good</b> waveform. Note that waveform traces the ideal waveform.	<b>Points Closed.</b> Points must be opened for testing. (Place a piece of paper in points for testing.)	<b>Bad Capacitor</b> causes faulty waveform.

- e. Detailed analysis:

		
<b>Good</b> waveform. Note that waveform traces the ideal waveform.		<b>Bad Capacitor</b> causes faulty waveform.

## 4. Single Fire Test

- a. Press button quickly for a single fire test.
- b. Examine the waveform:

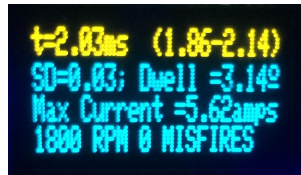
		
<b>Good</b> waveform. Nice ramp with clean drop off.	<b>Double Spark</b> caused by improper adjustment of cushion spring.	<b>Bad Capacitor</b> causes faulty waveform.

- c. If the waveform is good adjust the spring tension to get the desired time-to-fire (i.e. 2 ms with 12 VDC source).



## 5. Multiple Fire Test

- Press the button for one to six seconds for the multiple fire test. This will repeat the single fire test for 50 cycles and take the average for the last 48. (The first two measurements are ignored.)
- The speed (rpm) of this test is controlled by the potentiometer. If the speed was faster/slower than desired, adjust to desired speed (500-2500 rpm). Most coils the speed doesn't change the outcome of the measurements, so it is suggested to set fully clockwise to measure at full speed 2500 rpm (or over 60 mph).
- Examine test results:

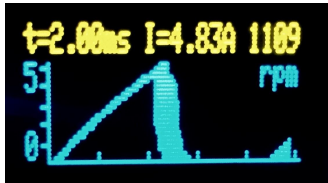
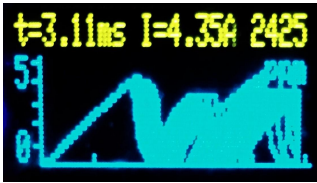



- Very statistics are desirable

Parameter	Description
t	Average time to fire in milliseconds. Numbers in brackets are the maximum and minimum values.
SD	Standard Deviation. The smaller the value the higher the precision, so a small value is desirable.
Dwell	Degrees of dwell. Determined by the range between max and min time-to-fire and answer is in degrees of rotation.
Max Current	Average of maximum currents measured.

## 6. Continuous Fire Test

- Press the button for more than six seconds for the continuous fire test. This will repeat the single fire test and give overlapping waveforms.
- Examine waveform:

		
<b>Good waveform</b> Waveforms overlap with narrow lines and a new waveform is just starting on the far right.	<b>Double Spark</b> causes lots of overlapping waveforms after the initial ramp.	<b>Bad waveform</b> Lots of inconsistent overlapping waveforms.

## 7. Adjust time to Fire

- Adjust lower bridge spring to get desired time to fire (i.e. 2.00 ms).
- Retest to verify performance.

## Basic Electrical Tests for Multiple Coils

### Connections/ Ohm Readings

A-B:  $\infty \Omega$  (w/points open)

A-C:  $0 \Omega$

A-E:  $0.295 \Omega$  (w/points closed)

B-E:  $0.295 \Omega$

C-D:  $3300 \Omega$

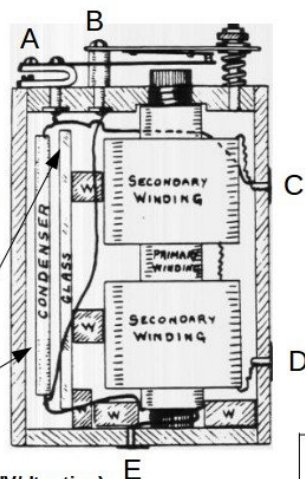
Note: Connections at A and B are sometimes reversed (more common on K-W coils).

### Condenser

$0.40-0.45 \mu F$

replacement capacitor spec:

$0.47 \mu F$ ,  $>400VDC$ ,  $>600V/\mu sec$  (dV/dt rating)

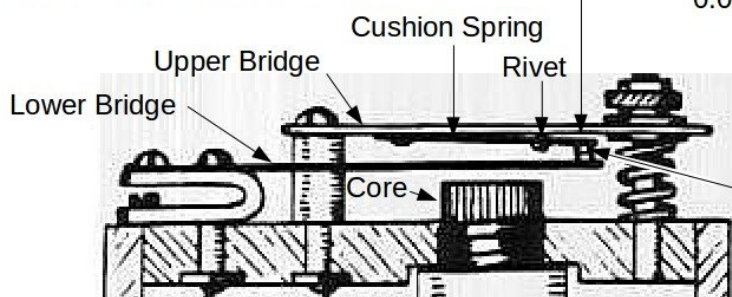


### Problem Causes - Symptoms

- **Condenser Open** – heavy blue arc on points but no spark (A-B  $\infty \Omega$  w/ points open)
- **Condenser Shorted** – no arc on points, no spark and irregular current draw (A-B  $0 \Omega$  w/ points open)
- **Secondary Coil Open** – points vibrate and no spark (C-D  $\infty \Omega$ )
- **Secondary Coil Shorted** – points vibrate but irregular spark (C-D  $0 \Omega$ )
- **Primary Coil Shorted** – points don't vibrate and irregular current draw (B-E  $0 \Omega$ )
- **Primary Coil Open** – points don't vibrate, no current draw and points are clean/adjusted (B-E  $\infty \Omega$ )

### Cushion Spring Gap:

(cushion spring touching rivet head with very light pressure, make all four coils the same gap)  
 $0.003-0.005"$



### Point Gap:

$1/32"$  or  $0.029-0.031"$   
(with lower bridge pulled down to core)

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(Figure above [drawn by John Carter.](#))

### Test results:

Coil #	A-B (w/Points open)	A-C	A-E (w/Points closed)	B-E	C-D	Point Gap	Cushion Gap	Condenser	Current Draw
Nominal	$\infty \Omega$	$0 \Omega$	$0.3 \Omega$	$0.3 \Omega$	$3300 \Omega$ (Ford) $2100 \Omega$ (some KW)	$1/32"$	$0.005"$	$.47 \mu F$ <small>If can't measure replace with new.</small>	$1.3 A$
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A
	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	"	"	$\mu F$	A

## Additional Articles/References

1. Figure drawn by John Carter from:  
<http://www.mtfca.com/discus/messages/599638/646227.html?1464833674>
2. Discussion on Cushion Spring Gap and how to adjust (.005" preferred, but can go up to .012" and most importantly all should be the same):  
<http://www.mtfca.com/discus/messages/80257/98687.html?1247931406#POST174792>
3. Ordering coil hardware:  
<http://www.mtfca.com/discus/messages/80257/94772.html?1250731519>
4. Another Model T Coil Cushion Spring Adjustment Tool:  
[http://www.pbase.com/jimthode/coil\\_current](http://www.pbase.com/jimthode/coil_current)
5. ECCT Instruction Manual (Lots of good info about coil adjustments) by Mictel LLC  
<https://img1.wsimg.com/blobby/go/f7680751-19cd-4e19-be37-bbb767146cbd/downloads/ECCT%20Instructions%20V12.pdf?ver=1606881770749>
6. Videos on Coil rebuilding (Part 1, click on next to see all three videos.)  
[https://www.youtube.com/watch?v=uhaXW3jaG0Q&list=PLYG\\_IhIwKyL1\\_nmd6sCkGZBwglKpRWA3](https://www.youtube.com/watch?v=uhaXW3jaG0Q&list=PLYG_IhIwKyL1_nmd6sCkGZBwglKpRWA3)
7. *More on Model T Ford Spark Timing*, by Ron Patterson  
<http://www.mtfca.com/encyclo/ignition2.pdf>
8. *The Double Spark Doctrine Paradox*, By Mike Kossor  
<https://img1.wsimg.com/blobby/go/f7680751-19cd-4e19-be37-bbb767146cbd/downloads/The%20Double%20Spark%20Doctrine%20Paradox%20V5.pdf?ver=1606881770750>
9. *The Model T Ignition Coil Part I: The Ford/K-W Ignition Company Story*, By Trent Boggess and Ronald Patterson  
[http://docs.wixstatic.com/ugd/3a96dc\\_cf55a51ac76a42ab9087dd905c5d4e55.pdf](http://docs.wixstatic.com/ugd/3a96dc_cf55a51ac76a42ab9087dd905c5d4e55.pdf)
10. *The Model T Ignition Coil* by Trent E. Boggess & Ronald Patterson  
Vital details primary (212 turns), secondary (16,600 turns), Buzz 200 times/second  
<http://www.mtfca.com/coils/Coils.htm>
11. *Model T Service Manual* by Ford  
<http://www.cimorelli.com/mtdl/servicemanual/1925smcolor.pdf>
12. *MTFCA Online Encyclopedia*  
[https://www.mtfca.com/model\\_t\\_encyclopedia/cd/](https://www.mtfca.com/model_t_encyclopedia/cd/)

## Appendix

Specifications of Coil Unit (see [Specifications of Coil Unit](#))

(1926) Accession 94, Box 171, Ford Archives

### Turns

Primary

212 turns

\*20 gauge wire with cotton wrapped insulation

Secondary

16,600 turns

\*38 gauge wire of multiple layers insulated between layers by waxed paper

Ratio of windings 78 to 1

### Resistance

DC resistance Primary .295 ohms

Secondary 3300 ohms Inductance (Some KW coils are 2100 ohms)

### Inductance

**Primary**

.0033 henrys (secondary open)

.0006 henrys (secondary shorted)

**Secondary**

22 henrys (primary open)

11.3 henrys (primary shorted)

### Impedance at 133 cycles (25 mph)

Primary

2.77 ohms (secondary open)

.580 ohms (secondary shorted)

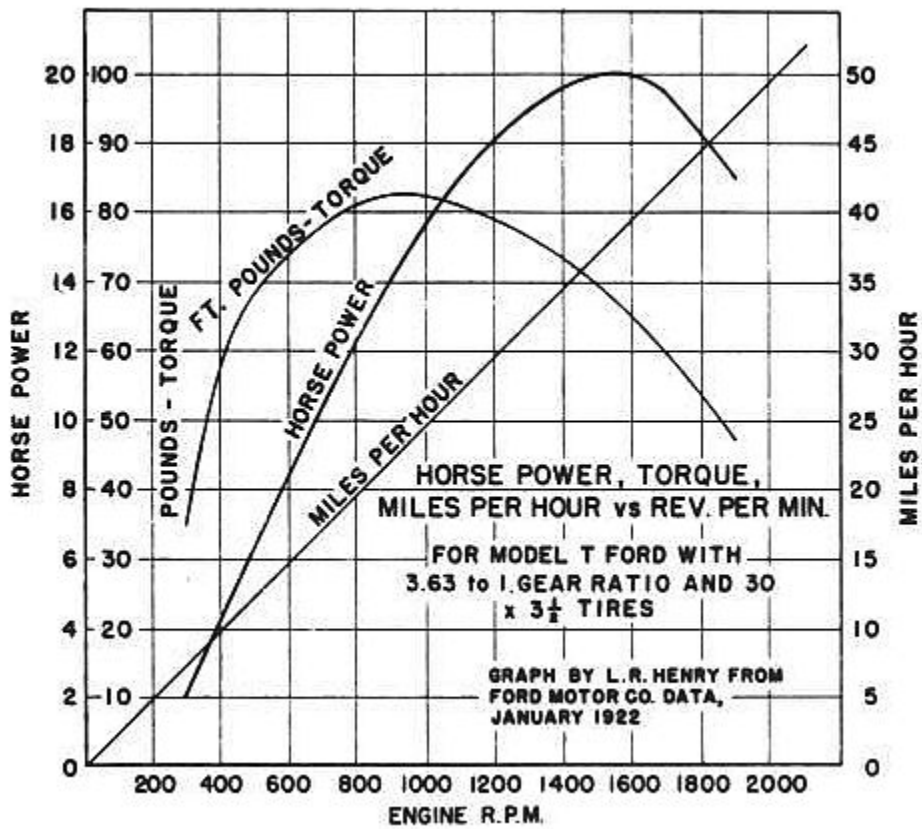
Secondary

18.700 ohms (primary open)

9.960 ohms (primary shorted)

### Capacitance

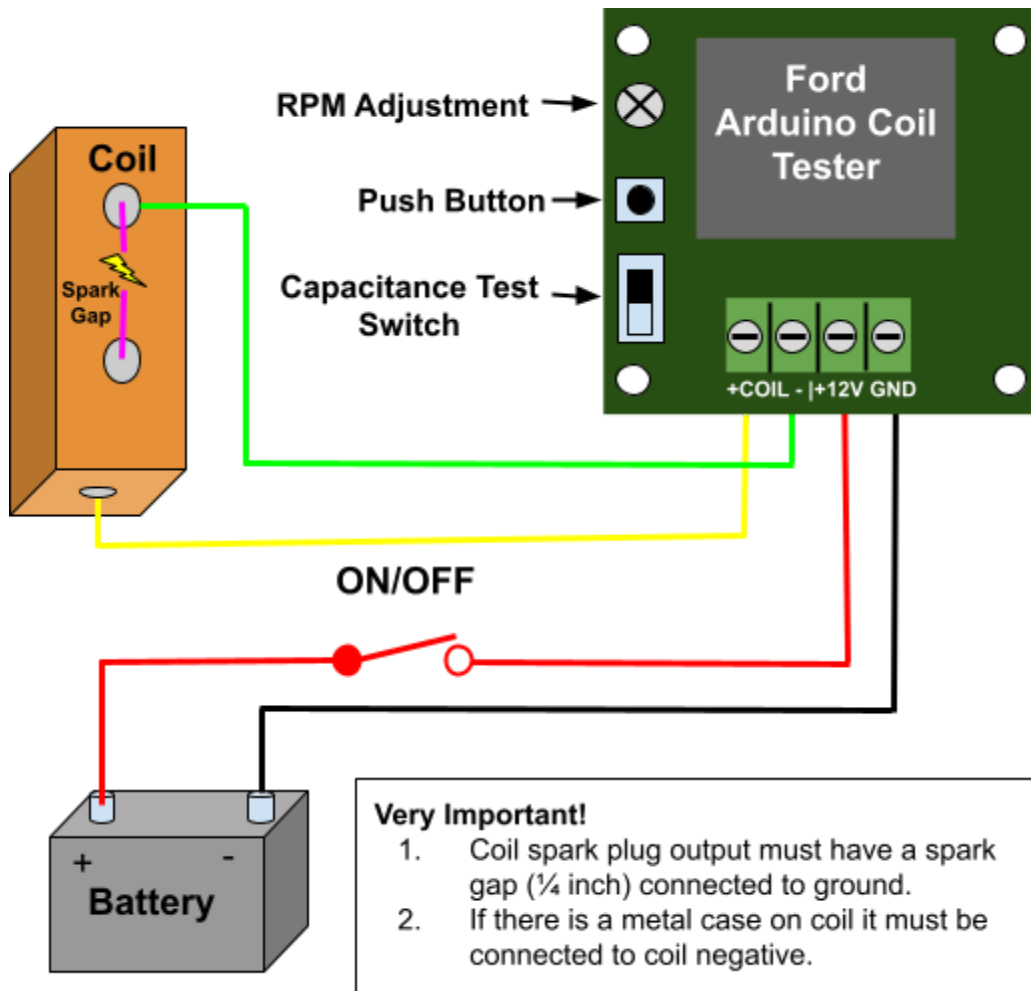
Capacitor .40 -.45 mfd





## FACT Coil Tester Two Page Reference

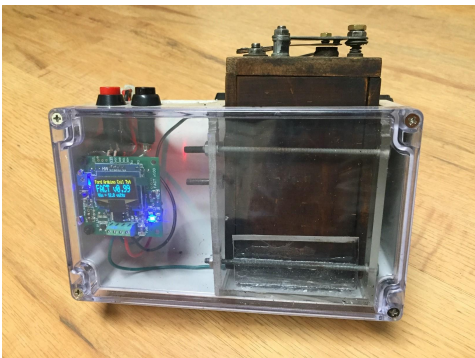
Please refer to the following pictorial diagram for connecting the Ford Arduino Coil Tester:



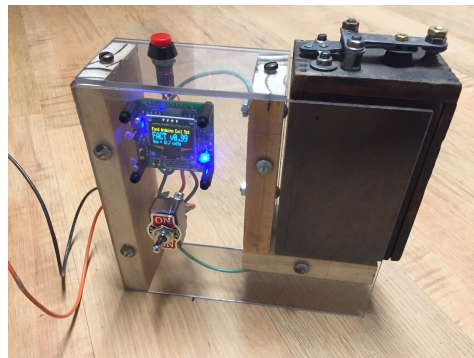
Simply put the FACT coil tester is an oscilloscope that graphically displays the time to fire and current consumed by the coil. The FACT does this by sending an electronic pulse for 50 ms. There are four test modes: single fire, multiple fire (50 times), continuous firing, capacitance test

### Example Test Fixtures

There are many options for building test fixtures. Here are two.


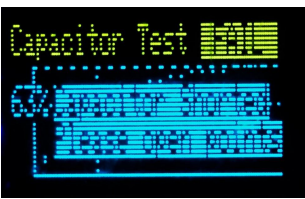

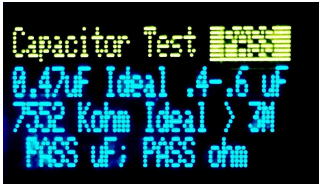

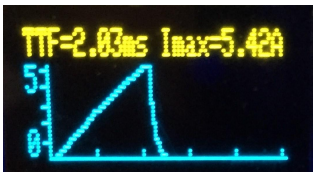
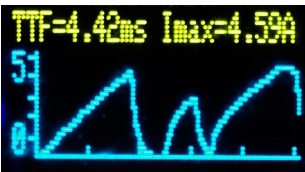
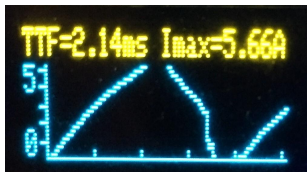
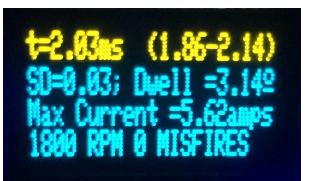
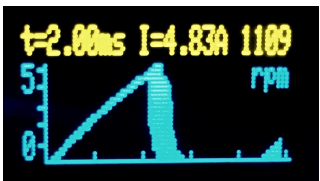
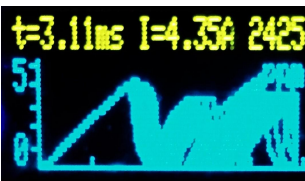



Premade Electronics Box



DIY Box

## FACT Testing Cheat Sheet

<b>Capacitance- Graphical Analysis</b>			
	<b>Good</b> waveform. Note that waveform traces the ideal waveform.	<b>Points Closed.</b> Points must be opened for testing. (Place a piece of paper in points for testing.)	<b>Bad Capacitor</b> causes faulty waveform.
<b>Capacitance- Detailed Analysis</b>			
	<b>Good</b> waveform. Note that waveform traces the ideal waveform.		<b>Bad Capacitor</b> causes faulty waveform.
<b>Single Fire Test</b>			
	<b>Good</b> waveform. Nice ramp with clean drop off.	<b>Double Spark</b> caused by improper adjustment of cushion spring.	<b>Bad Capacitor</b> causes faulty waveform.
<b>Multiple Fire Test</b>			
<b>Continuous Fire Test</b>			
	<b>Good waveform</b> Waveforms overlap with narrow lines and a new waveform is just starting on the far right.	<b>Double Spark</b> causes lots of overlapping waveforms after the initial ramp.	<b>Bad waveform</b> Lots of inconsistent overlapping waveforms.