Model A Generators
Electronic Voltage Regulation

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Michael Hill, October 2024

Introduction

The output current of a Model A generator is regulated by manually moving a brush within the generator that supplies current to the generator field coils. The challenge is finding the optimum brush setting to match the car's electrical needs so that the battery is neither being drained nor being overcharged.

If the brush setting is too high and the battery is being overcharged, the battery electrolyte can boil off and potentially damage the battery. Conversely, if the generator output is set too low (i.e. low 3rd brush setting and driving with lights on at night) the battery may become discharged. An undercharged battery may be damaged by sulfation.

This article describes the principle of voltage regulation for the Ford Model A and introduces modern Electronic Voltage Regulators (EVRs) that can be used to regulate generator output voltage to safe levels. The article also highlights my involvement with redesigning and commercializing a popular EVR design and provides information on its functionality, benefits and limitations.

Model A Battery Charging System

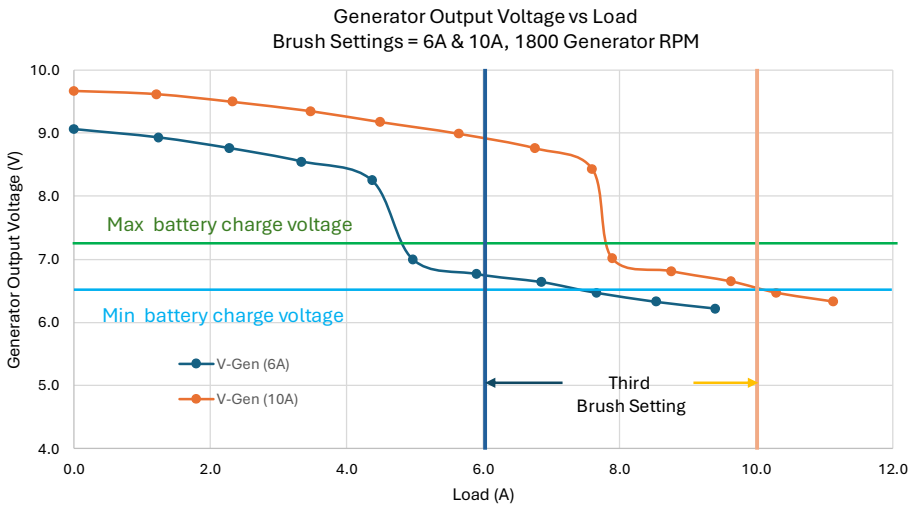
In the Model "A" Instruction Book[i], Ford recommended: "*During the winter months in sections where low temperatures prevail, the charging rate should be adjusted to 10 amperes; in the summer this rate should be cut down to 6 amperes*". The instructions further note the adjustments should be increased or decreased to meet individual requirements.

Indeed, the challenge for the Model A driver was optimizing the current and voltage provided to/from the battery under various driving conditions. A typical 6V lead acid flooded car battery has the following characteristics[ii]:

- Full Charge (at rest) = 6.3 – 6.4V
- Min Voltage to charge battery = 6.45V
- Max Battery Charge Voltage = 7.1V -7.2V

If the input voltage to the battery exceeds 7.1V to 7.2V for a sustained period, the battery will start gassing off hydrogen caused by the electrolyte boiling off. Should the battery electrolyte level go below the top of the battery plates, the battery will be permanently damaged. Conversely, an undercharged battery can be damaged by sulfation.

Generally, the Model A generator produces well above 8V while driving. The following chart is indicative of generators tested by the author. Under regular ignition load, the generator output is typically in the 8 to 10 volt range. It is not until the generator output amperage is close to the third brush setting value that the generator outputs voltage lower than 7.2 volts – the maximum level of charge for a 6V battery[iii].



Ford likely knew the implications of the battery overcharge condition and for this reason, the Instruction Book recommends the battery electrolyte level be checked every two weeks.

The Model A dashboard ammeter indicates the current flow to, and from, the battery. Although generally directionally correct, the ammeter is not very accurate. Model A drivers know that the best position for the ammeter in the car while driving is in the zero range[iv]. A number of tricks and techniques are/were used by Model A owners to adjust the battery charge rate including regularly adjusting the 3rd brush and driving with the car lights on during the day. A more advanced technique included installing a variable resistor to more conveniently adjust the battery charge rate while driving. Another solution involved incorporating a resistor into the headlight switch circuit so when the headlights were off the resistor reduced the battery charge voltage equivalent to the headlight load.

All of this was very confusing for drivers and for the most part, the majority of drivers simply allowed the battery life to be compromised by over or under charging. Further, during the winter months, dead batteries were a common occurrence as a result of undercharging.[v]

Voltage Regulators

In the late 1930's automobile manufactures started to introduce voltage and current regulators. Part of the reason for this was increasing automobile electrical loads resulting from the introduction of radios, heaters, more lights, brighter headlamps, and other accessories. These loads necessitated more powerful generators and in conjunction with the battery, a way to better regulate the generator output. In addition, voltage regulation served to reduce the power consumption of the generator during driving (fuel economy) by optimizing the output required.

The solution used was an electro-mechanical regulator which, in addition to incorporating a cutout circuit, used coils to regulate the maximum generator output voltage and amperage as shown in the figure below[vi]. The voltage regulator circuit varied the current to the generator field coils to maintain a constant output voltage. Typically, at generator output voltages above 7V the circuit would disengage the field coils and thus drop the generator output. This created cycling of the voltage regulator coining the "vibrating" voltage regulator name. For overcurrent protection, a current coil limited generator output, however, in most cases, the regulator voltage control circuit governed. There are good videos and descriptions available online to explain how these devices worked[vii].

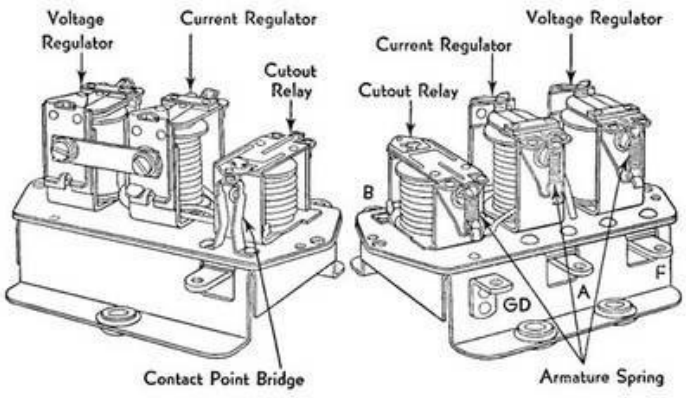


Fig. 2 Auto-Lite vibrating voltage and current regulator. VRB and VRP types shown

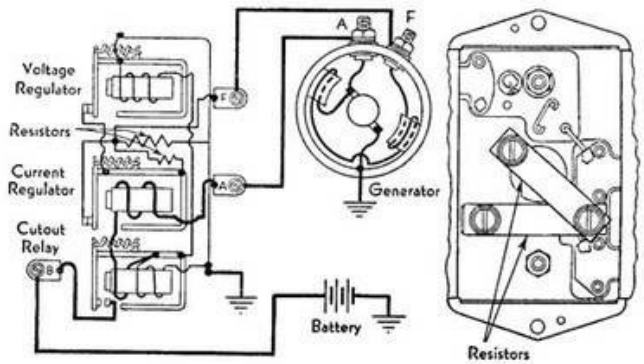
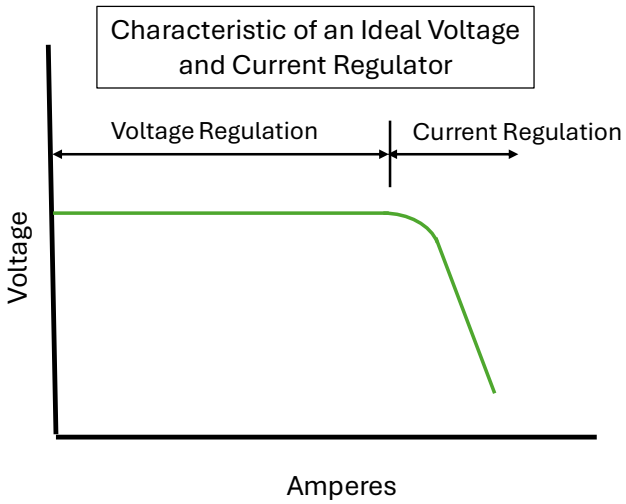


Fig. 3 Wiring diagram of Auto-Lite voltage and current regulator. VRB and VRP type shown



Source "The Story of the Automobile Voltage Regulator", Bernard Cain

Ford introduced a “2-Step” voltage regulator in 1934 for cars equipped with radios and vehicles with greater electrical demands such as police vehicles and bus chassis[viii]. In 1939 Ford introduced a regulator with voltage and current regulation.

With the later introduction of the alternator, facilitated by the introduction of the transistor in the 1950’s, there was no longer a need for a separate voltage and amperage regulator as an alternator’s mechanical and electrical design controls the output voltage and current.

Model A - Electronic Voltage Regulator (EVR)

People have equipped Model A generators with electro-mechanical voltage regulators, however, this requires modifications to the generator to get the field coil wiring to the outside of the generator case and does not look original to the car. As a more practical alternative, several approaches to incorporate EVRs have been used over the past 10 to 20 years.

Based on my research there are two types of EVR’s that have been built and sold for the Model A:

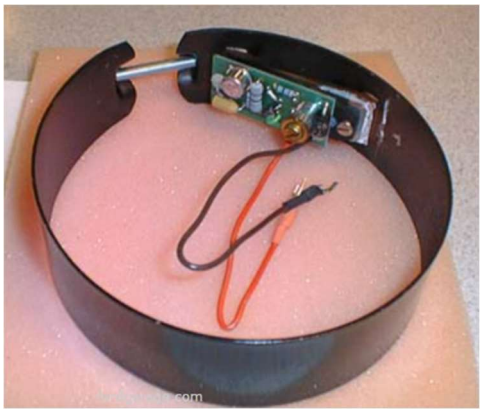
- Internal Style
  - Tom Wesenberg (TW) (deceased)– recently re-introduced
  - James Peterson (deceased) – no longer available
- Cutout Style
  - John Regan - Fun Projects – discontinued
  - Jeff Stevenson – New Fun-Projects style – in development

<u>Internal Style EVR</u>

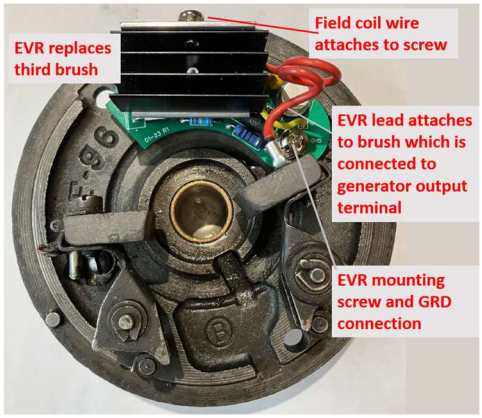
The regulators designed by Wesenberg and Peterson mount inside the generator housing. The EVR replaces the 3rd brush in the generator requiring simple internal modifications to the generator.

This EVR design regulates the current to the field coils to maintain the generator output at a constant output voltage (at the cutout) of around 7.0V to 7.2V - at driving speed engine RPM. The approach is somewhat similar to how the electro-mechanical voltage regulators worked. These designs use a Zener diode as the voltage reference and a power transistor to control the field coil current level. The designs will work with an electro-mechanical or diode cutout. I have been running a Wesenberg EVR for over 12 years using both LED and incandescent bulbs using a diode cutout with no issues.

The Peterson device, shown below, mounts on the inside of the generator band and only works with the long-style cylinder generator[ix]. .



Peterson EVR



Wesenberg-type EVR in Cylinder Generator

The Wesenberg design is also installed within the generator. The picture above shows a Wesenberg-type EVR installed in the long-style cylinder type Model A generator back plate.

<u>Cutout Style EVR</u>

The Cutout Style EVR replaces the regular generator cutout and as such does not require internal modifications to the generator. This EVR type regulates the generator output by “shorting” the generator output to ground when the output voltage exceeds 7V. The EVR incorporates a voltage comparator integrated circuit and MOSFET as the basis of the circuit design.

The John Regan Fun Projects regulator was previously available commercially, however, one of the main circuit components became obsolete and production of the EVR was discontinued. The design was re-engineered by a group of Model T enthusiasts looking for a voltage regulation device for the T generator.[x]

Jeff Stevenson (modeltstarters.com) currently markets this type of EVR for the Model T under various voltage and polarity configurations.[xi] At the time of writing, a 6V positive-ground Model A version is still pending. Information on this device is currently limited, however, I understand the EVR output voltage range cycles between 6.2V and 7.2V during driving. It appears the recommendation for the third brush setting is for a maximum of 5 Amps output which potentially limits available generator capacity. User adjustments can potentially be made to the regulator to fine tune the output voltage if necessary.

Both the Fun Projects and Stevenson EVRs can be damaged by inducing a reverse current through the devices by way of applying a jumper across the terminals (i.e polarizing, motoring or "flashing" the generator) and may experience complications if the battery is disconnected while the generator is operating. Limitations may also apply for powerhouse generators.



Fun Projects – Cutout Style EVR

Both EVR designs achieve the same result with different pros and cons. The main advantage of the Cutout design is that it is a simple retrofit of the cutout, however, the generator power output is limited by the adjustment of the third brush. The new Cutout design provides a cycling of the output voltage to the battery - meaning the car's ammeter will fluctuate while driving. The Wesenberg design is more electronically simple and regulates the field coil amperage allowing for a broader generator power output range. With the Wesenberg EVR, the car ammeter will generally hold steady at a 1A to 2A charge except after starting when a higher charging load is required to replenish the battery.

Another benefit of an EVR is less generator load on the engine as the generator is not working as hard as it would otherwise to charge the battery. This is particularly the case with a Powerhouse generator.

Tom Wesenberg (TW) Voltage Regulator Redesign Background

Tom Wesenberg was an active contributor to the Model A forums and well recognized for his understanding and rebuilding of generators and cutouts. His EVR design was motivated in response to the battery overcharge situation associated with the Model A generator and electrical system. Wesenberg designed and produced his EVR for a variety of Model A generators including the Long Style and 3 and 5 brush Powerhouse generators. Tom's EVRs were very popular with Model A enthusiasts, however, they were very hard to get. I was fortunate to obtain one in 2009 but was unsuccessful ordering one since.

The Wesenberg EVR allows for a maximum generator output voltage of 7.0 to 7.2 V which is the optimum charge voltage for a 6V battery. As a secondary benefit, the EVR continues to regulate the power to the field coils in the event the generator is disconnected from the battery thereby protecting the generator from overheating. Disconnecting a generator from the battery causes a runaway effect resulting in high currents in the field coils and commutator arcing ultimately creating high temperatures which destroy the generator wiring. As a precaution always ground the output post of the generator in case the generator becomes disconnected from the battery during driving (e.g. Blown fuse or failed ammeter connections).

The voltage regulation principal Wesenberg used in his EVR is well known and used in many applications. However, Tom's design was unique because it was located within the generator housing enabling Model A owners to maintain the stock look of the generator rather than use an alternator.

Sadly, Tom passed away in early 2022 and the EVR design and bill of materials was lost.

Starting in 2022, I undertook to re-engineer the Wesenberg EVR along with incorporating some improvements to the design. This involved some challenges as Tom had obscured the markings on some of the key components which turned out to be unavailable anyway. Tom also produced his own printed handcrafted circuit boards. A picture of the new design mounted on a generator brush plate is below.

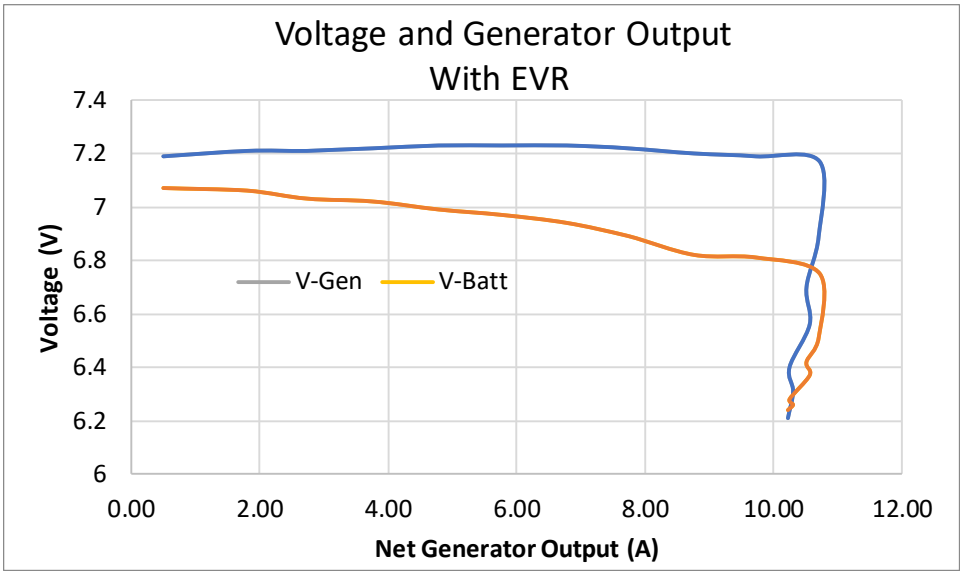


Wesenberg-type EVR mounted on generator

The new “Wesenberg-type” EVR is available for all long-style generator styles and versions for the Powerhouse generators are being considered for development.

The EVR holds the generator output voltage constant by altering the field coil power until the maximum generator capacity is reached. The chart below shows that the EVR maintains the generator output voltage (V-Gen) at around 7.2 V until the output capacity of the generator is achieved. Thereafter the generator output voltage decreases as load increases and the battery starts supplementing the load draw. The results below are shown for a specific generator tested but are indicative of how most generators behave using the EVR. I have tested many generators with the EVR and they all tend to have their own “personality” depending on the generator vintage and condition.

The battery voltage signature (V-Batt) starts lower than the generator output and decreases linearly as external load is applied. This is a result of wire resistances and battery buffering behavior as load is applied over time. Up to the maximum power output of the generator (approximately 10A in the case below), the battery charge voltage stays above the 6.5V minimum required.



In the event the load applied exceeds the generator output level a discharge would be indicated on the vehicle’s ammeter as the battery is supplying the required incremental power.

The maximum output (wattage) of a generator can vary substantially by generator, however, the EVR’s ability to produce constant voltage performance up to the generators maximum output is generally the same. Generator output will also vary with engine RPM. The generator tends to “kick in” above a 1000 engine RPM range. To understand the limitations of my Wesenberg-type EVR I have successfully tested EVR equipped generators up to 15A load and at varying RPM levels.

Summary

The addition of an EVR is a good upgrade for most Model A owners. An EVR is very likely to extend battery life and on balance make sure the battery remains in a charged state. The increased use of LED bulbs with accompanying low power requirements can tend to result in generator over-voltage situations due to limitations on how low the generator third brush output current can be physically set. An EVR also serves to mitigate this issue.

The installation of an EVR is fairly simple requiring basic knowledge and tools. The operation of the EVR during driving can be confirmed by observing the vehicle’s ammeter gauge or by taking direct readings of the battery voltage as a test.

A Side Note on Generator Performance

A Model A generator will produce up to 10A to 12A[xii] of power output under ideal conditions based on generator condition and engine RPM. However, the heat produced by the generator at this level of sustained output level is high which could damage the generator. Owners with high current loads (e.g. 50cp incandescent bulbs, sealed beam headlamps, air conditioning, Christmas lights 😊) should consider an alternator.

Traditionally with incandescent headlamp (32 CP authorized by Ford) and taillamp bulbs, maximum nighttime driving load, including the ignition system (2A) is around 8A to 9A[xiii]. The intermittent loads, typically incandescent brake and signal lights and the horn, add approximately 5A to 6A and typically require incremental battery capacity under night driving conditions. The consequence of these varying loads is the battery is being cycled between being charged and supplementing the car's power loads while driving. Arguably, the use of LED lights reduces generator and battery loads, however, the high generator voltage output occurring below the third brush setting being achieved is still an issue.

I would NOT recommend the generator, equipped with an EVR, or not, be used at its maximum capacity on a sustained basis as a lot of heat will be generated and engine drag occur. A safe 3rd brush setting for a generator is around 6 amps. Again, the third brush setting is not applicable with the Wesenberg-type EVR, however, sustained high current load may compromise it.

If you are driving a lot at night with a generator, I would recommend both an EVR and LED headlamps - not only for the lower power consumption but for better visibility and some of the "focused" bulbs having a proper light cutoff line. LED brake lights also have a brightness advantage over incandescent brake lights and cars should also be equipped with a center LED brake light for additional safety.

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References

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[ii] Battery University – Learn About Batteries https://batteryuniversity.com/articles

[iii] Based on testing of various generators by the Author. The brush setting for this particular generator is under no load at a generator RPM of 1720. In a car, the ignition coil would draw approximately 2A.

[iv] This is a bit challenging as the car ammeter is not that accurate.

[v] First-Hand: The Story of the Automobile Voltage Regulator, Bernard Cain - https://ethw.org/First-Hand:The_Story_of_the_Automobile_Voltage_Regulator

[vi] Autolight Voltage Regulator Manual http://www.wildriders.org/threads/autolite_gen_maintenance.pdf

[vii] YouTube – Generator Regulator, Peter Mak - https://www.youtube.com/watch?v=BYOE8RyL1Sw

[viii] Ford Service Bulletin for March, 1934, Page 156

[ix] Fordgarage.com – Model A&B Solid State Generator Regulator True Field Current Regulation https://www.fordgarage.com/pages/generator.htm

[x] Model T Ford Club of America Forum - A $20 (or less!) DIY regulator, and other issues. https://www.mtfca.com/phpBB3/viewtopic.php?f=2&t=25609, https://www.mtfca.com/phpBB3/viewtopic.php?f=2&t=25609&hilit=%2420+diy#p196149

[xi] Modeltstarters.com – Model T Voltage Regulator & Diode Cutouts - https://modeltstarters.com/voltage-regulators-cutouts/

[xii] Repair Manual Generator and Starting Systems 1933-1947, Ford Motor Company June27, 1947. Specification for B-10000 Generator

[xiii] Based on author's measurement of various lightbulb loads. 32/32 CP headlamps and 32CP brake light bulbs draw approximately 3.5A to 3.7A each at 6.5V.

Acknowledgements

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