6 Volts or 12?

A common question from newcomers to Model T's is, "Should I convert the car to use a 12V electrical system"? The response might be, "What's wrong with the 6V system it came with"? The purpose of this article is to explain the situation with both systems.

What voltage for cars?

In the early days of electric starting and lighting, 6V became standard with most cars. An objection to higher voltages was that the lamp filaments had to be thinner and longer (i.e. more fragile), and thus gave shorter life with excessive vibration from dirt roads. Nevertheless, a few luxury cars did use 12, 18, or 24V for their electrical systems.

Wiring resistance, and starter motor current draw, make anything less than 6V impractical, so the three cell battery became standard for most American cars, including Ford, up until around 1954.

The 1950's and 12V.

6V served the auto industry well, with everything from cars to trucks and tractors using it, without any inherent problems. However, in the affluent 1950's of the U.S., cars were placing increased demand on their electrical systems. Cars now had heaters, air conditioners, power windows, electric seats, more powerful headlights, and so on. The problem here was keeping the battery charged. A typical automotive generator can only provide about 20 Amps before the brushes and commutator overheat. How to get more power? Seeing as the current is limited, the voltage then has to go up. 6 Volts at 20 Amps is 120 Watts. But, if we make the generator voltage 12, then we can have 240W without overheating the generator. And so the problem was solved effectively, until alternators with their much higher output, became available. A further advantage of using 12V was that the thickness of the wiring could be reduced, saving copper costs. This comes about because for the same power, the current is half of what it is at 6V. It is current flow that causes voltage drop in the wiring.

12V and the Model T.

The first documentation regarding 12V in a Model T appears to be an old Vintage Ford article, where a decrepit T was found, and having difficulty getting the starter to work, the owner decided to try a 12V battery. Effectively, it was made to work by brute force; which it apparently did quite well. He also found the coils worked off the higher voltage, and the generator charged. After replacing all the light bulbs he continued to use it this way. Word got around that this was a way to "fix'" hard to start cars and so began the trend.

Let's look at some of the reasons owners give to use 12V in a Model T today:

- Poor starter motor performance at 6V
- Poor light output from headlamps
- Dead magneto and a desire to retain the Ford coils
- Ability to use modern accessories such as GPS or CB radios
- Easier to obtain bulbs and batteries.

Poor starter performance.

Starter motors barely able to turn, and dim orange headlights, are not in fact, a characteristic of 6V electrical systems. Instead, they are indicative of an electrical system in poor condition, or one that has been poorly rebuilt.

Often, a starter motor is pressed into service with nothing more than painting it black. That the commutator or brushes may need attention, the windings may have shorted turns, or the bushings may be worn, are conveniently overlooked. And, if the car has been rewired, it may well have an incorrect gauge of starter motor cable fitted. The starter switch too, may have merely had the black paint treatment, ignoring the high resistance burnt contacts within.

And so, with the car 'restored' to a gleaming state, in goes a 6V battery and what a disappointment! The starter barely turns and car can hardly start. The owner, thinking of how fast a modern car starts with its 12V battery then thinks the same should fix the T. And sure enough, with a 12V battery fitted, the starter cranks at a rapid pace and the engine bursts into life.

But, let's have a closer look at what's really happening here. The higher voltage battery is merely allowing for voltage to be dropped across all the high resistance points, and still provide enough to drive the starter. Or, it could be that the bushings have worn and the armature is off centre, or maybe the old oily rotting cloth insulation on the windings has partially broken down. Here, the higher current makes it work simply by brute force. Nevertheless, the owner is now convinced of the virtues of 12V, and the original 6V system is dismissed as being a serious design fault, having no place in any car.

Dim Lights.

The next scenario is the car with dim lights. The orange filaments that throw light only a few feet in front of the car, cause the owner to again think of the modern car, and its piercing white light shining for several hundred metres.

Again, 12V is seen as the cure; in go a set of 12V bulbs and the owner is convinced even more. What's happened is the rusty chassis connections, thin wiring, and dirty switch contacts aren't dropping as much voltage, because the 12V bulbs draw half the current, for the same candlepower. Now, had the wiring been properly restored, with correct gauge cable, and good clean connections, it would have been noticed the 6V bulbs gave out the same amount of light. Light bulbs in the early days were rated in candlepower. That's the amount of light it puts out, regardless of anything else. So, a 32CP bulb puts out 32 candlepower of light whether it is 6, 12, or even 240V. The optics of the Model T headlights are often overlooked as being a contributor to low light output. Unlike modern cars with their pencil beams, the T headlights provide more of a flood light. One has to realise that 32CP spread over a large area is going to appear dimmer than if it's concentrated into a narrow beam. Tarnished reflectors only make this worse.

Coils work better at 12V if no magneto.

For those without a working magneto, 12V is seen as the next best thing. And indeed, results are good. But is it actually necessary? Coils performing poorly at 6V are usually a result of them being in poor condition to start with, or other ignition troubles. Again, by means of brute force, 12V often ensures a good spark. See here for further information.

Modern accessories.

This is one of the most common reasons for the switch to 12V, but in many situations 6-12V converters can be used. These are still available new, or at a considerably lower price, from swap meets. They were made for when car audio equipment became fashionable, about 40 years ago, with many 6V cars still extant. Most examples provide at least 2A at 12V. I designed and built my own here.
Where higher currents need to be drawn, there is some justification for a totally 12V electrical system, partly because the Model T generator output power is limited to only 100W. In other words, just one modern halogen headlight bulb would take it to the limit of charging capability.

6-12V converters like these can be picked up at swap meets for only a few dollars.

Parts availability.

While it is true that 6V batteries aren't on the shelves of every car parts supplier, is this really a problem? You wouldn't expect to find band linings or fan belts in your local Supercheap either.
It's not as if batteries fail all the time. It only takes a day to have one ordered in, or delivered by the NRMA; a good deal faster than obtaining most other T parts!
Luckily, the T is provided with a starting handle, so in actual fact, a dead battery won't put an end to the trip. And it's extremely rare that a battery will be unable to provide the small current, for the ignition system in cars with no magneto. It is actually quite possible, and practical, to run Ford coils from a 6V lantern battery which is available at any corner store. This can be used as an emergency measure to complete the trip. Cars with a good magneto do not require any battery to start and run.
A point to consider is that the lead plates in a 6V battery are thicker than those of a 12V one, and there's less of them. This in theory should give longer life. So far, I've had over eight year's service with my battery.
Furthermore, is that where a 12V battery is used to drive an unmodified 6V starter motor, much more current is being drawn, than by a proper 12V starter, which can only reduce its life.
Headlamp and ancillary light bulbs are often said to be available 'everywhere' if you use 12V. One has to question just how often bulbs burn out, given the infrequent use most T's get. There seems to be a fear of being stranded in the dark with no headlights, should a bulb blow, despite most T's never being driven at night. One has to remember that with the two headlights, there are actually four filaments that have to burn out before being plunged into darkness.
The double contact bayonet headlight bulbs, even in 12V, are in fact, not used in any

modern car, and are certainly not on the shelves of every service station. Seeing as they're going to have to be ordered in anyway, this makes them no more convenient to obtain than 6V bulbs.
For those with non standard cars, even parts like fuel pumps and distributor type ignition coils are readily available in 6V. An eBay search of "6 volt" turns up some very interesting items.

Voltage drop.

This is the enemy of any low voltage electrical system, particularly where there are high current loads, such as a starter motor. Voltage drop comes about from several things:

- Wiring resistance.
- Resistance of terminals and contacts.
- Chassis connections.
- Battery internal resistance.

Wiring resistance is the result of an insufficient gauge (or thickness) of the copper conductor. The original Model T wiring harness is quite sufficient for the job, but many cars have been rewired using something of lesser gauge. While such wire might be satisfactory for 12V, remember the current draw for any given power at 6V is double. All wire has resistance, and the more current flowing, the more voltage is lost. For example, if a length of wire has a resistance of 0.1 ohms, and it's feeding lamps drawing 120W, then 1V will be lost with a 12V system, or 2V with a 6V system. So, before rewiring your car, be sure the wire has adequate thickness. A common trap is the starter motor cable. This, as sold for 12V cars, is much thinner that what is required for 6V. The result is a very sluggish starter motor on 6V, when this has been used.

85 years of tarnishing and corrosion, of all the switch contacts, bulb socket contacts, and various terminals, also contribute to a poor electrical system. Again, 12V will mask this, but the correct procedure is to ensure all connections are clean and tight. All that's usually needed is a clean with a scouring pad until the connections are bright and shiny. And, of course, terminals must be tight. The screws on the Fordite terminal block need to be checked from time to time as they do loosen. A reproduction terminal block can be used to eliminate this problem if desired.

The starter motor.

The most serious problem is the starter switch. Here, we are switching around 150 Amps. The slightest voltage drop will cause overheating, and eventual loss of temper of the switch contacts. This can be clearly felt by holding the terminals of the starter switch after cranking the engine. That heat is power which the starter motor has been deprived of, so it's no surprise it runs poorly.
While starter switches can sometimes be rebuilt, it is a futile exercise once the phosphor bronze leaves have lost their temper and continue to burn up. Fortunately, there is a good reproduction switch available.

The brass leaves of this switch have lost their springiness after being overheated. It is impossible to achieve reliable contact, thus causing voltage drop.

Further power can be wasted in the earth return. Does the battery earth strap get hot after cranking? If so, chances are it's too thin and/or the connections are dirty. Are the chassis rails clean where the engine mounts sit? All the starter motor current flows through here, so is a potential point of power loss. And finally, how well is the starter connected to the hogshead? Are all four screws clean and tight? Remember, the gasket here is an insulator, and through those four screws is the only way the current can flow back to the battery. A highly recommended reliability enhancement is to run a thick gauge wire from one of these screws direct to the negative battery terminal.

Now, what of the starter motor itself? Few are so bad they won't rotate at all, but if the windings have shorted turns, the brushes or commutator are poor, or if the bushings are badly worn, then it won't work properly under load, and may well draw excessive current, causing further damage.

There should be at least 4.5V at the starter motor terminal and it should crank the engine quite rapidly; if not, it indicates a problem with the wiring or starter motor, not a reason to install a 12V battery.

The final thing not to overlook is clutch drag. If the car is hard to crank by hand, then the starter will be loaded down too. Again, rather than 'force' the starter to overcome this drag with a 12V battery, the bands and high speed clutch need to be examined. If a T can't be hand cranked all year round to start it (back wheel jacked up or not), there are problems that need to be looked into before blaming the electric start being poor on 6V.

Lighting.

Usually the contacts of the ignition and lighting switch are in good condition and only need a clean. Some care needs to be taken in bending the tabs holding the fibre contact plate to the back of the switch.

Using the chassis of the car as an earth saves on wire which is why manufactures do this. And, it works well – while the metal is all bright and shiny. Once the rust has set in, and mud gets between the body panels and chassis rails, the dim light and intermittent ignition problems start to appear. Examining the headlights reveals about half a dozen chassis and body panel joins, before we get back to the negative battery terminal. One either has to keep all these clean, or more reliably, run an earth wire direct to the negative battery terminal from each electrical accessory.

The headlights themselves contain several connections before the outer bulb contact reaches the headlight body itself. The focussing mechanism is one place precious volts can be lost. Here it's a good idea to solder a wire direct from the lamp socket to the headlight body.

Summary.

To make a T run well with 6V is really nothing more than following the stock standard design, while ensuring all electrical components are in good condition. The points to observe are as follows:

- Appropriate wiring gauge for the wiring harness, starter motor cable, and battery earth strap. The reproductions are satisfactory.
- Starter motor switch with clean and springy contacts.
- Starter motor with good windings, brushes, commutator, and bushings. (A shiny coat of black paint is not a sign of these things!)
- Reliable earth returns, whether body connections are kept clean, or separate earth wires are used.
- Lighting switch contacts clean and tight.
- Headlamp sockets clean, particularly with regards to earthing.

Rate of charge.

Now we've got our car running successfully with 6V, what to set the third brush to? Given that the battery on charge will be around 7V, and the generator is limited to 100W, this gives about 14A maximum charge. However, this amount of current will soon overcharge the battery (unless the headlights are used continuously). It also puts needless stress on the generator. In practice, I've found 5A to be quite sufficient. Not only is the generator lightly loaded, but the battery won't be damaged from over charge.
For those who wish to have a higher charge rate, the Fun Projects http://www.funprojects.com voltage regulator is highly recommended. This works by cutting off the generator output when the battery reaches full charge at 7V. It is a direct replacement for the standard cutout, looks identical, and requires no modifications.

If you've made your mind up that 12V is for you, then there's a few important things that need to be considered in order to do the conversion correctly.

Lighting.

The only modification here is to simply change the bulbs for their 12V equivalents, and to use a 12V flasher if indicators are fitted. All these are available from the usual repro parts sources, while flashers and some bulbs can be obtained from modern car parts suppliers. For those contemplating LED indicators, beware of problems with some flashers not being compatible, and also magneto interference causing erratic operation. As the LED's draw such a low current, it is necessary to load them down with 15 ohm 10W resistors, if these problems are evident.

Ignition.

Ford coils are happy with 12V as they are, but should not be left buzzing continuously. Points life will be shorter than with 6V or magneto, but still many thousands of km. Distributor ignition obviously requires a 12V coil, but check whether or not a ballast resistor is required with the coil you're using. For example, the Bosch GT40 connects directly to 12V, whereas the GT40R requires a ballast resistor to drop the voltage to around 9V. Use of such a coil with no ballast resistor will cause it to overheat and burn the points.

Horn.

The standard battery horn could be rewound with twice as many turns of wire having half the thickness. Most will find it easier to just install a dropping resistance, which is satisfactory. Here, ceramic bodied ignition ballast resistors (typically these are 1 to1.5 ohms) can be used, but it may be necessary to use two in series. The horn voltage should be checked with an analogue volt meter and resistance adjusted accordingly, to get around 6-8V at the horn terminal.

Digital meters are likely to give erroneous readings given the sharp pulses of current drawn by the horn. Motor driven “ahooga” type horns are used in some cars. If the motor windings are such that the field coils are in parallel with the armature, then the motor can be rewired so that they are in series.

Again, a dropping resistor can be used to avoid any modification, and as with the standard horn, the value has to be found experimentally.

Generator and Cutout.

The stock standard generator will in fact charge a 12V battery. This is because it has a constant current output. If, for example the third brush has been set to 5A at 6V, it will put around the same current into a 12V battery.

The third brush adjustment is much more critical and tricky to set to the exact current at 12V, and the generator is still limited to 100W. This gives a maximum 8A charge rate. However, the battery is liable to be overcharged and damaged, if constantly charged at this current, so either install the Fun Projects regulator, which is also available for 12V, or keep the charge current down to 3A. Unless the generator has been rebuilt, it is likely that the windings will be in poor condition with failing insulation, so it is worth having the generator rewound for 12V.

While the standard cutout will function, the voltage coil will be exposed to twice its working voltage. Either replace it with a diode type cut out, or again, use the Fun Projects regulator.

Some owners install alternators to obtain higher power. Something to bear in mind here is that the alternator fan has to be removed, when the alternator is mounted in the normal generator position.

This removes the forced cooling, and therefore the output available is not as high as first thought.

The Starter Motor.

This is the most awkward part of the conversion, and thus usually incorrectly done. Many owners simply put 12V into the stock 6V starter. Several undesirable things happen (which are unfortunately out of sight, and therefore out of mind). Firstly, the current flow through the windings, brushes, and commutator is higher than at 6V. Eventually, and it may take many years, depending on how much the car is used, these abused parts will fail.

Secondly, the torque of the starter motor is much increased. This puts much more stress on the Bendix, which in turns chews out the ring gear teeth faster, once it has slammed into the flywheel with greater force.

It is no surprise that Bendix failures occur more often in cars with a 12V battery and 6V starter.

Bendix Spring Resistor.

The much used "Bendix spring resistor" method of using a 6V starter on 12V is unfortunately a fallacy, although it's better than nothing. Firstly, if 6V really was dropped across the Bendix spring, it would glow red hot. Assuming a 160A starter current, the power dissipated would be something approaching 960W! This it doesn't, because there's actually nothing like 6V dropped.

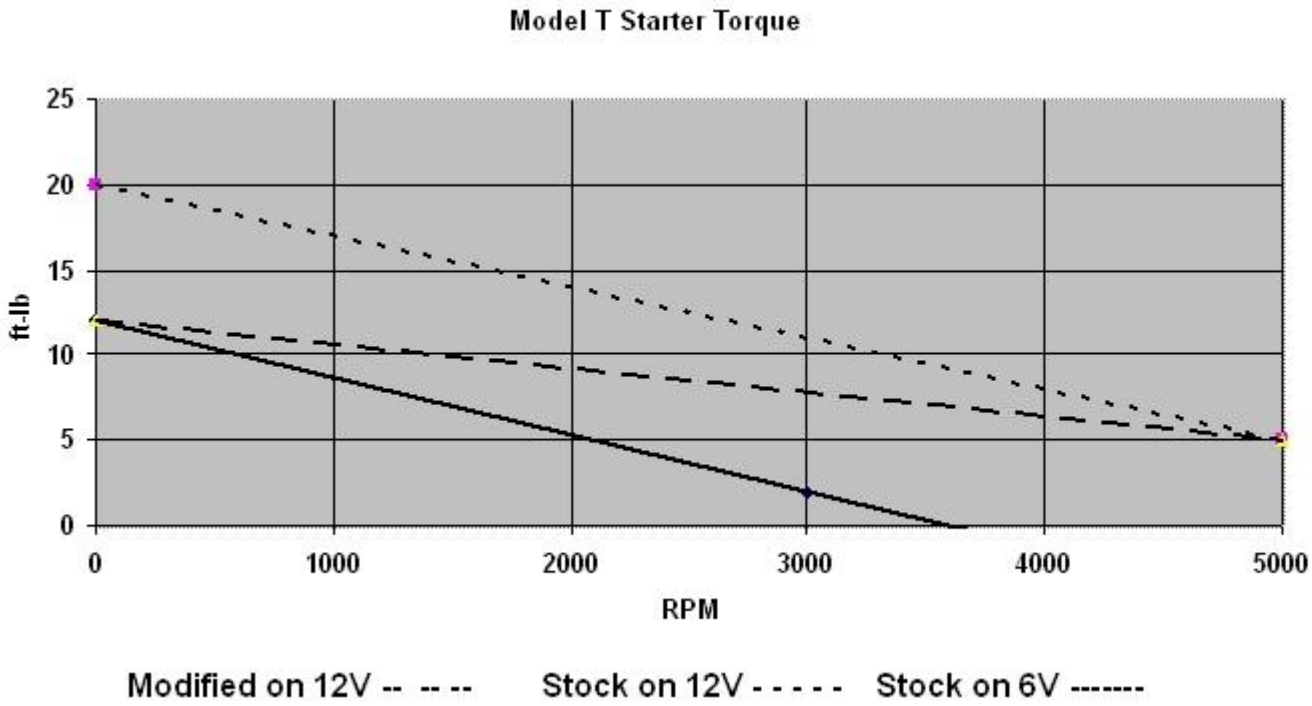
There are two problems using a resistor here. One is that the voltage dropped across a resistor depends on the current flow. The greater the current, the greater the voltage drop. And, the current required by the starter is not constant! The unloaded current for the Model T starter motor is much less than when it cranks an engine full of cold oil. What this means is that pretty much the full 12V appears across the starter motor as soon as the switch is activated, driving the Bendix into the ring gear at a greater force than intended. With the starter under load cranking, the current increases and the voltage now drops. But the Bendix and ring gear damage has already begun.

Secondly, it is an extremely inefficient method. As pointed out above, a lot of energy has to be wasted in heat during starting. It could be argued that this is for a very short and intermittent period of time, but the fact remains that more current is drawn from the car battery, than if a 12V starter had been used.

The same comments apply, as to when a long cable used as a voltage dropper to the starter motor.

12V Starter.

The proper way to start a T on 12V is to have the starter rewound for 12V. Alternatively, it is possible to rewire the motor so that the four field coils are all in series with the armature. This chart comes from Ron Patterson on the mtfca forum.



As can be seen from this graph, modifying the motor for 12V will give performance much closer to 6V operation with similar torque at cranking speed.

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