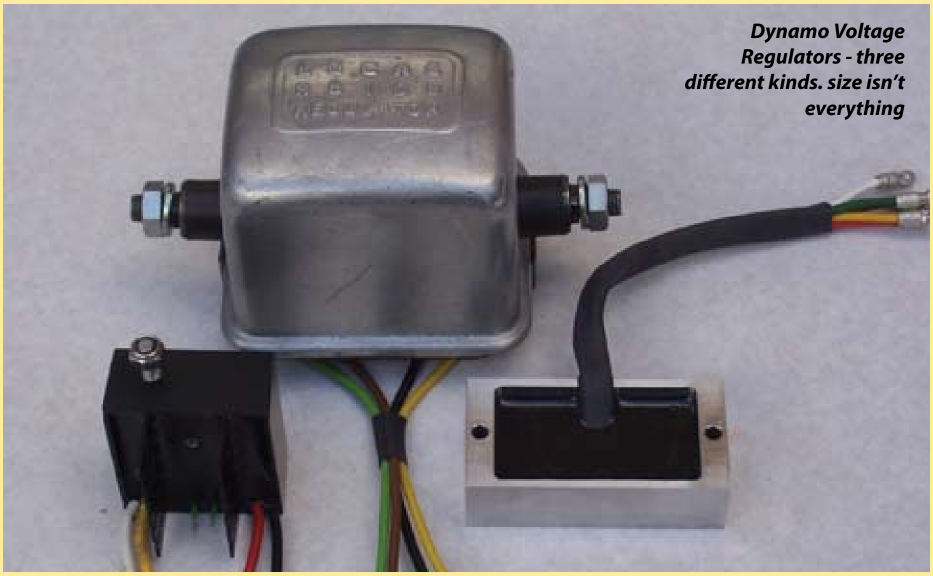
CLASSIC TECHNIQUES

Regulation, Regulation, Regulation

Mike Hutchings reveals the dark inner workings of the voltage regulator, and suggests alternatives

Illustrations by Mike Hutchings, RC RChive

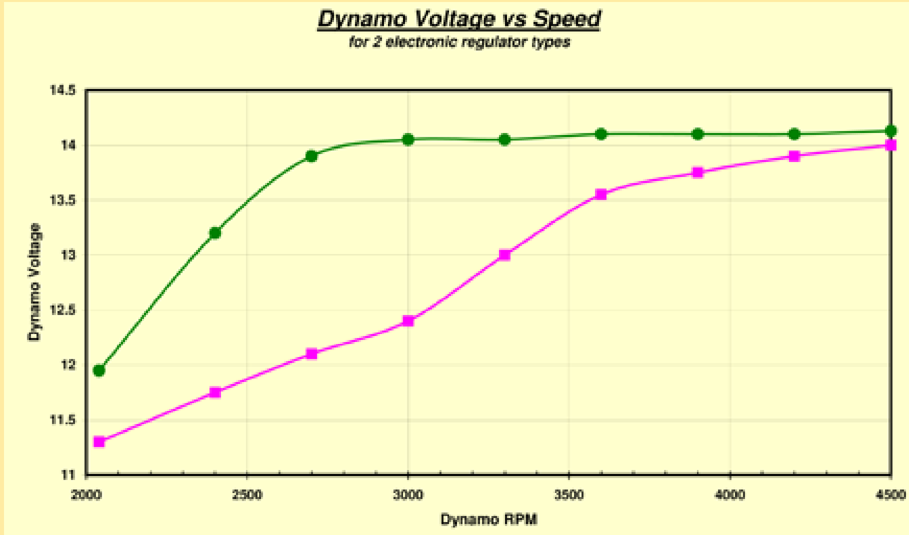
How often is it that you hear of a RealClassic (defined here as a machine with dynamo charging and magneto ignition) suffering from electrical problems? Some form of electrical gremlin is behind many a machine breakdown, particularly in these dark winter days (nights?). Magneto issues often lead to being stranded and a breakdown call. But charging problems and no lights are commonplace as well. The fault will lie in the dynamo and / or the regulator, given the big assumption that the wiring and battery are OK. In practice the author believes that the voltage regulator is more often to blame than the maligned but basically



Dynamo Voltage Regulators - three different kinds. size isn't everything

BSA's A10 was entirely conventional for its day, with separate magneto and dynamo, the latter regulated by a voltage control unit under the seat

All electronic regulators are not the same; here are two which offer very different characteristics



robust motorcycle dynamo. So this piece will attempt to highlight some regulator issues and describe fitment options.

The favourite source of electrical current for our classic machines up to the 1960s was the dynamo or dc generator. To be useful, the output has to be controlled or bulbs will blow, batteries will boil and smoke will be generated. Early machines often used a third brush to effect essentially current control, with additional options for high and low output currents (ref. PUB, RC52).

As early as the mid 1930s the voltage control box or regulator was introduced. This was the familiar electromechanical device using two (sometimes three) relay-like coil bobbin and contact arrangements. These units greatly improved lighting and charging behaviour. They changed relatively little in the thirty or so years from their introduction to the widespread advent of the alternator. From MCR1 to RB108 their operation is much the same, while production details and fittings changed with the times. The three brush dynamo can usually be readily converted to a two brush design using this type of voltage regulator.

With the advent of electronic components at a reasonable cost, solid state regulator designs appeared some thirty years ago. Problem was that dynamos were already obsolete by well over a decade. There was scant prospect of Lucas, etc putting in the design effort to create a modern regulator for their forgotten product range. Often designs had a hobbyist slant: Here's a circuit diagram, build it, fit it, job done, easy… or not. If memory serves, it took a long time before an electronic unit with reasonable performance was brought to market. But, as is the way with technology, improvements in devices and construction methods continue to the present, and it is not surprising that more recent electronic regulators are generally a better all-round product.

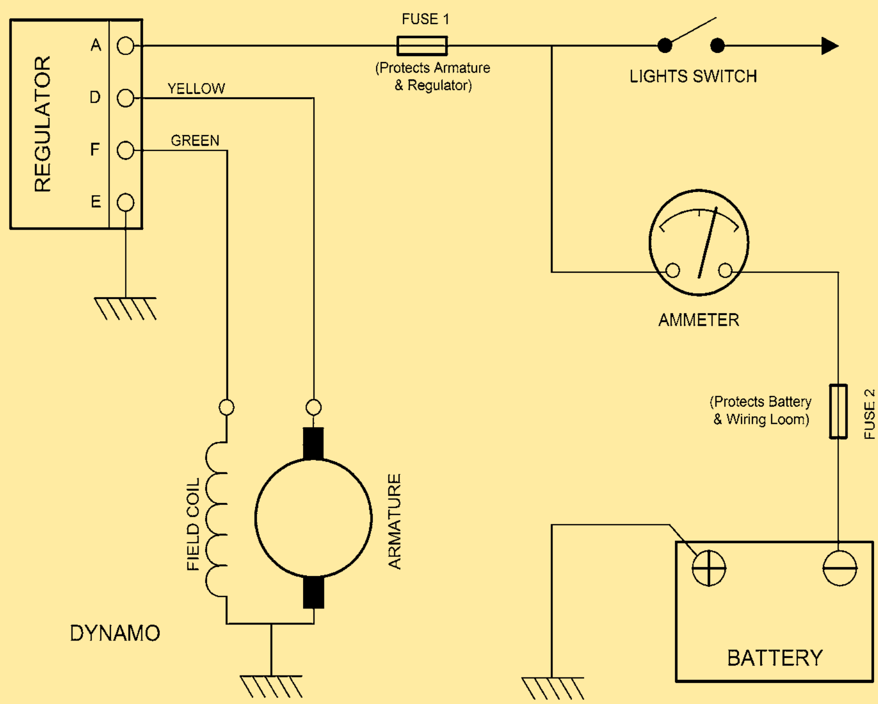
CHOICE IS AVAILABLE

With so many regulator types available the RealClassicist is spoilt for choice, or maybe left confused. A little factual information should help.

In essence, the output voltage from our motorcycle dynamo is dependent only on the rotational speed of the armature, and on the magnetic field strength through which it turns. As this field is provided by a field coil, the output voltage depends upon the voltage drive applied. The regulator as we know it controls the average field drive to give the demanded electrical output (very early-on, systems were developed ➤

It's easy to get distracted by speedo and tacho; the ammeter lets you know about the health of your charging system, and deserves a little attention

The main components of a typical charging circuit, along with suggested fuse positions



which governed the dynamo speed). The conventional mechanical regulator achieves this via a bobbin coil which opens a set of electrical contacts to cut the supply to the field as the voltage rises above a set level. So the output voltage drops a little, the contacts close again, and voltage is again applied to the field, increasing the output in turn. This cycle happens hundreds of times per second so the dynamo output is actually close to a steady level, as needed to charge the battery and drive the lights and other electrical loads. Another set of contacts in the cut-out closes another contact set at a suitable voltage to connect the load side (and opens when the dynamo output has fallen to less than that of a charged battery) so as not to discharge the battery at low speeds or when stopped.

Most modern electronic regulators provide a similar regulating function, switching the field voltage on and off in a rapid cycle to give the appropriate average voltage output. Instead of a set of points, the switching is achieved using a transistor. The cut-out function is performed in straightforward style by a diode (a device which allows current flow in one direction only). Some older designs sought to control the field drive voltage to a steady state level. This can be effective but leads to much higher heat being wasted in the driving transistor. In turn the greater heat demands more expensive and bulkier devices, or to higher operating temperature and component failure.

So it is a simple choice then, between an original-style bobbin regulator or an electronic one? Well, original electromechanical types can be very reliable when set up correctly. Obviously they prefer routine cleaning and adjustment of points gaps, and occasional tweaking of the various voltages to keep them performing well. But this is not too onerous with a decent voltmeter and a careful approach. And they are original. Modern replica boxes, most apparently from India, seem though to have a very poor reputation. Suspect materials quality means that setting up in the first instance is tricky (and they will not usually be properly adjusted off the shelf). Then they do not tend to stay in adjustment for long in use. But they are cheap!

And of course there is a small band of specialists who will refurbish original Lucas and Miller types when necessary. So it is perfectly possible to continue using the old style regulator box, and many will happily continue so to do. Either for originality's sake or a desire to keep a hands-on maintainable and adjustable charging control.

WHAT TO LOOK FOR IN AN ELECTRONIC REGULATOR

A lot of riders consider modernising this important electrical accessory to be a good investment both from reliability and performance viewpoints. Surely it would be surprising if electronics could not bring some benefits? But the procession of different electronic designs across many years may indicate that these did not all make the grade. So what should the rider be looking for in an electronic dynamo voltage regulator? Try these:

- **Steady charging voltage of correct value from lowest engine speed**
- **Easy to fit and connect**
- **Day-to-day ease to live with, reliability and robustness**

The first is not always achieved. The ideal charging voltage for most types of lead acid battery is between 7 and 7.2 or 14 and 14.4 Volts. Too low a long term voltage leads to reduced capacity and possible sulphation. Too high leads to gassing and eventual cell damage. Lower speed voltage output for different manufacturers' units varies remarkably. This may be reflected as a low charge on the machine's ammeter. Colour changing LED monitor lights may be purchased to show when the battery voltage is ideal or not. These are undoubtedly useful, particularly when lower speed charging presents a problem.

The easy to fit requirement is a given, and if they're small they can be fitted in alternative places, or into emptied original cases. The author's BSA A10 has its regulator fitted under the front of the tank (akin to where the hot-running Zener diode is fitted on 12 V alternator machines). An electronic ignition box occupies the regulator's space in the toolbox. Although not strictly requiring the available cooling air, cooler-running electronics are more reliable in the long term. The main advantage is shortened wiring runs on the bike. The dynamo field and output goes up to the regulator and the regulated output direct to the ammeter in the headlamp.

Whether the dynamo will start up with a low battery may be included in day-to-day reliability. Or even if running without a battery as an emergency get you home mode. The ability to switch from 6 to 12 V or back at any time, and moving from one machine to another is another consideration. Original electromechanical types will sometimes require a readjustment to suit a different dynamo.

Designing any electronic device for reliability on a motorcycle is 'non-trivial'. Vibration, temperature extremes, possible contamination with salt water, oil or fuel, as well as a need to withstand voltage spikes in the electrics are all considerations. The designer will hopefully have built in conservatively rated components and included transient (spike) protection as necessary. The inclusion of electrolytic capacitors which dry out with age, switches, variable trimmer resistors will be to the detriment of continued reliability. It is desirable that all the components will be potted for environmental protection.

Although various protection features should be included, it is also a very wise precaution to include a fuse or fuses in the system, as most manufacturers recommend. In the case of accidental battery reverse connection the fuse should blow and not the electronics. One minor limitation is that the electronic regulator will be either negative or positive earth. Unlike the original box it cannot be used with either polarity by flashing the dynamo.

The buying price of the electronic unit should also be mentioned here. There is a fair range, but really the initial cost is well down the list of considerations. What price the hassle of your battery running flat from delayed cut-in, or extra battery maintenance and shorter life? Apart from all these considerations, and probably others not mentioned, maybe there is truth in the sometimes heard expression 'electronic regulator boxes are all the same'.

12 VOLT CONVERSION

Another decision which faces the user is whether to change the 6 V system to 12 V. There are advantages in doing so including:

- **More electrical power available**
- **Better range of modern bulbs**
- **Less power wasted in the wiring**
- **Compatibility with modern accessories**

There is, in the yin-yang of these things, a set of downsides:

- **Need more dynamo speed to balance output (as visible on the ammeter)**
- **Cost of changes, including optional belt drive conversion**
- **Thinner bulb filaments – shorter bulb life?**
- **Loss of face in eyes of 'originalists' (oh the shame of it!)**

Take as an example the popular Lucas E3L dynamo, which is rated at 60W. Actually Lucas state 8.5 Amps at 7V at the relatively low speed of 2000rpm. Fortunately the dynamo is not aware of how much power it should generate. The dynamo armature is probably safe to run at the same current at 12V (in that the commutator solder joints and brushes should be working at the same levels of stress), giving 120W output. But considerations of extra field drive and stresses on the bearings mean that an extra 50% output is probably about the long term safe limit. To attain this output the dynamo speed must be getting on for twice as high… you can't get owt for nowt.

Note that the standard field coil must not be driven at close to 14 Volts. This would not only increase the heat dissipated in the coil to four times (2 x current and voltage) the design rating, but actually will not double the magnetic field and thus armature output. The maximum field is limited by the magnetic circuit design and is not readily changed. (The flux gradually saturates from about 6 V.)

But half as much again is worth having, and the 90W ceiling at 12V certainly gives enough power to light a 60W halogen headlight, keep the battery fully charged and leave about 20W for an electronic ignition system or other 'improvement' (if you're that way inclined).

So you have your bright lighting and universal bulb availability. But to keep the charge balancing road speed as low as may be desirable, it is worth considering up-gearing the dynamo drive speed. This is safe for the armature unless you are in a habit of using peak revs frequently. You may be able to get different sprocket sizes where chain-driven, or a number of belt drive kits are on the market. There are choices here of belt type. Plain 'V' belts can suffer from oil contamination leading to slippage. Notched belts are resistant to slip but may suffer from stripping due to shock loading. And aluminium pulleys on tapered shafts have been known to slip as well, leading to expensive damage. But it can be done successfully albeit at some expense.

Hopefully this short article has helped you decide how you may be able to upgrade your charging system for better performance and / or reliability. Dynamo charging systems may be obsolete, but there are modern choices of equipment and accessories to improve electrical output and reliability. It is even possible to go further and fit one of the new breed of alternator replacements in dynamo form. But for the majority, careful selection of regulator is at the core of achieving consistent good performance from the charging system at a reasonable cost. This goal achieved, an even higher proportion of electrical failures will be down to ignition systems, or to the magneto in most dynamo-fitted machines. Next step; Electronic Ignition? RC

Ariel singles were also conventional, with their regulator sheltering beneath the rider's posterior…

Velocette riders will be familiar with the Miller charging circuit. In this example, the voltage regulator is mounted above the dynamo