'You haven't got much, so husband it well'

Pithy advice from an athletics coach in my past, and oddly appropriate for elderly British motorcycle electrical systems.

Of all the things that help to complete a journey with a motor vehicle, an ample supply of electricity and fat sparks come high on the list. Modern vehicles have heavy electrical loads that the designers are aware of, and sophisticated generating solutions to provide for them. Only we choose to ignore that, and in standard form rely on 6 Volts at 5 Amps, a puny 30 Watts, assuming all is well, to keep us going. Hall Green, of course, in the main, knew there was a mag to keep the fires lit, and after that you could always join the caving fraternity with a candle on the peak of yer flat 'at when the darkness comes.

But we are here now, and the benefit of lights, indicators and electronic ignitions beckon, in roads populated by overpowered shopping trolleys and massive road yachts. So there it is, that little black cylinder of iron and copper. How are we going to get the most out of that space, particularly when we are stuck in traffic at 30mph?

Silicon Rectifiers are just marvellous. Electricity only goes one way through them, with only a slight drawback, and that's a small forward voltage drop when conducting, a measly half a Volt or so lost in the transaction. So for a 10 Amp current, that's 5 Watts gone to heat the world. With a bridge rectifier, needed for an alternator, there's two rectifiers involved, so 10 Watts gone west. But for a small, totally dependable and cheap as chips device that is worth paying. So the use of alternators with AC current output is viable without selenium rectifiers. Remember those?

A dynamo is an alternator with a mechanical rectifier in the form of the commutator, kept in sync with the generated current by being on the same shaft. There's no voltage lost, except in the (sometimes very good) brushes arrangement. But we do need a way of stopping the current flowing back into the dynamo from the battery when the output voltage of the dynamo is less than that of the battery. In olden days this was a relay in the regulator box, dropping out when the dynamo slowed down. But now a rectifier gets in there somewhere, but we can use a thing called a Schottky diode, with a voltage loss of something less than 0.2 of a Volt.

These generators are essentially amplifiers, they take an input current and multiply it by rotational energy to produce an output current. That input current goes into an electromagnet, and consequently can consume a significant part of the device output power. If to make 10 Amps, five are used, that's not very good.

Excluding filling that cylinder with an alternator, we have three ways to get more out of it. We can reduce the loss of the connection to the system by using a fancy blocking diode, we can mitigate the input current as much as possible, and we can run the thing at twice voltage. The dynamo has a current rating, and exceeding this will burn it out, while if the insulation fails at 12V rather than 6, it wasn't going far anyway. Getting 12V out of it at a useful RPM is the work of the regulator, and that's where most of the effort has gone.

Make Mine Switched Mode.

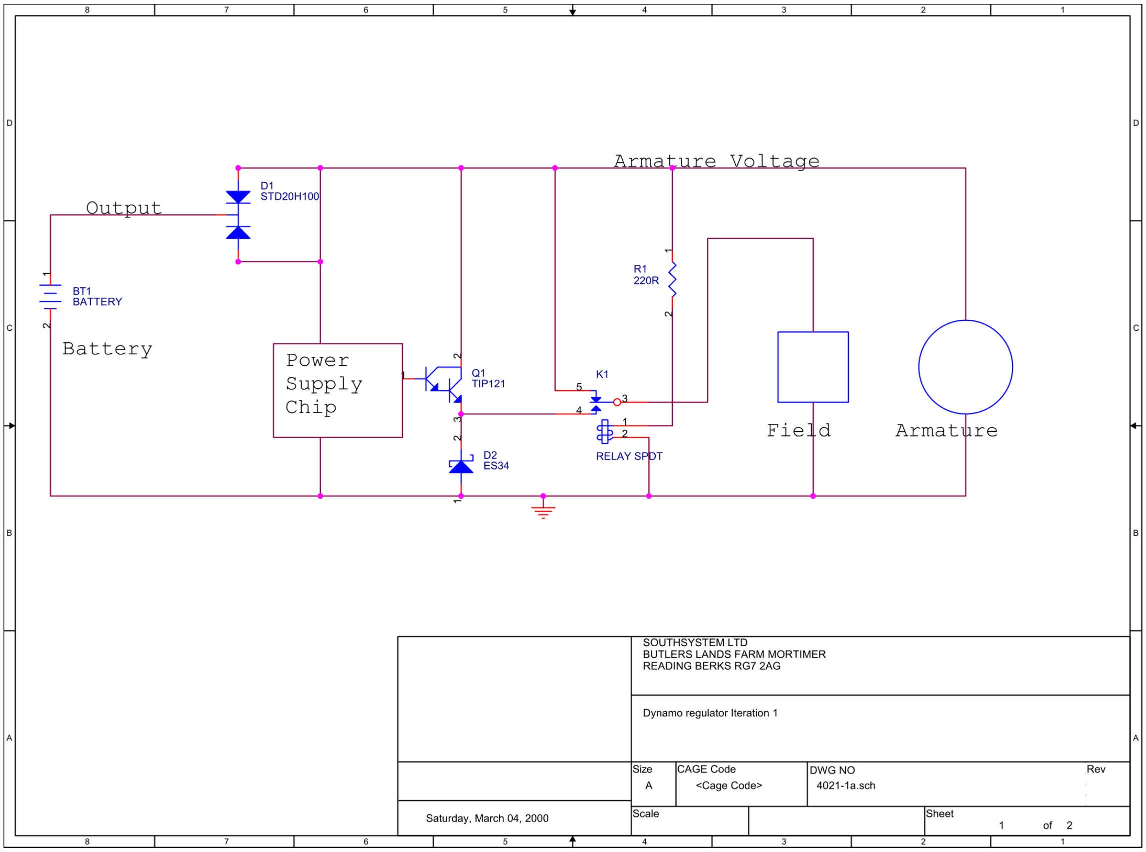
So we have to feed a current into the field which is inversely proportional to the output voltage. The volts go over a limit, the field goes down, and vice versa. There are at least two ways of controlling a current into a load. Imagine a water pipe feeding a tank. The water flows at a fixed rate, so we could match the input to the tank by diverting some of the input water away and leaving a little to go into the tank so as to not overflow it. Not a particularly good analogy, but an electrical system can do the same by constantly allowing current in and turn what it doesn't want into heat. This approach gave us hefty electrical goods that made a lot of heat - a bit like the valve amplifier I'm listening to now, bought from eBay as a kit. And very good too, but heavy and hot. We want light, not heat, so forget that. Modern electronics give us mains adaptors in the plug, which provide 5V at an Amp, by using switch mode technology.

Suppose you took that input pipe, and rapidly turned the water on and off. The volume flowing would be a function of the mark/space ratio of the tap, and there's no waste. The difference with electricity is you can use an energy storage device and get a higher current out than you put in, albeit at a lower voltage or we would all have free electricity. And low voltage, high current is what we want for the input current that goes into the field of the dynamo.

Every bit of electronic kit needs a power supply, and these are now just a single chip. The chip has to look at it's output power, and if it rises, reduce the input power. And vice versa. Exactly the same as we need for a dynamo regulator. So by using a power supply chip, we can derive the high current low voltage for the dynamo field from a higher voltage at a lower current. And reducing the current is what we want**.**

We still need the same field current for a given output, but the switch mode approach will provide that at less source current than a resistive regulator.

Iteration 1



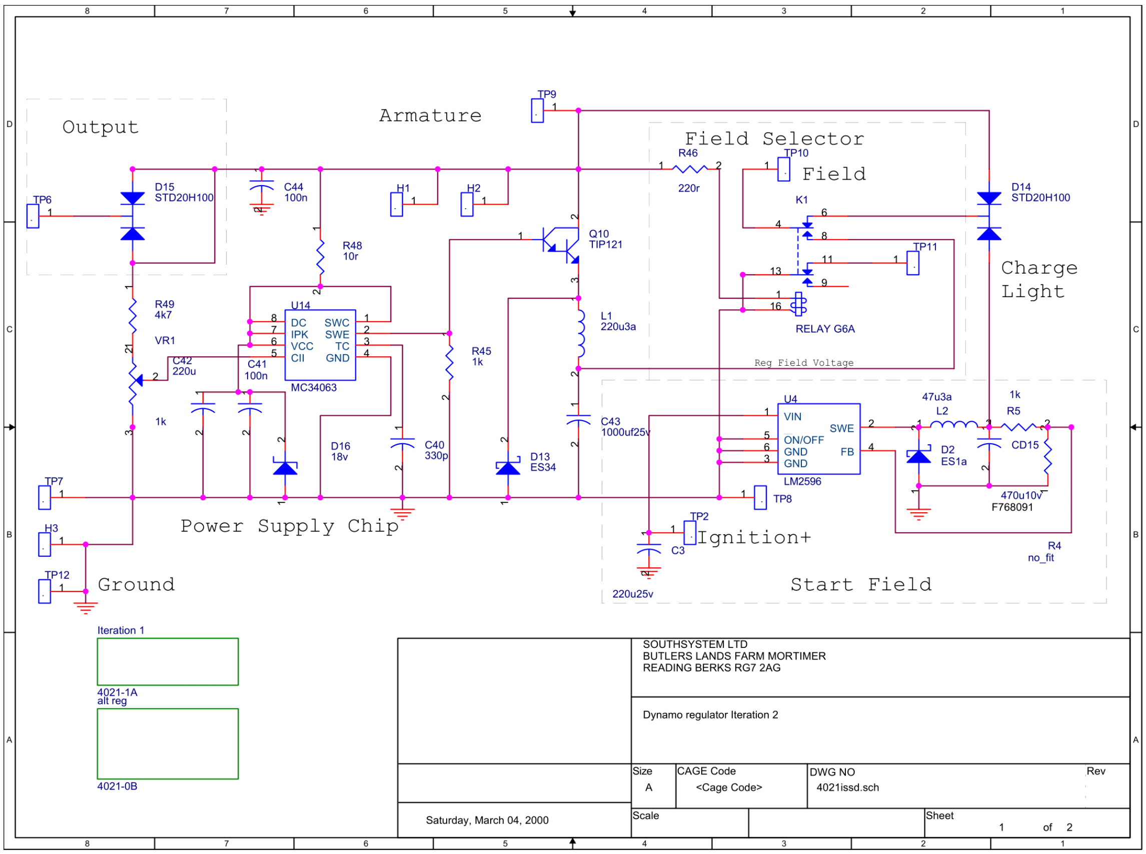
The key to this, and subsequent iterations, is the relay. This is how we are going to switch between field voltage sources. This is a 12 Volt part which actually energises at about 8 Volts. The relay voltage is increased by resistor R1, so that 12 Volts is required to turn it on. This iteration relied on the hope that the dynamo had sufficient residual magnetism to spark itself up with no field current. It did sometimes. The idea is that when the armature voltage is below 12 Volts, the relay connects the field directly to the armature. The residual magnetism provides the small start current which rapidly increases, and at no cost we quickly have 12 Volts on the relay, which changes over to the regulated supply. If the rotational speed is insufficient, the armature energy is small and the field current correspondingly small, so no tiresome burn out.

When the relay changes over, the power supply chip is then in charge. If the rail voltage is too low, it ups the field current, until the correct rail is reached, at which point, it adjusts the field current according to the load.

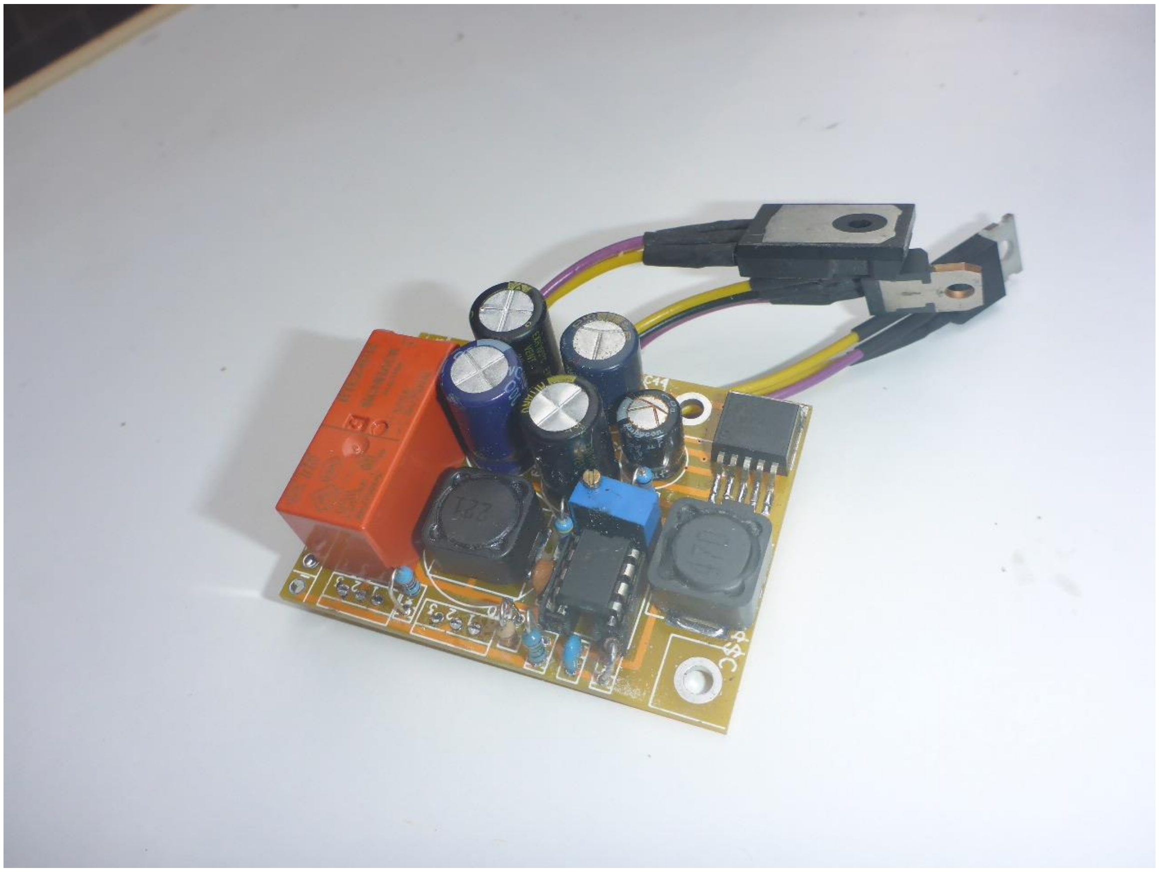
This worked marvelously, except my dynamo didn't always spark up. When it did, there was never a shortage of charge and all was good in the woods.

A few details. D1 is the blocking diode, Q1 is a current amplifier for the power supply chip. When the supply voltage is between relay change over and correct regulation, Q1 provides a very low resistance path between the armature and the field, getting us charge very quickly. This design uses the field as an inductor, giving us our energy storage. D2 is part of that story.

Iteration 2



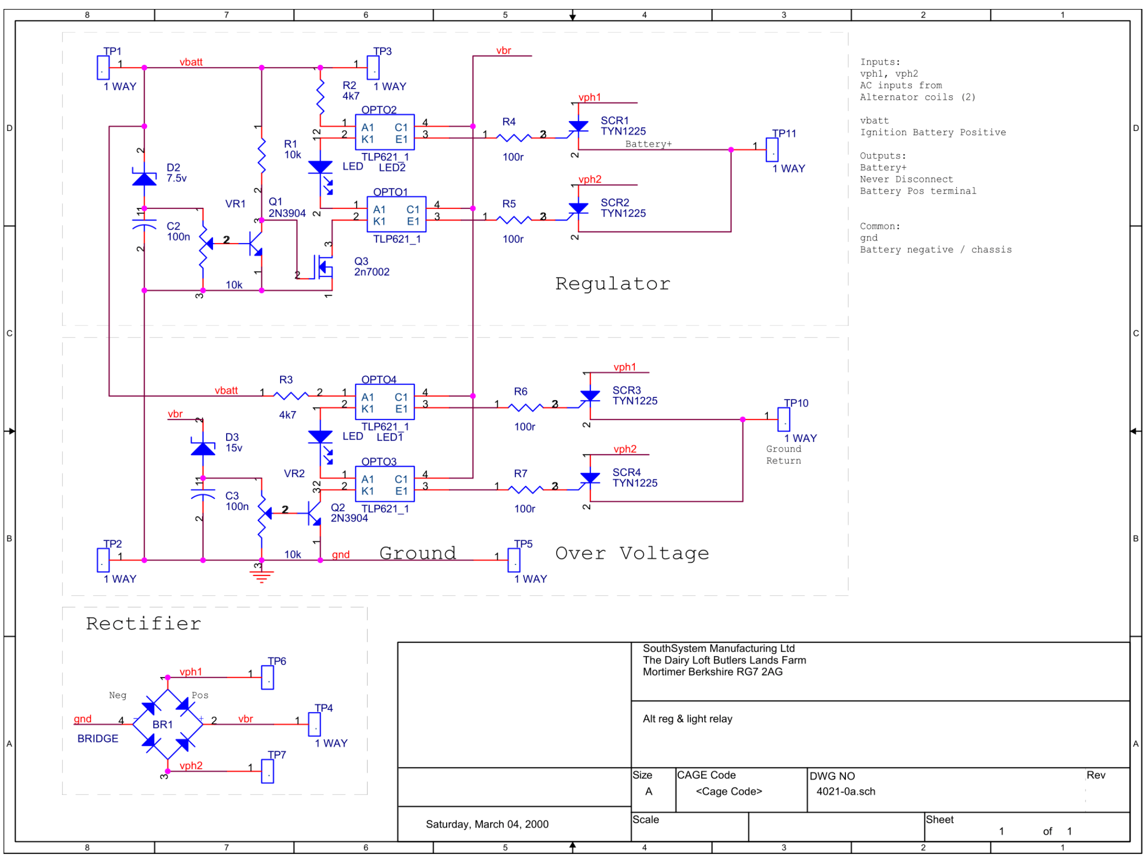
This is the same as iteration 1, only it provides a feed current into the field coils from a separate supply to guarantee start up. The switch mode principle is used by the second supply to provide 1.2 Volts across the field when the ignition is live. This uses 85mA at 12 Volts, and sparks the dynamo up instantly. There's a double rectifier (D14) that chooses the highest voltage between the 1.2 Volts from the power supply or the rapidly rising voltage from the armature. Once the relay clicks in, the main power supply drives the field and away we go. I tried using one power supply, but for various reasons it became more complicated than it was worth, so two separate power supplies are doing the same job. Colin Chapman would not approve! The relay buys me my charge light, so there is a two for one deal there.



So my interest was aroused by the Kubota alternator solution. Aha, we like alternators, much power, no brushes, all good. They can fit the Velo too, this should be good. eBay produced one for a parsimonious 20 quid, and an interesting thing it is. It's a bike dynamo, strong magnets flying past coils, a standard fixed output generator, and none the worse for that. Two wires, no control, we need a regulator. The part I bought has a very close fitting stainless shroud on the rotor over the magnets, that makes a very close fit between the backplate and the rotor, keeping small children and metal objects out. Half a potato field was in the thing when I got it, but it was all very fine particles.

The traditional method with fixed output devices is to absorb the output into the load, and if the output voltage goes too high, short out the device so it contributes nothing. There are special rectifiers which are very suitable for this sort of thing in they have a third terminal and remain inert until current is pushed into the control point. These are called SCR's or thyristors. Upon triggering they become rectifiers, current will pass only one way. The device remains as such even after the trigger has been removed until the current through the main terminals falls to nothing. So in an AC supply such as from an alternator, they can be turned on with a pulse and reset automatically when the supply voltage reverses. They are very robust devices and generally cheap as chips. All good.

When you are flying along and the alternator is making much more than the bike needs, the excess could be lost by thyristors, shorting the output. The energy loss is not so high, I measured 25 Amps short circuit current at 6k RPM, but as the output is short and there's maybe a Volt developed in the circuit somewhere, that's only 25W of Velo urge not making it into the countryside. If you consider the approach with a Zener diode, the favourite solution for some alternator systems that clamps the system voltage by dissipation, there will be maybe 20 Amps at 14 Volts , the best part of a third of a horse being chucked away. We won't do that (although switched coils in the alternator helped). But suppose we turned the tap on when we wanted juice, and turned the tap off when we had enough? As I discovered as a yoof hurtling down a hill and fiddling with the Miller dynamo on my pushbike, large voltages are developed off load by these machines. Consequently, open circuiting the device may create enough terminal voltage to break down insulation or damage the regulator, so what to do?



Turning to the mass of squiggles that is the alternator regulator schematic above, there are three parts.

The component bottom left marked 'Rectifier' accepts the alternator output, and four rectifiers turn it from a bi-directional current flow into a pulsing unidirectional flow. These guys are a large block with spade terminals which make for obliging wire terminations. Only the lower half, conducting the negative voltage to ground carries any real current, the top creating a positive voltage used to drive the circuit. It's here we would see excess voltage.

The section marked 'Regulator' is what we are interested in. To the left in this section are transistors, Q1 and Q3, which allow current to flow down through the opto-isolators, opto1 and opto2 if the battery voltage falls below a threshold set by VR1. When that happens, current flows between the output pins - and as suggested, it is optically coupling with galvanic isolation from the input, up to 1500 Volts worth here. That current flows into the control terminals of SCR1 and SCR2, which then become rectifiers and hey presto, out comes current into the load. When the battery voltage goes up, Q1 turns on, Q3 turns off, the SCRs turn off, and the battery is not fried.

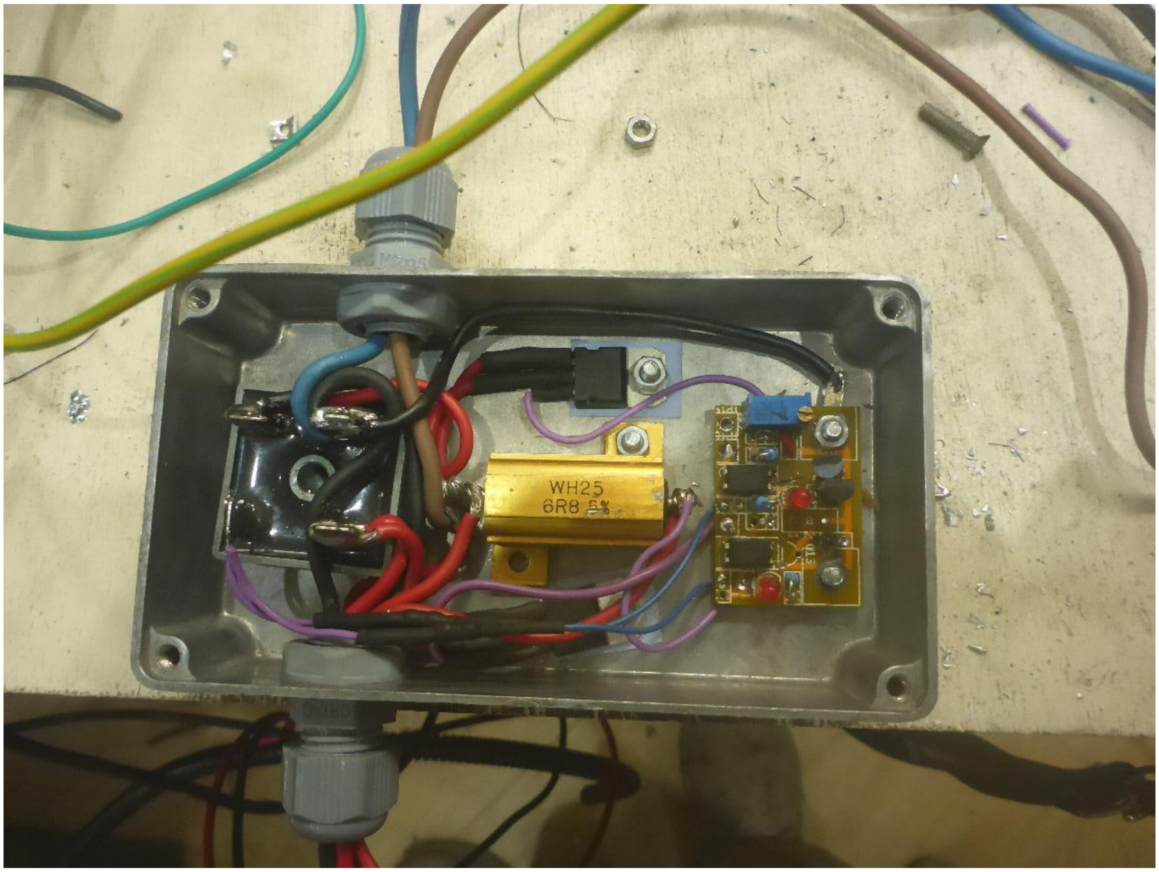
Aha! I hear. What about the open circuit voltage? The words 'Over Voltage' give it away, when the setting of VR2 says 'Too Much', Q2 turns on and SCR3 and SCR4 are turned on, draining all those lovely Amps to ground. Because they only develop a Volt or so across them their power dissipation is quite small. The short circuit current of the alternator is limited probably by the core saturating and the winding inductance at the higher frequency of the induced current at full chat.

The LEDs just show it's all working.

A couple of points.

The huge golden resistor in the middle of alternator regulator was initially employed as the destination of overcurrent in an earlier iteration of this. It took great exception to 10A and let go, in quite a big way. The remains are being used, as it's very open circuit now, as a terminal block.

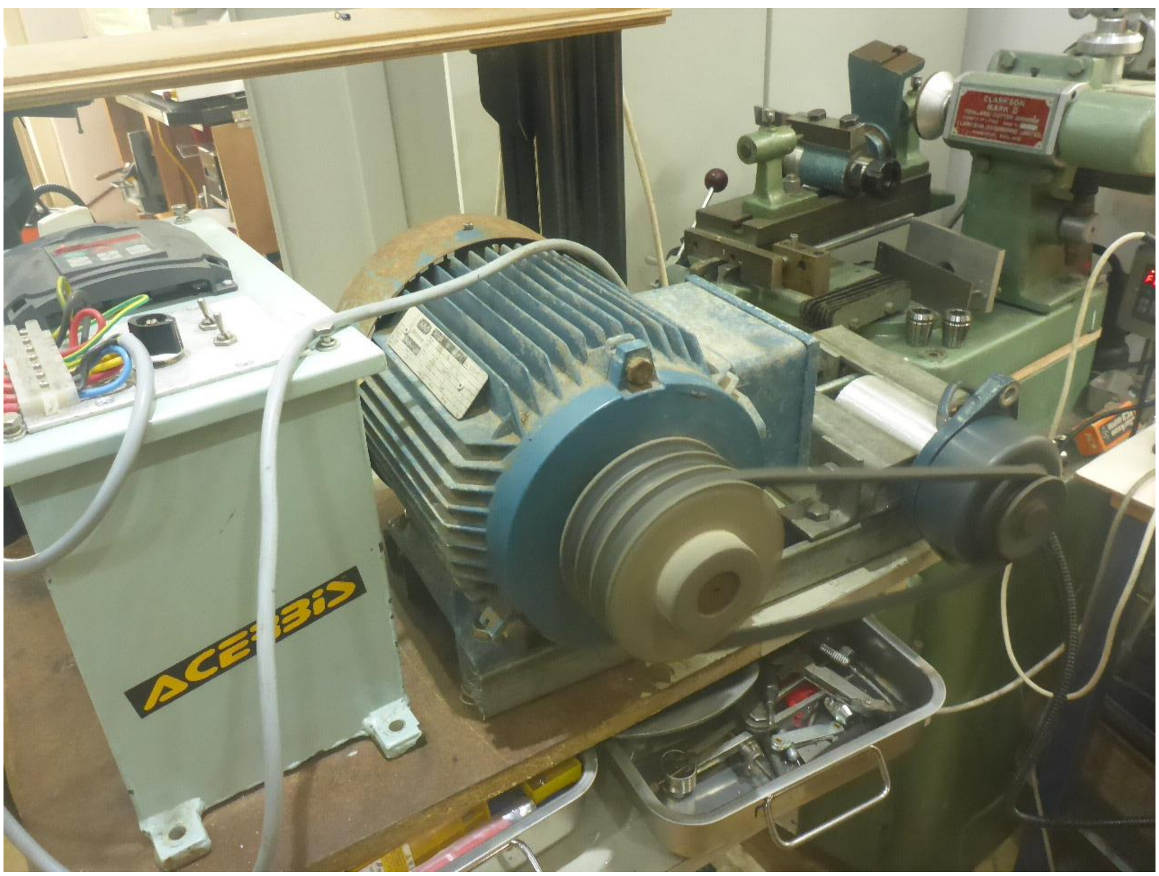
The Test Points in the full schematic of the dynamo reg are where the wires from outside join.



Numbers, My life.

The Dynamo.

The field coil exhibits about 4 Ohms resistance, which with 6 Volts applied will draw 6/4 = 1.5 Amps, 9 Watts, which would have been the design maximum for the dynamo. The armature for a 30W dynamo can supply 30 / 6 = 5 Amps, so we can stay in design with this 5 Amps limit, but by doubling the voltage, we get 60W. The dynamo will produce whatever voltage you want, so long as it's going around fast enough. By using the relay, ignoring the spark-up supply, the armature voltage rises very quickly to 12 Volts as the rpm increases, getting us output soonest. When the relay changes over, the primary field supply can deliver 8 Volts into the field, a bit of an overdrive of 25 %, and assuming we don't saturate the field then 80 Watts seems reasonable. The Velo uses LED headlights and body lights, so the peak load will be intermittent. The start of charge corresponds to about 35mph in top, and below that, that's what storage batteries and third gear are for. The spark-up current is nothing once it starts.



The Alternator

This guy was quite brutal on current, able to get 17V on a large mobility battery without difficulty , until tamed. Off load at 6k RPM, it produced about 45V, and I prefer not to worry about that rather than put 25 Amps short circuit through the wiring and connectors. So it's the rev limit that determines the max PD of the alternator and the overvolt protection is left off.

Costs.

There's an awful lot of gubbins in these things, but the components are spectacularly cheap for what they are, and making electronics is my meat and drink. Include development time, expensive - but I like a little engineering research, so overall, not expensive.

It's easy to be generous with the silicon. Iron and copper things can to horrible things to electronics, but I have used 1200 Volt, 25 Amp silicon controlled rectifiers and a 400V, 35 Amp bridge rectifier in this. If I was designing it for Dyson to sell I'd have been a little tighter, but I'm not, and the price delta for the extra Amps and Volts is negligible.

The Beat Goes on.

So, we have a working and adequate dynamo solution for the Velo, and an alternator solution, along with a suitable mounting system to put the alternator on the Velo. But we also have a BSA B31 in need of generating plant. As kids we had what I think was a MAC to ride around a field - and the sound of the timing wheels hooked me there - and I had an M20 to consistently fail get to start of my own. That taught me all I wanted to know about Joe Lucas, Prince of Darkness, so I'm always keen to get him off the pitch. I sold that to a mate for a tenner and he never got it to go. So while visiting a bike show, a chappie with a fistful of M21's kicked one over, and the asthmatic gurgle of the open carb hooked me again, and a few weeks later Small Heaths' finest was in the back of my car. Along with a B31 engine, so I could have the high power option....

I remember seeing a B31 with a car alternator slung on it at a motorway services once, and I always liked the idea. I had a Ural 650 flat twin for a while, which we all thought was hilarious, a motorcycle named after a gent's convenience, but having stuck on a car alternator , dumped the points, and twin-plugged it, I developed a deep respect for that doughty machine. It would have always got Sven to the tractor factory. Probably pushed over the tractor factory. It had some form on building re-development involving the neighbors wall, and if you wanted a conversation, ride that into Reading. But meanwhile, the Bizza has the Kubota alternator, not least as it has a sealed beam headlight on it. Quite why I'll need that whilst having my eyes shaken out at 45 MPH, I'm not sure.

Meanwhile, having fished the Velo regulator and dynamo off for a bit of measuring, the next day I hop on the bike to go to work. Chuffa chuffa, says the belt in the dynamo drive case, rubbing. Okay, drop the cover off and off we go. Too lazy to adjust the inner cover, I'll do that at work. Charge light on, must have failed to connect the regulator, press on. Arrive at the office to find the dynamo pulley and belt have frisbee'd themselves off somewhere, the pulley a worthy iron unicycle heading for the camouflage of the summer cover over the ditch, and the belt also hula-hooping into oblivion. Oh Poo, says I. Do I remember doing up the pulley nut? D'oh!

So the evening is spent making and fitting another pulley to the spindle of the dynamo, which fitted a belt I had. That's on a carrier on the dynamo taper, which will be used to carry a toothed belt pulley when that arrives from a far off land. So I can really run the dynamo to death on that.

So all in all, although I can occasionally succeed in the ‘Ancient One-Legged Dinosaur’ category I'm in now, I have never won a middle or long distance running event, but I have always finished, and never come last. And the whole point of all of this is to ensure that likewise we finish a journey that we start, maybe not the fastest, but always getting in. We just need to keep the battery full and the sparks fat.

Stop Press! I have just about managed to stop the oil falling out of the Bizza. That's a labour of Hercules.

Many thanks to Mike Raffe for the effort to review.

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