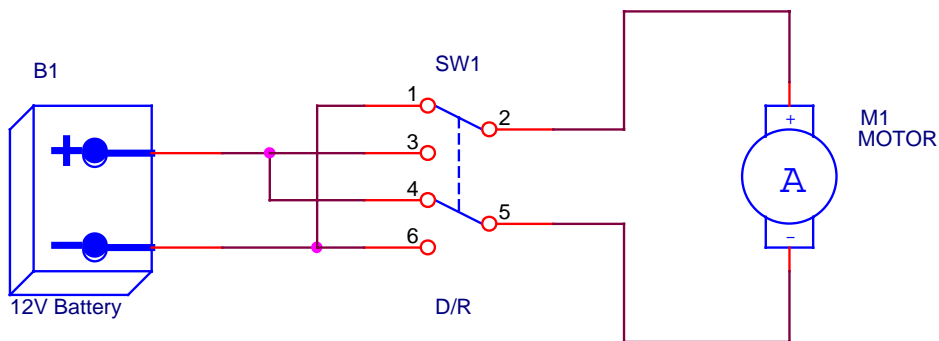


101 uses of HTC852 or practical guide to Electric vehicle

Before we jump into applications of the HTC852 PWM controller let's spend some time understanding the basics of DC power control. We will discuss motor controller case in some theoretical electric car where we have a 12V battery connected to a 12V DC motor. For simplicity we will assume that this motor uses 10A nominal current and battery has a capacity of 10 Amp / hour. To further simplify our study case we assume our system is built from ideal components where there is no energy loss. After building our imaginary electric vehicle we found that we can drive it for one hour at 40 mph. We also realize that our design is not mature and lacks some basic features. Let's analyze what would make our electric car a more mature product.

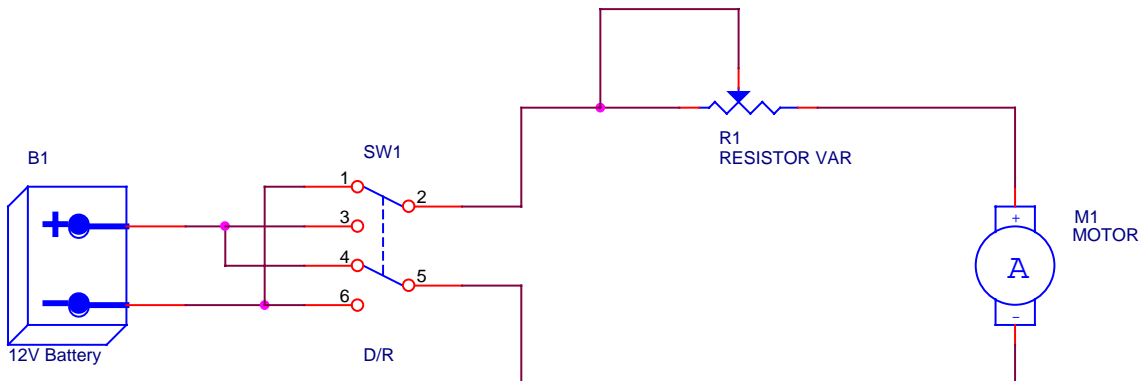
1. We need means of efficient speed control.
2. We need to increase the range of our electric vehicle (EV).



Let's try some ways to control the speed of our EV.

First solution:

One way to control the speed of our EV is by inserting variable resistor R1 in series with M1. This way we can control the voltage supplied to M1. Assuming that power output of M1 versus voltage across M1 terminals is linear we can say that if we supply 6V to M1 then our EV will develop 20 mph speed etc...



Solution seems simple and elegant but has one serious flaw. Even though we are using ideal components we are going to have some energy loss. The source of our energy loss is obvious even without doing any calculations. When we are running M1 at some less than maximum speed, we will have a voltage drop across R1, and R1 will dissipate energy in form of heat. This energy is wasted unless we are designing

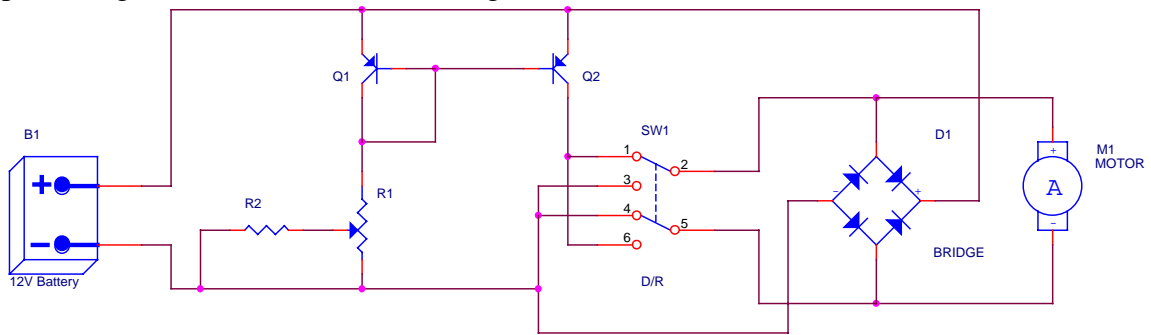
this EV for northern states (where we can use the heat to keep the driver warm and this energy loss would not be considered a loss). This means that when we drive our EV at 20 mph or 40 mph the battery will last one hour even though useful work differs in both cases. It seems that the resistor in the above schematics is the culprit. But even replacing it with a linear regulator will not solve the problem.

Conclusion:

This solution fails to meet both of design objectives.

Second solution:

This solution involves using “constant” current source to control the M1 speed. The schematic below shows one way to implement it. Q1 and Q2 forming a current mirror and R1, R2 pair control minimum and maximum current sourced by Q2. D1 is protecting Q1 and Q2 from over voltage due to inductive nature of M1.

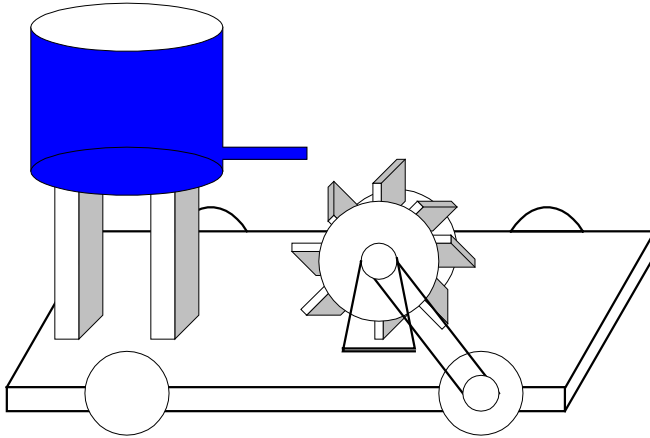


To control the speed of our EV we control the amount of current supplied to M1 using variable resistor R1. This solution is more elegant than the one above and could cost less if someone is crazy enough to build it. Basically the schematic above suffers from low efficiency because of power loss on Q2 and it is not much different from previous schematics in that respect. Most tape players use this configuration to keep motor speed constant. Advantage of this configuration is its good temperature stability which we have no use in our electric car design.

Third solution or crash course in PWM theory:

Lets take an imaginary approach to our problem. Lets change a battery with a water tank and our motor with a propeller. So our EV will become a PV (potential energy vehicle) and will look like a water tank on four wheels and propeller connected with wheels through drive belt. To charge our PV we will add water to water tank and we will control the water flow to propeller to control the speed of our PV. Considering this analogy we can easily explain why previous approaches did not work. In our previous examples we were emptying our water tank at a constant rate and applying only a portion of it to the propeller. It is one way to control the speed of the propeller and it is obviously not the most efficient way. Using a model of PV we can come up with several ways to deliver potential energy stored in the water tank efficiently. We can use an android with a small bucket and tell him to empty the tank at some rate. By changing the rate we can control the speed of our PV. The disadvantage of this method is that an android has limited range of rates that it can operate. Similar

method was used in the past in variable frequency switching power supplies (with no help from androids). To regulate the output voltage, feedback was used to control the frequency of the switch. We will call this PFM (Pulse Frequency Modulation). This method is not used anymore and more advanced power supplies currently use PWM (Pulse Width Modulation).

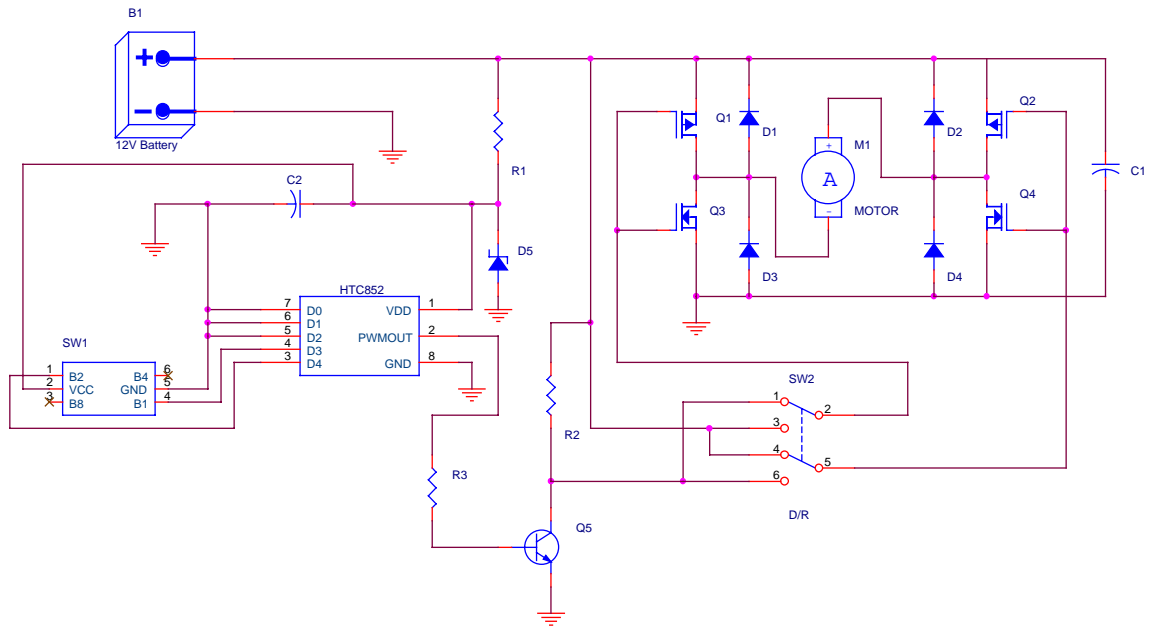


Despite the complicated name it is simple to understand. Lets use our PV model to understand the PWM technique of power control. We will use the help of an android to construct a four speed PV with extended range. We will instruct the android to use four different size buckets to power our PV at four speeds. Buckets differ in size and android is emptying the tank at constant rate. This is basically PWM method of power distribution over time.

Lets assume that the smallest bucket is four times smaller then the biggest bucket and the speed achieved is ten and forty miles per hour accordingly. To draw some parallels with our EV lets assume that our PV will travel forty miles in one hour assuming the android uses the biggest bucket to power it. Now to demonstrate the superior efficiency of our approach we will instruct our android to use the smallest bucket (slowest PV speed). This time our PV will travel forty miles in four hours. This shows that no matter what speed we drive our PV our energy output will be the same. This proves to be an efficient means of speed control. If we convert our imaginary PV to an everyday EV we can say that an equivalent EV will use two-bit PWM controller to regulate the power supplied to electric motor. The constant rate of our android will translate to a constant frequency of operation of PWM. And four bucket sizes will translate to four pulse widths selectable by two digital inputs of PWM. This does not seem to be simple and we are forced to use the services of our android to demonstrate an experimental EV. We will use a battery connected to electric motor through ON/OFF switch to power our EV. We will instruct our android to turn the switch on every five seconds and keep it on for one (two, three or four) seconds to reach the speed of ten (twenty, thirty or forty) miles per hour. The electrical signal generated by the android would have frequency of 0.25Hz and a period of one to four seconds. Here the android issues you a certificate of completion to “PWM crash course” and you are suggested to grade yourself.

Now lets talk about characteristics of HTC852. HTC852 can generate thirty-two pulse widths (thirty two bucket sizes per our PV model) in one-microsecond increments and has a constant output frequency of 31250Hz (not bad compared to the android in our

experimental EV, is it?). It has five control inputs for selecting one out of thirty-two output periods. Before going further let's draw a schematic using our HTC852 to control our EV. From the schematics we see that an electric motor is connected to a bridge type of a switch formed by Q1-Q4. D1-D4 are protecting the electronics from over voltage caused by switching inductive load (M1). D1-D4 might not be necessary for some MOSFET's because by design they contain such a diode in the silicon but they are necessary if we use bipolar power transistors. Q5 is the driver we use and could be replaced with any other MOSFET driver. Note that HTC852 is controlled by a turn switch (SW1) with hexadecimal output.



We decided to connect only two outputs of the switch to HTC852 and that will make our EV a four speed vehicle. We could as well connect all four outputs of the switch and our EV will have more smooth speed transactions or in other words will have sixteen speeds. The question that we did not answer with this design is how can we increase the range of our EV. Well the answer is as simple for EV as it is simple for our PV. We should use a battery with higher capacity for our EV and bigger or higher tank for our PV. To draw some parallels with similar technology we can say that none of the D/A converters can replace HTC852 in power control applications. Another question that is still open is that this is only one use of HTC852, what about the other one hundred uses?

It is a valid question that we can answer two ways:

1. We can build one hundred more EVs.
2. We can write down any toys, tools, appliances etc. that are using DC current and come up with complete map of possibilities. The list is so long that we are not going to bore you by including it in this article. At the end of this article we would like to say few words about electric vehicles.

Some thoughts about EVs

As interesting as it may seem, electric vehicles were invented earlier than internal combustion vehicles (ICV). My own opinion is that only limited range and power

were the main issues in those days that prevented wide spread production of EVs. Another reason at the time was an absence of any efficient means of speed control (electronics were not invented until the 19th century. Without going into further detail I can say that we can currently build efficient EVs with current technology level. The only advancement that could speed up the process is development of new types of energy storages or batteries. One more reason for less EV popularity is that there is no infrastructure for EV ownership. Think what would happen to current cars if t gas stations ware rare and if it took about ten hours to feel the gas tank of our ICVs. To summarize here is the short list of issues that slow down EV development:

1. Low range (Batteries to be blamed for that).
2. Long recharge times (again batteries).
3. Absence of infrastructure to support EVs. We need charging stations, repair and maintenance stations for EVs.

All of those issues I addressed in one posting into nanotechnology forum called liquid batteries. I think it solves all the problems mentioned above and opens the doors for wide spread EV production in less then a year!

I hope this article was informative and that it will trigger someone to come up with a better and more practical EV. I want to express my gratitude to TNT Franklin who helped me with this article.

Vardan Antonyan

P.S.

No Androids were hurt during the writing of this article. TNT is shorthand for “The National Treasure” and it wasn’t me who gave Franklin this nickname.