Re: What passes as Pulse Width Modulation in DC Motor Control?

Source: http://sci.tech−archive.net/Archive/sci.electronics.basics/2009−01/msg00472.html

- *From*: "amdx" <amdx@xxxxxxxxxxx>
- *Date*: Wed, 28 Jan 2009 16:05:02 −0600

"Dan Coby" <adcoby@xxxxxxxxxxxxx> wrote in message news:N5adnf0AQc5yiB3UnZ2dnUVZ_hadnZ2d@xxxxxxxxxxxxxxxx

> amdx wrote:
>
>> "Jamie" <jamie_ka1lpa_not_valid_after_ka1lpa_@xxxxxxxxxxx> wrote in message news:heNfl.27335$2o3.14283@xxxxxxxxxxxxxxx
>>
>>> Rich wrote:
>>>
>>>> Can anyone please tell me what passes as
>>>> PWM in Motor Control?
>>
>> Now that it's all sorted out.
>> Assuming a PWM 50% duty cycle,
>> If I put an ampmeter in the positive lead from the battery
>> and a second ampmeter in series with the motor,
>> Will the two ampmeters read the same?
>
> No. That may seem to be a little strange but it is true.
>
> Lets take an example. We have an ideal motor (i.e. no resistance losses, etc.) which is being driven by an ideal PWM (i.e. a PWM with no losses). Also let us assume that the PWM is being powered by 20 volt DC supply and the PWM is switching the motor drive between 20 volts and 0 volts. And we are driving the motor with a 10% duty cycle and that the average motor current is 3 amps. We will also assume that the PWM frequency is high enough that there no significant changes in the motor speed and current during a cycle. (This is usually a reasonable assumption. PWMs are usually run at a high enough frequency to make this true. See below.)
>
> The average voltage at the motor is 2 volts (20v times 10%). The power in the motor is 3 amps times 2 volts = 6 watts. Since there are no losses

with our ideal motor and ideal PWM, then the power from the 20 volts power supply must also be 6 watts. The power from the supply is only provided while the PWM is turned on (i.e. during the 10% on part of the cycle). During the on part of the cycle we have to be providing 60 watts of power (6 watts / 10% = 60 watts). This means that we are getting 3 amps (60 watts divided by 20 volts during the 'on' cycle. (So in this sense the currents are equal since we are putting 3 amps into the motor and we are drawing 3 amps from the power supply during the 'on' cycle.) HOWEVER the ammeter connected to the power supply will indicate the average current from the supply. Since we are supply 3 amps for 10% of the cycle and 0 amps for 90% of the cycle, we will an average current of 0.3 amps.

So the average motor current will be 3 amps and the average power supply current will be 0.3 amps.

This leaves a few questions:

1) What is supplying the 3 amps of motor current during the 90% part of the duty cycle when the PWM circuit is 'off'?

The PWM is switching the drive between 20 volts and 0 volts. During the 'off' part of the cycle, the 3 amps is being pulled from the 0 volt side of the PWM (i.e. the motor is pulling current from the circuit ground).

2) Is the motor's current and speed really constant the entire PWM cycle?

In theory, no. There is always a small amount of speed and current ripple but the amount of ripple can be made very small by increasing the PWM frequency. Since we are assuming an ideal motor (i.e. no resistance losses) then our motor looks like it has a back EMF and a series inductance. the back EMF of the motor will be equal to the 2 volt average voltage at the motor. (A real motor with a non−zero winding resistance would have a lower back EMF since there would be some voltage drop across the winding resistance.)

During the 'on' part of the PWM cycle, there is an 18 volt difference (20 volt power supply versus a 2 volt back EMF) between the motor's back EMF and the power supply. This voltage difference will try to increase the current flowing into the motor. The inductance of the motor will limit the increase in current. But there is a small (usually very small) increase in current during the 'on' part of the cycle. This increased current will try to accelerate the motor. However the inertia of the motor and its connected load will oppose the acceleration but there will be a small change in speed.

During the 'off' part of the cycle, there is −2 volt difference between
the
motor's back EMF and the drive voltage from the PWM circuit. This −2
volts
will try to decrease the motor current. The decrease in current will
decrease
the motor's torque and motor will start to slow down. Once again, the
motor's
inductance will oppose the change in the motor's current. The inertia of
the
motor and its connected load will oppose the change in speed. The rate of
decrease in current speed will be 1/9 (18 volts version 2 volts) of the
rate
of increase in speed and current during the on part of the cycle but it
also
lasts 9 times as long. Thus the total increases and decreases will
balance.

So there is some small changes in motor current and speed during the PWM's
period. However if the PWM frequency is 100 kHz and the motor and its
connected
load weigh 10 pounds, the changes in speed will be very very small.

A couple of final notes:

Please note that PWM circuits are not magical, even though we are only
drawing an average of 0.3 amps from the power supply, we are drawing
6 watts. This is the same 6 watts that is being provided by the motor
to its load. We are not getting something for nothing.

In much of the previous analysis, it is very important that we are looking
at a motor being driven by a PWM. If, instead of motor, we are driving a
simple resistor, then the current through the resistor and the current
from the power supply would be exactly the same. The resistor does not
store any energy. However the motor stores energy in both its inductance
and the inertia of the motor and its connected load.

Dan

Hi Dan,
I new the answer, I just wanted to see the responses to the inquiry.
It took me a while to get my head around it. When someone finally
pointed out Power in = Power out. Duh! So if we have 20v battery pack
flowing .3 amps that's 6 watts. If we have a 50% duty cycle
the average voltage is 10 volts so the current must be .6amps.
You described it well, especially where that current comes from.

Thanks, Mike

.