Speed Control of a DC Motor Using Pulse-Width Modulation Through LabVIEW

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CDA 4170 – Data Acq. and Control Systems, Spring 2009
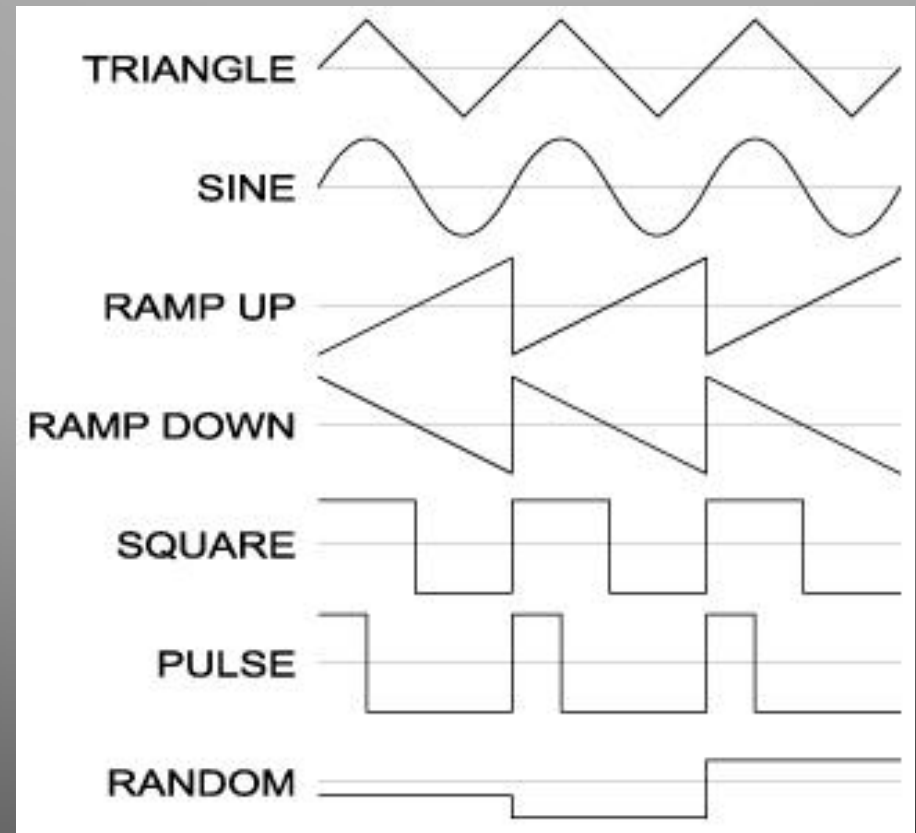Mentor: Professor Janusz Zalewski

Introduction: Pulse–Width Modulation

- Pulse – an electromagnetic wave or modulation thereof of brief duration

- Width Modulation - to adjust to or keep in proper measure or proportion the width of the pulse with respect to the frequency of the wave
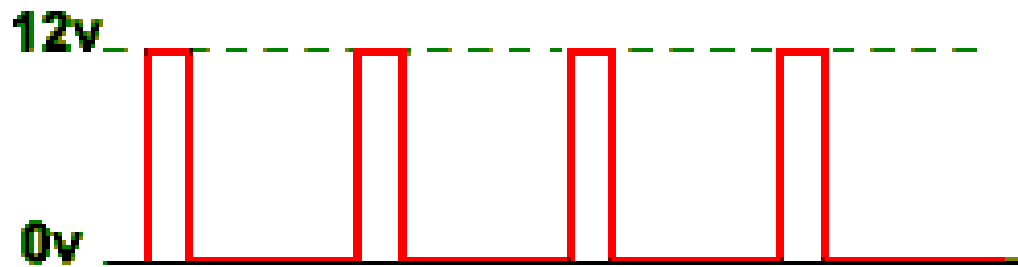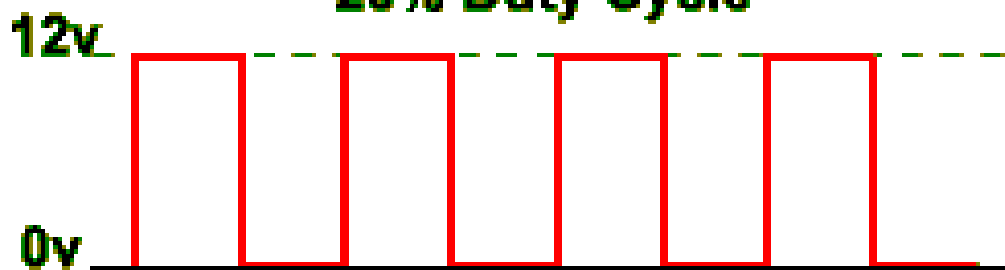
Introduction: Pulse–Width Modulation

- Different types of waves: sine, square, sawtooth, triangle
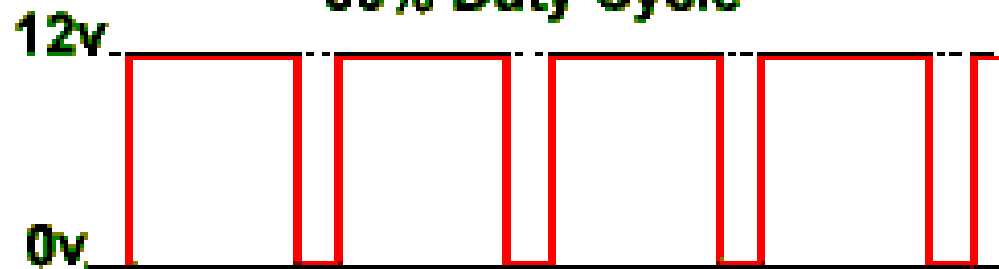
- PWM uses square waves

- Discrete on / off values

TRIANGLE

SINE

RAMP UP

RAMP DOWN

SQUARE

PULSE

RANDOM

Introduction: Pulse-Width Modulation

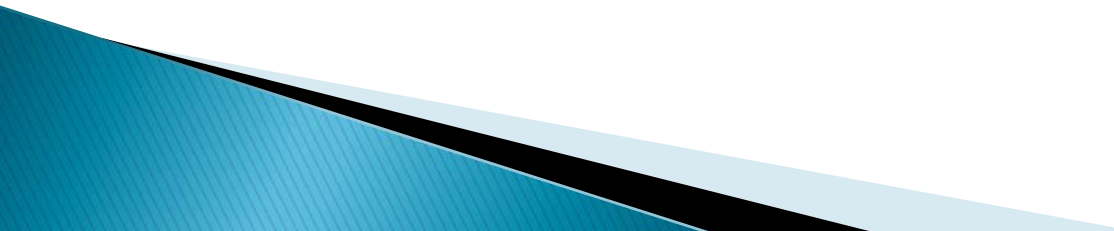
12v

0v

20% Duty Cycle

12v

0v

50% Duty Cycle

12v

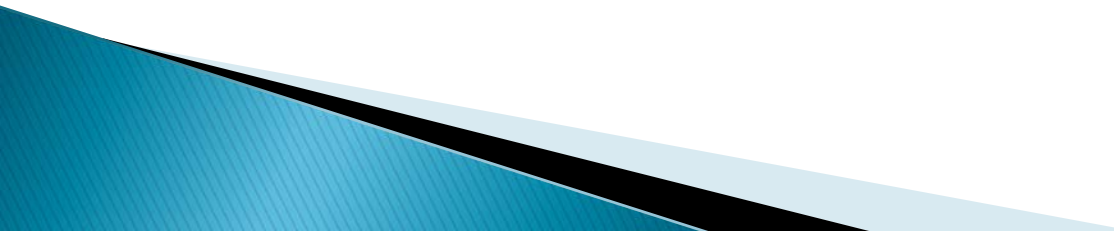0v

80% Duty Cycle

Introduction:
Advantages of PWM

- The motor consumes less power

- Significantly less energy loss due to heat

- Allows finer motor control

Introduction:
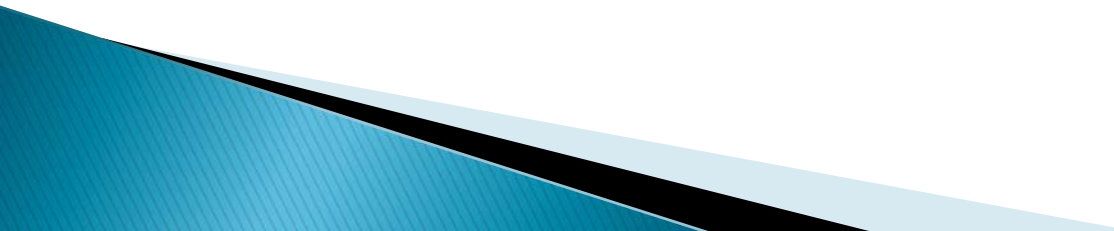# Perceived Disadvantages of PWM

▸ Shortens the life of the motor by putting more stress on the fan bearings and windings
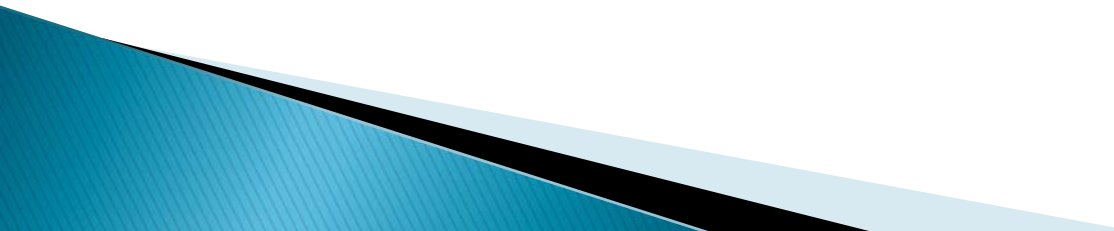
▸ The fan can 'kick' due to slow RPMs

Problem Description:

- Constantly supplying power to a device seems wasteful, in part due to the amount of energy wasted as heat when using a resistor to limit the amount of current delivered to the motor. Also, when using a resistor, if the load changes, the amount of current presently being used by the device has to be re-distributed over the new load.
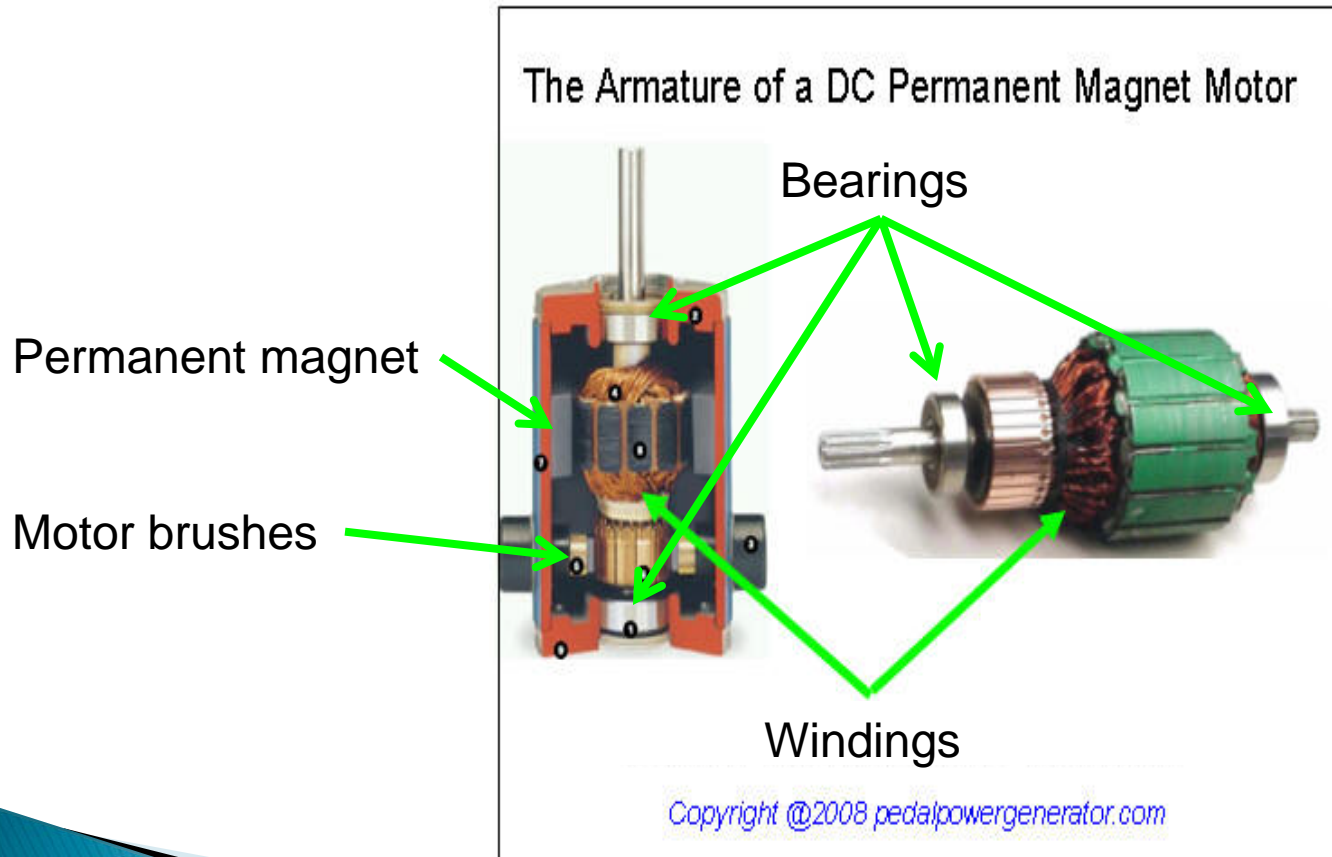
Problem Description:

- This means a constant adjustment of the resistor(s) in the circuit. This is obviously less than ideal.

- Because of Newton's first law, motors require a significant amount of energy to start turning. This initial energy requirement depends on the size of the motor used.
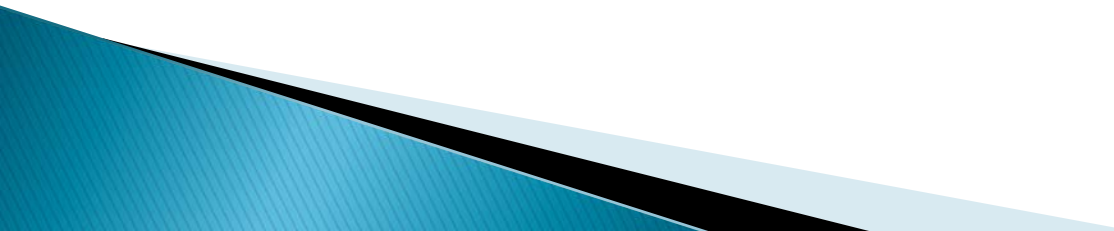
Problem Description:

▸ Likewise, once the motor is turning, it requires much less energy to maintain the spin than it did to get it spinning. All of that extra energy is wasted. Inversely, initially supplying just enough energy to maintain an already-spinning motor won't be enough to get it started spinning.
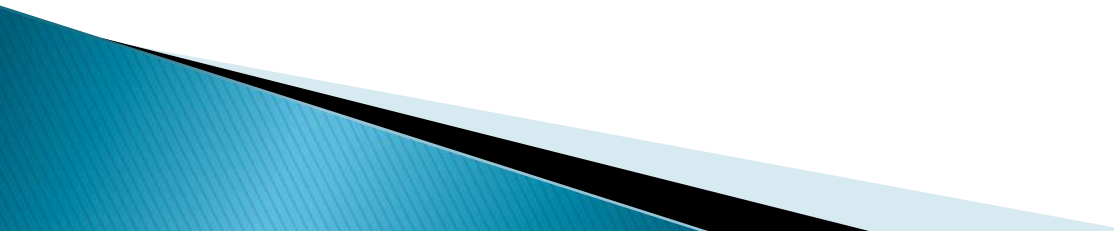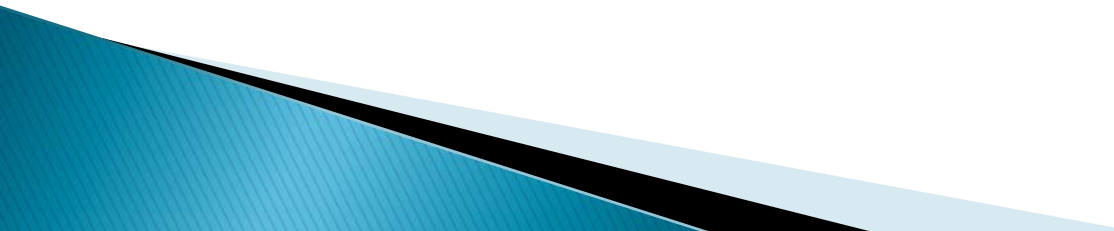
Problem Description:

‣ Typical DC motor:

The Armature of a DC Permanent Magnet Motor

Bearings

Permanent magnet

Motor brushes

Windings

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Proposed Solution:

▸ PWM can solve both of these problems!

▸ Because we are modulating the *on/off time*, rather than the *power*, this allows us to do some things we were not able to do before.

▸ We can now supply enough initial power to start the motor turning, while still conserving power after the motor is spinning.
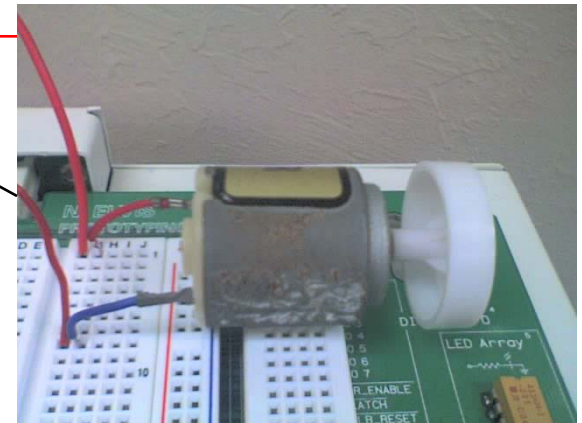
Proposed Solution:

▸ Since we are supplying the full voltage to the motor from the start, this should be enough to get the motor to a full spin from a dead stop.

▸ Since we are modulating the amount of time that full power is applied to the motor, we can use short bursts of full power to 'boost' the motor, and then let the motor 'glide' under it's own inertia.

Proposed Solution:

- By varying the amount of time the signal is 'on', the average of the signal approximates the level of the analog DC voltage needed to drive the motor at the same speed.

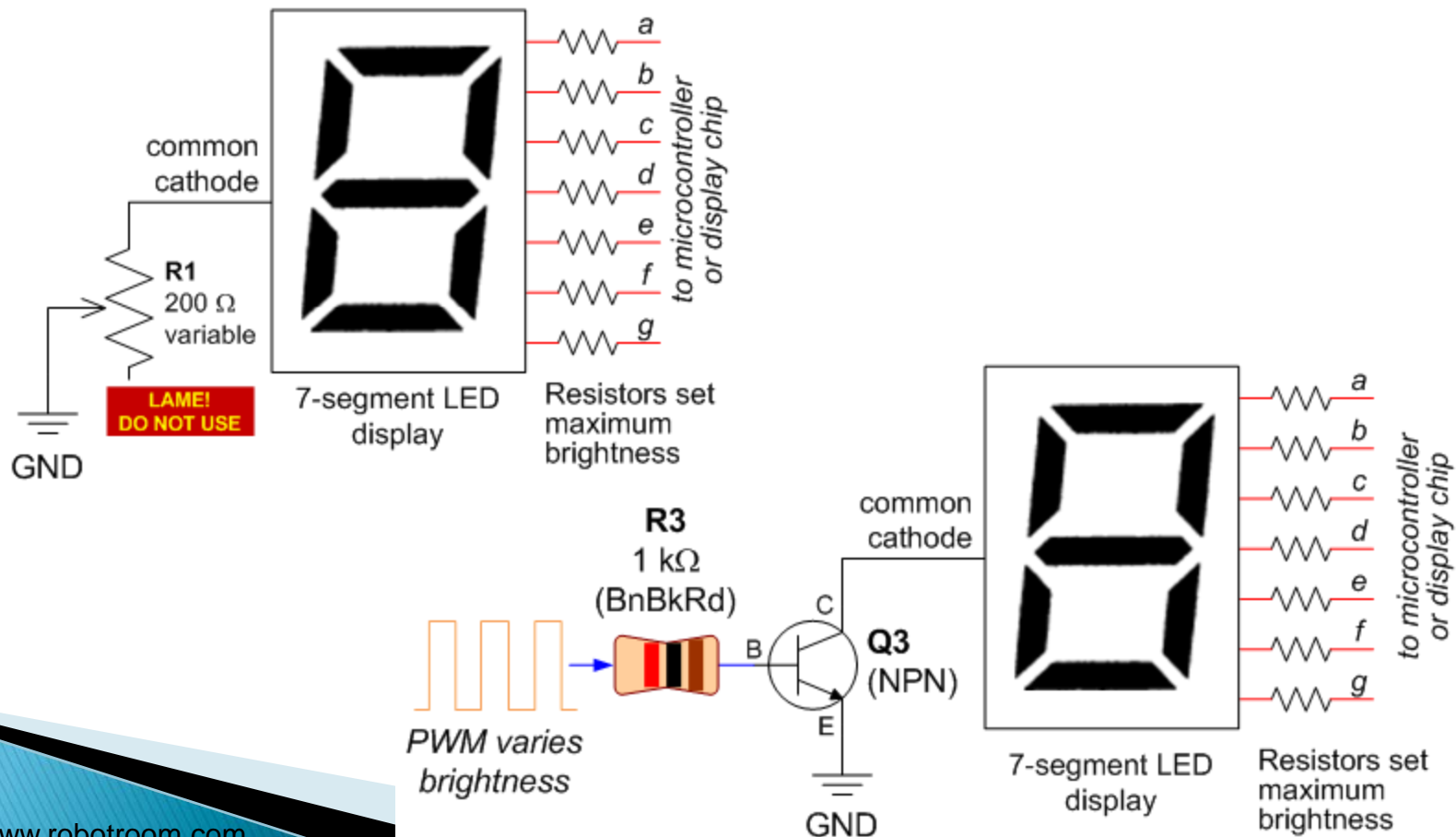- This lets us vary the speed of the motor without 'blocking' some current and generating waste heat.

Proposed Solution:

▸ Using a function generator with a small motor, we can test this:

Proposed Solution:

▸ This solution can also work in other situations, such as 7-segment LEDs:

Implementation:

▸ Using National Instruments' LabVIEW development software, integrate with the NI-ELVIS to produce a working function generator capable of generating square waves with a modifiable duty cycle, as well as being able to control the function generator through the LabVIEW software.
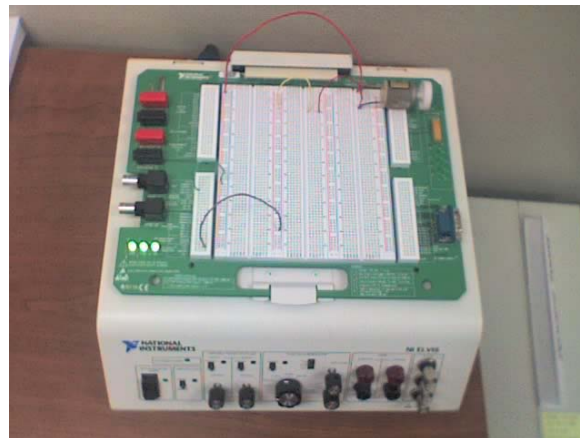
Current Issues:

- Unfamiliarity with both hardware and software

- Lots of materials detailing 'features' (i.e. – why you should buy this!), but nothing really detailed about device-specific I/O, or even which types of I/O to use ('counters' vs. analog output)

- NI-DAQmx ??