Control and Navigation 2
Cornerstone Electronics Technology and Robotics III

(Notes primarily from "Underwater Robotics – Science Design and Fabrication", an excellent book for the design, fabrication, and operation of Remotely Operated Vehicles ROVs)

- **Administration:**
  - Prayer
- **Basic Control and Navigation System:**
  - This section discusses the hardware to build a vehicle control system.
  - Overview of Electrical Switches:
    - Switches are used to turn ON and OFF each of the electrical systems incorporated on your ROV.
    - Category of switches:
      - Manual switches
      - Relays
      - Magnetic switches
      - Transistor switches

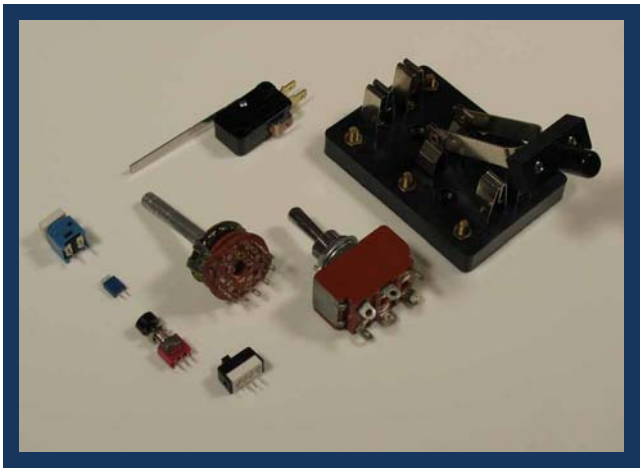

Figure 1: An Assortment of Manual Switches

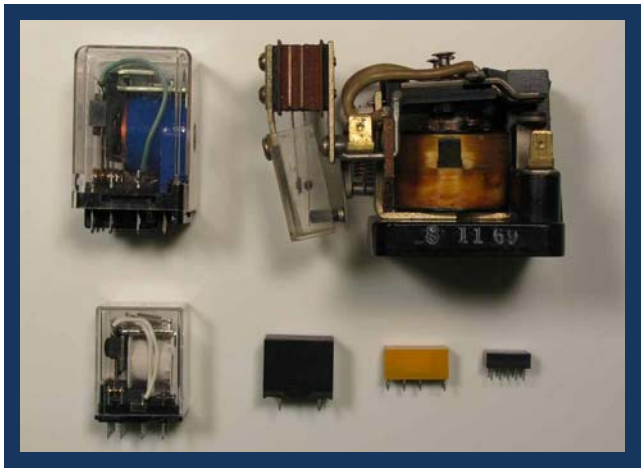

Figure 2: A Variety of Relays

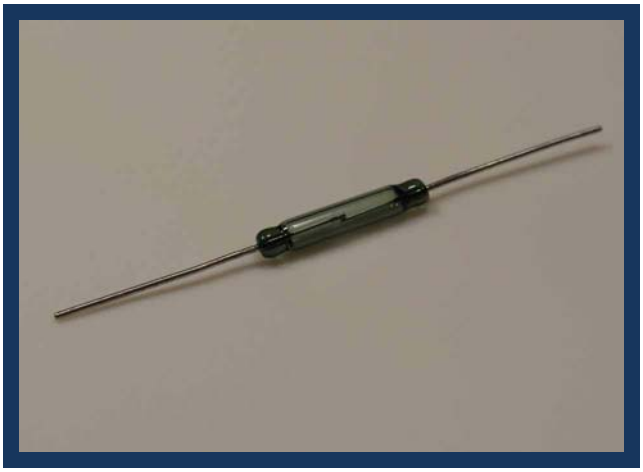

Figure 3: Magnetic Switch (Reed Switch)

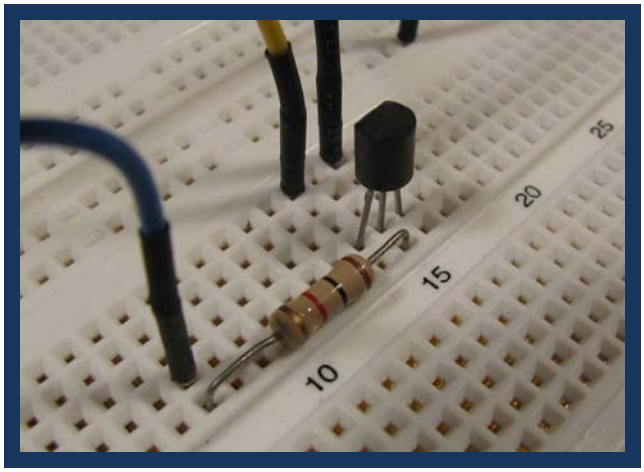

Figure 4: Transistor Switch

- Manual Switches:
  - The mechanical part of a switch used to change the electrical contact can be a lever (also referred to a toggle), a pushbutton, a rotating knob or another mechanism.
  - The mechanism to turn a manual switch ON or OFF is normally operated by a person's finger.
- Magnetic Switches:
  - Include reed switches and proximity switches.
  - Operated by the force of a magnet which opens or closes the switch contacts.

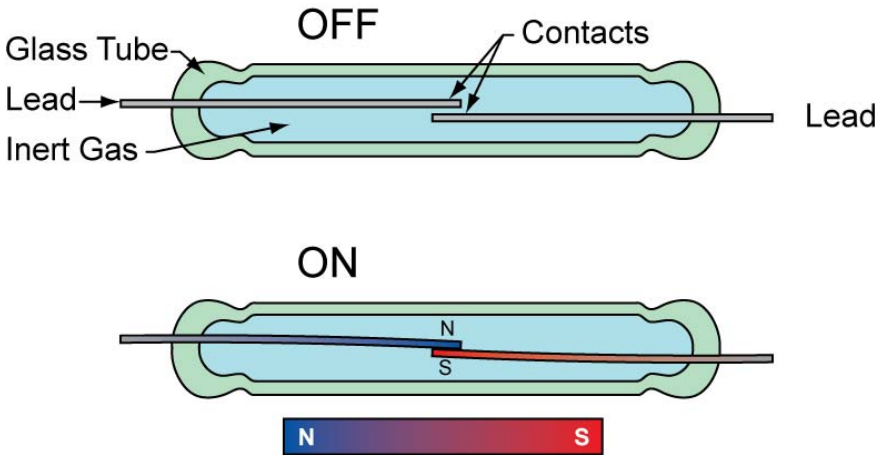

Figure 5: Function of a Reed Switch

- Magnets on the outside of a waterproof housing can activate a magnetic switch inside the housing without the need to drill another hole through the housing. See Figures 6 and 7 on the next page.

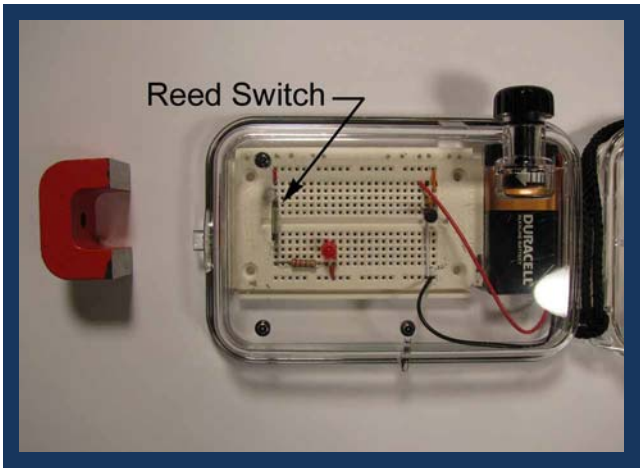

Figure 6: The magnet is too far away to close the reed switch.

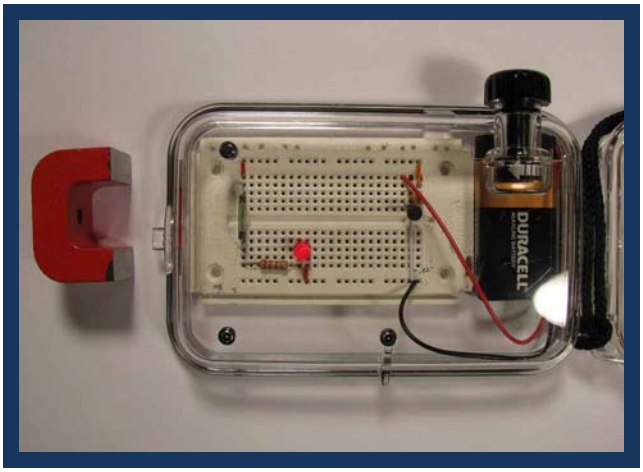

Figure 7: Without any direct mechanical connection with the switch, the magnet closes the reed switch and the LED is illuminated.

- Relays and Transistor Switches:
  - Activated by electrical energy, not by manual effort or magnetism
  - They are the obvious choice for automated systems.
- Poles and Throws:
  - The number of "poles" is the number of separate circuits which are controlled by a switch at the same time. For example, a "2-pole or double pole" switch has two separate identical sets of contacts controlled by the same lever, button, or knob.
  - The number of “throws” indicates how many different output connections each switch pole can connect its input to. A “single-throw” switch is a simple on/off switch that connects or disconnects two terminals. A “double-throw” switch connects an input terminal to one of two output terminals. Thus, a double-pole switch has three terminals. See Figures 9 - 11 on the next page.
- Digi-Key Switch Training Module:
  - Non-audio: http://dkc1.digikey.com/us/en/tod/NKK/SwitchBasics_NoAudio/Switch_Basics_NoAudio.html
  - Audio: http://dkc1.digikey.com/us/en/tod/NKK/SwitchBasics/Switch_Basics.html

Basic Switch Symbols and Corresponding Photos

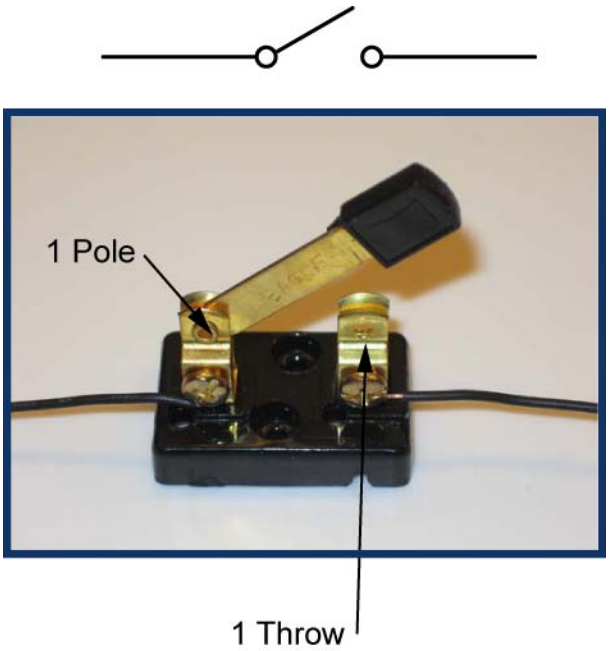

Figure 8: SPST Switch and Symbol (Single Pole Single Throw)

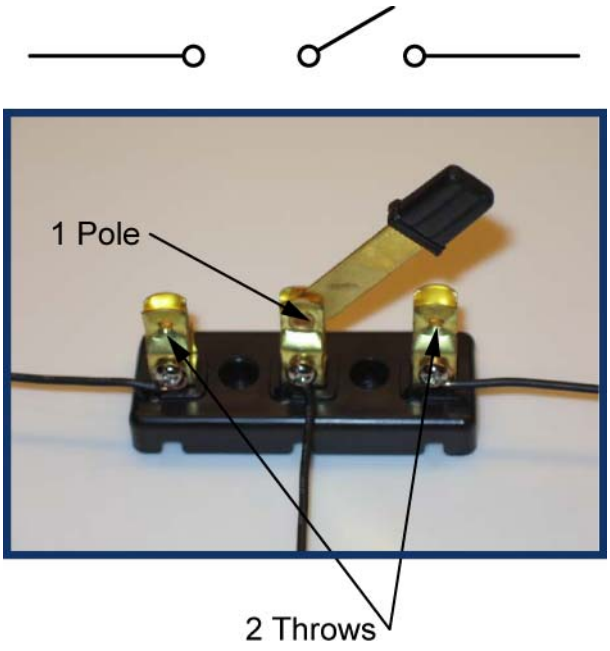

Figure 9: SPDT Switch and Symbol (Single Pole Double Throw)

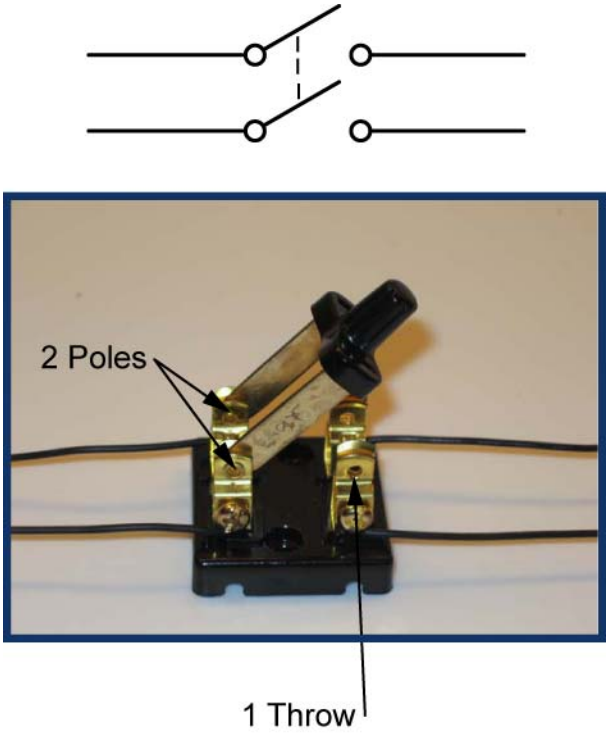

Figure 10: DPST Switch and Symbol (Double Pole Single Throw)

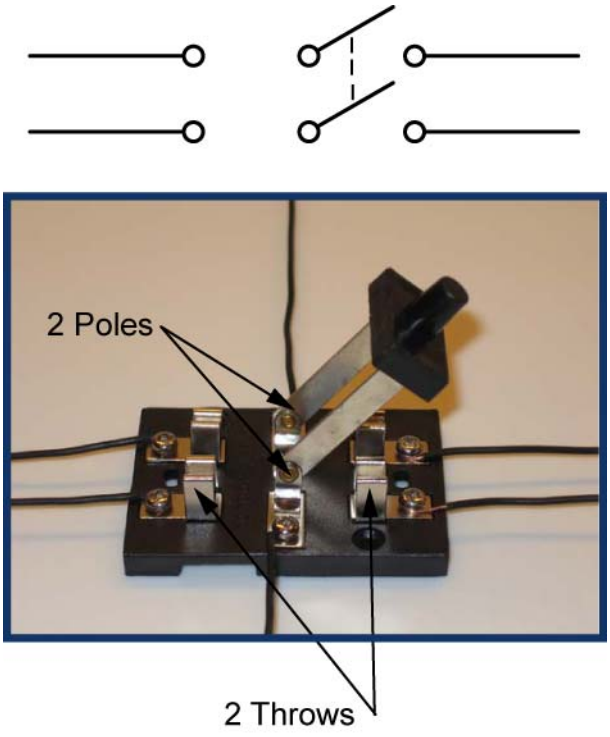

Figure 11: DPDT Switch and Symbol (Double Pole Double Throw)

- Other DPDT Symbols:

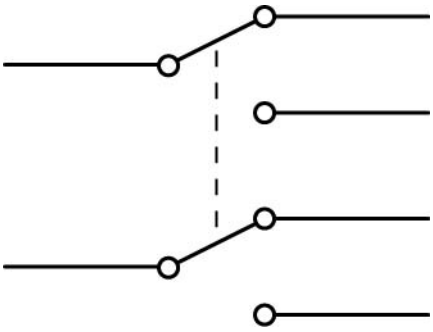

Figure 12: DPDT Symbol Reoriented

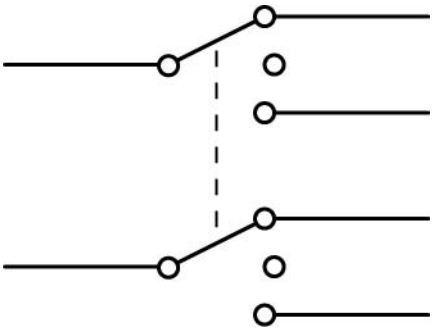

Figure 13: Three Position DPDT with Central OFF Position

- Momentary Switches:
  - A momentary ON-OFF switch (such as on a laser pointer) usually takes the form of a button which is spring-loaded and only closes the circuit when the button is depressed.
  - Normally Open/Normally Closed Terminology: A **n**ormally-**o**pen or NO switch makes contact when the button is pressed and breaks when the button is released. A **n**ormally-**c**losed or NC switch, on the other hand, breaks contact when the button is pressed and makes contact when it is released.
  - Symbols:

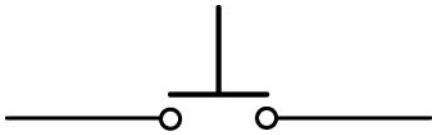

Figure 14: SPST Normally Open (NO) Switch Symbol

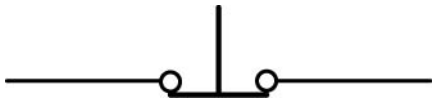

Figure 15: SPST Normally Closed (NC) Switch Symbol

  - In some of the three-position DPDT momentary switches, the central OFF position is the default and the two ON positions are momentary, a good feature for motor control.
  - Sources for momentary toggle DPDT with center OFF(Mom-Off-Mom):
    - 30 VDC 20A and Solder Lugs: Digi-Key Part #360-1913-ND
    - 30 VDC 20A and Screw Lugs: Digi-Key Part #360-1914-ND
    - Miniature: Electronix Express Part #17TOGMOMDD8012A

- Using a Manual DPDT Switch to Control Brushed DC Motor Direction:
  - If you connect a 12 volt DC motor to a 12 volt battery, the motor will rotate in one direction. Reversing the polarity of the connection will reverse the motor's direction of rotation. (Note: most brushed motors run slightly better in one direction than the other. This is slight difference is ignored in normal ROV uses.)
  - Changing DC motor direction with a three-position DPDT switch:

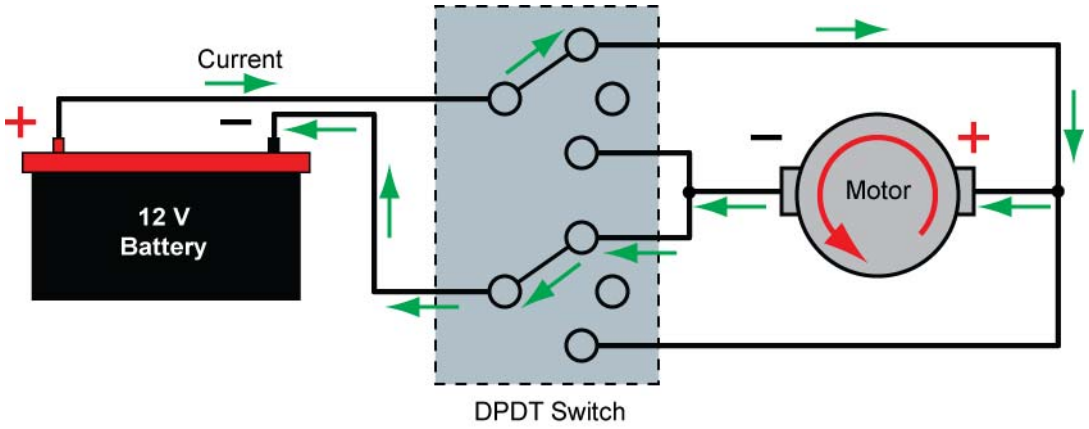

Figure 16: Toggle Up – Counterclockwise Rotation

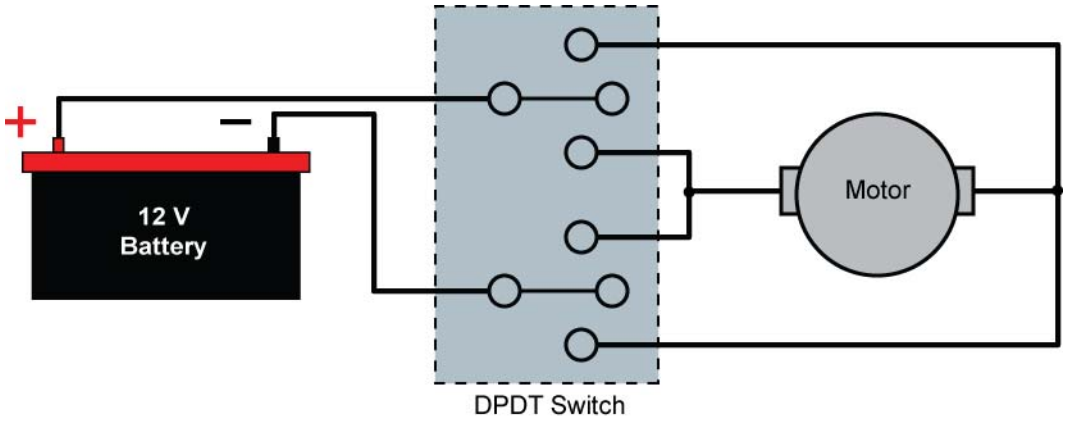

Figure 17: Toggle Center – Motor OFF

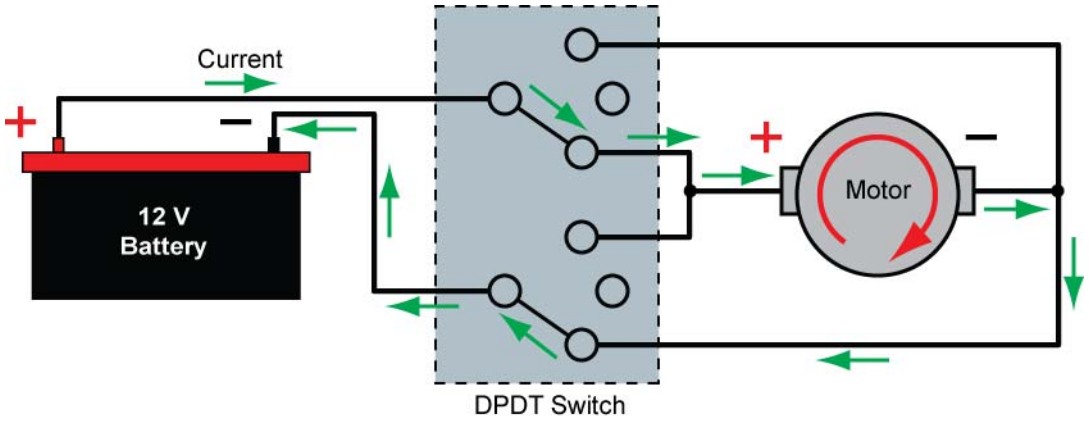

Figure 18: Toggle Down – Clockwise Rotation

- Wiring a DPDT switch to reverse the polarity of a DC motor:

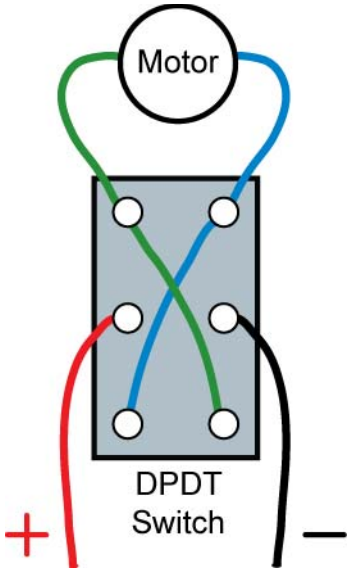

Figure 19: Wiring Diagram that Matches the Schematic in Figures 16 – 18

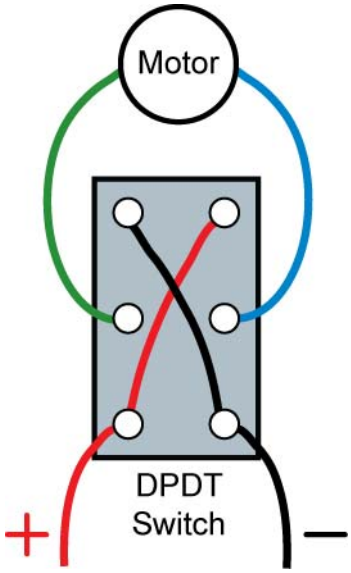

Figure 20: Second Wiring Diagram that Produces the Same Results as Figure 19

    - Limitations of Manual Switch Control:
        - Operating multiple devices with manual switched requires separate wires for each device, making the tether bulky.
        - When running high currents through a long tether, voltages supplied to the device on the ROV can be dramatically reduced. Because of this, using manual switches is limited to tethers of 20 to 30 meters in length.
        - This method of control results in full ON or OFF; running motors at variable speeds or dimming lights is not possible.
        - Manual switches cannot generate complex electrical pulse patterns needed to run devices such as brushless motors, stepper motors, and servos.
        - This control technique is not suitable for fully automated control systems found on AUVs and autopilots of many advanced ROVs.
- Adding a Basic Set of Navigational Sensors:
    - Choosing and Installing a Video Camera:
        - Specs to check when choosing a video camera:
            - Operating Voltage
            - Current requirements
            - Output signal format (NTSC, PAL, Ethernet, etc.)
            - Field of view or angle of visual coverage
            - Resolution
            - Capability to operate in low-light environments
            - Type of lens and focal length
            - Black-and-white or color
            - Camera shape and size
            - Cost
            - Delivery time

- NTSC and PAL:
    - NTSC is the video system or standard used in North America and most of South America. In NTSC, 30 frames are transmitted each second. Each frame is made up of 525 individual scan lines.
    - PAL is the predominant video system or standard mostly used overseas. In PAL, 25 frames are transmitted each second. Each frame is made up of 625 individual scan lines.
- Pan-and-Tilt Mountings: Allows one camera to view different tool locations on board and also permits looking at several views beyond the ROV without having to move the ROV.

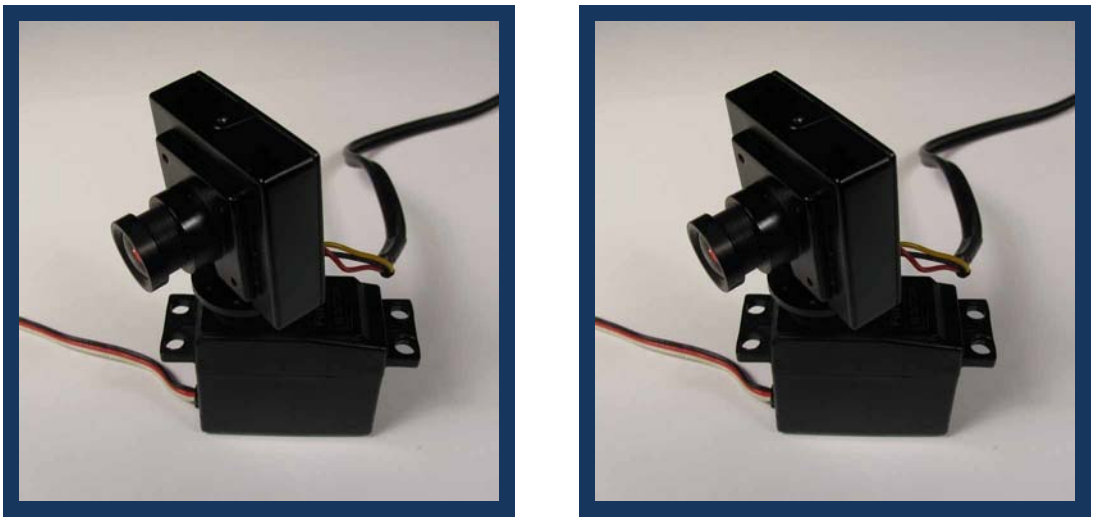

Figure 21: Colored Camera Mounted for Tilting on a Hobby Servo

- Hookup and Testing a Camera:
    - Supply the correct power requirements to the camera as specified in the camera datasheet.
    - Next, if you are modifying the camera power connections, do not reverse the polarity to the camera; if you do, the camera will more than likely be destroyed.
    - Connect the NTSC video from the camera to the TV monitor, VCR, or computer. RCA and BNC are common connectors (see Figures 22 and 23). Hooking up video to the computer may require a scan converter.

Figure 22: RCA Connectors

Figure 23: BNC Connector

        - The easiest way to connect the video signal from your ROV to the surface monitor is through a coaxial cable or twisted pair wires. See textbook for additional details on sending a video signal over a long wire.
        - Perform Control and Navigation 2 Lab 1 – Video Cameras
- Choosing and Installing a Compass and Depth Gauge:
    - Simplest way to incorporate a compass and depth gauge into your ROV is to mount these devices into view of one of your onboard cameras. See textbook for further information.
    - An eight direction digital compass was introduced in Control and Navigation 1 Lab 1.
    - A digital compass with one to two degree resolution will be introduced in Control and Navigation 4.

Cornerstone Electronics Technology and Robotics III
Control and Navigation 2 Lab 1 – Video Cameras

- **Purpose:** The student becomes familiar with a basic micro video camera system by connecting a micro video camera system together.

- **Apparatus and Materials:**
  - 1 – Micro Video Camera (We Use the CM320 Color Video Camera)
    - Sources:
      - http://www.geeks.com/details.asp?invtid=CM320&cat=VID
      - http://www.supercircuits.com/Security-Cameras/Micro-Video-Cameras/
      - Check ebay.com for micro video cameras
  - 1 – Security Camera CCTV Color Quad Splitter Processor 8 Channel (8 Camera)
    - Source: http://evertech-usa-corp.amazonwebstore.com/Evertech-Office-Home-Video-Security-Camera/M/B004TMXIKY.htm?traffic_src=froogle&utm_medium=CSE&utm_source=froogle
  - 1 – BNC to VGA Converter with Cables
    - Sources:
      - http://www.amazon.com/VideoSecu-Converter-Adapter-Switch-RCA2VGA/dp/B000V58F9M
      - http://www.buy.com/pr/product.aspx?sku=212323438&sellerid=24018099
  - 1 – Monitor
  - 2 – BNC Male to BNC Male Adapters

BNC Male to BNC Male Adapter

- **Procedure:**
  - Plug in the color quad splitter processor AC/DC **12VDC 1A** power adapter into the AC outlet and the processor.
  - Connect the video camera to the power outlet using the AC/DC **12 VDC 500 mA** adapter.
  - Also connect the camera video BNC female to the color quad splitter processor CAM1 BNC female connector using a BNC male to BNC male adapter.
  - Plug in the BNC to VGA converter AC/DC **5 VDC 1A** power adapter into the AC outlet and converter.
  - Also connect the BNC to VGA converter BNC female to the color quad splitter processor monitor out BNC female connector using a BNC male to BNC male adapter.

- Set the DIP Function Switch on the side of the converter to the proper setting:

Name	Description
SXGA	Resolution 1280x1024
XGA	Resolution 1024x768
SVGA	Resolution 800x600

- Plug in and turn on the monitor.
- Connect the monitor VGA cable into the BNC to VGA converter.
- Photos of the video system connections:

- **Discussion:**
    - What modifications are necessary to send the video signal through a 60' MATE cable? Use illustrations.

    - How would you deliver 12 volts to power the camera? Use illustrations.