**2002-07 GENINFO**

**Electronics - Overview - MINI**

# MINI ELECTRONIC SIGNALS

## MINI ELECTRONIC SIGNALS

### Purpose of Electronic Signals

Electronic signals move information much like cars move passengers down the highway. It would be difficult to get to work without transportation, and there would be no transportation with out signals.

Signals allow devices (e.g. sensors or switches) to communicate with control modules (either complicated processors or simple relays) which in turn perform or request (through more signaling) other functions to be carried out.

Signals inform the Climate Control of the outside air temp or tell the brake lights the right time to illuminate.

The use of electronic signals goes far beyond the basic application of electron flow to control components, enabling complex information to be passed from one component to another.

The data (input or output) is conveyed through various forms of changing voltages, resistances, current or frequency modulation.

Signals are divided into TWO main groups:

- AC type signals

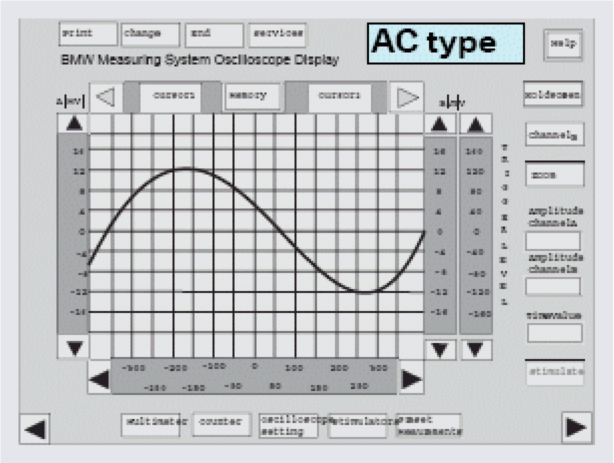



**Fig. 1: AC Type Signals Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

- DC type signals

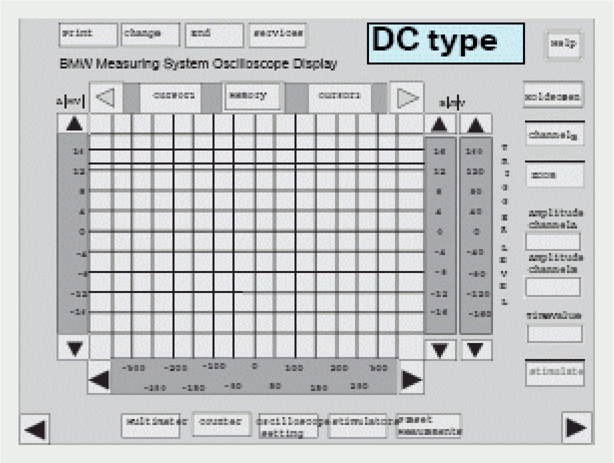



**Fig. 2: DC Type Signals Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

### AC Voltage Signals

#### Inductive Signals (Induced Voltage)

Inductive sensors produce an AC Sine Wave signal. The AC voltage is induced by the shifting of a magnetic field. The sensor consists of an impulse wheel (the moving part) and a coil wound magnetic core (the stationary part).

As each tooth of the impulse wheel approaches the sensor tip, the magnetic field of the sensor shifts toward the impulse wheel and induces a voltage pulse in the windings.

As the teeth move away from the sensor, the magnetic field shifts back inducing a voltage pulse in the opposite direction.

This shifting of the magnetic field produces an alternating current (positive to negative).

Control modules which receive this alternating current, count the impulses (shifts from positive to negative) and interpret the speed of rotation of the impulse wheel.

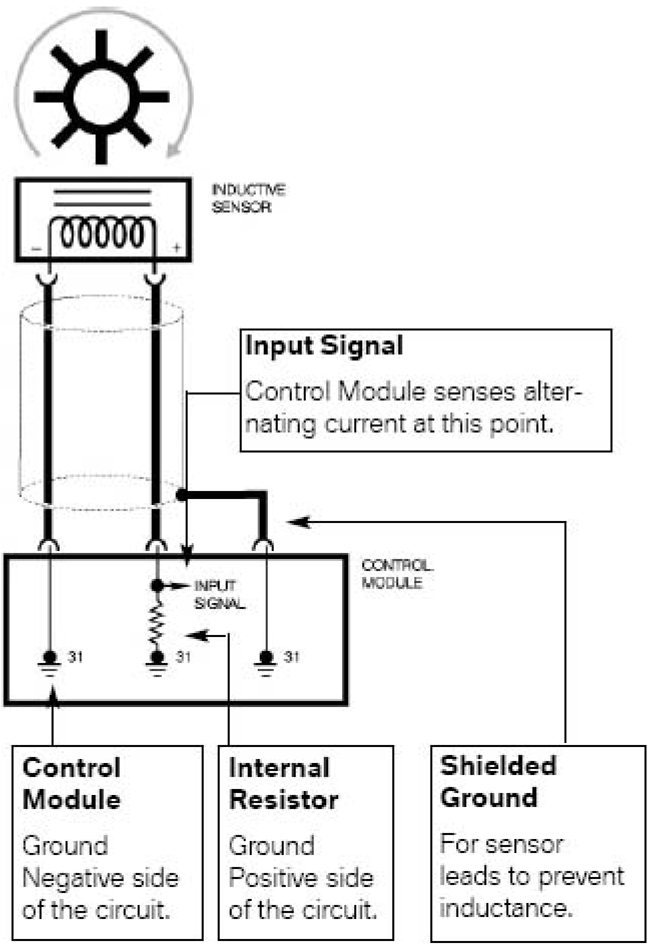



**Fig. 3: Input Signals Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

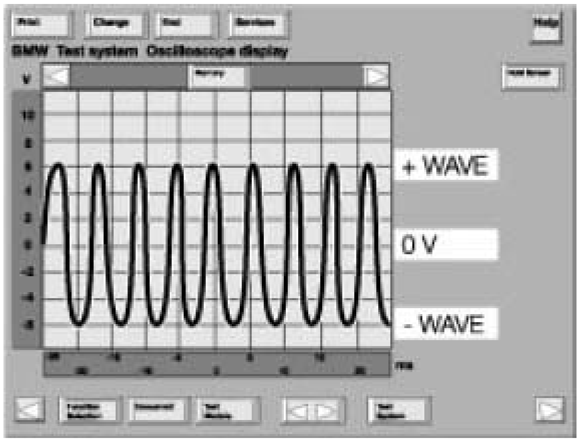



**Fig. 4: AC Voltage Signals Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**NOTE:** **Voltage levels are dependent on sensor design. Not all inductive sensors produce 12 volts.**

#### DC Voltage Signals

Five Types of DC Voltage Signals Are Used:

- Analog Signals
- Digital Signals
- Designated Value Signals
- Coded Ground Signals
- Transistor Signals

DC voltage signals are based on either 5 volts or 12 volts.

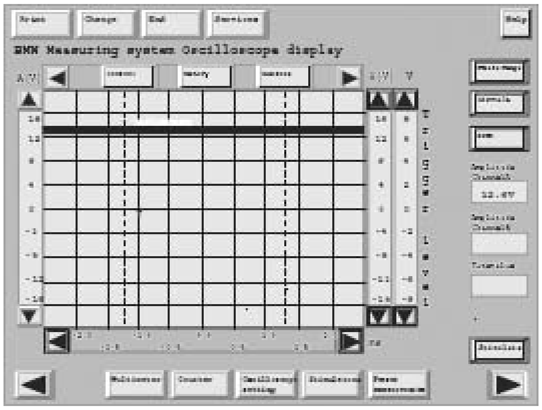



**Fig. 5: DC Voltage Signals Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

#### DC Analog Signals

Analog signals transmit information through an electrical circuit by regulating or changing the current or voltage.

The voltage of the signal has no fixed value. The value may be anywhere in the operating range of the signal.

Three sources of analog signals are:

- NTC Sensors
- PTC Sensors
- Potentiometers

#### DC Analog Sensors

**NTC Sensors**

NTC (Negative Temperature Coefficient) sensors change resistance based on temperature.

As the temperature goes up the resistance goes down. This decrease in resistance causes the voltage drop across the sensor to decrease and the input signal voltage at the control module decreases.

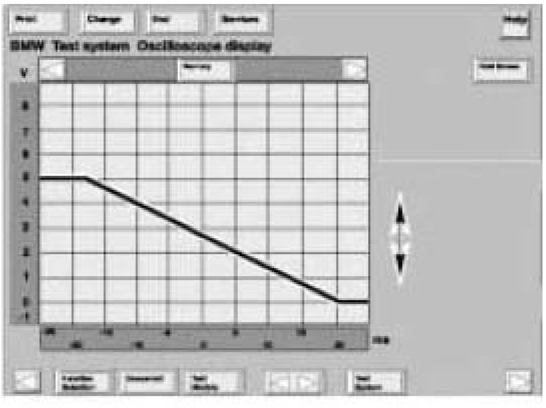



**Fig. 6: Typical NTC Sensor Signal Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

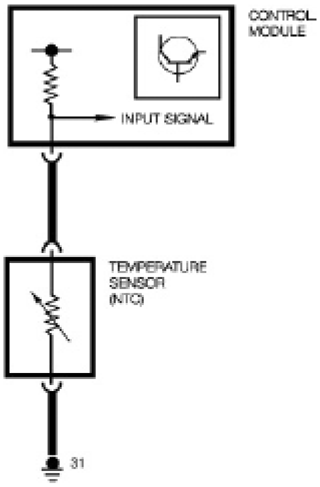



**Fig. 7: Control Module And Temperature Sensor Communication Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**PTC Sensor**

PTC (Positive Temperature Coefficient) sensors also change resistance based on temperature. In a PTC sensor as the temperature goes up the resistance also goes up. The increase in resistance causes the voltage drop across the sensor to increase and the input voltage signal at the control module increases.

When troubleshooting a faulty input display, the input signal must be verified as "good" BEFORE the control module is replaced.

When checking a NTC Sensor look for these voltages and problems:

- 0v = no supply voltage or shorted to ground.
- 2v = sensor is indicating a warm condition for system being measured.
- 4v = sensor is indicating a cold condition for system being measured.
- 5v = sensor or wiring harness is open.

Remember a PTC type sensor will indicate opposite results on intermediate readings (i.e. 4 volts = warm).

Typical Application of NTC Type sensor:

- Engine Coolant Temp Sensor
- Transmission Temp Sensor
- T-MAP Sensor
- IHKA interior air temp sensor

**Notes:**

### Potentiometers

A Potentiometer produces a gradually changing voltage signal to a control module. The signal is infinitely variable within the operating range of the sensor.

This varying voltage reflects a mechanical movement or position of the potentiometer wiper arm and its related components.

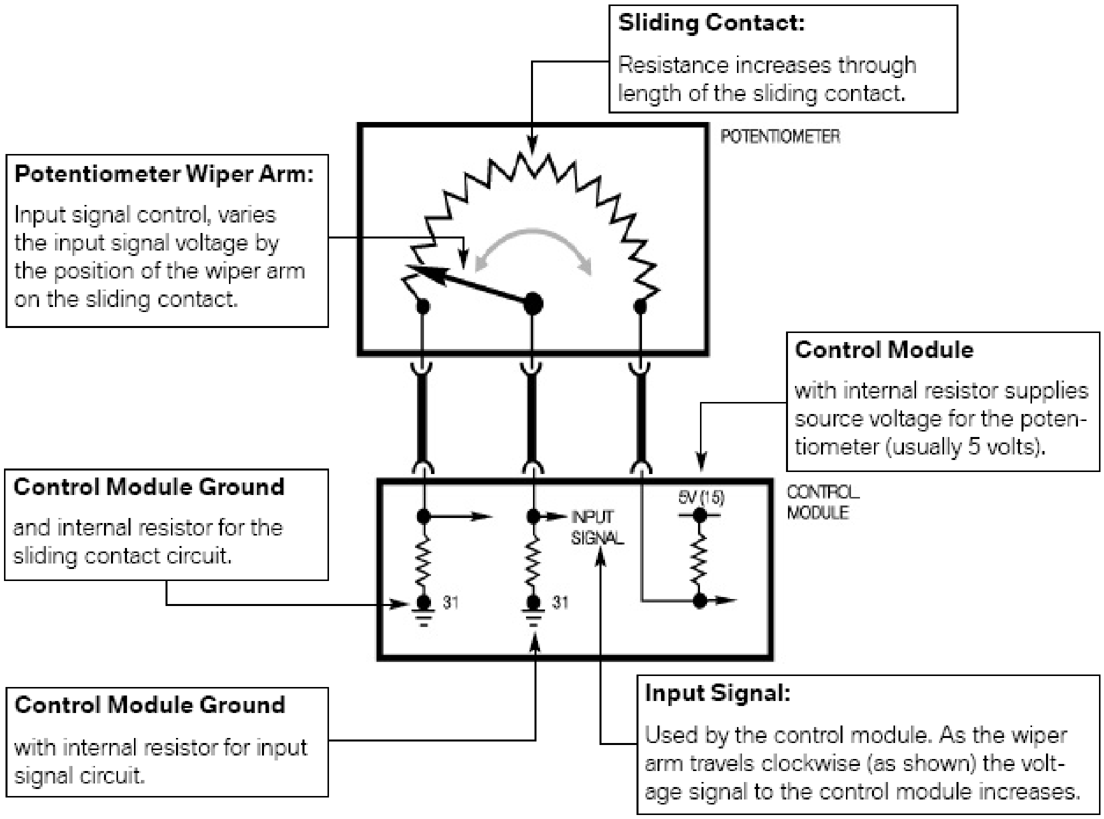



**Fig. 8: Potentiometer Wiper Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Typical Application of Potentiometers:**

- Pedal Position Sensors
- Throttle Position Sensors (Also Feedback Potentiometers)

### DC Digital Voltage Signals

Digital Signals transfer information through an electrical circuit by switching the current on or off. Unlike analog signals which vary voltage, a digital signal has only two possible states, control voltage or 0 voltage.

Two types of Digital Signals:

- Switched (High/Low) Signals
- Modulated Square Wave signals

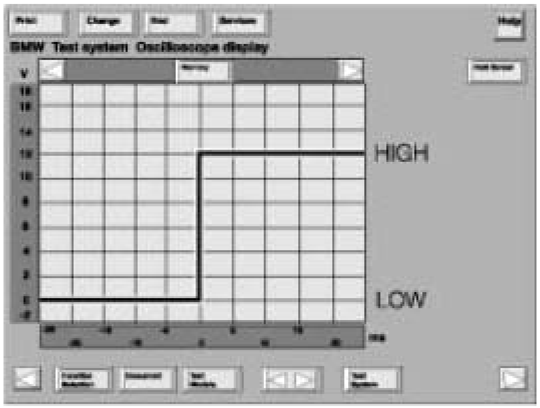



**Fig. 9: DC Digital Voltage Signals Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Switched B+ (High/Low) Signal**

This DC voltage signal produces an ON/OFF type input to the control module. The voltage level will indicate a specific operating condition.

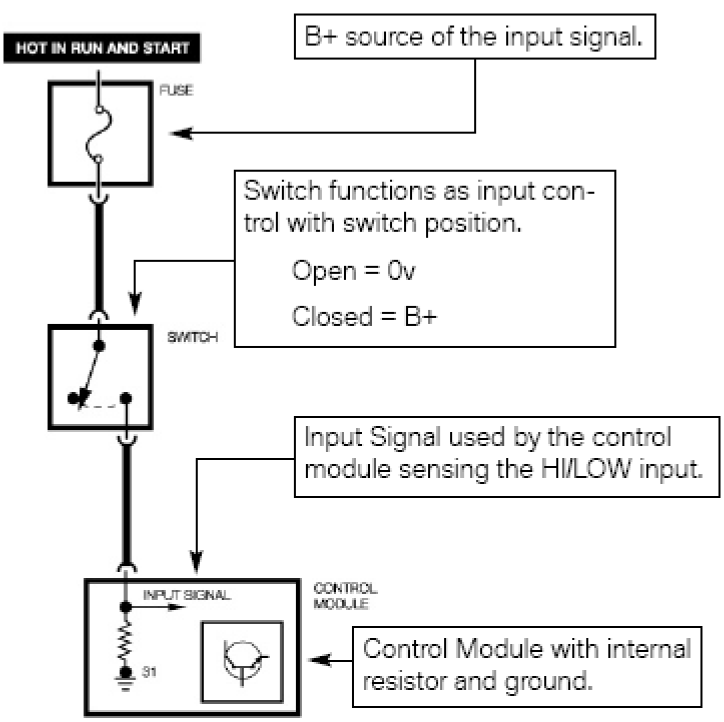



**Fig. 10: Voltage Level Specific Operating Condition**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Typical Application of Switched B+**

- Ignition Switch

- Light Switch
- Reed Switch
- Seat Belt Switch
- Hall Effect Switch (e.g. Brake Light Switch)

**Switched B- (High/Low) Signal**

This Ground Signal produces an ON/OFF type input to the control module. The voltage level will indicate a specific operating condition.

The only difference between a switched B- and a switched B+ is the voltage in which the signals are switched.

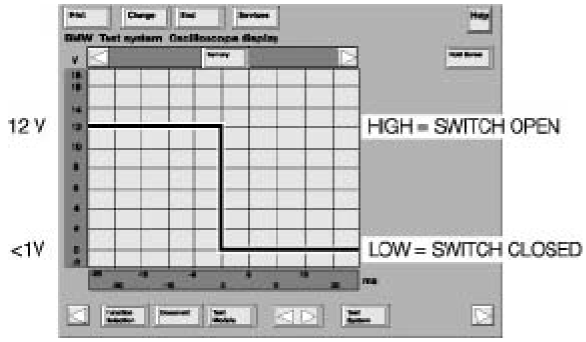



**Fig. 11: Voltage Signal Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

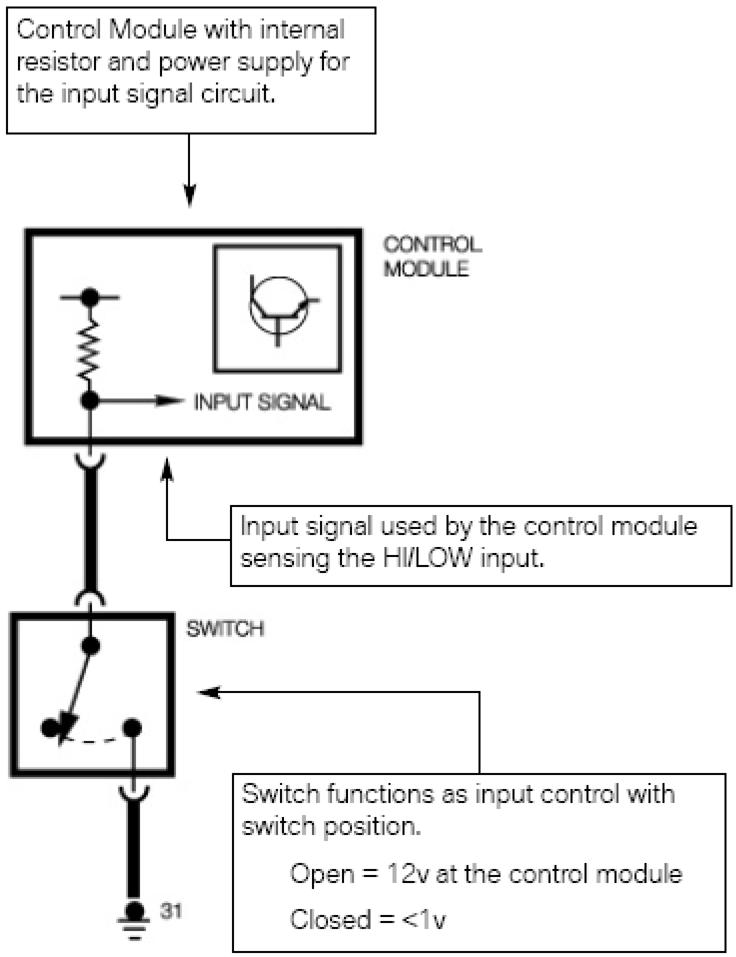



**Fig. 12: Control Module And Switch Communication Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Typical Application of Switched B-**

- Door Position Switch
- Window Switches
- Sunroof Switch

**Modulated Square Wave**

A Modulated Square Wave is a series of High/Low signals repeated rapidly.

Like the switched signals (B+, B-) the square wave has only two voltage levels.

A high level and a low level.

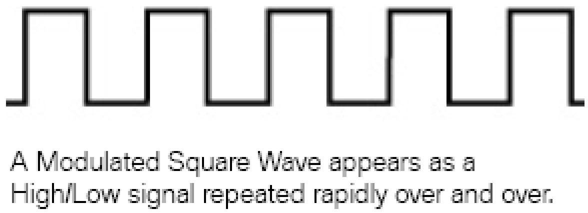



**Fig. 13: Voltage Levels Blinking Pattern**
**Courtesy of BMW OF NORTH AMERICA, INC.**

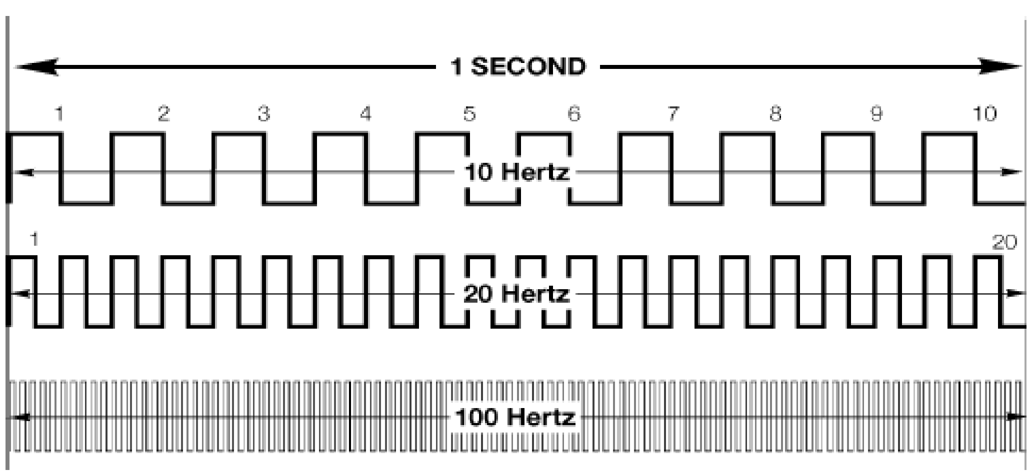
A modulated square wave has 3 characteristics that can be modified to vary the signal:

- Frequency
- Pulse Width
- Duty Cycle

**Frequency**

The frequency of a modulated square wave signal is the number of complete cycles or pulses that occur in one second. This number of cycles or frequency is expressed in Hertz (Hz). 1Hz = 1 complete cycle per second.

An output function may use a fixed or varied frequency.




**Typical Application of Fixed and Varied Frequency**

| | |
|---|---|
| Fixed | Throttle command from EMS2000 to EDR |
| Varied | Hall effect crank sensor<br>Hall effect wheel speed sensor<br>Hall effect camshaft sensor |

**Fig. 14: Frequency Signal Blinking Pattern**
**Courtesy of BMW OF NORTH AMERICA, INC.**

### Pulse Width

The Pulse Width of a signal is the length of time a pulse is on. Vehicle systems may use fixed or varied ON times/pulse width. Pulse width is expressed in milliseconds (ms).

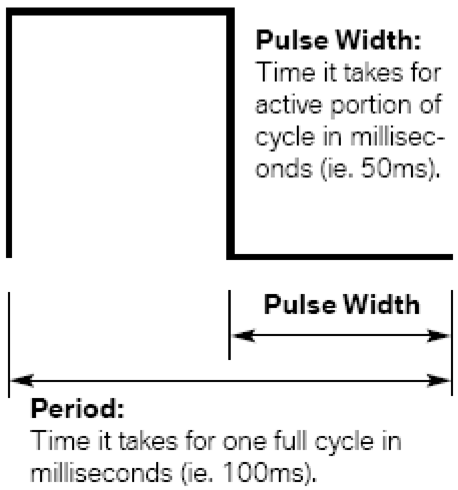
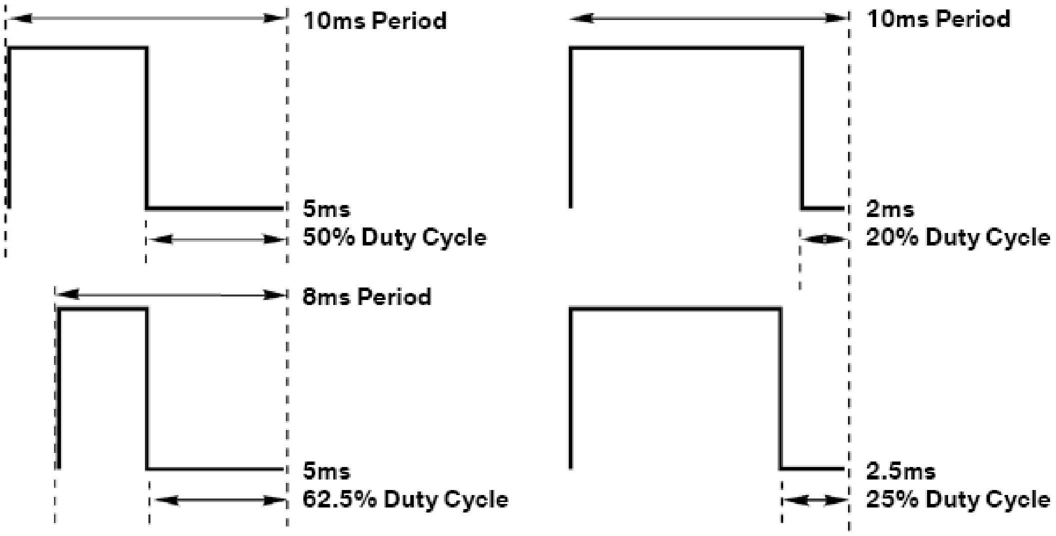



**Fig. 15: Identifying Pulse Width**
**Courtesy of BMW OF NORTH AMERICA, INC.**

### Duty Cycle

The Duty Cycle of a square wave is the ratio of ON time to OFF time for one cycle. Duty cycle is expressed in %.

Vehicle systems use both fixed duty cycle signals and variable duty cycle signals.




**Time**

| | |
|---|---|
| 1 second = 1000 milliseconds (ms) | 1/2 second = 500 milliseconds |
| 1/4 second = 250 milliseconds | 1/10 second = 100 milliseconds |
| 1/100 second = 10 milliseconds | 1/1000 second = 1 millisecond |

**Fig. 16: Variable Duty Cycle Signals**
**Courtesy of BMW OF NORTH AMERICA, INC.**

### DC Digital Sensors

#### Hall Effect Sensors

Hall Effect Sensors can be used to produce ON/OFF signals or modulated square wave.

Hall Effect Sensors are electronic switches that react to magnetic fields to rapidly control the flow of current or voltage ON and OFF. It consists of an epoxy filled non-magnetic housing containing a hall element and a magnet, and a trigger wheel.

The Hall element is a thin non-magnetic plate which is electrically conductive. (Voltage will flow through the plate.) Electron flow is equal on both sides of the plate.

Since everything between the magnet and the hall element is non-magnetic the magnet (magnetic field) has no effect on the current flow.

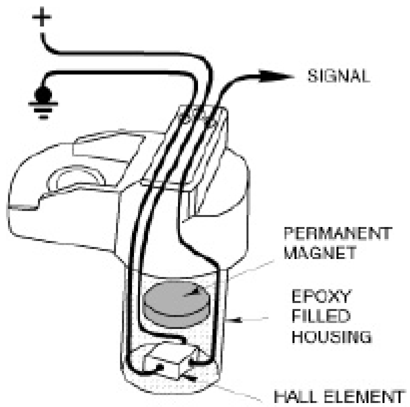



**Fig. 17: Hall Element And Field Housing**
**Courtesy of BMW OF NORTH AMERICA, INC.**

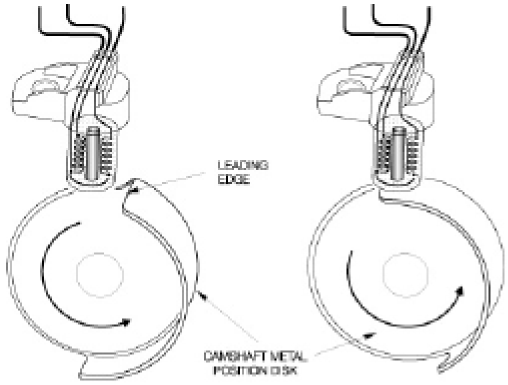



**Fig. 18: Camshaft Metal Position Disk**
**Courtesy of BMW OF NORTH AMERICA, INC.**

As a metal disk or solid area of a toothed wheel, flywheel or other trigger device approaches the sensor, a magnetic field is created between the magnet and the disk. This magnetic field cause the electron flow to stop on one side of the plate. Electrons continue to flow on the other side of the plate.

The Hall Sensor Signal is a measurement of the voltage drop between the two sides of the plate or element. When the magnetic field increases (disc or solid toothed area in front of sensor) the voltage drop across the two sides of the element increases. High voltage on one side, low voltage on the other. The signal output from the sensor is High.

As the disc moves away from the sensor the magnetic fields weakens and is lost. The loss of the magnetic field (blank toothed or open area of the wheel in front of the sensor) produces very little voltage drop across the two sides of the element. The output signal is Low.

A rapid switching of the voltage ON/OFF produces a HIGH/LOW signal that the control module uses to recognize speed and position.

**Typical Application of Hall Effect sensors**

- Crankshaft Sensors
- Camshaft Sensors
- Motor Position and Speed Sensors (e.g. Window Motor, Sunroof Motor)

**Magnetoresistive Sensors**

The active sensing of the Magnetoresistive Sensor is particularly suitable for advanced stability control applications in which sensing at zero or near zero speed is required.

A permanent magnet in the sensor produces a magnetic field with the magnetic field stream at a right angle to the sensing element.

The sensor element is a ferromagnetic alloy that changes its resistance based on the influence of magnetic fields.

As the high portion of the pulse wheel approaches the sensing element a deflection of the magnetic field stream is created. This creates a resistance change in the thin film ferromagnetic layer of the sensor element.

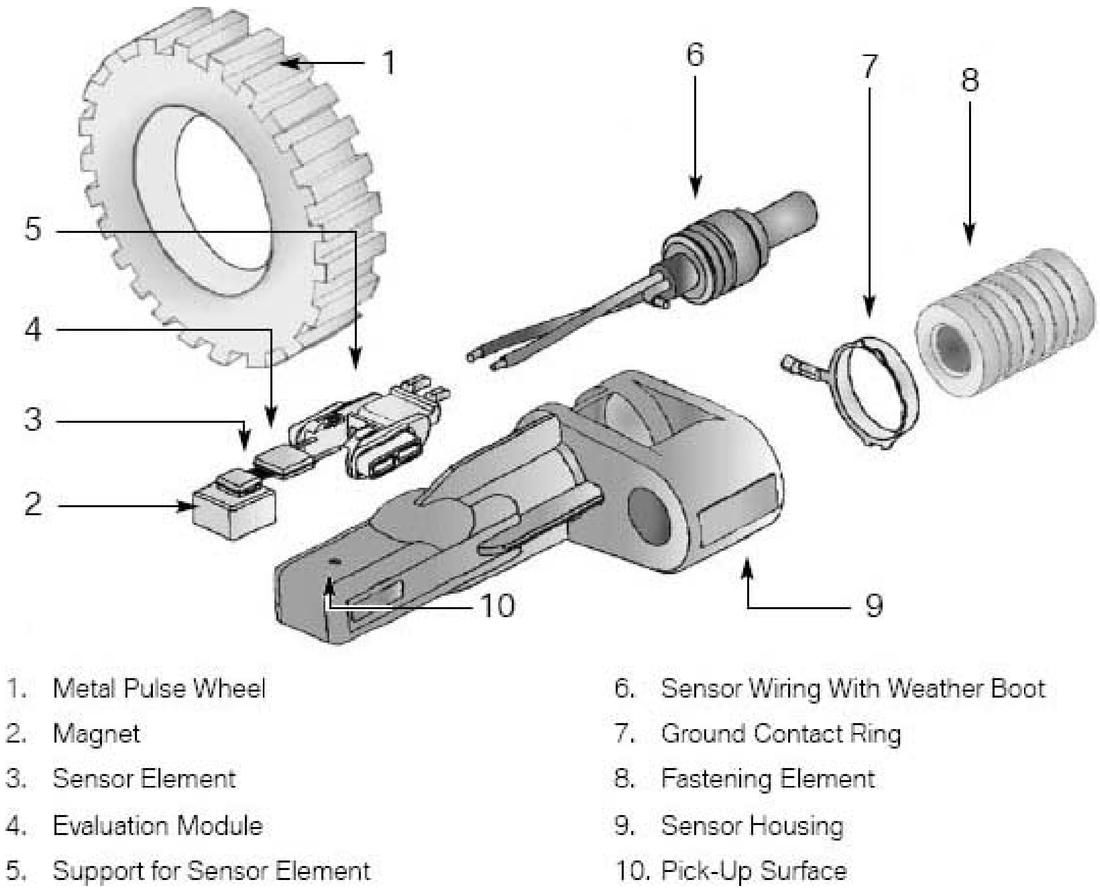



**Fig. 19: Identifying Magnetoresistive Sensors Components Location**
**Courtesy of BMW OF NORTH AMERICA, INC.**

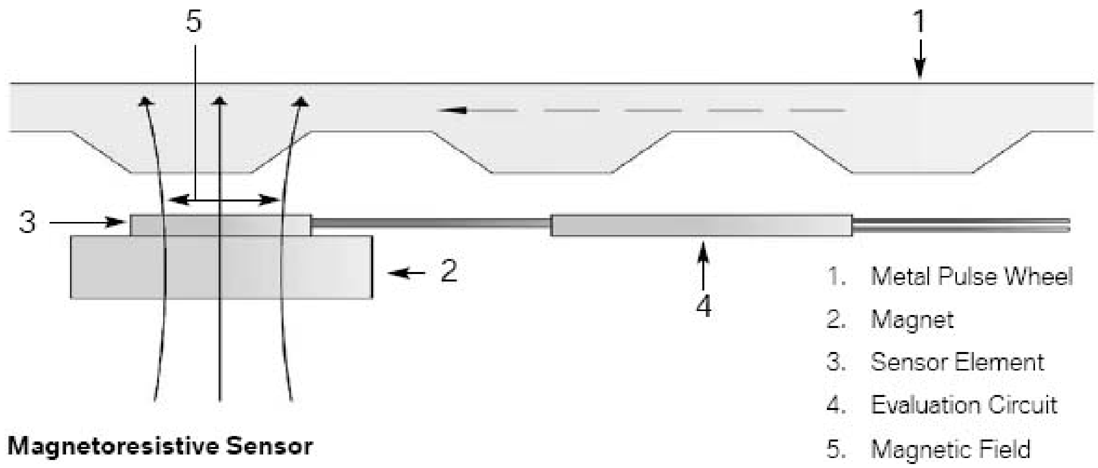



**Fig. 20: [Identifying Magnetoresistive Sensor]**
**Courtesy of BMW OF NORTH AMERICA, INC.**

The sensor element is affected by the direction of the magnetic field, not the field strength. The field strength is not important as long as it is above a certain level. This allows the sensor to tolerate variations in the field strength caused by age, temperature, or mechanical tolerances.

The resistance change in the sensor element affects the voltage that is supplied by the evaluation circuit. The small amount of voltage provided to the sensor element is monitored and the voltage changes (1 to 100mv) are converted into current pulses by the evaluation module.

- Signal Low-7mA
- Signal High-14mA

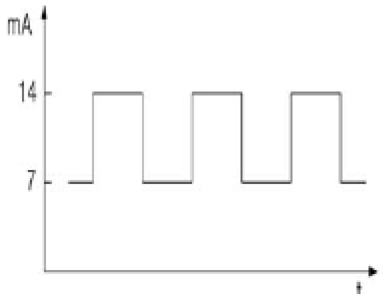



**Fig. 21: Voltage Signal - Blinking Pattern**
**Courtesy of BMW OF NORTH AMERICA, INC.**

The sensor is supplied 12V by the control unit. Output voltage from the sensor is approximately 10V. The control unit counts the high and low current pulses to determine the wheel speed.

**Typical Application of Magnetoresistive Sensor**

- Currently used for wheel speed sensors.

**Designated Value Signals**

Designated values are produced through fixed resistance positions of a multi-position switch. As the switch is operated the voltage drop across the resistor(s) of each switch position causes the voltage level of the input signal to change to a predetermined voltage value.

These predetermined (designated) voltages signal the control module to perform specific functions.

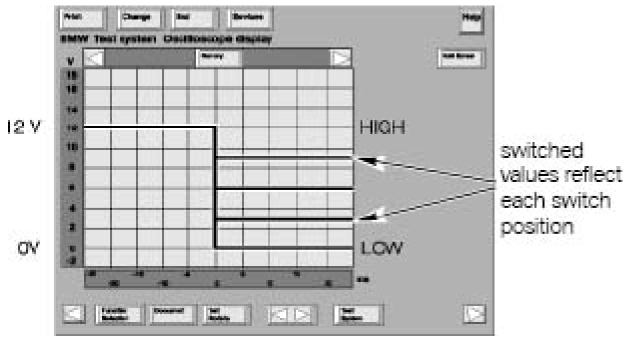



**Fig. 22: Value Signal Graph**
**Courtesy of BMW OF NORTH AMERICA, INC.**

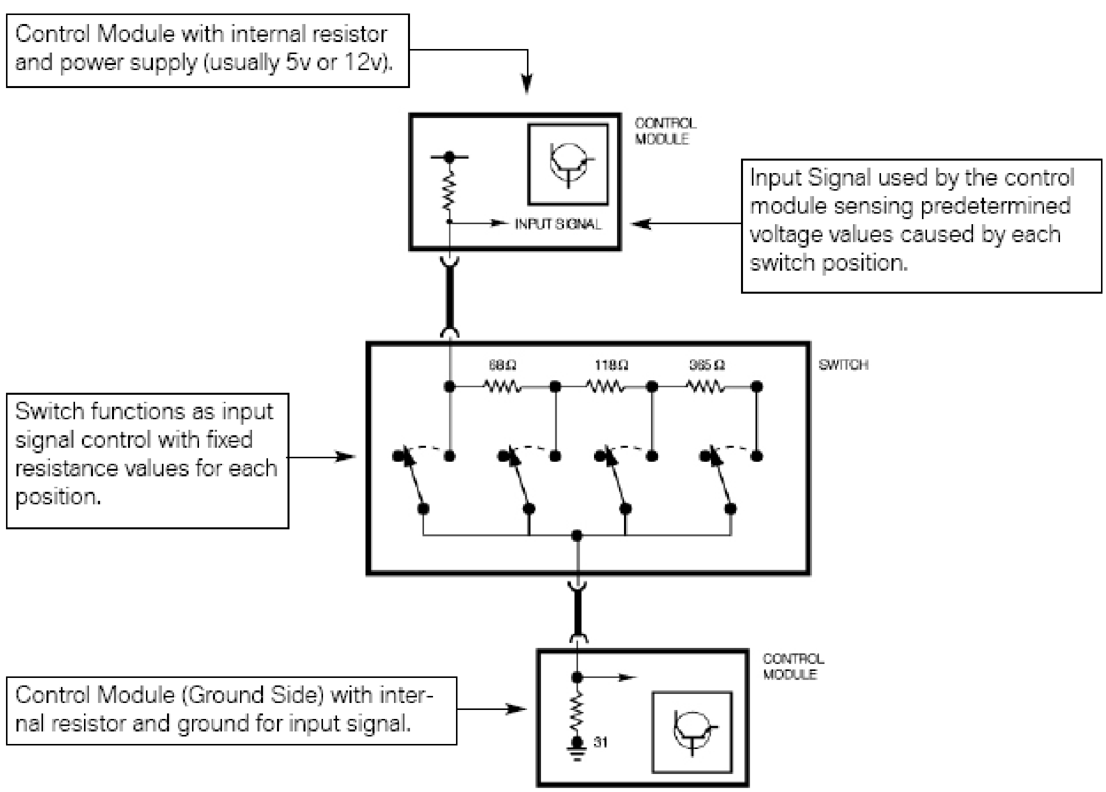



**Fig. 23: Control Module Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Coded Ground Signals**

Coded ground signals produce a set of High/Low requests, the combination (pattern) of which is interpreted by the control module to perform a specific function.

Coded ground signals are generated through a switch or series of switches signaling the control module requests for operation.

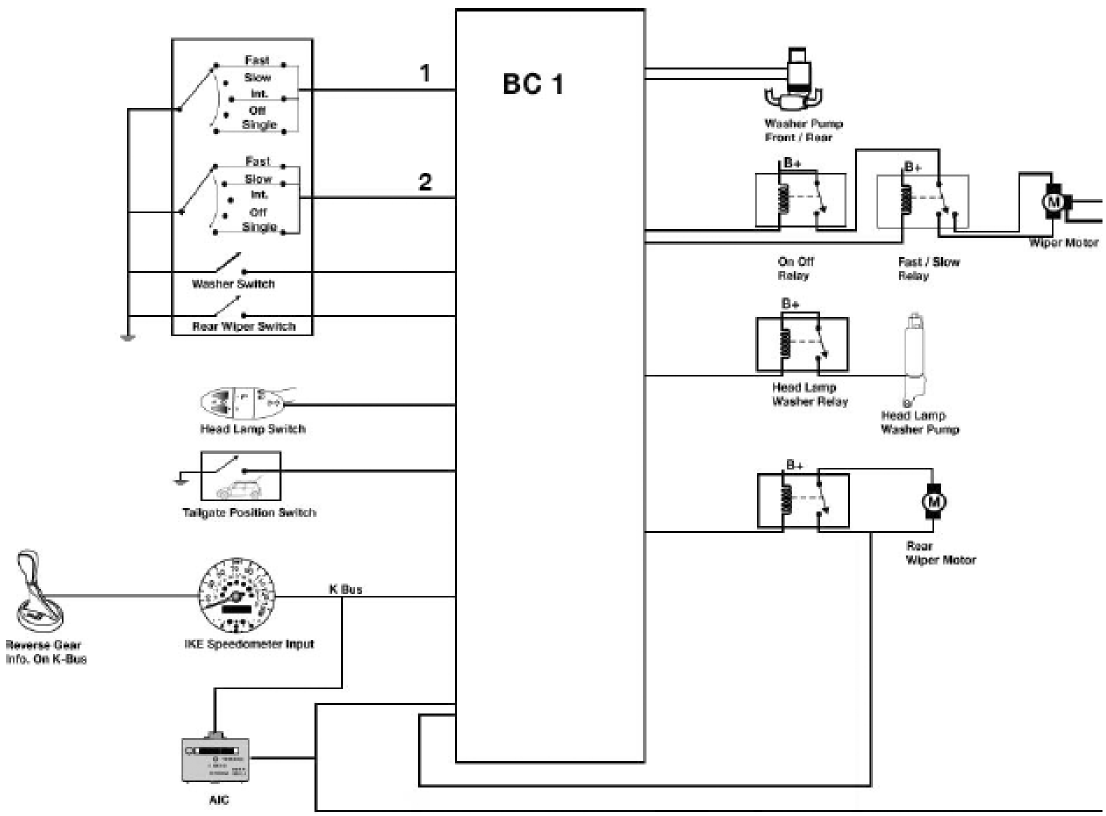



**Fig. 24: Wiper Switch - Schematic Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Wiper Switch Schematic**

**WIPER SWITCH REFERENCE**

| Switch Logic | Pin 1 | Pin 2 |
|---|---|---|
| Single Wipe | Hi | Hi |
| OFF | Low | Low |
| Intermittent | Hi | Low |
| Slow | Low | Hi |
| Fast | Hi | Hi |

**Typical Applications of Coded Ground Signals**

- Wiper Switch

**DC Digital Input/Output Stages**

**Transistor Final Stage Function**

The transistor takes on a number of applications that must be understood to effectively analyze a circuit. The transistor in operation functions as two parts much like a relay. Both the relay and the transistor control high currents with a low current signal.

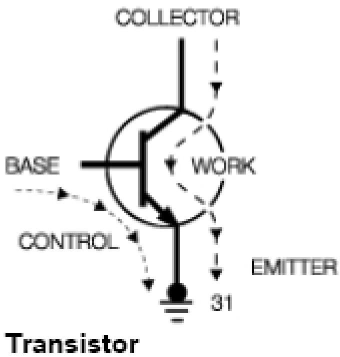



**Fig. 25: Transistor In Operation Functions**
**Courtesy of BMW OF NORTH AMERICA, INC.**

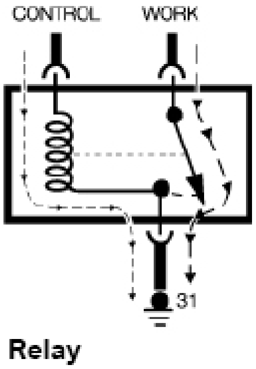



**Fig. 26: Relay Circuit Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

The transistor consists of three major sections:

- Base
- Emitter
- Collector

The base/emitter path functions as the control circuit activated by the control module to oversee or control the work.

The collector/emitter path functions as the work side of the circuit, supplying power or switching on the work.

In operation the transistor can either be switched ON momentarily, or supply a constant power or ground. The transistor can also be modulated or pulsed to supply a modulated square wave signal.

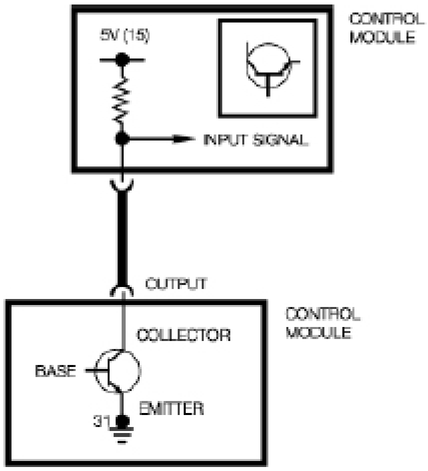



**Fig. 27: Control Module Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Modulated, Momentary, Constant B- as Input/Output**

The input signal of control module 1 is an output signal of control module 2.

Control module 2 through activation of its internal transistor provides a ground input for control module 1.

The input signal at control module 1 is either a momentary/constant signal (i.e torque convertor signal from TCM to DME) or a modulated signal (i.e. vehicle speed signal ASC to DME).

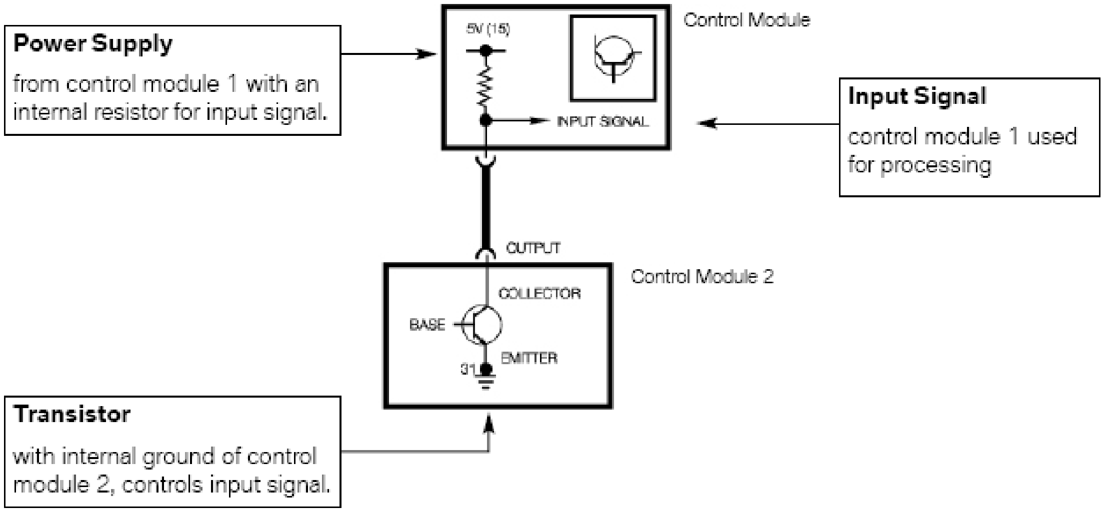



**Fig. 28: Input Signal Of Control Module Diagram**

**Courtesy of BMW OF NORTH AMERICA, INC.**

**Momentary/Constant B+ as an Input/Output Signal**

The input of control module 2 is controlled by control module 1 through internal activation of the transistor. Control module 1 provides power for the input circuit of control module 2.

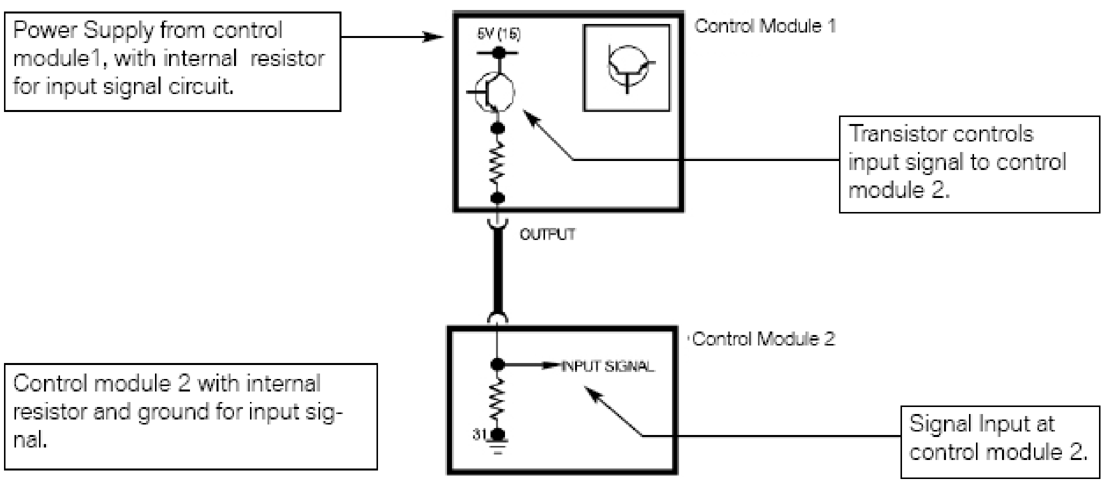



**Fig. 29: Control Module Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Constant B-/B+ To Energize a Component**

**Constant B-**

Output function to energize a component.

Relay is energized by activation of the transistor inside the module. The transistor provides a ground for the relay coil. control module.

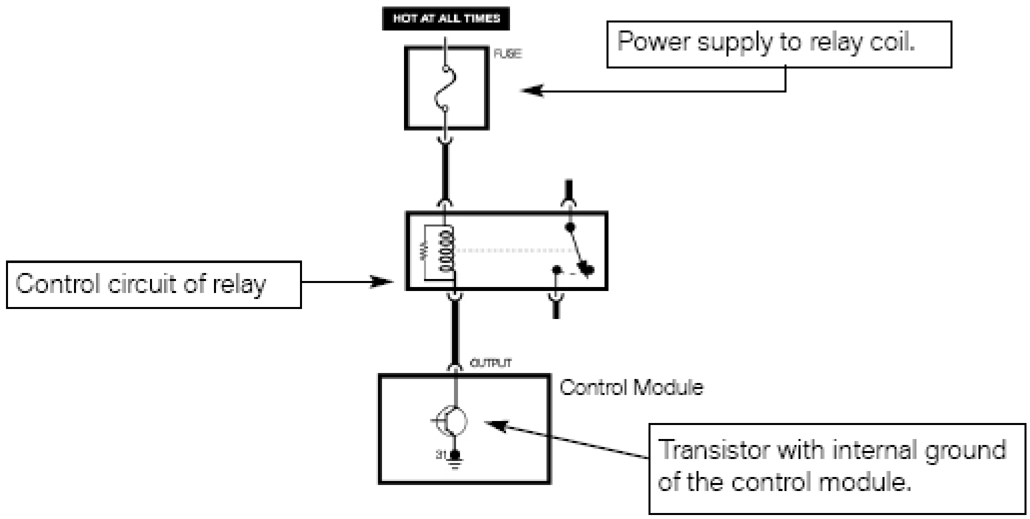



**Fig. 30: Power Supply To Relay Coil Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Constant B+**

Control module output function to energize a component.

Transistor controls output function of the control module.

Control module supplies power to the relay.

The relay is activated by the control module through activation of the transistor which provides a ground for the relay coil.

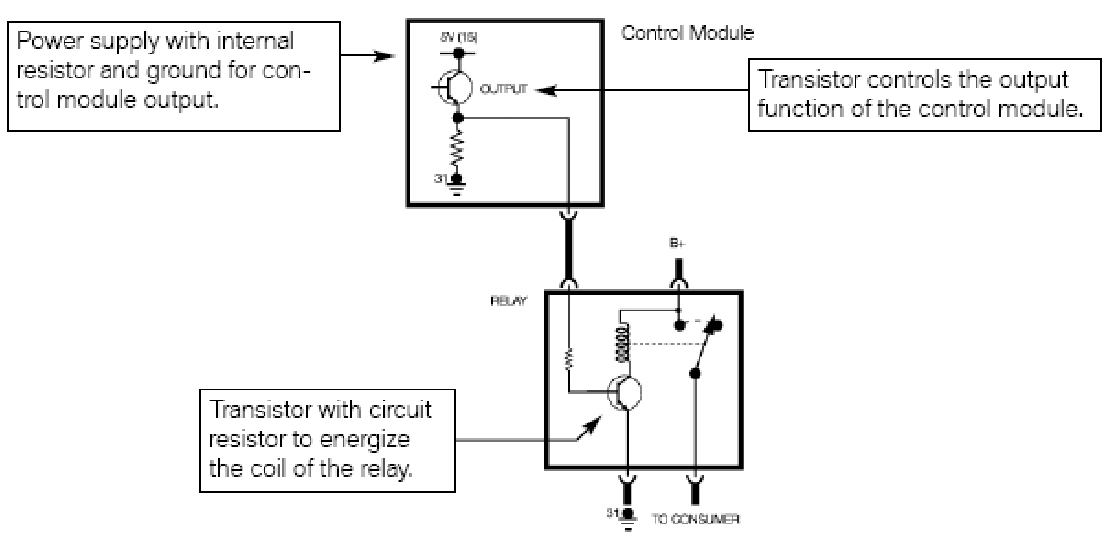



**Fig. 31: Power Supply To Relay Coil Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

**Modulated B-/B+ To Operate A Component**

## Modulated B-

Output function to operate a component.

The idle valve motor is operated by the control module through activation of the transistor which provides a ground for the open winding of the valve.

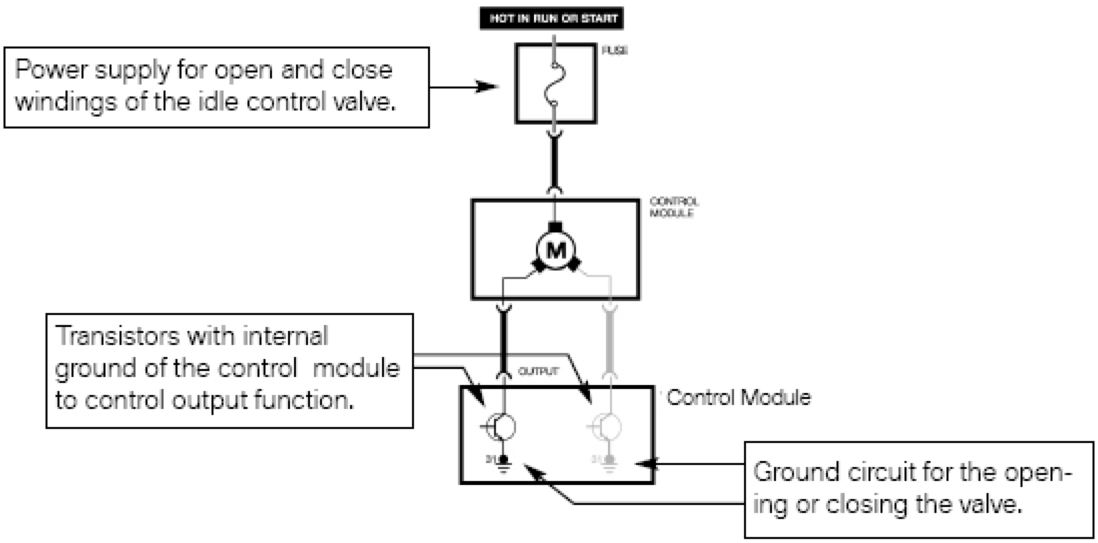



**Fig. 32: Idle Valve Motor Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**

## Modulated B+

Output function to operate a component.

The motor is controlled by a transistorized function of the control module, which provides a modulated voltage at a specific frequency to the motor. The throttle position is changed by altering the Duty Cycle of the pulses.

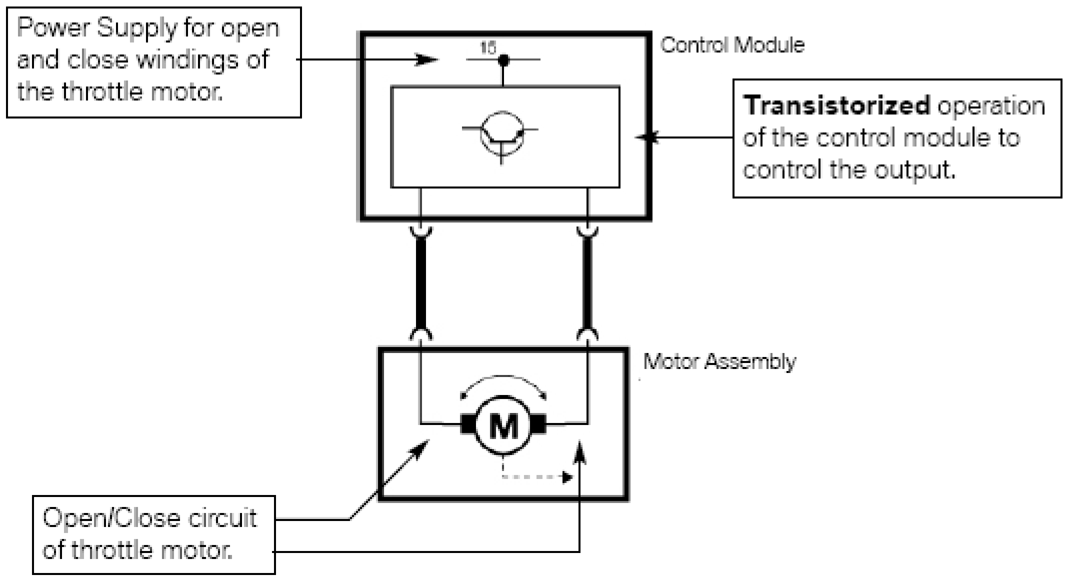



**Fig. 33: Idle Valve Motor Diagram**
**Courtesy of BMW OF NORTH AMERICA, INC.**