Technical Note

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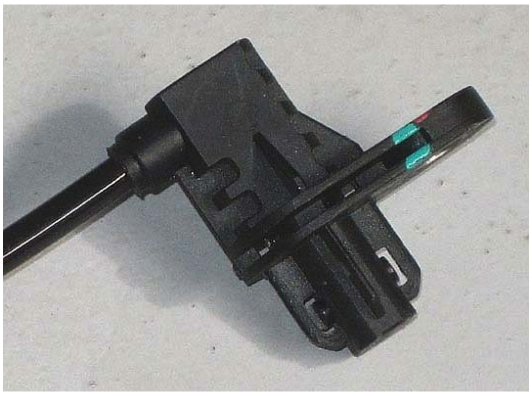
Active/Magneto-Resistive Sensors



Magneto-Resistive speed sensors (also called Active Wheel Speed Sensors) offer the switching benefits of Hall sensors with 2-wire connection. These rely on the presence of an external magnetic field for sensing, and are typically used for wheel speed, water speed, and crankshaft position sensors (for example, Evo X wheel speed, Seadoo RXP water speed).

These sensors are unusual in that they do not switch to ground as a Hall sensor might be expected to do. Rather, they operate as a variable current switch with two levels, both of which require some current to pass through the device. For this method to work in a 2-wire sensor a pull-up is required on the signal line to ensure that sufficient current is available to power the device.

Typically 3 to 6 mA might be passed, with corresponding output voltage levels dependent upon the size of the supply pull-up resistor. In all cases the low level voltage is still considerably higher than 0 V.

Scope

This document describes the use of Magneto-Resistive Speed sensors with MoTeC hundred series ECUs and Dash Loggers.

Using Magneto-Resistive Sensors with MoTeC Devices

Powering the Sensor

Magneto-resistive sensors must have current flowing even in the 'low' state. The standard pull-up resistors which are used on MoTeC digital inputs (4k7 Ω to 5 V) do not normally provide enough current for the sensors to operate correctly. Thus an additional pull-up resistor may be required to 5 V, 8 V, or 12 V. As the sensors are current-based, any of these supply voltages may be used so long as the pull-up resistor is chosen to limit the maximum current.

Output voltage levels are a result of the series current through the device, in each of its two switching states. The output voltage is never switched fully to the supply or ground.

Hundred Series ECUs

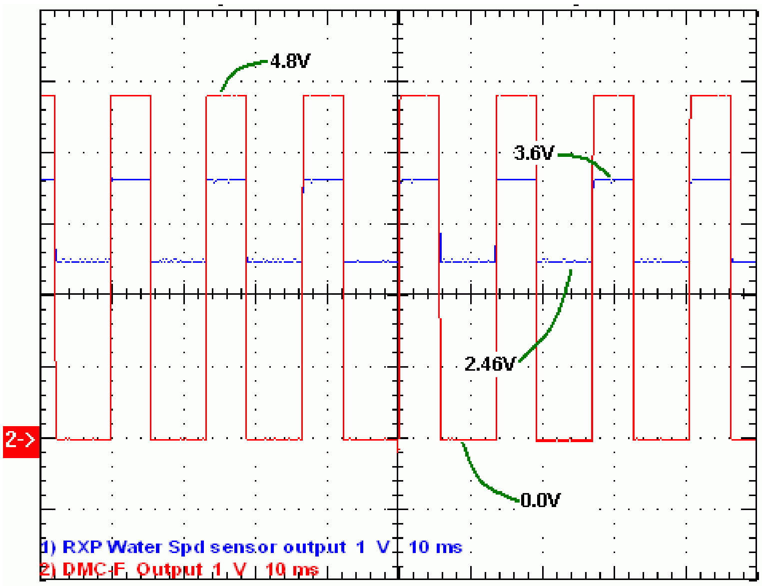
For MoTeC Hundred Series ECUs, digital inputs are used for speed measurements. These digital inputs require a low signal below 1.0 V and a high signal above 3.5 V. To operate magneto-resistive sensors, a suitable supply resistor value must be found to reach these values.

It is not likely to find a supply resistor to directly interface with magneto-resistive sensors. In some cases MoTeC's DMC-F, Dual Magnetic Converter may be a simple solution. The DMC-F with an internal pull-up resistor of 440 Ω to 5 V, a voltage threshold of 3.0 V and output switch might provide a suitable signal for the ECU's digital inputs. You should test the sensor in order to determine If your sensor can operate at these levels. The output is equivalent to a Hall sensor output and normal ECU settings are used.

Example of DMC-F usage

The oscilloscope capture shows (in blue) a Seadoo speed sensor powered from 5 V via a 440 Ω pull-up resistor. The output voltage levels are 2.46 V and 3.6 V from the sensor.

The Red trace is the switched output from a DMC-F device. In this case, the low voltage level is below 1.0 V and the high signal above 3.5 V.



Dash Logger

For MoTeC's Dash Loggers (e.g. ADL2, ADL3) speed inputs are used. They have user-adjustable voltage levels and can be used with a suitable pull-up resistor and appropriate settings. Dash Logger digital inputs are not suitable for use with magneto-resistive sensors.

Testing unknown sensors

Determining Sensor Polarity

The sensor will frequently be in an existing harness where positive and negative wires can be determined. If not, use a digital voltmeter to make resistance and diode voltage drop tests to ascertain the likely polarity. Create a table as shown and replace the example values with your actual measurements.

Resistance Measurements		
		Example Values
(+) probe to wire 1	(-) probe to wire 2	*22.1 kΩ*
(+) probe to wire 2	(-) probe to wire 1	*22.1 kΩ*
Diode Volts Drop Measurement		
		Example Values
(+) probe to wire 1	(-) probe to wire 2	*0.645 V*
(+) probe to wire 2	(-) probe to wire 1	*1.164 V*

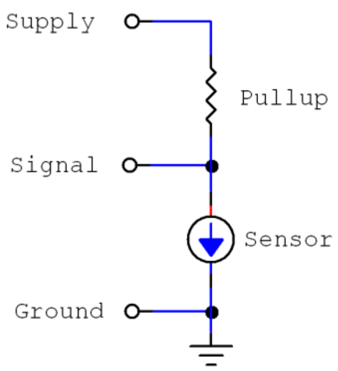
In this case, the resistance measurements do not help to identify polarity, but the diode volts drop measurement indicates that wire 1 is the negative and wire 2 is the positive wire. This is indicated by the 0.645 V drop when the sensor is wired in reverse, a typical protection diode reading when the +probe is connected to the negative pin and the –probe is connected to the positive pin.

If you need assistance, complete this table and send it to MoTeC for evaluation.

Determine Pull-up Resistor

Connect the sensor with a pull-up resistor to a sensor supply voltage pin:

M800 supply pins	
Supply voltage	**pin no**
8 V	A12,
5V	A21, A9
Ground	B14, B15, B16
ADL2 supply pins	
Supply voltage	**pin no**
8V	62
5V	18,28,44
Ground	51, 56, 61



Power up the sensor and monitor the signal voltage levels on an oscilloscope or voltmeter. As the target is moved, the output voltage should vary from high to low voltage levels.

Start with a 5 V supply and 4k7 (4700 Ω) pull-up resistor. If the pull-up resistance is too high, (insufficient current to operate the sensor) the output voltage will not change, and may be around ½ the supply voltage.

Reduce the resistance until there is enough difference in low and high output voltage to enable a correct configuration on the ECU or Dash Logger.

Note – if the pull-up resistance is too low, excess current may flow and damage the sensor. These sensors should never be connected directly to a supply voltage without a pull-up resistor.

A table of results should show supply voltage, pull-up resistance, and high and low output levels.

Supply Voltage	Pull-up Resistance	Example Values*		
		High output V	Low output V	Comment
5 V	4.7 kΩ	*2.7 V*	*2.7 V*	*Unsuitable – not enough current*
5 V	2.0 kΩ	*2.7 V*	*2.7 V*	*Unsuitable – not enough current*
5 V	1.0 kΩ	*2.92 V*	*2.74 V*	*Just usable with Dash Logger.*
5 V	560 Ω	*3.22 V*	*2.88 V*	*OK for Dash Logger, not for M800*
8 V	2.0 kΩ	*3.0 V*	*2.76 V*	*OK for Dash Logger, not for M800*
8 V	1.0 kΩ	*3.8 V*	*3.0 V*	*Good for Dash Logger, not for M800*
8 V	560 Ω	*5.0 V*	*3.64 V*	*Good for Dash Logger, not for M800*

* These figures are example results from an EVO X wheel speed sensor with integral hub magnet ring. Replace these values with your actual measurements

If you need assistance, complete this table and send it to MoTeC for evaluation.

None of the pull-up tests shown above resulted in a voltage change which would trigger an hundred series ECU DIG channel.

In this case, the sensor was used with a Dash logger and a pull-up of 1 kΩ to 8 V was chosen, with a midpoint of 3.4 V.

Example of Sensor Setup

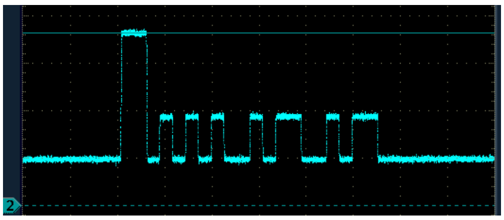
Wheel speed sensors into Speed inputs - pins 63-66 for Speed channels 1-4.
Input **Spd1** pin no **63** Channel **Wheel Speed FL** - repeated for other 3 speed inputs

Calibration

Sensor Type	Magnetic
Magnetic Levels calibration	*3.4 V: 0 kmh* *3.4 V: 300 kmh**
Pulses Per Revolution	*48 **
Rolling Circumference	*2000 mm**

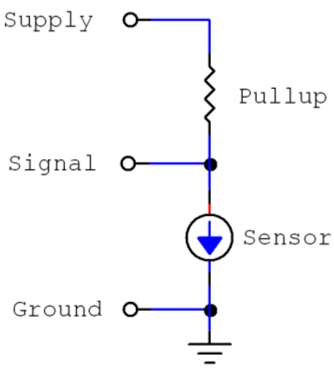
* Replace the example values with your values

Note – some sensors (for example BMW wheel speed sensors) generate three output levels rather than two (see scope capture).



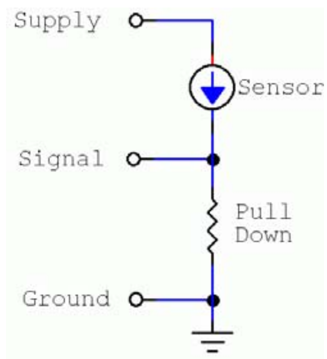
In this example, the high level of 3.64 V represents a logic high and the low level of 1.04 V a logic low for speed measurement. The middle level of 1.92 V is used for status/diagnostics. For correct triggering in a Dash Logger the voltage threshold would be set to 2.4 V, so all of the status data would be ignored.

Connection Diagrams



Pull-Up configuration

Some vehicles (for example Hyundai i30) use an alternate connection method for these sensors, where the series resistor is used as a pull-down to ground, with the positive side of the sensor wired direct to 12 V. This is functionally the same, but would produce different sensor output voltages to a pull-up configuration. In both cases the polarity of the sensor is the same, as is the direction of current flow in the two switched states.



Pull-Down configuration

Summary

- Hundred series ECUs are not likely to directly interface with Magneto-Resistive Sensors. A DMC-F may be suitable once confirmed by testing.
- Polarity may be determined using a diode test on a voltmeter, but OEM schematics are preferable.
- Pull-up resistor values should be determined by starting with higher values (example 4k7 Ω) and reducing the resistance until a suitable voltage change shows for the two states.
- Sensors with multi-level outputs and triggering threshold voltages must be set to 'filter' unwanted data.