

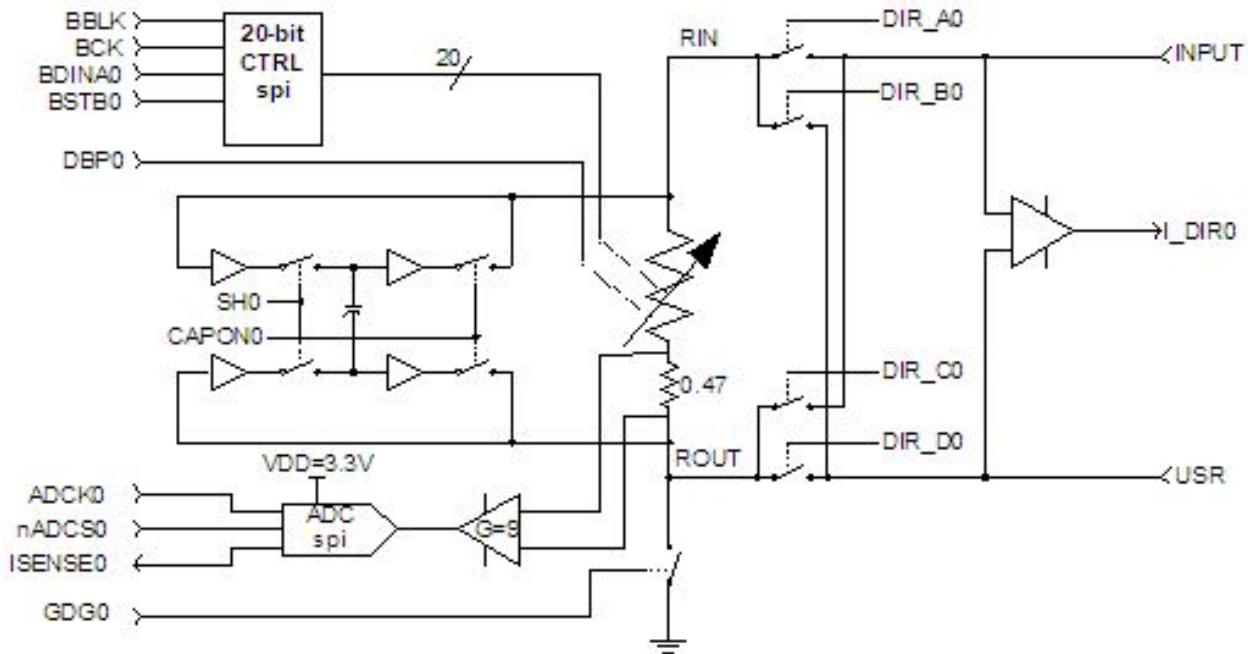
# Resistive Sensors

- Termination voltage
- Current direction protection
- Power dissipation and over current protection
  - Maximum voltage values for different patterns of resistances

Each resistive sensor channel consists of a set of twenty resistors, the combination of which defines the resistance value of the channel, in the range 0.5 and 262.14375k.

The operator controls the resistance value from the [RSM Run-Time Panel](#). This value is then transferred to the FPGA module of the card via the real-time model. From this value, the FPGA program determines the pattern of resistors to be activated to produce the desired resistance and applies this pattern value to the card via a 20-bit deserializer.

Each channel provides an input pin and a user-supplied reference input pin at the ELCO-56 connector. When the ECU signal is connected to the input pin, it is tied to either the user-supplied reference voltage (USRx) or GND, through the programmed resistor set,



The 20 individual resistance values are listed below. the current sensing circuitry adds a 0.47 resistance.

| Resistance Position | Resistance Value |
|---------------------|------------------|
| 19                  | 131072           |
| 18                  | 65536            |
| 17                  | 32768            |
| 16                  | 16384            |
| 15                  | 8192             |
| 14                  | 4096             |
| 13                  | 2048             |
| 12                  | 1024             |
| 11                  | 512              |
| 10                  | 256              |
| 9                   | 128              |

|   |      |
|---|------|
| 8 | 64   |
| 7 | 32   |
| 6 | 16   |
| 5 | 8    |
| 4 | 4    |
| 3 | 2    |
| 2 | 1    |
| 1 | 0.5  |
| 0 | 0.25 |

## Termination voltage

For each channel, the user is able to select the termination voltage via a drop-down list in the [RSM Configuration Panel](#). The three choices are **Open**, **Ground**, and **User-Defined Voltage**.

- The inputs default state is **Open** circuit state and this is achieved by opening both of the termination voltages.
- When **User-Defined** voltage is selected, the user must supply a reference voltage on the corresponding USRx input.

Both the Input and the User Supplied Termination voltage are [Operating Voltage](#) tolerant.

## Current direction protection

A voltage comparator signals the current flow (I\_DIR0) and the 4 input switch allows to select the current flow direction (DIR\_?0) when operating between the Input and the User supply reference voltage.

## Power dissipation and over current protection

Each input is able to support 1/4 watt of dissipation. The table below illustrates the power range detection for all the resistor range.

As shown in the sensor diagram above, a sampling (SH0) and buffer (CAPON0) mechanism allows limiting the transition between resistor values within 5% overshoot/undershoot. A current sense circuit monitors the current within the circuit and opens it when the power dissipation exceeds ¼ watt. As power dissipation is function of the selected resistance, an Analog To Digital Converter (ADCK0, nADCS0, ISENSE0) is used to monitor the flowing current. The control module monitors continuously the current. Upon detecting a fault, it reports an error and opens the circuit.

When an error condition is detected, the fault is reported via the model to the user interface. After removing the fault condition, the operator can acknowledge the fault from the [RSM Run-Time Panel](#). The fault is then cleared by the FPGA module if the condition is no longer present, otherwise, the fault is raised again.

## Maximum voltage values for different patterns of resistances

| RANGE | Res Reg | R     | R real | Vmax | I <sub>max</sub> | V <sub>r</sub> | V <sub>adc</sub> |
|-------|---------|-------|--------|------|------------------|----------------|------------------|
| 0x1F  | 0       | 5.00  | 5.00   | 1.12 | 0.22             | 1.12           | 1387.72          |
| 0x13  | 1       | 0.24  | 5.24   | 1.14 | 0.22             | 1.09           | 1355.57          |
| 0x12  | 2       | 0.47  | 5.47   | 1.17 | 0.21             | 1.07           | 1326.76          |
| 0x12  | 3       | 0.71  | 5.71   | 1.19 | 0.21             | 1.05           | 1298.58          |
| 0x11  | 4       | 1.00  | 6.00   | 1.22 | 0.20             | 1.02           | 1266.81          |
| 0x11  | 7       | 1.71  | 6.71   | 1.30 | 0.19             | 0.97           | 1197.91          |
| 0x10  | 8       | 2.00  | 7.00   | 1.32 | 0.19             | 0.94           | 1172.84          |
| 0x10  | F       | 3.71  | 8.71   | 1.48 | 0.17             | 0.85           | 1051.42          |
| 0xF   | 10      | 4.00  | 9.00   | 1.50 | 0.17             | 0.83           | 1034.34          |
| 0xF   | 1F      | 7.71  | 12.71  | 1.78 | 0.14             | 0.70           | 870.39           |
| 0xE   | 20      | 8.00  | 13.00  | 1.80 | 0.14             | 0.69           | 860.63           |
| 0xE   | 3F      | 15.71 | 20.71  | 2.28 | 0.11             | 0.55           | 681.86           |
| 0xD   | 40      | 16.00 | 21.00  | 2.29 | 0.11             | 0.55           | 677.14           |
| 0xD   | 7F      | 31.71 | 36.71  | 3.03 | 0.08             | 0.41           | 512.15           |

|     |       |           |           |        |      |      |        |
|-----|-------|-----------|-----------|--------|------|------|--------|
| 0xC | 80    | 32.00     | 37.00     | 3.04   | 0.08 | 0.41 | 510.14 |
| 0xC | FF    | 63.71     | 68.71     | 4.14   | 0.06 | 0.30 | 374.35 |
| 0xB | 100   | 64.00     | 69.00     | 4.15   | 0.06 | 0.30 | 373.56 |
| 0xB | 1FF   | 127.71    | 132.71    | 5.76   | 0.04 | 0.22 | 269.36 |
| 0xA | 200   | 128.00    | 133.00    | 5.77   | 0.04 | 0.22 | 269.07 |
| 0xA | 3FF   | 255.71    | 260.71    | 8.07   | 0.03 | 0.15 | 192.18 |
| 0x9 | 400   | 256.00    | 261.00    | 8.08   | 0.03 | 0.15 | 192.07 |
| 0x9 | 7FF   | 511.71    | 516.71    | 11.37  | 0.02 | 0.11 | 136.51 |
| 0x8 | 800   | 512.00    | 517.00    | 11.37  | 0.02 | 0.11 | 136.47 |
| 0x8 | FFF   | 1023.71   | 1028.71   | 16.04  | 0.02 | 0.08 | 96.75  |
| 0x7 | 1000  | 1024.00   | 1029.00   | 16.04  | 0.02 | 0.08 | 96.73  |
| 0x7 | 1FFF  | 2047.71   | 2052.71   | 22.65  | 0.01 | 0.06 | 68.49  |
| 0x6 | 2000  | 2048.00   | 2053.00   | 22.66  | 0.01 | 0.06 | 68.48  |
| 0x6 | 3FFF  | 4095.71   | 4100.71   | 32.02  | 0.01 | 0.04 | 48.46  |
| 0x5 | 4000  | 4096.00   | 4101.00   | 32.02  | 0.01 | 0.04 | 48.46  |
| 0x5 | 7FFF  | 8191.71   | 8196.71   | 45.27  | 0.01 | 0.03 | 34.27  |
| 0x4 | 8000  | 8192.00   | 8197.00   | 45.27  | 0.01 | 0.03 | 34.27  |
| 0x4 | 7FFF  | 16383.71  | 16388.71  | 64.01  | 0.00 | 0.02 | 24.24  |
| 0x3 | 10000 | 16384.00  | 16389.00  | 64.01  | 0.00 | 0.02 | 24.24  |
| 0x3 | 1FFFF | 32767.71  | 32772.71  | 90.52  | 0.00 | 0.01 | 17.14  |
| 0x2 | 20000 | 32768.00  | 32773.00  | 90.52  | 0.00 | 0.01 | 17.14  |
| 0x2 | 3FFFF | 65535.71  | 65540.71  | 128.00 | 0.00 | 0.01 | 12.12  |
| 0x1 | 40000 | 65536.00  | 65541.00  | 128.00 | 0.00 | 0.01 | 12.12  |
| 0x1 | 7FFFF | 131071.71 | 131076.71 | 181.02 | 0.00 | 0.01 | 8.57   |
| 0x0 | 80000 | 131072.00 | 131077.00 | 181.02 | 0.00 | 0.01 | 8.57   |