

# MicroStrain<sup>®</sup>

## Microminiature and Subminiature DVRT<sup>®</sup> Quick Start Guide

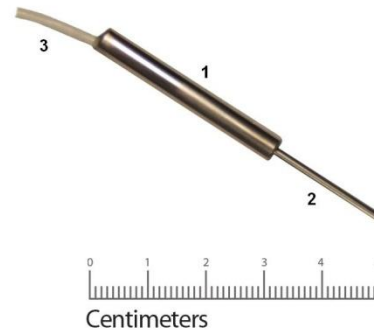
| Microminiature DVRT <sup>®</sup> | Subminiature DVRT <sup>®</sup> |
|----------------------------------|--------------------------------|
| M-DVRT-1.5                       | S-DVRT-4                       |
| M-DVRT-3                         | S-DVRT-8                       |
| M-DVRT-6                         | S-DVRT-24                      |
| M-DVRT-9                         | S-DVRT-38                      |
| M-DVRT-PE-3.0                    | HS-DVRT-6                      |
| M-DVRT-PE-9.0                    | HS-DVRT-6-HSS                  |
| HM-DVRT-1.5                      | NANO-DVRT-0.5                  |

### DVRT<sup>®</sup>

The Differential Variable Reluctance Transducer (DVRT<sup>®</sup>) is designed for precision linear measurements.

The DVRT<sup>®</sup> is comprised of 3 main components:

1. a rigid **body**,
2. a free sliding **core**,
3. and a **connector cable** for electronics.



### Electronics

The DVRT<sup>®</sup> may be connected to any of the following MicroStrain signal conditioning products:

- DEMOD-DVRT housed in either a Motherboard chassis or Smart Motherboard chassis
- DEMOD-DVRT-TC housed in either a Motherboard chassis or Smart Motherboard chassis
- DEMOD-DIN
- DEMOD-DC<sup>®</sup> 2
- DVRT-Link<sup>™</sup>

### Certificate of Calibration

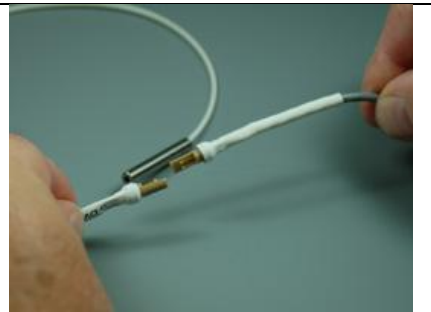
Every DVRT<sup>®</sup> is paired and calibrated at the factory with its own signal conditioner. Each DVRT<sup>®</sup> and signal conditioner pair are shipped with a Certificate of Calibration which should be consulted to insure that the pair is always connected and used together. An example Certificate of Calibration is shown below:

| <b>Certificate of Calibration</b>   |                                   |                |                         |
|---|-----------------------------------|----------------|-------------------------|
| This document certifies that the equipment referenced below meets published specifications. |                                   |                |                         |
|   | Date of Calibration:              | 12/28/2006     | <u>Sensor Color Key</u> |
|   |                                   |                | __ black                |
|   | Sensor Model:                     | S-DVRT-8       | __ red                  |
|   | Sensor Serial Number:             | 1211-2028      | __ blue                 |
|   |                                   |                | __ green                |
|   | Signal Conditioner Model:         | DEMODO-DC      | __ yellow               |
|   | Signal Conditioner Serial Number: | 3118-2455      | __ white                |
|   | -3dB Bandwidth:                   | 800            |                         |
|   | Slope (mm/V):                     | 1.67821        | *                       |
|   | Offset(mm):                       | -4.2131        |                         |
|   | Calibrated by:                    | jpc            |                         |
|   | Calibration Temperature (deg C):  | 22             |                         |
|   | Calibration Frequency:            | Static (< 2Hz) |                         |
|   | Warm up time:                     | >15 minutes    | †                       |

Here we see an S-DVRT-8 with serial number 1211-2028 calibrated with a DEMOD-DC<sup>®</sup> 2 serial number 3118-2455. Each DVRT<sup>®</sup> and each signal conditioner are clearly marked with their serial number. If you have received multiple DVRT<sup>®</sup>s and signal conditioners, it is mandatory that you marry the pairs together using the information from the Certificates of Calibration.

### **Connections**

The DVRT<sup>®</sup> **connector cable** terminates in a 4 pin hermaphroditic LEMO connector and requires a CBL1, CBL2 or CBL25 mating cable to connect to a DEMOD-DVRT, DEMOD-DVRT-TC or DEMOD-DIN. No mating cable is required to connect to the DEMOD-DC<sup>®</sup> 2 or DVRT-Link<sup>™</sup>.



The CBL1, CBL2 and CBL25 mating cables have a 4 pin hermaphroditic LEMO connector on one end and a 4 pin keyed locking LEMO connector on the other with a **red dot** for alignment.



### Connecting the DVRT<sup>®</sup> and DEMOD-DVRT

- Connect the DVRT<sup>®</sup> to the CBL1, CBL2 or CBL25.
- Connect the CBL1 to the 4 pin LEMO connector on the DEMOD-DVRT by aligning the **red dots** and pushing the connector in until it locks.
- Connect your DAQ to the BNC connector on the DEMOD-DVRT.



### Connecting the DVRT<sup>®</sup> and DEMOD-DVRT-TC

- Connect the DVRT<sup>®</sup> to the CBL1, CBL2 or CBL25.
- Connect the CBL1 to the 4 pin LEMO connector on the DEMOD-DVRT-TC by aligning the **red dots** and pushing the connector in until it locks.
- Connect your DAQ to the BNC connector on the DEMOD-DVRT-TC.



### Connecting the DVRT<sup>®</sup> and DEMOD-DIN

- Connect the DVRT<sup>®</sup> to the CBL1, CBL2 or CBL25.
- Connect the CBL1 to the DEMOD-DIN by aligning the **red dots** and pushing the connector in until it locks.
- Connect your DAQ to the V Out and GND connectors on the DEMOD-DIN.



**Caution!!!** When removing the LEMO connector from the DEMOD-DVRT, DEMOD-DVRT-TC or DEMOD-DIN, grasp the knurled diameter and pull straight out. The lock will release and the connector will detach. Do not twist or rotate the LEMO connector.

### Connecting the DVRT<sup>®</sup> and DEMOD-DC<sup>®</sup> 2

- The DVRT<sup>®</sup> connector cable is plug-compatible with the DEMOD-DC<sup>®</sup> 2.
- Connect the DVRT<sup>®</sup> directly to the DEMOD-DC<sup>®</sup> 2.
- Connect your DAQ to the 0-5 Volts Output and Ground on the DEMOD-DC<sup>®</sup> 2.



### Connecting the DVRT<sup>®</sup> and DVRT-Link<sup>™</sup>

- The DVRT<sup>®</sup> connector cable is plug-compatible with the DVRT-Link<sup>™</sup>.
- Connect the DVRT<sup>®</sup> directly to the DVRT-Link<sup>™</sup>.
- Use the DVRT-Link<sup>™</sup> with the USB Base Station and Agile-Link software.



### Powering and Wiring the Signal Conditioner

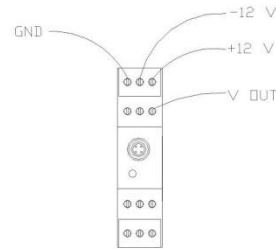
#### Powering the Motherboard and Smart Motherboard

- The DEMOD-DVRT and DEMOD-DVRT-TC are housed within the Motherboard chassis.
- Plug the 5 pin male connector of the power supply into the female connector on the Motherboard backplane.



#### Powering and Wiring the DEMOD-DIN

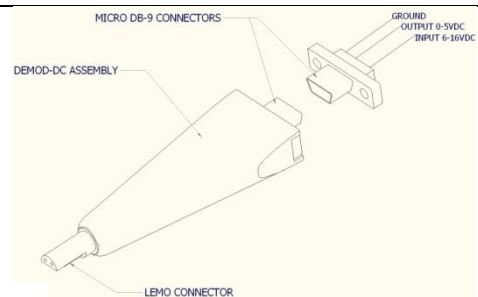
- GND from power source
- +12 V from power source
- -12 V from power source
- V Out to DAQ
- GND to DAQ



#### Powering and Wiring the DEMOD-DC<sup>®</sup> 2

- Black Ground from power source
- White 0-5 VDC Output to DAQ
- Red 6-16 VDC from power source

**Caution! Do not connect the output lead to power. The circuit is unprotected and unwarranted damage will result.**



### Attaching the DVRT<sup>®</sup>

MicroStrain provides a range of attachment fixtures to secure both the **body** and the **core** in the environment to be measured. Please consult with your MicroStrain support engineer to find the best approach for your particular requirements. **Note:** For the calibration to remain valid during operation, the fixture material must be a polymer or 300 series stainless steel.

### **Locating the Linear Range of the DVRT®**

After connecting the DVRT®, powering up the signal conditioner and connecting the DAQ, you need to locate the **core** within the **body** and establish the linear range by moving the **core** back and forth, and observing the DVRT®'s output on the DAQ. **Note:** It is possible to insert the wrong end of the **core** into the **body**. If there is less than a 50 millivolt reading on the DAQ, you have the **core** in backwards.

#### **Locating the range with a DEMOD-DVRT**

- A DEMOD-DVRT provides a maximum of -10.0 to +10.0 volts output.
- The linear region of the DVRT® is typically +/- 4.5 volts.
- Without the core installed in the body, the output will be 0 volts.
- Carefully insert the core into the body and observe the output.
- As you slide the core in, you will see the voltage go first to a negative voltage.
- Continue sliding and the voltage will increase to 0 volts, indicating it is passing the mid point of its specified linear region.
- Continue sliding and the voltage will continue increasing to a positive voltage.
- Using our 8mm S-DVRT-8 as an example, if the linear slope from the Certificate of Calibration is 1 mm/V, the linear region would be between -4.0 volts and +4.0 volts. The 8 volt range reflects our 8mm measurement range.

#### **Locating the range with a DEMOD-DVRT-TC**

- A DEMOD-DVRT-TC provides a maximum of -10.0 to +10.0 volts output.
- The linear region of the DVRT® is typically +/- 4.5 volts.
- Without the core installed in the body, the output will be 0 volts.
- Carefully insert the core into the body and observe the output.
- As you slide the core in, you will see the voltage go first to a negative voltage.
- Continue sliding and the voltage will increase to 0 volts, indicating it is passing the mid point of its specified linear region.
- Continue sliding and the voltage will continue increasing to a positive voltage.
- Using our 8mm S-DVRT-8 as an example, if the linear slope from the Certificate of Calibration is 1 mm/V, the linear region would be between -4.0 volts and +4.0 volts. The 8 volt range reflects our 8mm measurement range.

#### **Locating the range with a DEMOD-DIN**

- A DEMOD-DIN provides a maximum of -10.0 to +10.0 volts output.
- The linear region of the DVRT® is typically +/- 4.5 volts.
- Without the core installed in the body, the output will be 0 volts.
- Carefully insert the core into the body and observe the output.
- As you slide the core in, you will see the voltage go first to a negative voltage.
- Continue sliding and the voltage will increase to 0 volts, indicating it is passing the mid point of its specified linear region.
- Continue sliding and the voltage will continue increasing to a positive voltage.
- Using our 8mm S-DVRT-8 as an example, if the linear slope from the Certificate of Calibration is 1 mm/V, the linear region would be between -4.0 volts and +4.0 volts. The 8 volt range reflects our 8mm measurement range.

### **Locating the range with a DEMOD-DC<sup>®</sup> 2**

- A DEMOD-DC<sup>®</sup> 2 provides 0.0 to +5.0 volts output.
- The linear region of the DVRT<sup>®</sup> is typically +0.5 to +4.5 volts.
- Without the core installed in the body, the output will be +2.5 volts.
- Carefully insert the core into the body and observe the output.
- As you slide the core in, you will see the voltage go first to 0.0 volts.
- Continue sliding and the voltage will increase to +2.5 volts, indicating it is passing the mid point of its specified linear region.
- Continue sliding and the voltage will continue increasing to +5.0 volts.
- Using our 8mm S-DVRT-8 as an example, if the linear slope from the Certificate of Calibration is 2 mm/V, the linear region would be between +0.5 volts and +4.5 volts. The 4 volt range reflects our 8mm measurement range.

### **Locating the range with a DVRT-Link<sup>™</sup>**

- A DVRT-Link<sup>™</sup> provides 0 to 4096 bits output.
- The linear region of the DVRT<sup>®</sup> is typically 48 to 4048 bits.
- Without the core installed in the body, the output will be 2048 bits.
- Carefully insert the core into the body and observe the output.
- As you slide the core in, you will see the output go first to 0 bits.
- Continue sliding and the output will increase to 2048 bits, indicating it is passing the mid point of its specified linear region.
- Continue sliding and the output will continue increasing to 4096 bits.
- Using our 8mm S-DVRT-8 as an example, if the linear slope from the Certificate of Calibration is 2 microns/bit, the linear region would be between 48 and 4048 bits. The 4000 bits range reflects our 8mm measurement range.
- **Note:** The DVRT-Link<sup>™</sup> is shipped with its calibration already programmed into non-volatile memory. The Certificate of Calibration will contain the conversion factor for bits to volts.

### **Scaling Volts to Displacement**

The Certificate of Calibration provides 3 calibration models to scale the voltage output of the DVRT<sup>®</sup> into a displacement measurement, being 1) Least Squares Linear Fit, 2) Multi-Segment Linear Fit, and 3) Polynomial Fit. The models provide the calibration coefficients and detail the formulas to compute displacement in millimeters (mm).

Using our example Certificate of Calibration shown above, we see the scaling method for Least Squares Linear Fit is as follows:

| Least Squares Linear Fit Model |                       | Least Squares Linear Fit Results |                                       |                        |
|--------------------------------|-----------------------|----------------------------------|---------------------------------------|------------------------|
|                                |                       |                                  | <b>Slope<br/>(mm/V)</b>               | <b>Offset<br/>(mm)</b> |
|                                | $D = M \cdot x + B$   |                                  | <b>1.67821</b>                        | <b>-4.21306</b>        |
| where                          | D = Displacement (mm) |                                  |                                       |                        |
|                                | M = Slope (mm/V)      |                                  | Residual Errors (within linear range) |                        |
|                                | x = Sensor Output (V) |                                  | Max (mm)                              | Min (mm)               |
|                                | B = Offset (V)        |                                  | 0.47899                               | -0.29585               |

Again using the 8mm stroke DVRT<sup>®</sup> (S-DVRT-8) shown on our Certificate of Calibration, an output of 1.5 volts from the signal conditioner would produce a displacement as follows:

$$-1.695 \text{ mm} = 1.67821 \text{ mm/V} * 1.5 \text{ V} + -4.21306 \text{ mm}$$

The Least Squares Linear Fit is the most common but least accurate way of calculating displacement. This method assumes that the DVRT<sup>®</sup> output is a perfectly linear straight line when in fact it is a curve function. It is easy to implement and is very good approximation.

The Multi-Segment Linear Fit and Polynomial Fit scaling methods are similarly detailed on the Certificate of Calibration. Computation is a bit more complex with a resultant higher accuracy.

**Congratulations!**

You are off and running! MicroStrain engineers are always available by email, phone or SKYPE to support you in any way we can.