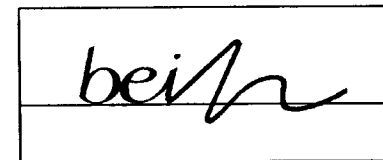


# TorqueTrak 9000 Digital Telemetry System Users Manual

Featuring

**TorqueTrak All-Digital™ Technology**



**Binsfeld Engineering Inc.**  
4571 W. MacFarlane  
Maple City, MI 49664  
800-524-3327  
FAX: 231-334-4903  
[www.torquetrak.com](http://www.torquetrak.com)

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## FCC Rules Part 15: Computing Devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

The user is cautioned that changes and modifications made to the equipment without the express approval of the manufacturer could void the user's authority to operate this equipment.

"Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference that may cause undesired operation of the device."



## System Overview

The TorqueTrak 9000 is a battery-powered digital radio telemetry system designed to transmit a single millivolt data signal (typically from a strain gage or gage-type sensor) up to 200 feet. Up to 8 individual systems can be operated concurrently to transmit multiple data signals.

The TorqueTrak 9000 consists of two primary components: the BT9000 Bridge Transmitter and the RD9000 Receiver.

The TorqueTrak 9000 features:

- fully encapsulated rotating electronics
- user-adjustable input range
- excellent accuracy and stability
- minimal drift with ambient temperature changes
- microprocessor-based digital circuitry from sensor input to signal output
- RF signal strength indicator
- reverse polarity switch

Ideal for short term diagnostic testing, the TorqueTrak 9000 is rugged, intelligent, and simple to use.

## System Components

### BT9000 Transmitter with

- 2" screw-mount antenna (reverse polarity SMA connector)
- 9V battery connector
- 10 ft 4-conductor ribbon cable

### RD9000 Receiver

AC110/12VDC Wall Plug Transformer  
(AC220/12VDC Wall Plug Transformer optional)

RA900 Receiver Antenna with 25 ft connecting cable

BS900 Bridge Simulator

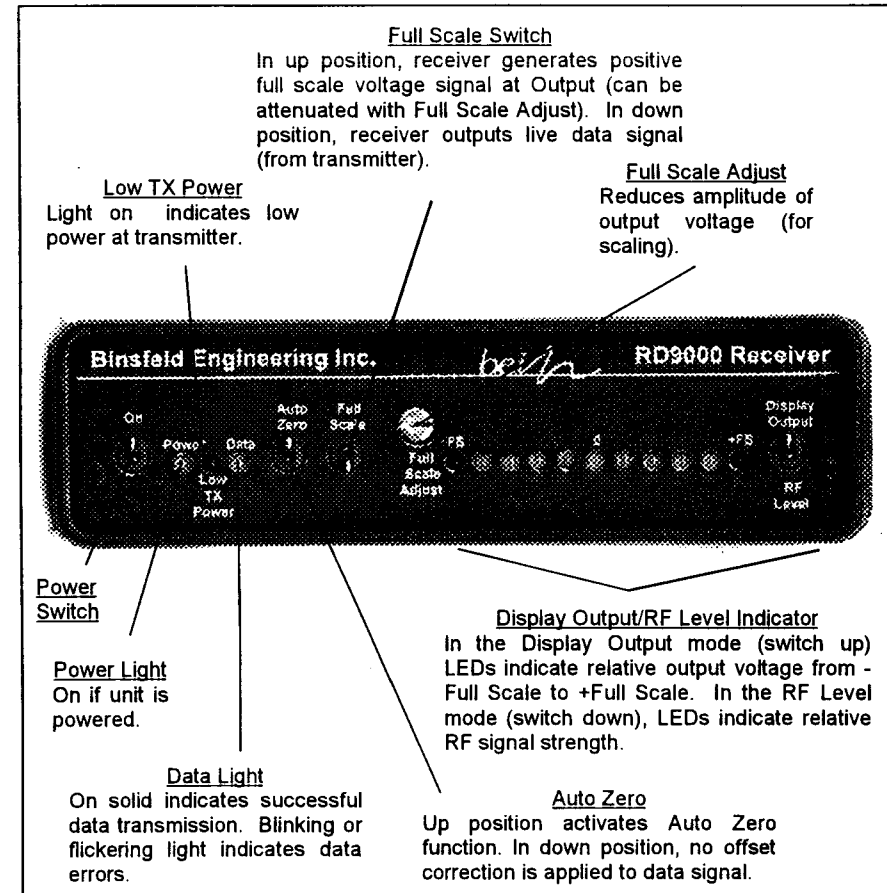
Screwdriver

9V Lithium Battery

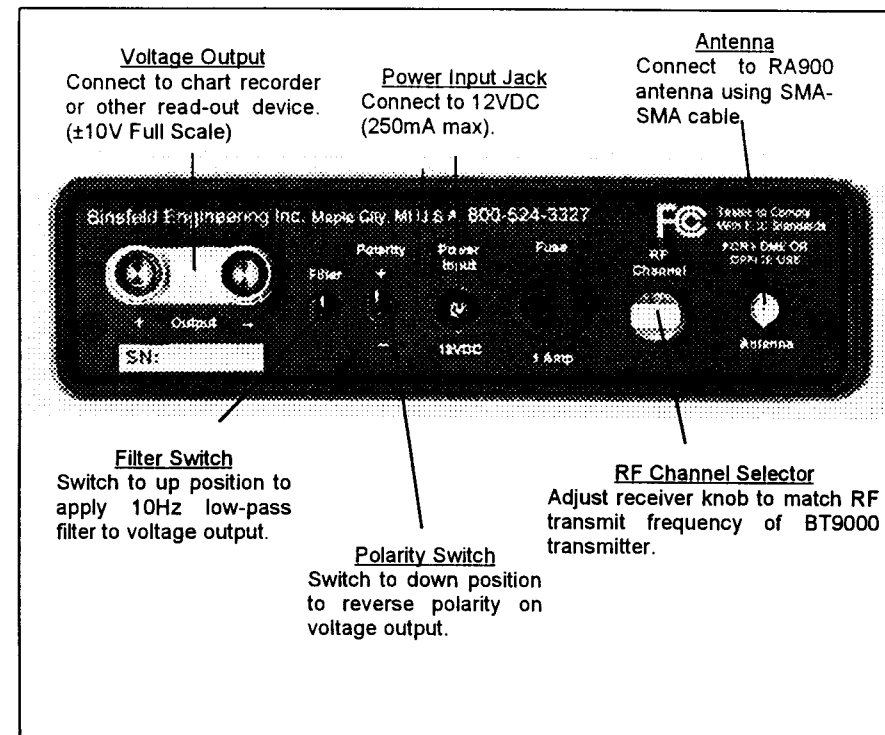
TorqueTrak 9000 Users Manual

## Features and Controls

### RD9000 Receiver

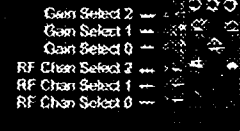


RD9000 Front Panel Controls



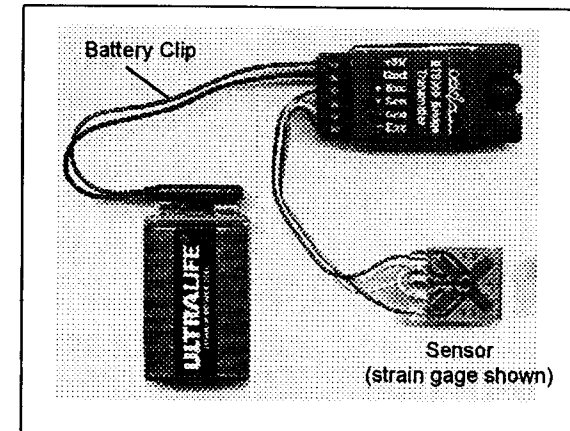
*RD9000 Rear Panel Controls*

# **IIIIIIIIII**



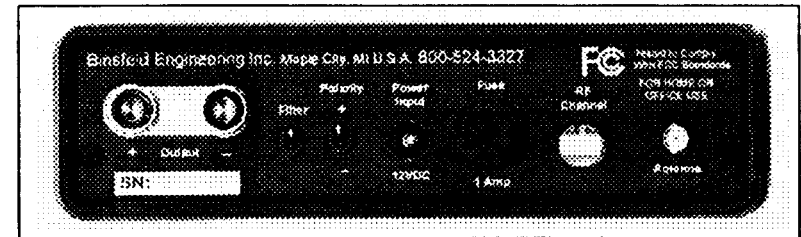
## Set Up Procedure

1. Attach sensor or strain gage(s) to shaft or device being measured. Be sure shaft and/or sensor is unstrained when attaching as this is the zero load reference.
2. Strap transmitter and 9 volt battery to shaft or device being measured. To secure transmitter and battery use fiberglass strapping tape (available at hardware stores). Alternatively, hose clamps, machined collars or other methods or devices may be used but care should be taken to avoid excessive compression on the transmitter and battery. CAUTION: Avoid injury by standing clear of attached items which may come off during rotation if improperly secured!
3. Solder an appropriate length of 4-conductor ribbon cable or suitable leads to gage or sensor (6 – 8 inches typical).
4. Connect other end of ribbon cable leads to appropriate screw terminals on BT9000 transmitter. Secure battery connector to appropriate screw terminals on BT9000, and attach to 9 volt battery.



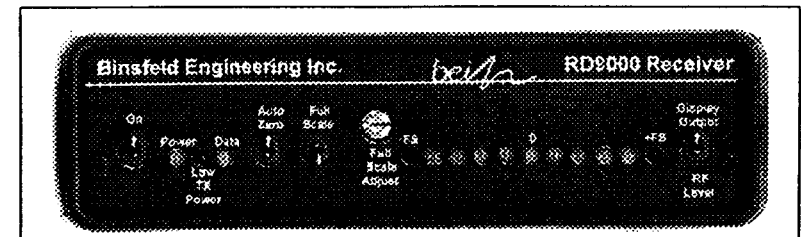
*Transmitter, Battery and Sensor Connections*

5. Position RA900 magnetic-mount receiving antenna near transmitter, typically within 10 feet.
6. Connect RA900 receiving antenna to **Antenna** connection on rear panel of RD9000 receiver.



*RD9000 Rear Panel*

7. Connect 12VDC AC adapter (Model AC110 or AC220) to **Power Input** jack on RD9000 rear panel. Plug adapter into appropriate power source (wall outlet). Move RD9000 power switch to **On**.



*RD9000 Front Panel*

8. Flip **Auto Zero** switch down to remove the previously stored reference. Confirm that **Full Scale** switch is down (used only for scaling and trouble shooting).
9. Confirm that **Data** light on front panel of RD9000 is on solid (indicating successful data transmission). If **Data** light is not on solid, see Trouble Shooting Guide in Appendix C.
10. To evaluate radio signal strength, flip **Display Output/RF Level** switch down to **RF Level**. Relative signal strength is indicated by position of lighted LED with **-FS** being low end

of scale and **+FS** being high end. If possible, rotate transmitter through complete range of motion to verify strong signal reception in all orientations.

11. Connect recorder or other voltage readout device to **Output** terminals on rear panel of RD9000.
12. Flip **Auto Zero** switch up to zero out any initial imbalance (sensor must be in unloaded state, e.g. no torque on shaft). Leave switch in up position during test to retain reference. **Auto Zero** can be reset by flipping switch down and then back up again. (Sensor must be in unloaded state). Note: If before activating **Auto Zero** there is an initial offset of more than 25% of full scale, contact technical support at Binsfeld Engineering.
13. Set **Filter** switch at rear of RD9000 to desired position, up to activate 10 Hz low-pass filter (averages dynamic data) or down to allow full 500 Hz frequency response.
14. Calibrate output voltage based on gain calculations determined mathematically as demonstrated in Appendix B: Simplified Torque Calibrations.
15. Adjust the gain of the chart recorder or readout device for the desired deflection. For example, if the system is calibrated to provide  $\pm 10\text{VDC}$  for  $\pm 10,000$  inch-pounds, the recorder could be set to deflect  $\pm 50$  mm (the center of the chart is usually considered the zero or balanced position). The plotted output on the chart would then be scaled at 200 inch-pounds/mm.
16. System is now ready to record data.

## Appendix A: System Calibration

The RD9000 is calibrated prior to shipping using instruments traceable to the United States National Institute of Standards and Technology (NIST). Calibration can be checked at any time with a NIST traceable reference such as a calibrated voltmeter.

Check the RD9000 calibration as follows:

1. Turn the unit on and allow a 15 minute warm-up.
2. Turn the **Full Scale Adjust** screw on the front panel fully clockwise.
3. Flip the **Full Scale** switch on the front panel to the down position.
4. Connect a calibrated voltmeter to the **Output** on the rear panel of the RD9000.
5. Without the RD9000 receiving a transmitted signal (e.g. transmitter not operating or RD9000 channel selector set to an unused frequency) the **Output** should read negative full scale ( $-10 \text{ VDC} \pm 0.01$ ).
6. Flip the **Full Scale** switch on the front panel to the up position.
7. The **Output** should read positive full scale ( $+10 \text{ VDC} \pm 0.01$ ).

It is recommended that the RD9000 be checked for calibration annually. If found to be out of specification, it can be returned to Binsfeld Engineering Inc. for calibration for a nominal fee (\$75.00, price subject to change).

## Appendix B: TorqueTrak 9000 Specifications

Sensor Input: Full (4-arm) Wheatstone Bridge strain gage  
(350 ohm standard)

Sensor Range (microstrain, user selectable):

| Gain Level | Torque, Bending            | Tension, Compression         | ¼ Bridge                   |
|------------|----------------------------|------------------------------|----------------------------|
|            | Full Bridge, 4 Active Arms | Full Bridge, 2.6 Active Arms | Single Gage (1 Active Arm) |
| 6          | ±125                       | ±192.3                       | ± 500                      |
| 5          | ±250                       | ±384.6                       | ±1000                      |
| 4          | ±500                       | ±769.2                       | ±2000                      |
| 3          | ±1000                      | ±1538.4                      | ±4000                      |
| 2          | ±2000                      | ±3076.8                      | ±8000                      |
| 1          | ±4000                      | ±6153.6                      | ±16,000                    |
| 0          | ±8000                      | ±12307.2                     | ±32,000                    |

(Assumed gage factor = 2.0)

Sensor and Power Connection: Screw terminal block

Transmitter Power Input: 7.5 to 12VDC

Transmitter Battery Life: 12 hours  
(9V lithium, 350 ohm bridge, 25°C)

Receiver Output Signal: ±10 volts full scale

Receiver Output Connection: 5-way binding posts (banana jacks)

Receiver Power Input: 12VDC (250mA max)  
(110VAC or 220VAC adapter supplied)

Gain Error: ±0.5%FS (unadjusted<sup>1</sup>)  
Gain Drift: 0.01%/°C

Zero Error: ±1% (unadjusted<sup>1</sup>)  
±0.1%FS (after AutoZero)  
Zero Drift: 0.01%FS/°C

[<sup>1</sup>Maximum errors which may be reduced by proper calibration]

Resolution: 14 bits ( $\pm$ full scale = 16384 points)

Frequency Response: 0 – 500Hz (-3dB typical @ 500Hz)

Operating Temperature:

BT9000 Transmitter: -0 to 70°C

RD9000 Receiver: -0 to 70°C

Weight:

BT9000 Transmitter: 2 oz (57 g)

RD9000 Receiver: 3 lbs (1.4 kg)

Size:

BT9000 Transmitter: 1.05" x 1.95" x 0.70"  
(27mm x 50mm x 18mm)

RD9000 Receiver: 5.5" x 7.5" x 1.5"  
(14cm x 19cm x 3.8cm)

## Appendix C: Sample Calculations

### LEGEND OF TERMS

|            |                                                                                   |
|------------|-----------------------------------------------------------------------------------|
| $e_g$      | Gage Strain (normal strain at 45° to shaft axis) (in/in)                          |
| $D$        | Shaft Diameter (in)                                                               |
| $T$        | Torque (in-lbs)                                                                   |
| $T_{FS}$   | Full Scale Torque (in-lbs)                                                        |
| $T_{TRIM}$ | Adjusted Torque (in-lbs)                                                          |
| $E$        | Modulus of Elasticity ( 30 x 106 PSI steel)                                       |
| $V$        | Poisson's Ratio (0.30 for steel)                                                  |
| $N$        | Number of Active Gages (4 for torque)                                             |
| $GF$       | Gage Factor (specified on strain gage pkg)                                        |
| $G_{XMT}$  | Telemetry Transmitter Gain (user configurable, typical is 2000 for +/-500e range) |
| $V_{EXT}$  | Bridge Excitation Voltage = 5 volts                                               |
| $V_{FS}$   | System Output Full Scale = 10 volts                                               |
| $V_{TRIM}$ | Adjusted Voltage Output                                                           |

### EQUATIONS

$$\frac{(V_{FS})(\pi)(D^3)(E)(4)}{(V_{EXT})(GF)(N)(16)(1+\nu)(G_{XMT})} = T_{FS}$$

Simplified, using the values listed in the table above provides the following:

$$\frac{(4531 \text{ lb/in}^2)(D^3)}{(GF)} = T_{FS}$$

(Note:  $G_{XMT}$  of 2000 used. See Appendix E.)

1. Based on the diameter of the shaft, and the strain gage's gage factor, Determine The Full Scale Torque ( $T_{FS}$ ) which will produce a full scale output of 10 volts from the telemetry system.

Example: A customer has a 2.50 inch diameter shaft.  
The strain gage package lists a gage factor (GF) of 2.045.

$$T_{FS} = \frac{(4531 \text{ lb/in}^2)(2.50^3 \text{ in}^3)}{(2.045)} = 34,620 \text{ in-lb}$$

2. Trim the Full Scale Voltage Output to reflect a round number Torque ( $T_{TRIM}$ ).

$$(T_{FS})(V_{FS}) = (T_{TRIM})(V_{TRIM}) \text{ OR, } (T_{FS})(V_{FS})/(T_{TRIM}) = (V_{TRIM})$$

Example: Trim the Full Scale Voltage Output to reflect a Torque ( $T_{TRIM}$ ) value of 40,000 in-lb.

$$(34,620 \text{ in-lb})(10 \text{ volts})/(40,000 \text{ in-lb}) = (V_{TRIM}) = 8.66 \text{ volts}$$

To apply this to the system:

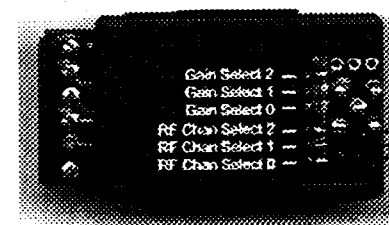
1. Flip the Full Scale switch up on the front of the RD9000.
2. Connect a volt meter to the Output on the rear of the RD9000.
3. Trim the Full Scale Adjust screw on the front of the RD9000 until the volt meter reads 8.66 volts. The system is now calibrated so that 40,000 in-lb equals 10 volts (i.e. the gain of the system is 4000 in-lb/volt).

## Appendix D: RF Channel Configuration

The RF frequency of the RD9000 receiver is selected simply by switching the **RF Channel** knob on the rear panel to the desired channel (0-7).

To change the RF frequency of the BT9000, solder a connection across the three **RF Channel Select** pads on the exposed circuit board of the transmitter according to the following table.

| RD9000 Channel | Frequency (MHz) | RF Chan Select 0 | RF Chan Select 1 | RF Chan Select 2 |
|----------------|-----------------|------------------|------------------|------------------|
| 0              | 921.37          | open             | open             | open             |
| 1              | 919.87          | shorted          | open             | open             |
| 2              | 915.37          | open             | shorted          | open             |
| 3              | 912.37          | shorted          | shorted          | open             |
| 4              | 909.37          | open             | open             | shorted          |
| 5              | 907.87          | shorted          | open             | shorted          |
| 6              | 906.37          | open             | shorted          | shorted          |
| 7              | 903.37          | shorted          | shorted          | shorted          |

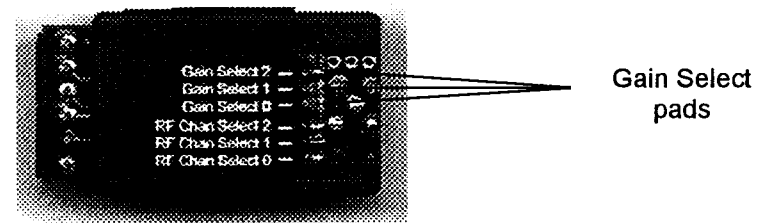


RF Channel Select pads

## Appendix E: Transmitter Gain Configuration

To change the full scale input range of the BT9000, solder a connection across the three **Gain Select** pads on the exposed circuit board of the transmitter according to the following table.

| Gain Level | Transmitter Gain ( $G_{XMT}$ ) | Gain Select 0 | Gain Select 1 | Gain Select 2 |
|------------|--------------------------------|---------------|---------------|---------------|
| 6          | 8000                           | don't care    | shorted       | shorted       |
| 5          | 4000                           | shorted       | open          | shorted       |
| 4          | 2000                           | open          | open          | shorted       |
| 3          | 1000                           | shorted       | shorted       | open          |
| 2          | 500                            | open          | shorted       | open          |
| 1          | 250                            | shorted       | open          | open          |
| 0          | 125                            | open          | open          | open          |



## Appendix F: Trouble Shooting Guide

**Symptom: No data (data light off)**

| Problem/Cause                      | Solution/Corrective Action                                                                                                                                                    |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low battery voltage at transmitter | Check transmitter power supply (measure voltage at "+9V" relative to "Gnd"). Check transmitter battery connections.                                                           |
| Mismatched frequencies             | Double check jumper settings on transmitter. Verify receiver is set on transmitter's frequency by rotating RF channel knob on rear panel of receiver through all 8 positions. |
| Incomplete RF transmission path    | Relocate receiving antenna to optimize transmission path from transmitter. Double check antenna cable connections.                                                            |

**Symptom: Unstable data, wandering zero**

| Problem/Cause                      | Solution/Corrective Action                                                                                                                                                                   |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low battery voltage at transmitter | Check to see if red "Low TX Power" light is on at RD9000 front panel. Measure battery voltage under load (i.e. connected to transmitter). Replace if battery voltage is less than 7.5 volts. |
| Faulty sensor wiring               | Check integrity of sensor connections. Shield sensor leads and move away from antenna.                                                                                                       |
| Faulty sensor.                     | Temporarily connect BS900 bridge simulator to transmitter; verify output of telemetry.                                                                                                       |

**Symptom: Red “-FS” or “+FS” light lit, won’t AutoZero**

| <b>Problem/Cause</b>                       | <b>Solution/Corrective Action</b>                                                                                  |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Sensor wired incorrectly                   | Check sensor wiring. Measure resistance of each “arm” of bridge, if possible; should be same.                      |
| Bridge too far out of balance as installed | Shunt one arm of bridge with resistor to bring gage into balance (Contact Binsfeld Engineering Technical Support.) |

**Symptom: Flickering “Data” light, spikes in data signal**

| <b>Problem/Cause</b>                    | <b>Solution/Corrective Action</b>                                                                                                                                        |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unsteady battery voltage at transmitter | Check transmitter power supply (measure voltage at “+9V” relative to “Gnd”). Check transmitter battery connections.                                                      |
| Faulty RF transmission path             | Relocate receiving antenna to optimize transmission path from transmitter. Double check antenna cable connections. Change RF channel (on both transmitter and receiver). |

## Warranty and Service Information

### LIMITED WARRANTY

Please record the date of purchase and your instrument serial numbers:

Date of Purchase: \_\_\_\_\_  
RD9000 Serial No: \_\_\_\_\_ BT9000 Serial No: \_\_\_\_\_

Binsfeld Engineering, Inc. (BEI) warrants this equipment to be free from defects in material and workmanship under normal use and service for 1 year from the date of purchase. This warranty extends to the original purchaser and does not apply to fuses, batteries, or any equipment which, in BEI's sole opinion, has been subject to misuse, alteration, or abnormal conditions of operation or handling.

To obtain warranty service, contact Binsfeld Engineering, Inc. (800-524-3327; [service@binsfeld.com](mailto:service@binsfeld.com)) or send the equipment with a description of the difficulty (postage and insurance prepaid) to Binsfeld Engineering, Inc., 4571 W. MacFarlane Rd., Maple City, MI 49664. BEI assumes no risk for damage in transit.

Binsfeld Engineering will, at its option, repair or replace the defective equipment during the warranty period. However, if we determine that the failure was caused by misuse, alteration or abnormal condition of operation or handling, BEI will contact you with a repair estimate to secure your approval before proceeding with the repair.

**This warranty is exclusive and in lieu of all other warranties, expressed or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose or use. Binsfeld Engineering, Inc. will not be liable for any special, indirect, incidental or consequential damages or loss, whether in contract, tort, or otherwise.**

NOTE (USA only): Some states do not allow limitation of implied warranties, or the exclusion of incidental or consequential damages so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights and you may have other rights which vary from state to state.