

TorqueTrak 9000 Digital Telemetry System Users Manual

Featuring

TorqueTrak All-Digital™ Technology



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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

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) 20 feet or more. Up to 8 individual systems can be operated concurrently on different frequencies 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-selectable input range
- user-selectable transmit/receive frequency
- AutoZero switch (sets output to zero at no load)
- RF signal strength indicator
- low battery voltage indicator
- switchable low pass filter
- reverse polarity switch
- excellent accuracy and stability
- minimal drift with ambient temperature changes
- microprocessor-based digital circuitry from sensor input to signal output

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

RD9000 Receiver

110VAC/12VDC Wall Plug Transformer
(220VAC/12VDC Wall Plug Transformer optional)

RA900 Receiver Antenna with 25 ft connecting cable (magnetic mount)

BS900 Bridge Simulator

Screwdriver

9V Lithium Battery

Butyl rubber

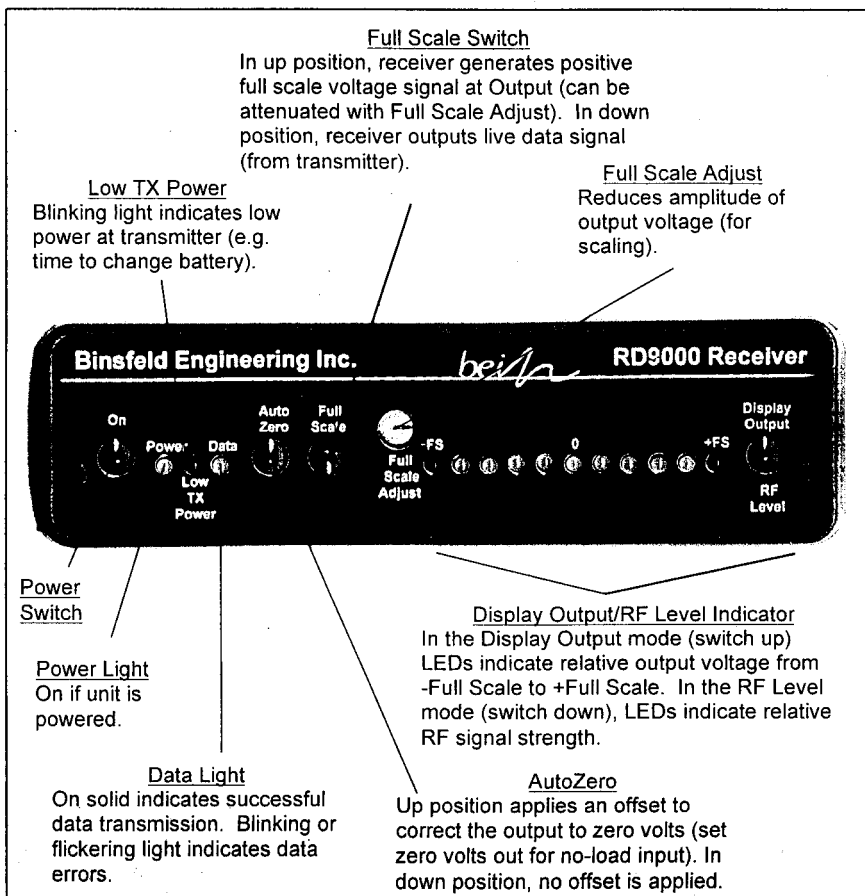
10ft 4-conductor ribbon cable

Solder braid

TorqueTrak 9000 Users Manual

Features and Controls

RD9000 Receiver

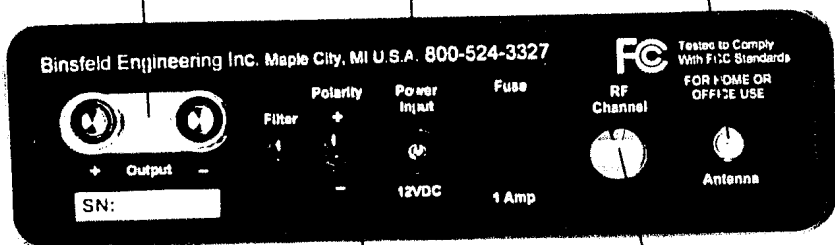


RD9000 Front Panel Controls

Voltage Output
Connect to chart recorder
or other read-out device.
($\pm 10V$ Full Scale)

Power Input Jack
Connect to 12VDC
(e.g. wall plug
transformer).

Antenna
Connect to RA900
antenna using SMA-
SMA cable.



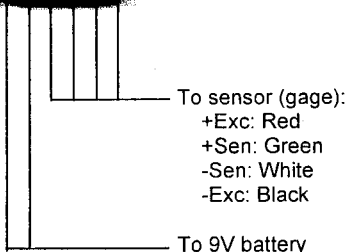
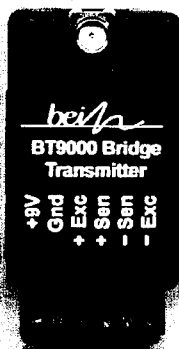
Filter Switch
Switch to up position to
apply 10Hz low-pass filter
to voltage output.

Polarity Switch
Switch to down position
to reverse polarity on
voltage output.

RF Channel Selector
Adjust receiver knob to match RF
transmit frequency of BT9000
transmitter.

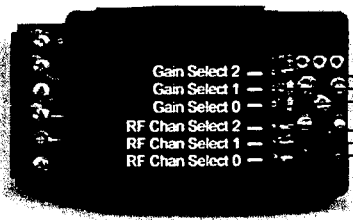
RD9000 Rear Panel Controls

BT9000 Bridge Transmitter



To sensor (gauge):
+Exc: Red
+Sen: Green
-Sen: White
-Exc: Black

To 9V battery



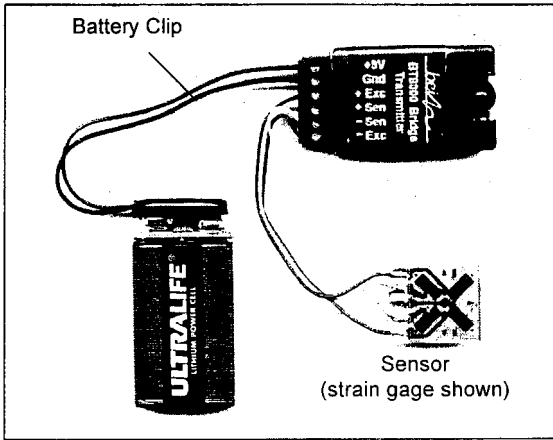
Gain Select pads
(See Appendix E.)

RF Channel Select pads
(See Appendix D.)

Set Up Procedure

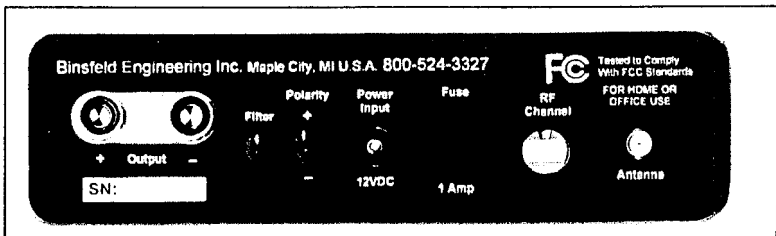
Before installing the telemetry it is important to verify that the gain setting of the transmitter is suitable for the expected sensor load. (The BT9000 transmitter is factory set for a gain of 2000 (Gain Level = 4) which will accommodate most torque applications.) To determine the appropriate gain setting for a given application refer to the calculations in Appendix C. Instructions for changing the transmitter gain setting are in Appendix E. For instructions about changing the RF channel see Appendix D.

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. Temporarily fix transmitter and battery to the shaft or device being measured by placing a 1 inch square of butyl rubber (supplied with system) under each. This will hold them in place for taping and prevent them from slipping out from under the tape when spinning.
3. Securely 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: Make sure all components are securely fastened to rotating equipment. Avoid injury by standing clear of attached items which may come off during machine operation if improperly secured!
4. Solder an appropriate length of 4-conductor ribbon cable or suitable leads to gage or sensor. (Note: Keep ribbon cable as short as practical (6-8 inches typical). Long cable runs may pick up unwanted electrical noise.)
5. 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.



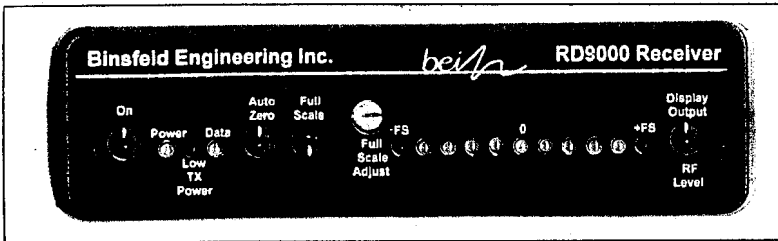
Transmitter, Battery and Sensor Connections

6. Using the provided 25ft coax antenna cable connect the RA900 receiving antenna to **Antenna** connection on rear panel of RD9000 receiver.
7. Position RA900 magnetic-mount receiving antenna near transmitter, typically within 10 feet.



RD9000 Rear Panel

8. Connect 12VDC AC adapter (Model AC110 or AC220) or other 12VDC supply 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

9. Flip **AutoZero** switch down to remove the previously stored reference. Confirm that **Full Scale** switch is down (used only for scaling and trouble shooting).
10. 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 F.
11. 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.
12. Connect recorder or other voltage readout device to **Output** terminals on rear panel of RD9000.
13. Flip **AutoZero** 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. **AutoZero** can be reset by flipping switch down and then back up again. (Sensor must be in unloaded state).

Note: Once the AutoZero feature is activated the initial offset voltage is subtracted from the full scale output. Consequently the full scale range of the system will be reduced by this offset. For example, if the initial offset is 1.6V then the full scale output of the system will be 8.4V after the AutoZero is set.

If before activating AutoZero there is an initial offset of more than 50% of full scale, it may be necessary to (1) use a lower

gain setting on the transmitter, (2) apply a shunt resistor to the gage to bring it closer to balance, or (3) replace the strain gage. For further assistance, contact technical support at Binsfeld Engineering.

14. 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 250 Hz frequency response.
15. Calibrate output voltage based on gain calculations as demonstrated in Appendix C: Calibration Calculations.
16. System is now ready to record data.

Note: The BS900 Bridge Simulator acts as a Wheatstone bridge type sensor and can be used to simulate a full bridge strain gage for bench testing and troubleshooting. The BS900 features a three-position switch. With the switch in the center position the device simulates a balanced bridge (zero load) and the corresponding output from the RD9000 receiver will be approximately 0 volts. In the "+" and "-" positions the device simulates a positive and negative sensor load, respectively. The simulated load is equivalent to 125 microstrain of torque and will produce approximately 2 volts output at the RD9000 receiver when the BT9000 transmitter is set at gain level 4 (gain = 2000). CAUTION: The BS900 is intended to be used as a basic indicator and is not provided as a calibration reference.

Appendix A: Calibration Verification

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.

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 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 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

BT9000 Transmitter

Sensor Input: Full (4-arm) Wheatstone Bridge strain gage
(120-1000 ohms; 350 ohms standard)

Bridge Input: 5.0VDC, regulated

Sensor Range: User selectable. See tables below.

Gain Level	Transmitter Gain (G_{XMT})	Torque, Bending
		Full Bridge, 4 Active Arms
6	8000	± 125 microstrain
5	4000	± 250 microstrain
4	2000	± 500 microstrain
3	1000	± 1000 microstrain
2	500	± 2000 microstrain
1	250	± 4000 microstrain
0	125	± 8000 microstrain

Gain Level	Transmitter Gain (G_{XMT})	Axial Strain (Tension, Compression)	$\frac{1}{4}$ Bridge
		Full Bridge, 2.6 Active Arms	Single Gage (1 Active Arm)
6	8000	± 192 microstrain	± 500 microstrain
5	4000	± 385 microstrain	± 1000 microstrain
4	2000	± 769 microstrain	± 2000 microstrain
3	1000	± 1538 microstrain	± 4000 microstrain
2	500	± 3077 microstrain	± 8000 microstrain
1	250	± 6154 microstrain	$\pm 16,000$ microstrain
0	125	$\pm 12,307$ microstrain	$\pm 32,000$ microstrain

(Assumed gage factor = 2.0)

Sensor and Power Connection: Screw terminal block

Transmitter Power Input: 7.5 to 12VDC, 60mA max
(with 350 Ω bridge)

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

Transmit Distance: 20 feet or more

Transmitter g-force Rating: 3000 g's (steady state)

Operating Temperature: 0 to 70°C

Size and Weight: 1.05" x 1.95" x 0.70" 2oz
(27mm x 50mm x 18mm) (57g)

RD9000 Receiver

Output Signal: $\pm 10\text{VDC}$, field adjustable
down to $\pm 5\text{VDC}$

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

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

Operating Temperature: 0 to 70°C

Size and Weight: 5.5" x 7.5" x 1.5" 3lb
(14cm x 19cm x 3.8cm) (1.4kg)

TT9000 System

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

Gain Error: $\pm 0.1\%$
($\pm 0.5\%$ before scale calibration)

Gain Drift: $\pm 0.02\% \text{FS}/^\circ\text{C}$ over operating
temperature range

Zero Error: $\pm 0.1\% \text{FS}$
($\pm 1\%$ typical before AutoZero)

Zero Drift: $0.02\% \text{FS}/^\circ\text{C}$ over operating
temperature range

Frequency Response: 0 – 250Hz
(-3dB @ 250Hz, nominal)

Step Response(Rise Time): 3 msec max

Appendix C: Calibration Calculations

The equations in this Appendix define the relationship between the input signal to the BT9000 transmitter (typically from a strain gage) and the full scale output voltage of the TorqueTrak 9000 system. The calculations are based on parameters of the device being measured (e.g. shaft diameter), sensor parameters (e.g. gage factor) and transmitter gain setting.

Section C1 is specific to torque measurements on round shafts (full bridge, 4 active arms).

Section C2 applies to axial strain (tension/compression) measurements on round shafts (full bridge, 2.6 active arms).

Section C3 is for use with a single grid (1/4 bridge).

C1: Torque on Round Shafts

Step 1: Calculate Full Scale Torque, T_{FS} (ft-lb) that corresponds to the maximum system output of 10.0V.

For a solid steel shaft, use this simplified equation:

$$\frac{(755.17 \times 10^3 \text{ ft-lb/in}^3)(D_o^3)}{(GF)(G_{XMT})} = T_{FS} \text{ (ft-lb)}$$

For all other shafts use the more general equation:

$$\frac{(V_{FS})(\pi)(E)(4)(D_o^4 - D_i^4)}{(V_{EXC})(GF)(N)(16)(1+\nu)(G_{XMT})(D_o)(12)} = T_{FS} \text{ (ft-lb)}$$

Legend of Terms	
D_i	Shaft Inner Diameter (in) (zero for solid shafts)
D_o	Shaft Outer Diameter (in)
E	Modulus of Elasticity (30×10^6 PSI steel)
GF	Gage Factor (specified on strain gage package)
G_{XMT}	Telemetry Transmitter Gain (user configurable, typical is 2000 for ± 500 microstrain range; See Appendix E)
N	Number of Active Gages (4 for torque)
T_{FS}	Full Scale Torque (ft-lb)
V_{EXC}	Bridge Excitation Voltage = 5 volts
V_{FS}	Full Scale Output of System = 10 volts
ν	Poisson's Ratio (0.30 for steel)

For metric applications with D_o and D_i in millimeters and T_{FS} in N-m the general equation is:

$$\frac{(V_{FS})(\pi)(E)(4)(D_o^4 - D_i^4)}{(V_{EXC})(GF)(N)(16000)(1+\nu)(G_{XMT})(D_o)} = T_{FS} \text{ (N-m)}$$

Where $E = 206.8 \times 10^3 \text{ N/mm}^2$.

Example: Given a solid steel shaft with
 D_o (shaft diameter, measured) = 2.5 inches
 GF (gage factor from gage package) = 2.045
 G_{XMT} (BT9000 gain based on μ meters) = 2000

$$T_{FS} = \frac{(755.17 \times 10^3 \text{ ft-lb/in}^3)(2.50 \text{ in})^3}{(2.045)(2000)} = 2,885 \text{ ft-lb}$$

so 10.0 V output at the RD9000 indicates 2,885 ft-lb of torque or 288.5 ft-lb/volt.

Step 2: Trim the Full Scale Output: If desired, the full scale output voltage of the RD9000 can be trimmed so that the voltage output corresponds to an even round number torque level, e.g. 100 ft-lb/volt. First, calculate the trimmed voltage value (V_{TRIM}) that corresponds to the round number (trimmed) torque level (T_{TRIM}). Note: T_{TRIM} must be greater than T_{FS} calculated above.

$$V_{TRIM} = \frac{(T_{FS})(V_{FS})}{T_{TRIM}}$$

Legend of Terms	
T_{FS}	Full Scale Torque (ft-lb)
T_{TRIM}	Trimmed Torque (ft-lb)
V_{FS}	Full Scale Output of System = 10 volts
V_{TRIM}	Trimmed Output of System

Example: The full scale torque (T_{FS}) has been calculated to be 2,885 ft-lb, for 10 volts. However the user would like to scale the system output to an adjusted torque (T_{TRIM}) of 4,000 ft-lb for 10 volts. (Note that $T_{TRIM} = 4,000$ is greater than $T_{FS} = 2,885$.)

$$\frac{(2,885 \text{ ft-lb})(10 \text{ volts})}{(4,000 \text{ ft-lb})} = V_{TRIM} = 7.21 \text{ volts}$$

Step 3: Adjust the Full Scale Output to equal V_{TRIM} on the RD9000.

- a) **Flip the Full Scale switch up** on the front of the RD9000. (This produces a full scale positive voltage output.)
- b) Connect a voltmeter to the **Output** terminals on the rear panel of the RD9000 to read the full scale output voltage.
- c) Turn the **Full Scale Adjust** screw on the front of the RD9000 until the voltmeter reads 7.21 volts.

The system is now calibrated so that 4,000 ft-lb equals 10 volts (i.e. the gain of the system is 400 ft-lb/volt).

In summary:

Before adjusting full scale output:

$$2,885 \text{ ft-lb} = 10 \text{ volts} \quad (288.5 \text{ ft-lb/volt})$$

After adjusting full scale output:

$$4,000 \text{ ft-lb} = 10 \text{ volts} \quad (400 \text{ ft-lb/volt})$$

C2: Axial Strain on Round Shafts

Step 1: Calculate Full Scale Forces P_{FS} (lb) that corresponds to the maximum system output of 10.0V.

For a solid steel shaft, use this simplified equation:

$$\frac{(72.50 \times 10^6 \text{ lb/in}^2)(D_o^2)}{(GF)(G_{XMT})} = P_{FS}$$

For all other shafts use the more general equation:

$$\frac{(V_{FS})(\pi)(E)(D_o^2 - D_i^2)}{(V_{EXC})(GF)(2)(1+\nu)(G_{XMT})} = P_{FS}$$

Legend of Terms	
D_i	Shaft Inner Diameter (in) (zero for solid shafts)
D_o	Shaft Outer Diameter (in)
E	Modulus of Elasticity (30×10^6 PSI steel)
GF	Gage Factor (specified on strain gage package)
G_{XMT}	Telemetry Transmitter Gain (user configurable, typical is 2000 for ± 770 microstrain range; See Appendix E)
P_{FS}	Full Scale Force (tension or compression) (lb)
V_{EXC}	Bridge Excitation Voltage = 5 volts
V_{FS}	Full Scale Output of System = 10 volts
ν	Poisson's Ratio (0.30 for steel)

Example: Given a solid steel shaft with
 D_0 (shaft diameter, measured) = 2.25 inches
 GF (gage factor from gage package) = 2.045
 G_{XMT} (BT9000 gain based on jumpers) = 2000

$$P_{FS} = \frac{(72.50 \times 10^6 \text{ lb/in}^2)(2.25 \text{ in})^2}{(2.045)(2000)} = 89,736 \text{ lb}$$

so 10.0 V output at the RD9000 indicates 89,736 lb of force or 8974 lb/volt.

Step 2: Trim the Full Scale Output: If desired, the full scale output voltage of the RD9000 can be trimmed so that the voltage output corresponds to an even round number force level, e.g. 1000 lb/volt. First, calculate the trimmed voltage value (V_{TRIM}) that corresponds to the round number (trimmed) force level (P_{TRIM}). Note: P_{TRIM} must be greater than P_{FS} calculated above.

$$V_{TRIM} = \frac{(P_{FS})(V_{FS})}{P_{TRIM}}$$

Legend of Terms	
P_{FS}	Full Scale Force (lb)
P_{TRIM}	Trimmed Force (lb)
V_{FS}	Full Scale Output of System = 10 volts
V_{TRIM}	Trimmed Output of System

Example: The full scale force (P_{FS}) has been calculated to be 89,736 lb for 10 volts. However the user would like to scale the system output to an adjusted force (P_{TRIM}) of 100,000 lb for 10 volts. (Note that $P_{TRIM} = 100,000$ is greater than $P_{FS} = 89,736$.)

$$\frac{(89,736 \text{ lb})(10 \text{ volts})}{(100,000 \text{ lb})} = V_{TRIM} = 8.97 \text{ volts}$$

Step 3: Adjust the Full Scale Output to equal V_{TRIM} on the RD9000.

- a) Flip the **Full Scale** switch up on the front of the RD9000. (This produces a full scale positive voltage output.)
- b) Connect a voltmeter to the **Output** terminals on the rear panel of the RD9000 to read the full scale output voltage.
- c) Turn the **Full Scale Adjust** screw on the front of the RD9000 until the volt meter reads 8.97 volts.

The system is now calibrated so that 100,000 lb equals 10 volts (i.e. the gain of the system is 10,000 lb/volt).

In summary:

Before adjusting full scale output:

$$89,736 \text{ lb} = 10 \text{ volts} \quad (8973 \text{ lb/volt})$$

After adjusting full scale output:

$$100,000 \text{ lb} = 10 \text{ volts} \quad (10,000 \text{ lb/volt})$$

C3: Single Grid (1/4 Bridge)

Step 1: Calculate Full Scale Strain, ϵ_{FS} (inches/inch) that corresponds to the maximum system output of 10.0V.

$$\frac{(V_{FS})(4)}{(V_{EXC})(GF)(G_{XMT})} = \epsilon_{FS}$$

Using the values listed in the table below, this equation reduces

$$\frac{(8)}{(GF)(G_{XMT})} = \epsilon_{FS}$$

Legend of Terms	
ϵ_{FS}	Full Scale Strain (inches/inch; 10^{-6} inches/inch = 1 microstrain)
GF	Gage Factor (specified on strain gage package)
G_{XMT}	Telemetry Transmitter Gain (user configurable, typical is 2000 for ± 2000 microstrain range; See Appendix E)
V_{EXC}	Bridge Excitation Voltage = 5 volts
V_{FS}	Full Scale Output of System = 10 volts

Example: GF (gage factor from gage package) = 2.045
 G_{XMT} (BT9000 gain based on jumpers) = 2000.

$$\epsilon_{FS} = \frac{(8)}{(2.045)(2000)} = 1956 \times 10^{-6} \text{ inches/inch}$$

so 10.0 V output at the RD9000 indicates 1956 microstrain or 196 microstrain/volt.

Step 2: Trim the Full Scale Output: If desired, the full scale output voltage of the RD9000 can be trimmed so that the voltage output corresponds to an even round number strain level, e.g. 1000 microstrain/volt. First, calculate the trimmed voltage value (V_{TRIM}) that corresponds to the round number (trimmed) strain level (ϵ_{TRIM}). Note: ϵ_{TRIM} must be greater than ϵ_{FS} calculated above.

$$V_{TRIM} = \frac{(\epsilon_{FS})(V_{FS})}{\epsilon_{TRIM}}$$

Legend of Terms	
ϵ_{FS}	Full Scale Strain (inches/inch; 10^{-6} inches/inch = 1 microstrain)
ϵ_{TRIM}	Trimmed Strain (inches/inch)
V_{FS}	System Output Full Scale = 10 volts
V_{TRIM}	Trimmed Voltage Output

Example: The full scale strain (ϵ_{FS}) has been calculated to be 1956 microstrain for 10 volts. However the user would like to scale the system output to an adjusted strain (ϵ_{TRIM}) of 2000 microstrain for 10 volts. (Note that $\epsilon_{TRIM} = 2000$ is greater than $\epsilon_{FS} = 1956$.)

$$\frac{(1956 \text{ microstrain})(10 \text{ volts})}{(2000 \text{ microstrain})} = V_{TRIM} = 9.78 \text{ volts}$$

Step 3: Adjust the Full Scale Output to equal V_{TRIM} on the RD9000.

- a) Flip the **Full Scale** switch up on the front of the RD9000. (This produces a full scale positive voltage output.)
- b) Connect a voltmeter to the **Output** terminals on the rear panel of the RD9000 to read the full scale output voltage.
- c) Turn the **Full Scale Adjust** screw on the front of the RD9000 until the volt meter reads 9.78 volts.

The system is now calibrated so that 2000 microstrain equals 10 volts (i.e. the gain of the system is 200 microstrain/volt).

In summary:

Before adjusting full scale output:

$$1956 \text{ microstrain} = 10 \text{ volts} \quad (195.6 \text{ microstrain /volt})$$

After adjusting full scale output:

$$2000 \text{ microstrain} = 10 \text{ volts} \quad (200 \text{ microstrain /volt})$$

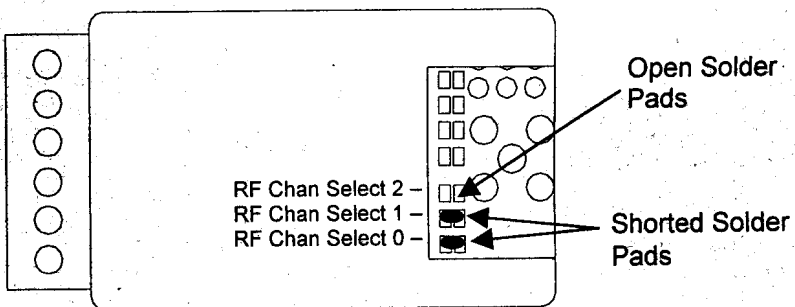
Appendix D: RF Channel Configuration

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 transmitter, configure the three **RF Channel Select** pads on the exposed circuit board of the transmitter according to the following table. To add a jumper simply form a solder bridge connection across the two rectangular solder pads. To remove a jumper, reheat the connection to break or remove the solder bridge. (Desoldering braid is ideal for this process.) **Caution:** Do not apply excessive heat to the solder pads!

Channel Number	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

The transmitter shown here has been configured for RF Channel 3 (shorted-shortened-open).

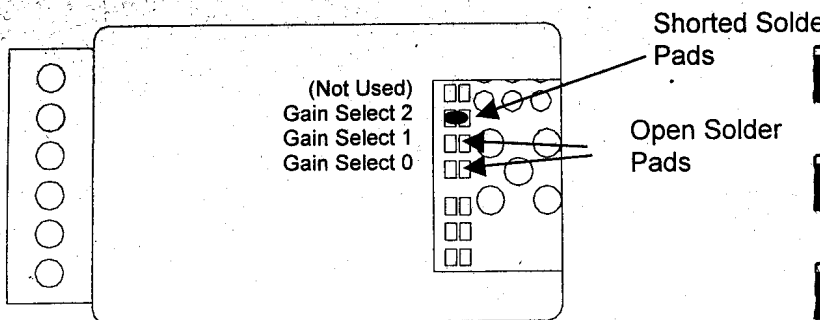


Appendix E: Transmitter Gain Configuration

To change the gain setting of the BT9000 transmitter, configure the three **Gain Select** pads on the exposed circuit board of the transmitter according to the following table. To add a jumper simply form a solder bridge connection across the two rectangular solder pads. To remove a jumper, reheat the connection to break or remove the solder bridge. (Desoldering braid is ideal for this process.) **Caution:** Do not apply excessive heat to the solder pads!

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

The transmitter shown here has been configured for Gain Select 4 (open-open-shorted).



Symptom: Red "-FS" or "+FS" light lit, won't AutoZero	
Problem/Cause	Solution/Corrective Action
Sensor wired incorrectly	Check sensor wiring. Measure resistance of each "arm" of bridge, if possible; should be approximately the 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. Request BB900 Bridge Balancer.)

Symptom: Flickering "Data" light, spikes in data signal	
Problem/Cause	Solution/Corrective Action
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).

Appendix G: Strain Gage Application

(Also refer to instruction bulletin B-127-12 provided with GAK-2-200 Strain Gage Application Kit)

PREPARING THE SURFACE

1. A 3-inch square area will be used for gaging. Scrape off any paint or other coatings and inspect shaft for oil residue. If necessary, use a degreasing solution or isopropyl alcohol to remove.
2. Rough sand the gaging area with **220 grit paper**. Finish the sanding procedure by wetting the gaging area with **M-Prep Conditioner A** and the wetted surface with **400 grit paper** provided. Rinse by squirting with **M-Prep Conditioner A**. Wipe the area dry with **tissue** taking care to wipe in only one direction. Each time you wipe use a clean area of the tissue to eliminate contamination.
3. Rinse shaft this time by squirting with **M-Prep Neutralizer 5A**. Wipe the gaging area dry with a clean tissue, wiping in only one direction and using clean area of tissue with each wipe. Do not allow any solution to dry on the surface as this may leave a contaminating film which can reduce bonding. Surface is now prepared for bonding.

MARKING THE SHAFT FOR GAGE ALIGNMENT

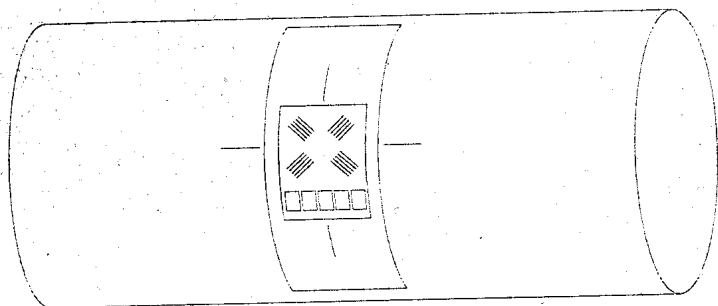
4. The gage needs to be perpendicular to the shaft axis. In general, this can be accomplished by eye since misalignment of less than 4 degrees will not generate significant errors. For higher precision, we recommend two methods for marking the shaft:
 - a) Use a machinist square and permanent marker or scribe for perpendicular and parallel lines; or
 - b) Cut a strip of graph paper greater than the circumference of the shaft. Tape it to the shaft while lining up the edges. Mark desired gage position with a scribe or permanent marker.

PREPARING THE GAGE FOR MOUNTING

5. Using tweezers, remove one gage from its package. Using the plastic gage box as a clean surface, place the gage on it, bonding side down. Take a 6" piece of **PCT-2A Cellophane Tape** and place it on the gage and terminal, centered. Slowly lift the tape at a shallow angle. You should now have the gage attached to the tape.

POSITIONING THE GAGE

6. Using the small triangles located on the four sides of the gage, place the taped gage on the shaft, perpendicular with the shaft axis, aligned with your guide marks. If it appears to be misaligned, lift one end of tape at a shallow angle until the assembly is free to realign. Keep one end of the tape firmly anchored. Repositioning can be done as the PCT-2A tape will retain its mastic when removed and therefore not contaminate the gaging area.



Positioning the Gage on the Shaft

7. Gage should now be positioned. Once again, lift the gage end of the tape at a shallow angle to the surface until the gage is free of the surface. Continue pulling the tape until you are approximately $\frac{1}{4}$ " - $\frac{1}{2}$ " beyond gage. Turn the leading edge of the tape under and press it down, leaving the bonding surface of the gage exposed.
8. Apply a very thin, uniform coat of **M-Bond 200-Catalyst** to the bonding surface of the gage. This will accelerate the bonding when glue is applied. Very little catalyst is needed. Lift the brush cap out and wipe excess on lip of bottle. Use just enough catalyst to wet gage surface. Before proceeding, allow catalyst to dry at least one minute under normal ambient conditions of + 75°F and 30-65% relative humidity.

NOTE: The next three steps must be completed in sequence within 3 - 5 seconds. Read through instructions before proceeding so there will be no delays.

Have Ready:

M-Bond (Cyanoacrylate) Adhesive

2" - 5" piece of teflon tape

Tissues

MOUNTING THE GAGE

9. Lift the leading edge of the tape and apply one or two drops of adhesive at the gage end where the tape meets the shaft. Adhesive should be of thin consistency to allow even spreading. Extend the line of glue outside the gage installation area.
10. Holding the tape taut, slowly and firmly press with a single wiping stroke over the tape using a teflon strip (to protect your thumb from the adhesive) and a tissue (to absorb excess adhesive that squeezes out from under the tape). This will bring the gage back down over the alignment marks on the gaging area. This forces the glue line to move up and across the gage area. A very

thin, uniform layer of adhesive is desired for optimum bond performance.

11. Immediately, using your thumb, apply firm pressure to the taped gage by rolling your thumb over the gage area. Hold the pressure for at least one minute. In low humidity conditions (below 30%) or if ambient temperature is below + 70° F, pressure application time may have to be extended to several minutes.
12. Leave the cellophane tape on an additional five minutes to allow total drying then slowly peel the tape back directly over itself, holding it close to the shaft while peeling. This will prevent damage to the gages. It is not necessary to remove the tape immediately after installation. It offers some protection for the gaged surface and may be left until wiring the gage.

WIRING THE GAGE

13. Tin each solder pad with a solder dot. (It is helpful to polish the solder tabs, e.g. with a fiberglass scratch brush or mild abrasive, before soldering.) Trim and tin the ends of the 4-conductor ribbon wire. Solder the lead wires to the gage by placing the tinned lead onto the solder dot and pressing it down with the hot soldering iron. (Note: For single-stamp torque gages, a short jumper is required between solder pads 2 and 4 as shown in the Setup Procedure.)
14. Use the **rosin solvent** to clean excess solder rosin from the gage after wiring. Brush the gage pads with the solvent and dab with a clean tissue.
15. Paint the gage area (including the solder pads) with **M-Coat A polyurethane** and allow to air dry 15 minutes. This protects the gage from moisture and dirt. To further protect the gage, cover with a 1.5 inch square patch of **butyl rubber** and a piece of M-Coat FA-2 **aluminum foil tape** (optional) then wrap with electrical tape.

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 a period of one year from the date of delivery to the original purchaser and that its products will conform to specifications and standards published by Binsfeld Engineering Inc. This warranty 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) 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 Inc. 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.