FM Telemetry Steering Effort Sensor

from Sensor Developments

Model 01184

Installation & Operators Manual 2.4

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Introduction

System Overview

Sensor Developments' FM Telemetry Steering Effort Sensor (Model 01184) is designed to measure the amount of effort needed to turn the steering wheel and the angular position of the steering wheel. This system provides:

- a 10 in. through-hole for uninhibited deployment of an air bag **without** the danger of the sensor being projected at the driver,
- a low mass-moment of inertia,
- selectable resolution for angular measurement (0.2° or 0.05°), and
- Non contacting torque signal transmission which permits unlimited wheel rotation.

System Components

The system consists of the following:

- a steering effort sensor with,
- an FM telemetry transmission system,
- an angular position sensor, and
- an analog converter.

The Steering Effort Sensor

The steering effort sensor is an auxiliary steering wheel with 12 in. OD. The sensor mounts to the vehicle's steering wheel with four cable ties. The sensor has four adjustable mounting plates to fit steering wheels from 14.5-16 in. OD. The sensor has a 2.6 in. offset from the steering wheel. (See illustration on next page.)

The FM Telemetry Transmission System

The non-contact data coupling system consists of a Sensor Developments Model 90338 transmitter and Model 90330 receiver. The transmitter is mounted to the steering effort sensor. Power to the transmitter is supplied by a 9 volt battery.

Note: SDI recommends replacing this battery at the beginning of each test day.

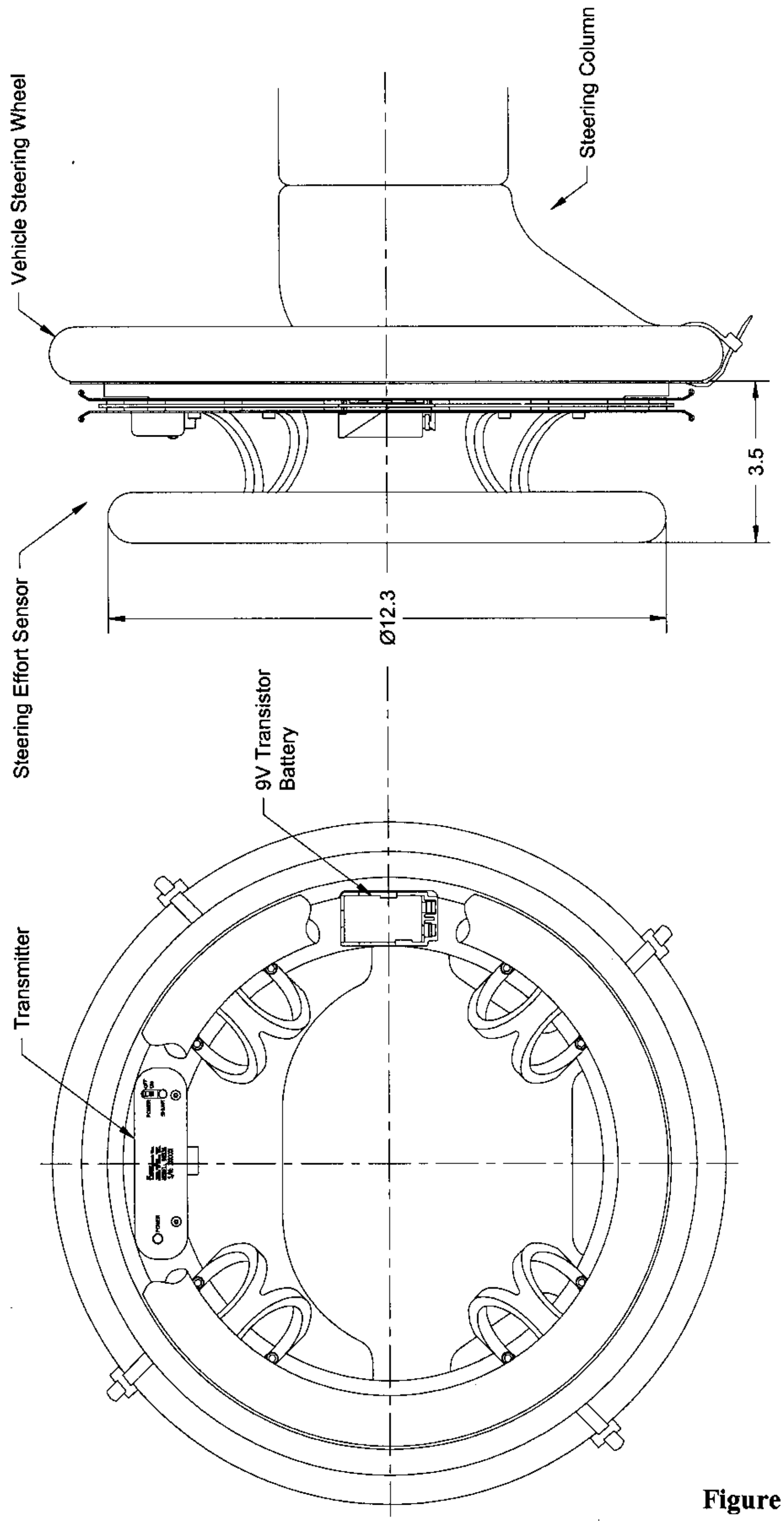
Vehicle Steering Wheel
Steering Column
3.5
Ø12.3
Steering Effort Sensor
9V Transistor
Battery
Transmitter

Figure 1

The Angular Position Sensor

The angular position sensor is an optical encoder mounted on the inside of the front windshield. A drive train assembly rotates the drive shaft attached to the encoder as the steering wheel sensor is turned.

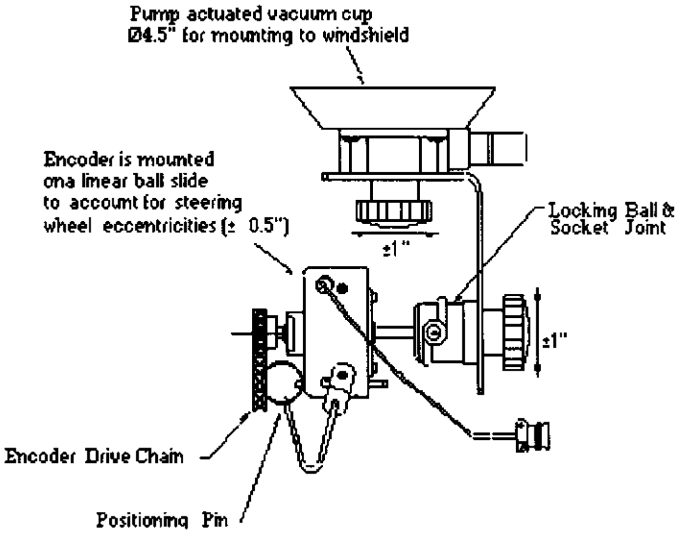

Figure 2

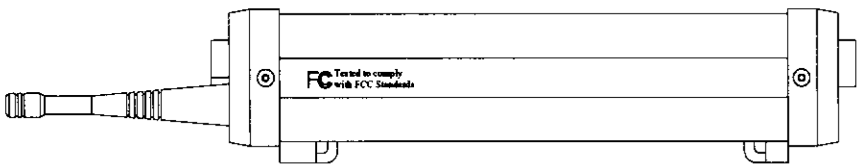

Figure 3 - The Model 90330 FM Receiver/Encoder to Analog Converter

The Model 90330 (figure 3) produces analog outputs from both the torque sensor and the encoder.

Installation

To install the system:

Step 1: Mount the steering effort sensor to the vehicle's steering wheel.

A. Position the sensor so that the it rests firmly against the front of the steering wheel, keeping the antenna away from the steering wheel spokes.

B. Adjust all four mounting brackets for the proper fit. Make certain to adjust all four brackets symmetrically.

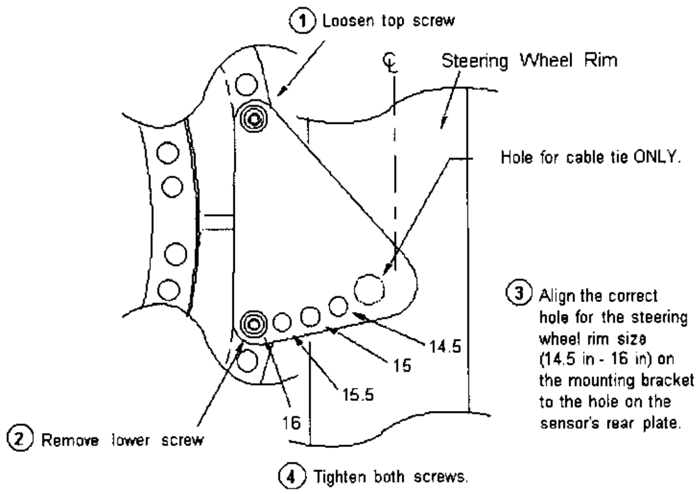

Figure 4

C. Tie the steering effort sensor to the steering wheel using one cable tie for each of the four mounting brackets.

D. Pull the cable ties firmly to tighten, and then trim the ties. (If not trimmed the ties may interfere with the drive train.)

Step 2: Mount the angular position sensor to the inside of the windshield.

A. Push the gear all the way up the linear ball slide, and place the positioning pin through the holes in the front and rear of the optical encoder to limit its travel to the midpoint.

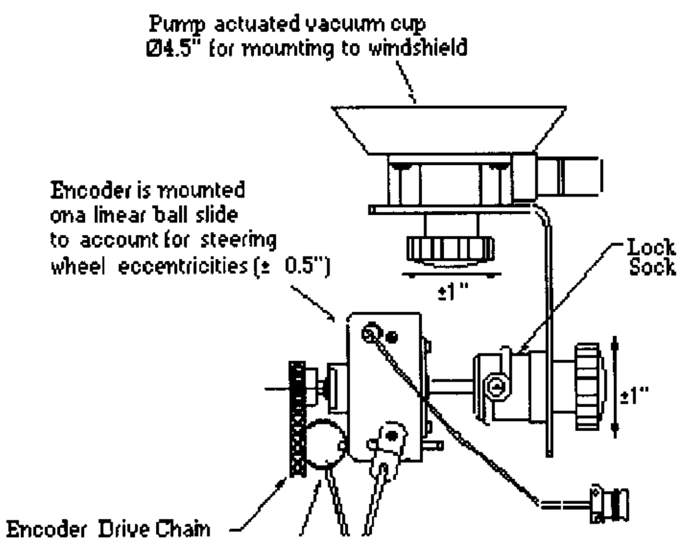

Figure 5

B. Place the drive chain around the gear of the steering effort sensor.

C. Position the angular position sensor on the windshield so that:

- the angle encoder is NOT in the drivers direct line of vision,
- the drive chain is taut, and
- the encoder gear is in the same plane as the gear on the steering wheel

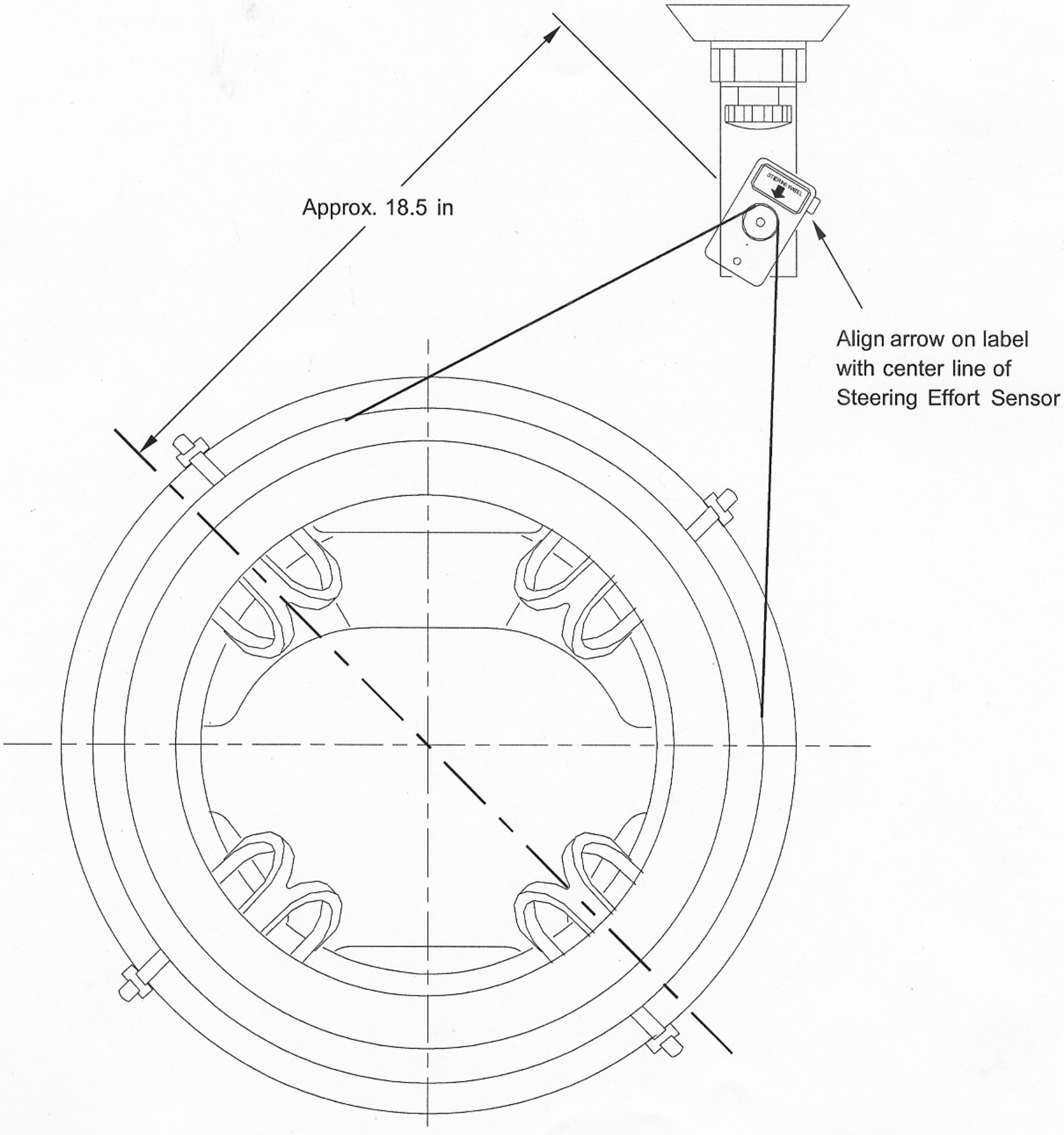

Figure 6

D. Attach the angular position sensor to the windshield by pumping the suction cup's plunger. Pump it until the red stripe is no longer visible.

E. [If necessary] adjust its position by loosening the knobs, and sliding the bracket to the correct position (See drawing on page 5 or 8).

F. Adjust the angle of the encoder so the arrow on its label is pointing directly toward the center of the steering wheel by loosening and the tightening the ball and socket joint.

G. Remove the positioning pin from the front and rear holes of the angular position sensor, and place it through the side holes.

H. Rotate the steering wheel to ensure that the encoder (on the angle position sensor) can travel along the linear ball slide without restriction.

Step 4: Connect the angular position sensor (encoder) to the Model 90330, and then connect the encoder signal outputs of the Model 90330 to the data acquisition system.

Step 5: Connect the torque sensor signal outputs of the Model 90330 to the data acquisition system.

Step 6: Connect a 9 V alkaline battery to the sensing element. Use the power switch to control power to the transmitter.

Note: SDI recommends installing a new battery at the beginning of each test day.

Operating the System

Calibration

This unit was calibrated at the factory. Calibration sheets have been provided with the unit specifying what each output will provide for a given input. The calibration on the torque output can be measured very accurately using the shunt cal. Refer to figure 7 for location of the shunt button. When the shunt button is pressed, a resistor is placed across a leg of the bridge, which produces a very repeatable simulated torque on the sensor. The shunt button is a momentary type button and will release the shunt when the button is released. To calibrate the torque sensor to the data acquisition system:

Step 1: Place the steering effort sensor at the desired neutral position.

Step 2: Adjust the "zero" potentiometer until the output voltage is 0 volts.

Step 3: Zero/tare the data acquisition system.

Step 4: Press the shunt calibration button on the sensing element and measure the simulated output produced. The output should reflect the number on the data sheet provided by the manufacturer.

Step 5: Input the simulated torque value to the data acquisition system.

Step 6: Alternate... use the capacity and full scale output numbers provided on the data sheet for the values entered into the data acquisition system. Use the shunt to verify cal.

The angle outputs do not have a simple method of verifying calibration, and if more than a "ballpark" verification is needed, an angle fixture will be required. To calibrate the angle outputs to the data acquisition system:

Step 1: Place the steering effort sensor at the desired zero position.

Step 2: Momentarily press the encoder zero button on the Model 90330. See figure 10 for location of this button.

Step 3: Zero/tare the data acquisition system on each encoder channel.

Step 4: Enter into the data acquisition system the range and output values from the data sheet provided with the sensor.

Collecting Data

Torque and position data are transmitted automatically and continuously when the system is powered up.

Overview of System Electronics

Model 90338 FM Transmitter

The transmitter consists of a strain gage amplifier, a 4 pole low pass butterworth filter, analog to digital converter, control electronics, and a 900MHz FM radio transmitter. The basic operation is that, when powered up, the transmitter amplifies the signal from the torque sensor, filters it, digitizes it and sends it out on a radio carrier to a receiver on the same channel.

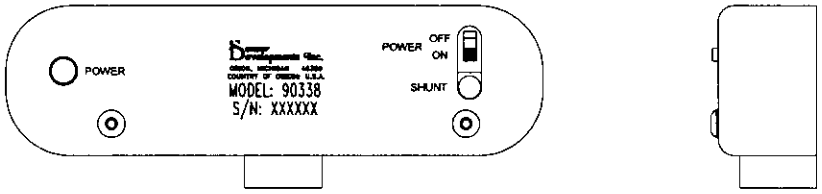

Figure 7

Under normal operation, the power indicator (see figure 7) will blink indicating that the unit is powered up and transmitting normally. The power switch (figure 7) controls power to the unit.

The shunt button is used to verify calibration of both this sensor, and any subsequent data acquisition system. It is a momentary switch that, when pressed, applies a shunt resistor to the sensor bridge. This has the effect of producing a simulated output from the sensor, and likewise, a signal will be produced at the receiver's output. The shunt is very repeatable and calibration information for its effect is documented in the calibration data provided with the sensor.

All data sent from the transmitter is encoded with a checksum. This is an error detection scheme that is used by the receiver to tell if the received data was good. When the transmitter's battery gets low, the transmitter will intentionally corrupt the checksum before sending it. The receiver will continually see the transmission as in error. Replace the transmitter's battery when this occurs.

This transmitter is equipped with 8 FM channels located in the 900MHz band. The frequencies are listed in table 1. Changing channels on this unit is done by selecting the proper switch combination. See figure 8. Be sure to switch the receiver to the same channel.

Freq.(MHz)	CS2	CS1	CS0
903.3	On	On	On
906.3	On	On	Off
907.8	On	Off	On
909.3	On	Off	Off
912.3	Off	On	On
915.3	Off	On	Off
919.8	Off	Off	On
921.3	Off	Off	Off

Table 1 - Channel Selections

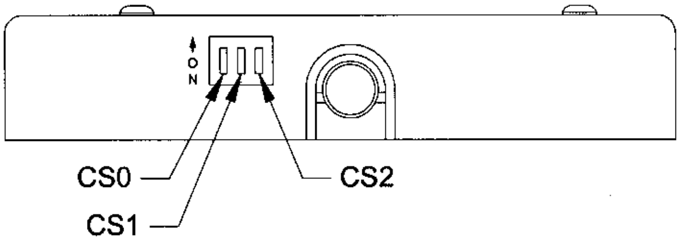

Figure 8 - Channel Select Switches

Model 90330 FM Receiver/Encoder to Analog Converter

The Model 90330 consists of a 900MHz radio receiver, control electronics, digital to analog (D/A) converters and buffer/filters. Basic operation is:

Step 1: Connect to the required signal outputs as shown in figure 9a or 9b.

Step 2: Connect the encoder as shown in figure 10.

Step 3: Screw on the antenna as shown in figure 10.

Step 4: Select the desired channel by the proper switch combinations as shown in table 2. Use figure 10 as a reference for the switch location.

Step 5: Connect power to the power input pins as shown in figure 10 and turn on the power switch.

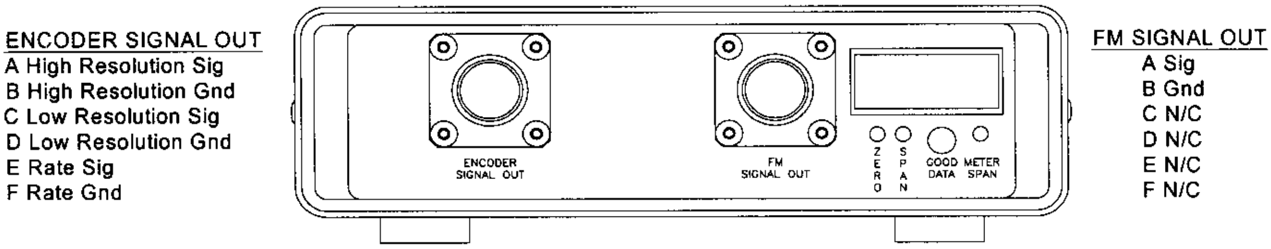

Figure 9a – Model 90330 PT Style Connections, side 1

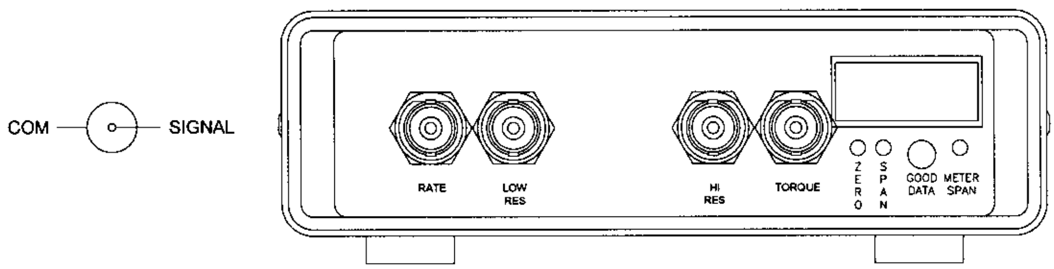

Figure 9b – Model 90330 Optional BNC Style Connections, side 1

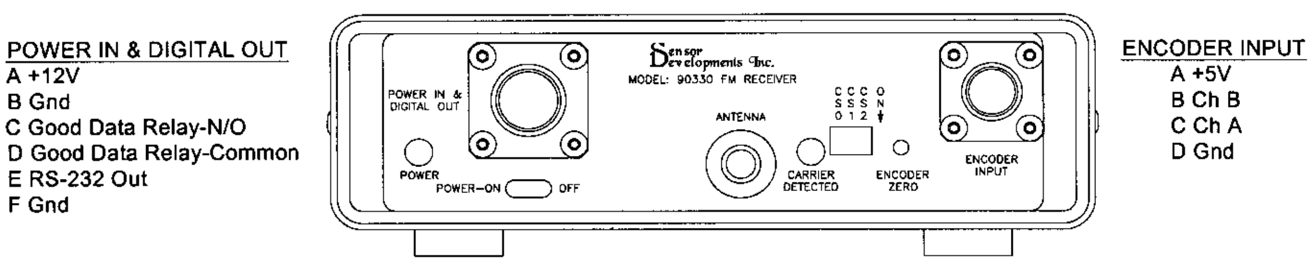

Figure 10 - Model 90330 Connections, side 2

Freq. (MHz)	CS2	CS1	CS0
903.3	On	On	On
906.3	On	On	Off
907.8	On	Off	On
909.3	On	Off	Off
912.3	Off	On	On
915.3	Off	On	Off
919.8	Off	Off	On
921.3	Off	Off	Off

Table 2 - Channel Selections

The unit will receive a digital signal from a near-by transmitter on the channel selected in step 4 above. When this happens, the yellow "carrier detected" indicator will light. The green "good data" indicator will light showing that the digital data was recovered without error. The good data is then fed to the Digital to Analog converter, and on to the analog output. The analog output is buffered and filtered. The filter is there to smooth the steps that are inherent in the output of the D/A converter. In the event that the data is found to be in error, the good data light will go out, a beeper will sound a short tone and the good data relay contacts will close. In the event that the unit loses power, the relay contacts will rest in the closed position, indicating an error. The contacts are available at the power connector as shown in figure 10.

The encoder's position and rate of change are available at the encoder output connector. As with the sensor output, the encoder outputs are buffered and filtered. Since the encoder input is compatible with incremental encoders only, the position output must be zeroed. To do this, position the encoder to the desired zero position, and press the "zero encoder" button. See figure 10. This button is recessed in the panel to prevent accidental zeroing. The zero value will be lost if power is removed. The encoder's output connector provides 2 position signals, thus providing 2 available resolutions. Refer to page 16 of this document for specifications on resolution and rate.

This unit comes with adjustments for zero and span on the sensor output, along with a span adjustment for the meter. Note that, in pre-installed and pre-calibrated systems, the span adjustments have been set at the factory, and covered with a calibration sticker. In this case, do not adjust the sensor or meter span or the calibration information furnished with the system will be void, and a recalibration will be required. The meter is simply a voltmeter connected to the sensor output signal. Adjusting the meter span has no effect on the sensor span, but adjusting the sensor span will effect the meter span. For the sensor output, the zero adjustment range is +/-20% of the full-scale output range and the span adjustment range is +/-10% of the full-scale output range. The meter has a span adjustment range that covers 0 to 2000 counts with a decimal point that is factory set. With 5 volts at the sensor output, units that have the meter configured for voltage will be adjusted to show 5.00 counts. Units that have the meter configured for engineering units will show those units in a unit that best fits the display. For example, if the sensor capacity was 7000 pounds, the meter would display 7.00 and the units would be understood to be in 1000's of pounds.

When measuring the signal outputs, note that the signal ground is isolated from the power supply ground to prevent ground loops. Measurements must be taken with respect to the signal ground and not the power ground. The signal ground is common for all output signals. The signal ground may be connected to the power supply ground without damaging the unit. Some applications may require that they be connected. For example, when using a DAQ system with differential inputs to read these signals, it is important to ground the negative signal input on the DAQ system to provide an absolute point of reference for the input. Without such a connection, erroneous data may be collected. For DAQ systems with grounded single-ended inputs, this is not an issue.

The Model 90330 is equipped with an RS-232 serial port for connection to a computer. See figure 10 for connector wiring. Data from the serial port reflects the sensor data only. The encoder data is not sent out the serial port. The data output is a binary number (12 bit A/D conversion) that requires the receiving program to scale the data and decide if the data is good or not, based on a flag set or cleared by this receiver. Data is sent out at 38.4 Kbaud and the format is 8 bits, 1 stop bit, no parity (8,1,N). The format of the data is high byte, low byte. The A/D's highest 6 bits are located in the lowest 6 bits of the first byte. The msb of the first byte is 1 to mark it as first. The next bit is the error flag, which is 0 if the data is good, 1 if it was bad. The second byte contains the A/D's lowest 6 bits located in the lowest 6 bits of the byte. The msb of the second byte is 0 to mark it as second. The next bit is a null bit that will always be 0. For example, if the A/D reading was 4095 counts, the binary representation of the reading would be 111111111111. Assuming the data was good, the first packet sent would contain 10111111 and the second packet would contain 00111111. If the data had been bad, the first packet would contain 11111111 and the second packet would contain 00111111.

The following notice applies to both the Model 90338 transmitter and the 90330 receiver. In each case, where it refers to "this device", substitute both units.

FCC NOTICE

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

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 device generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in the 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:

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

Appendix

SPECIFICATIONS

Torque Transducer Data

Capacities	200, 500, 1000 in-lbs
Output at Full Scale (nominal)	± 5 V
Optional Output at Full Scale (nominal)	± 10 V
Overload Capacity	50%
Hysteresis	0.25% of F.S.
Non-linearity	0.25% of F.S.
Mass moment of inertia (calculated)	0.20 in-lbs sec^2
Resolution	12 bits (11 bit + sign)
Sample rate	1250 samples/second
Low pass anti-aliasing filter	4 pole @ 300Hz
Power supply input	7.5 – 20VDC
Power supply current	30mA
Recommended battery	9V Alkaline
Approximate battery life with recommended battery	8 Hours

Secondary Steering Wheel

OD	12 in
Offset	2.6 in

FM Transmission System

Analog Output (nominal)	± 5 V
Optional Analog Output (nominal)	± 10 V
Output low pass filter	2 pole @ 1000Hz
Resolution	0.05% of F.S.
Transmitter	9 V battery
Receiver	12 V dc unregulated
Transmitting range	10 ft.

Position/Velocity System

Encoder	7,200 ppr
Low Resolution Output	
Resolution	0.20 degrees
Maximum Range	± 1638.4 degrees
Output at maximum range	± 5VDC
Optional Output at maximum range	± 10VDC
Update rate	56 updates/second
Low pass filter	2 pole @ 50Hz

High Resolution Output

Resolution	0.05 degrees
Maximum Range	± 409.6 degrees
Output at maximum range	± 5VDC
Optional Output at maximum range	± 10VDC
Update rate	56 updates/second
Low pass filter	2 pole @ 50Hz

Rate Output

Resolution	2.8 degrees/second
Maximum range	+/- 1000 degrees/second
Signal Output at maximum range	± 5VDC
Optional Signal Output at maximum range	± 10VDC
Update rate	56 updates/second
Low pass filter	2 pole @ 50Hz

Serial Port Digital Output (Sensor Data Only)

Update Rate	1250 updates/second
Baud rate	38.4Kbaud, 8, 1, N

Power Requirements for Model 90330

Voltage range	11 - 16VDC
Current Consumption	750mA max.

SERVICE WARRANTY

Sensor Developments warrants its products to be free from defects in material and workmanship for a period of one year from shipment from our factory. In that period we will, at our option, repair or replace a defective component or entire product which has been submitted for our examination. This is our sole obligation. We are not responsible for any costs or liabilities arising from but not limited to de-installing, consequent or collateral damage, delays, loss of use, re-installing, or any others. The warranty is in effect provided the component or product is properly used in the application for which it is intended. Products which have been modified without Sensor Developments' approval, on which repairs have been attempted by non-qualified persons, which have been subjected to physical or electrical stress beyond our ratings, or which have had their identifying marks removed or altered are not covered by this warranty.

In cases of incorporation of a product by the user in a larger system provided by a third party or sold on to a third party, we make no warranties except those above. We assume no responsibility for fitness for purpose in these circumstances.

Warranty returns must be authorized by us and shipped prepaid to us. Our return authorization number must appear on the packaging and any correspondence. We will return the goods prepaid. Products, which have been exposed to hazardous materials, will not be accepted unless they have been properly decontaminated. Sensor Developments reserves the right to refuse any shipment which it believes may create a physical or health hazard to our employees.

Products returned out of warranty for repair are subject to a minimum inspection fee. The fee is waived if the repair is authorized. It is also waived if the product is un-repairable and/or a replacement is purchased.

REPAIR SERVICES

Sensor Developments' products requiring repair should be returned freight prepaid to: Attention - Service Department. Information should be included stating what is wrong with the item(s) returned and name of contact. No item shall be returned for repair which has been exposed to hazardous materials without suitable decontamination. Hazardous materials include, but are not limited to: poisons, materials capable of producing toxic fumes, radioactive waste materials which can spread viral or other diseases and materials which pose hazards by airborne ingestion, such as asbestos. Sensor Developments reserves the right to refuse and/or return any shipment which it believes poses any health risk to its employees. Unless the repair is covered under the terms of Sensor Developments' warranty, there will be a minimum inspection and evaluation fee for each item returned. This fee may be waived if the item proves non-repairable, and a comparable replacement is ordered.

Revised: August 10, 2007