
Model 4000
Microwave Receiver
Operators Manual

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Houghton Office

Infrared Telemetrics, Inc.
P.O. Box 70
Houghton, MI 49931
Phone: 906.482.0012



Detroit Office

Infrared Telemetrics, Inc.
22040 Drexel Drive
Mt. Clemens, MI 48036
Phone: 810.463.2579

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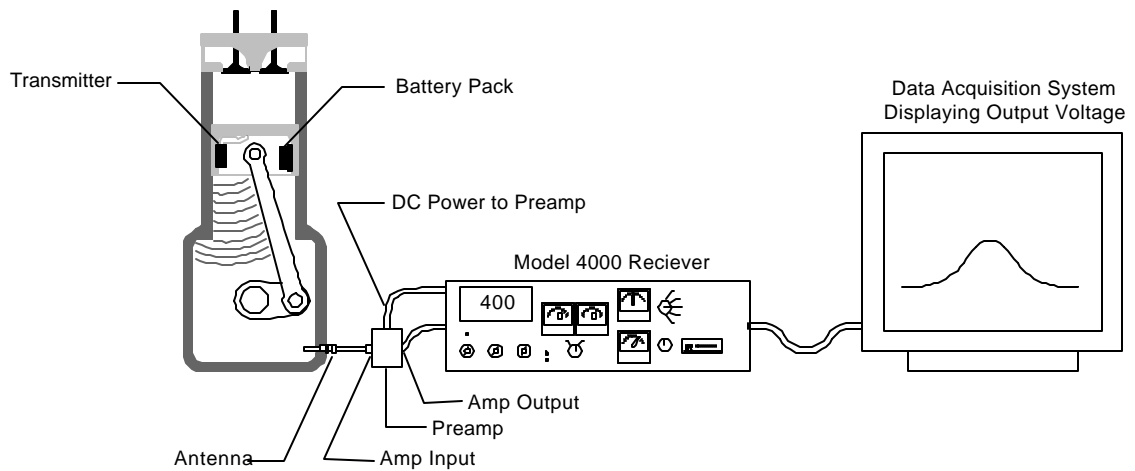
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Section 1 GENERAL INFORMATION

Overview

The Model 4000™ Microwave Receiver is part of the microwave telemetry system designed by IR Telemetrics for your specific application. Figure 1 illustrates a typical microwave telemetry system.

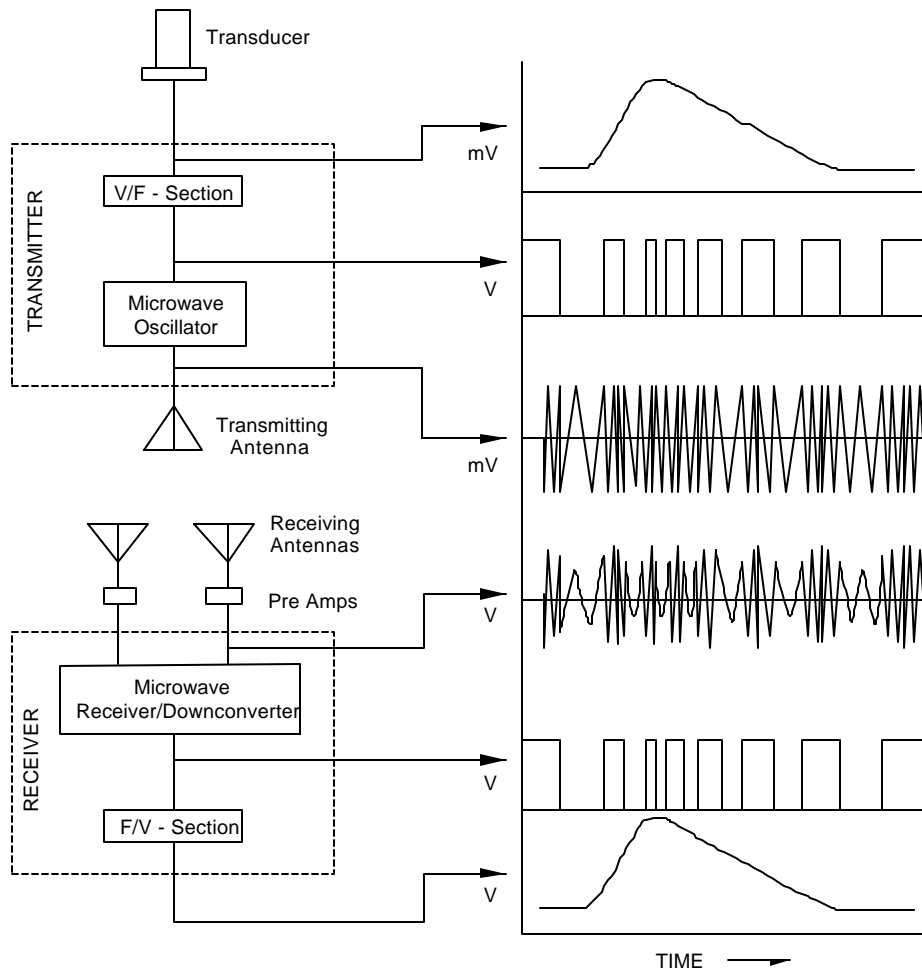
Figure 1. Typical Microwave Telemetry System.



Theory of Operation

The Model 4000 Microwave receiver is capable of resolving up to 15 channels of data from the microwave transmitter unit mounted on your component. The microwave transmitter unit multiplexes the individual channels sequentially, along with a marker or “timing” channel. The transmitter performs two frequency modulations on the transducer signal (a “double” FM), and transmits this FM signal. The first FM produces what is termed a subcarrier. The subcarrier is then used to modulate the microwave carrier.

Figure 2. Microwave Telemetry Signal Evolution (Double FM).



The microwave signal being transmitted is picked up by two receiving antennas, which are typically mounted as close to the transmitter as possible, and spaced approximately twelve inches apart. In engine applications where the transmitter is on the piston, the antennas would typically be mounted in the oil pan, near the bottom-dead-center of piston travel.

Both antennas receive the same signal. A DC powered preamp is mounted in line with each receiving antenna. The preamp boosts the signal strength before the signals enter the individual channels of the microwave receiver. In the receiver, the signals are downconverted, demodulated once, and then added together for diversity. This technique is used to increase the signal strength before processing and to provide a diversity function to prevent momentary signal loss in case of a null at one of the antenna locations. The second demodulation is performed by a frequency to voltage (F/V) converter.

The analog data can be obtained at the VOLT OUT connection on the front of the receiver and sent to your data acquisition system. The voltage level obtained for each channel must then be converted using the appropriate calibration equations. In addition to the analog voltage output, the frequency signal, after the first demodulation, is made available on the front panel as FREQ OUT. It is very important to monitor this on a separate oscilloscope, while acquiring data, to verify that the signal is being transmitted properly from the transmitter.

Specifications

RECEIVER

| | |
|----------------------------|---|
| Power | 120 V, 60 Hz (or a portable power pack) |
| Fuse | (2) 1.25x.25" 400 mA (3 AG) |
| Input | 2500 MHz from antennas |
| Output Power to Amplifiers | 12V – 70 mA |
| Dimensions | 5" x 11" x 17" |
| Weight | 10 lbs |

ANTENNA

| | |
|----------------------------------|--------------------------------|
| Diameter | 3/16" typical |
| Length | 6" typical |
| Material | copper |
| Cable | 5' coaxial with SMA connectors |
| Engine connection ⁽¹⁾ | 1/8" male NPT x 3/16" OD |

AMPLIFIER

| | |
|---------------|----------------------------|
| Length | 2" |
| Width | 1.5" |
| Height | 1" |
| Cable | coaxial with SMA connector |
| Power input | 12V – 70 mA |
| Signal input | 2500 MHz |
| Amplification | 24 dBm |

BATTERY PACK

| | |
|------------------------------------|---|
| Size | (varies with application) |
| Material | High strength aluminum alloy |
| Battery type | Lithium Thionyl Chloride |
| Maximum operating temperature | 150 °C |
| Maximum inertial load on batteries | 2000 g's reciprocating; 5000 g's constant |
| Thermal switch | 70 °C typical |

TRANSMITTER

| | |
|--------------------------------------|---|
| Size and weight | 30-50 grams (varies with application) |
| Accuracy | ± 1% of F.S. |
| Maximum Transmitter temp | 150 °C |
| Maximum inertial load on transmitter | 2000g's reciprocating; 5000g's constant |
| Scan rate | 5ms to 60 sec/channel |

¹ SMA bulkhead connector available as an option

Section 2 SAFETY AND PREPARATION FOR USE

Safety

WARNING

Electrical shock could result in serious injury or death:

- Use only the power cord specified for this instrument. If the power cord becomes damaged or unusable, order an exact replacement from IR Telemetrics.
- Ensure that the power cord is plugged into a properly grounded receptacle before making connections to the instrument input or output terminals.
- Unplug the power cord before attempting to remove or replace any fuses.
- Do not remove the instrument panels; the instrument contains no user-serviceable parts.

Fires or explosions could result in serious injury or death:

- Use fuses of the correct type, voltage rating, and current rating as specified for the instrument.
- Do not operate the instrument in an explosive atmosphere.

Line Voltage

The receiver is capable of continuous operation with a 120 V, 60 Hz input. It is also configured to operate with a portable DC power supply, which is available as an option from IR Telemetrics.

Instrument Fuse

The instrument fuse holder is located in the power entry module located on the back panel of the receiver cabinet. To check the fuse or install a new one perform the following procedure:

1. Unplug the power cord from the power source.
2. Unplug the power cord from the power entry module.
3. Remove the fuse holder assembly portion from the power entry module.
4. Verify that the fuse in the assembly is good. Replace if necessary.
5. Re-install the fuse holder assembly in the power entry module.

Handling Instructions

Take special care in handling the battery and electronics packs that make up the microwave telemetry system mounted on your component. Electrostatic discharge that occurs during normal activity (usually unnoticed) can damage or destroy the semiconductors in these units.

It is extremely important that you never contact the terminal pins that extend through the aluminum cases. Handle the units by the aluminum cases only.

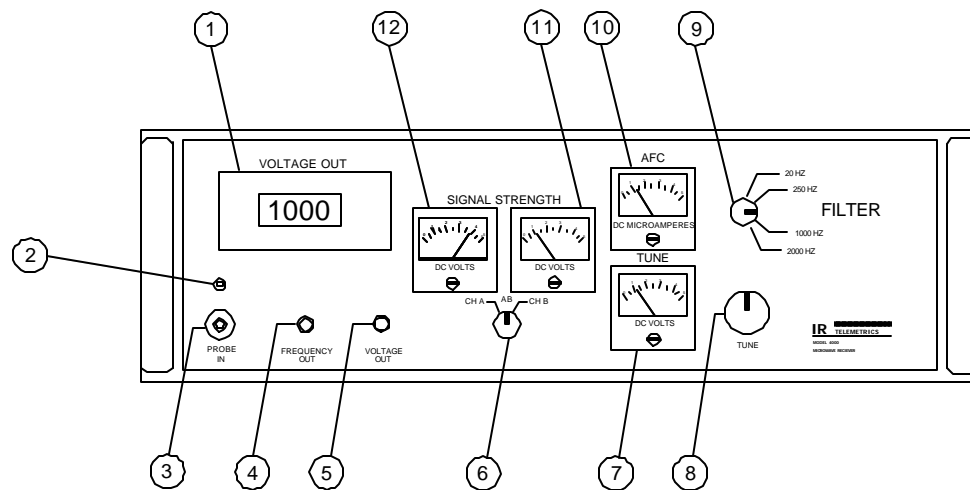
If it becomes necessary to solder or de-solder wires to any packs, you must wear a properly grounded wrist strap and use a properly grounded soldering iron to eliminate the possibility of damage through electrostatic discharge.

Section 3 OPERATION

Front Panel

Figure 3 shows the front panel layout of the Model 4000 Microwave Receiver. Each component is numbered and the corresponding function is described below:

Figure 3. Model 4000 Front Panel Layout.



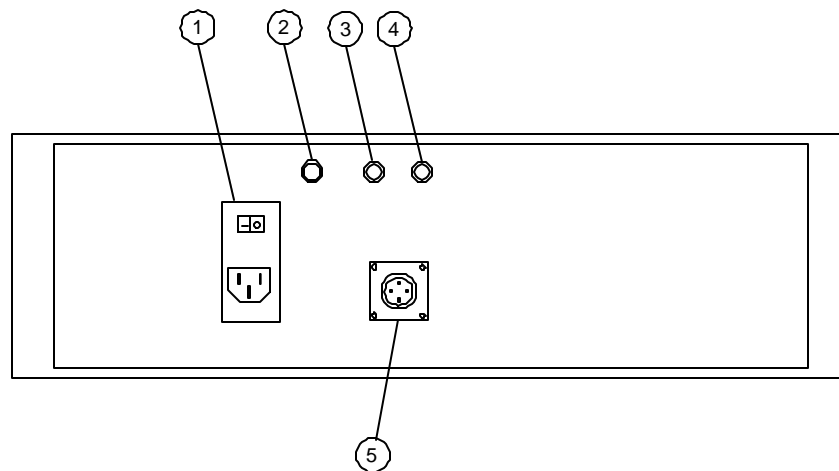
- 1) **DIGITAL VOLTMETER** – The digital voltmeter displays the analog voltage output of the receiver. The meter displays the same voltage as the VOLT OUT connection on the front panel. If there is no signal being input to the receiver, or if the receiver is out of tune, the voltmeter should read zero.
- 2) **MARKER STATUS LIGHT** – The status light illuminates when the marker channel frequency is being transmitted and received (in multiple channel telemetry systems). The light illuminates only when the transmitter is on and the receiver is in tune.
- 3) **PROBE IN** – The probe in connection is provided for use only when the Model 4000 Microwave receiver is being used as an Infrared Telemetry Receiver. For a complete description of this operational mode refer to the manual for the Model 1015 IR Telemetry Analog Receiver. This connection is not used with the microwave telemetry system.
- 4) **FREQUENCY OUT** – The frequency out coaxial connection provides a means for frequency output to an oscilloscope for monitoring the transmitted signal quality and troubleshooting. It represents the purest form of data coming from the transducer mounted on your component. This output can be recorded with a data acquisition system and can later be converted to temperature, pressure, strain, etc., bypassing the frequency-to-voltage (F/V) conversion that takes place in the receiver.
- 5) **VOLTAGE OUT** – The voltage out coaxial connection provides a means for an analog voltage output, which corresponds to the output of the transducer mounted on your component. This output is typically fed into a data acquisition system.

- 6) **INPUT CHANNEL SELECTOR** – The input channel selector allows you to select which antenna is being received for processing by the Model 4000 receiver. The A or B position inputs only that particular antenna. The AB position takes input from both antennas and provides a diversity function, which can prevent momentary signal loss at either of the antenna locations in case of a null. If a particular antenna is not selected for input, the corresponding signal strength indicator will read approximately **0**. AB is the recommended position.
- 7) **TUNE INDICATOR** – The tune indicator provides a visual indication of the position of the tuning dial. As the tuning dial is adjusted during the tuning process, the tune indicator moves according to the relative position of the dial. The position at which the signal strength for each antenna is maximized is the desired position for data transfer. The tuning position will be unique for each transmitter mounted on your component. If the power is off, the indicator will read **0**.
- 8) **TUNE DIAL** – The tune dial adjusts the receiver to the microwave frequency coming from the receiving antennas. Used in conjunction with the TUNE METER, the position of the tune dial that yields the maximum signal strength for each channel is the desired position for data transfer. The tune dial is disabled when the power is turned off.
- 9) **FILTER SELECTON SWITCH** – The filter selection switch allows you to select the frequency of the low pass filter being used to condition the final analog output of the receiver. If you are using the frequency output of the Model 4000 to transfer your data to a data acquisition system, the position of the filter selection switch will have no effect on the frequency content you are recording.
- 10) **AFC INDICATOR** – The AFC indicator provides a means for monitoring the incoming frequency signal as you adjust the instrument. To ensure maximum signal strength, adjust the level to zero using the tuning dial. Once this is achieved, the AFC function in the receiver tracks the incoming frequency signal and automatically makes small adjustments to stay locked to the maximum signal strength level during data transfer.
- 11) **SIGNAL STRENGTH INDICATOR (CH B)** – The signal strength indicator (CH B) provides a visual indication of the relative strength of the microwave signal being received through channel B. When the transmitter is off or the receiver is out of tune, the level should read approximately **1** on the meter. When the transmitter is on and the receiver is tuned in, the level should read approximately **4**, and should remain fairly stable during the course of your test. The signal strength indicator is also used in the tuning process, which is described later in this section.
- 12) **SIGNAL STRENGTH INDICATOR (CH A)** – The signal strength indicator (CH A) provides a visual indication of the relative strength of the microwave signal being received through antenna A. When the transmitter is off or the receiver is out of tune, the level should read approximately **1** on the meter. When the transmitter is on and the receiver is tuned in, the level should read approximately **4**, and should remain fairly stable during the course of your test. The signal strength indicator is also used in the tuning process, which is described later in this section.

Rear Panel

Figure 4 shows the rear panel layout of the Model 4000 Microwave Receiver. Each component is numbered, and the corresponding function is described below:

Figure 4. Model 4000 Rear Panel Layout.



- 1) **POWER ENTRY MODULE** – The power entry module is the input location for your AC power cord. Verify that the power supply outlet that you are using is properly grounded prior to powering up the Model 4000. The module also contains the instrument fuse holder.
- 2) **DC POWER OUTPUT CONNECTION** – The DC power connection supplies DC power to the amplifiers through the power cable included in your antenna harness.
- 3) **CHANNEL A INPUT CONNECTION** –The channel A input connection is used for the antenna cable coming from the in-line amplifier connected to the antenna location labeled “A”.
- 4) **CHANNEL B INPUT CONNECTION** – The channel B input connection is used for the antenna cable coming from the in-line amplifier connected to the antenna location labeled “B”.
- 5) **DC POWER INPUT CONNECTION** – The DC power input connection is the interface for the MODEL MPS4000 Portable power supply, and is used only when AC supply voltage is not being used.

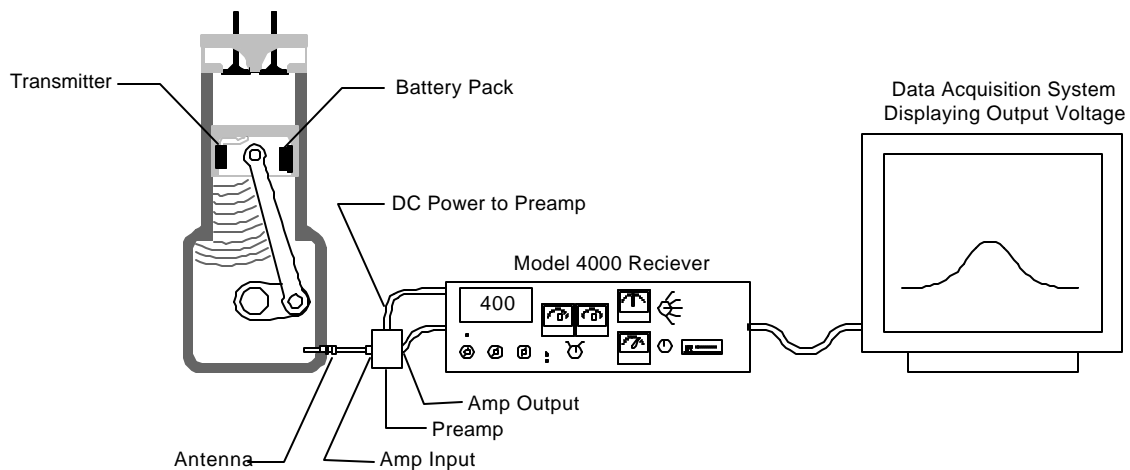
Connections

After you install the component containing the on-board telemetry system electronics, perform the following procedure to set up your Model 4000 Microwave Receiver for data transmission:

1. Install the antennas in a location as recommended by IR Telemetrics, and follow the Antenna Installation Instructions provided with your component.
2. Attach a six-inch antenna cable to each antenna and the input side of each preamp.
3. Attach a five-foot antenna cable to the output side of each preamp and the channel input connection on the rear panel of the Model 4000 Receiver.
4. Attach the DC preamp power supply cable to each preamp and the DC output connection on the rear panel of the Model 4000 Receiver.
5. Connect the AC power cord to the Model 4000 and turn the power on. **Verify that the AC power receptacle is properly grounded.**

Figure 5 shows a typical system configuration for piston measurement.

Figure 5. Typical Microwave Telemetry System for Piston Measurement.



Tuning the Instrument

The following procedure outlines the tuning process for the Model 4000 Receiver, and provides general guidelines for observations you should make while tuning the instrument and gathering test data.

1. Verify that all connections are correct and that the power to the Model 4000 is switched on. If the tuning meter reads zero, check the AC supply outlet for power. If the supply is adequate and the tuning meter still reads zero, check the fuse in the power entry module on the rear panel of the Model 4000 (see “Instrument Fuse” in Section 2).
2. To prepare to tune the instrument, operate the system in a “warm up” mode for approximately ten minutes. The battery pack mounted on your test component contains a thermal switch to preserve battery life. The switch is configured to turn on when the transmitter reaches a specified temperature, which is determined by IR Telemetrics for your specific application.
3. After ten minutes, slowly turn the TUNING DIAL back and forth through its full range of motion, taking note of the position that yields the greatest value on the SIGNAL STRENGTH METERS. You should be able to achieve a signal strength above 3.
4. Make a note of the approximate location of the needle on the TUNING METER, and repeat the dial adjustment through its full range to see if any other position yields a signal strength greater than that which you have already noted. The objective is to find the tuning position that yields the maximum signal strength.
5. Once you have found the position that yields the maximum signal strength, fine tune the TUNING DIAL to adjust the AFC METER until the needle indicates zero. You are now ready to acquire data.

Acquiring Data

While acquiring data, monitor the AFC METER and the SIGNAL STRENGTH METERS to verify that they maintain the levels observed while tuning. Slight drops or fluctuations in the signal strength of either input channel are normal. To compensate for drops or fluctuations, you can readjust the TUNING DIAL to maximize signal strength and zero the AFC. **Do not make adjustments during a data recording cycle unless signal strength is lost on both input channels.** If you attempt to make adjustments during a data recording cycle, you could lose the signal entirely.

IR Telemetrics recommends that you monitor the FREQUENCY OUTPUT of the receiver with an oscilloscope during your test. Doing so would allow you to see the frequency content of the data you are recording.

Section 4 OUTPUT

Figure 6. Signal Evolution Diagram

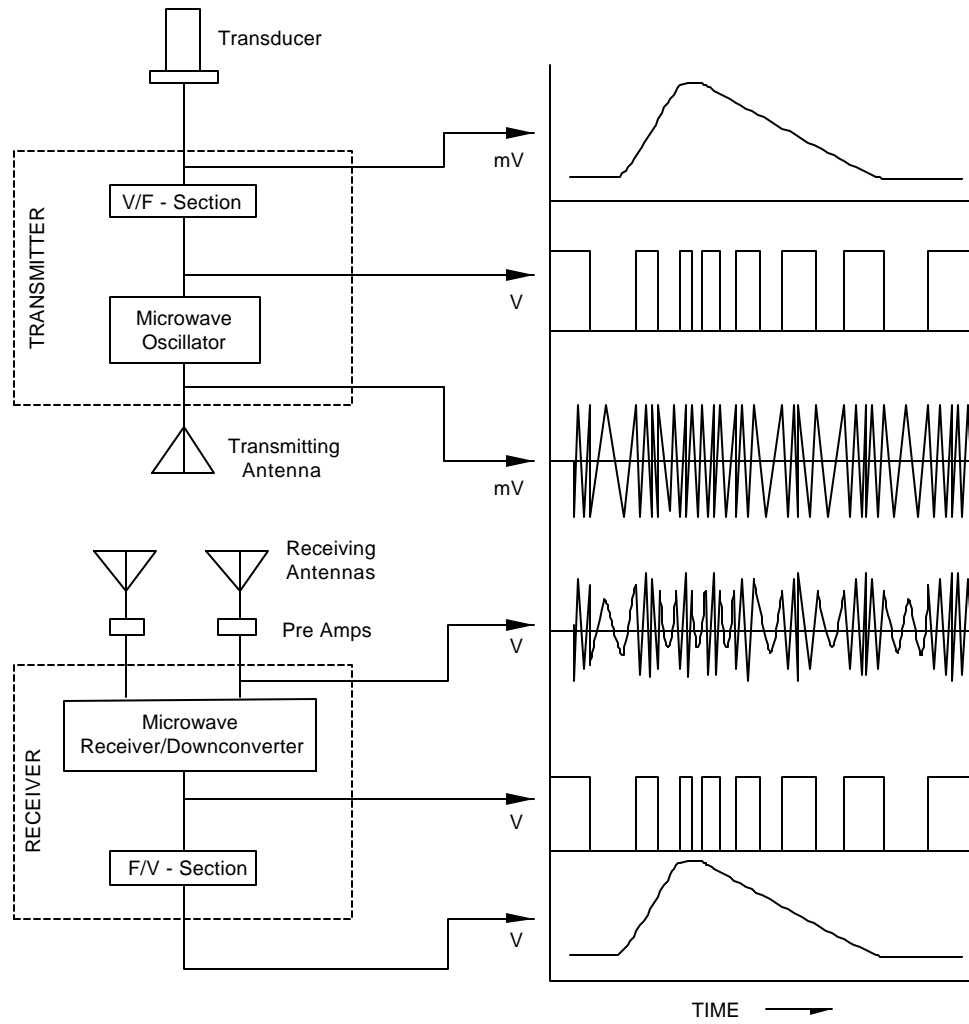


Figure 7. Typical Frequency Pulse Train Diagram.

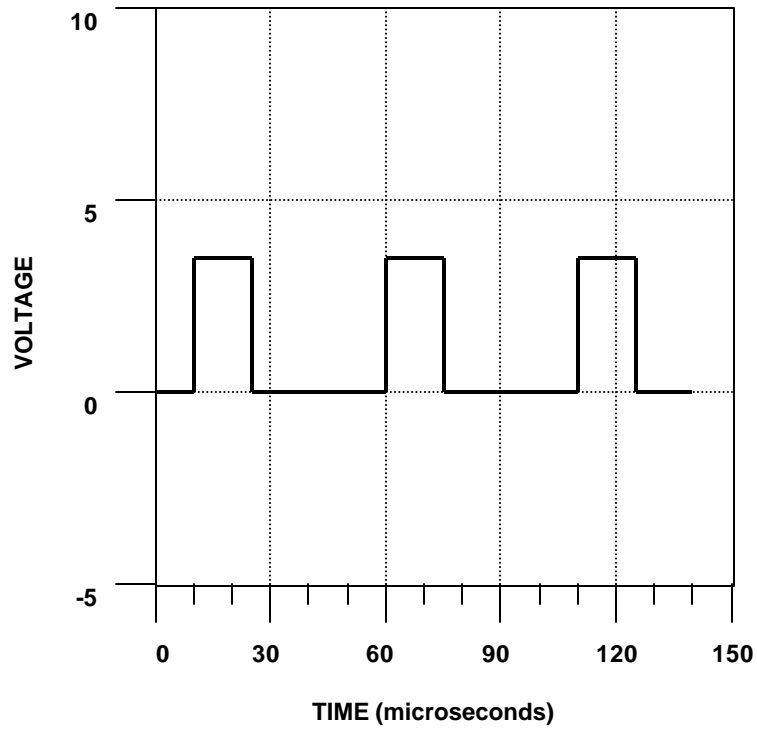
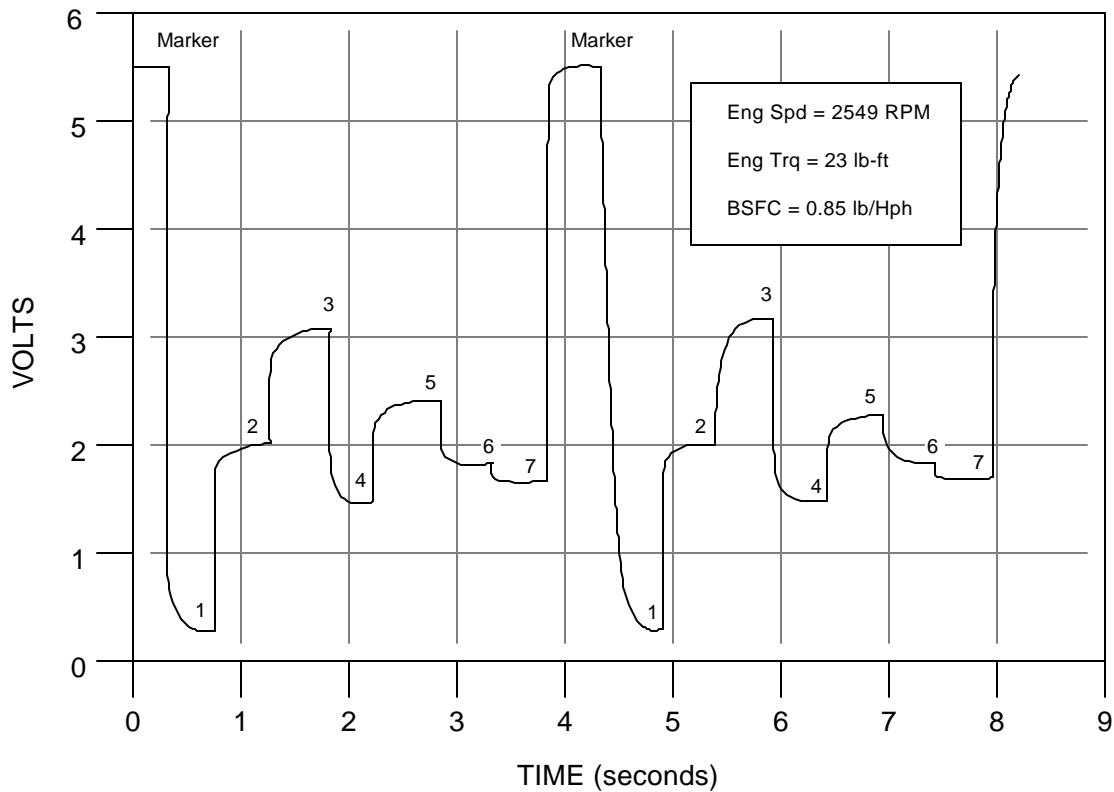
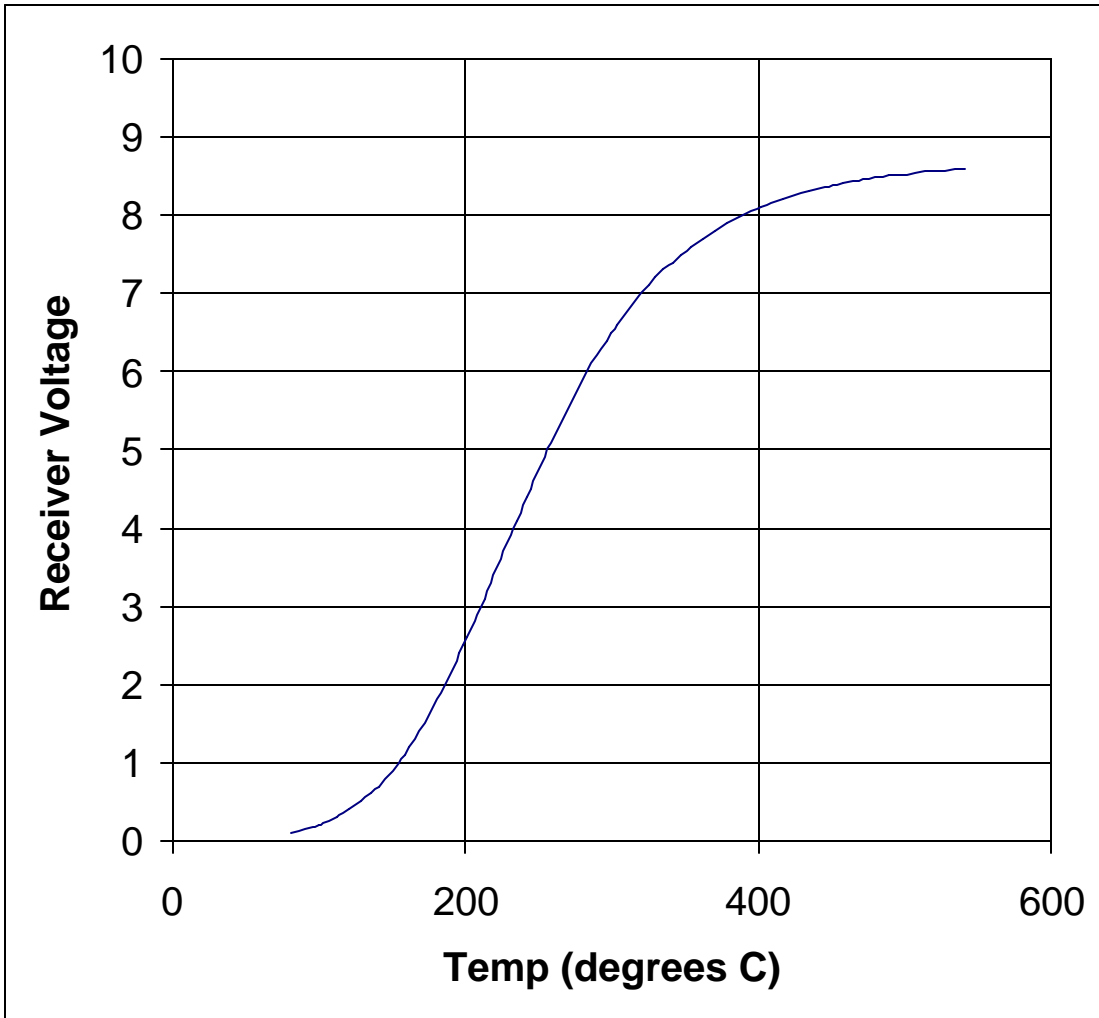


Figure 8. Typical Analog Voltage Signal Diagram.



Appendix CALIBRATION DATA

Figure 9. Typical Calibration Curve for Thermistors.



Houghton Office

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P.O. Box 70
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Detroit Office

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22040 Drexel Drive
Mt. Clemens, MI 48036
Phone: 810.463.2579