Daniel Measurement and Control

UNIVERSAL PREAMPLIFIER DATA SHEET

REVISION 1.1

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1. INTRODUCTION

The Weston Technology Universal Preamplifier (Preamp) converts the low level signal from a turbine meter inductive pickup to high level pulses. It is distinguished by the following features:

- **Tailored Frequency Response**

The sensitivity of the Preamp rolls off as frequency increases, matching the characteristic output of a turbine meter with inductive pickup. High sensitivity at low frequencies allows the turbine meter to operate at its lowest possible flow rates. Reduced sensitivity at high frequencies prevents spurious counting due to RFI and transients.

- **Common Mode Rejection**

The Preamp employs a differential amplifier, which responds only to differences between the COIL+ and COIL- wires. Spurious signals such as 60Hz, RFI, or transients typically appear on both wires as "common mode" signals. The Preamp is hundreds of times less sensitive to common mode signals than to the "normal mode" signals produced by the meter.

- **Dual Outputs**

With its dual outputs, the Preamp works with virtually any end device. One output swings from 0V to 5V regardless of the power supply voltage, and is suited for most inputs with thresholds of 4V or less. An open collector output swings from 0V to any available power supply voltage up to 36V, sinking up to 50mA.

- **Wide Power Supply Range, Low Power Operation**

The Preamp operates with any power supply voltage from 5.4 to 36V and requires less than 1mA. It can be added to virtually any system without special power conditioning, and typically with no impact on power system requirements.

- **Bullet-Proof I/O**

The Preamp tolerates continuous short circuits to ground or up to ±36V on any field wiring terminal without damage. All field wiring terminals are protected against ESD (electrostatic discharge) and transients.

- **Rugged and Convenient Packaging**

The Preamp is fully encapsulated in a compact package suitable for mounting on a panel or in a standard 3" ID explosion-proof housing. Pluggable cage-clamp type connectors allow convenient, reliable connections without the need for lugs. Terminals are labeled with signal names to simplify installation.

2. FIELD WIRING

The Preamp has six field wiring terminals, designated as follows:

J1	SIGNAL	DESCRIPTION
1	PWR	Power supply input (5.4 to 36VDC)
2	COMMON	Power supply and signal return
3	0-5V OUT	Signal output which swings from 0V to 5V
4	OC OUT	Open collector output which swings from 0V to a pullup voltage
5	COIL+	Connects to one side of the pickup coil
6	COIL-	Connects to the other side of the pickup coil. If polarity is not indicated for the coil, COIL+ and COIL- are interchangeable.

Field wiring connects to a pluggable cage-clamp type connector. The connector accepts wire sizes from 24AWG to 14AWG, with a recommended strip length of ¼".

The Preamp conditions the low-level output of the meter/pickup coil and produces a corresponding high-level output for an end device (the end device is a readout, flow computer, PLC, or other device which acquires the meter output). Where possible, the Preamp should be located close to the meter. Use twisted-pair wiring if the cable between the pickup coil and Preamp is longer than a few feet. Do not run the pickup coil wiring together with other wiring which may cause interference, such as 120VAC or signals which switch high voltage or current levels. Refer to section 3 of this document for installations where high levels of EMI (electromagnetic interference) may be present.

There are two basic wiring configurations used between the Preamp and the end device. Figure 1 below shows the preferred configuration, using the Preamp 0-5V output. In this configuration, the end device receives a signal which swings nominally from 0V to 5VDC. Use this configuration if the end device has a threshold of 4.2V or less and input current of 0.5mA or less. The 0-5V output is preferred because it is simpler to use and dissipates less power.

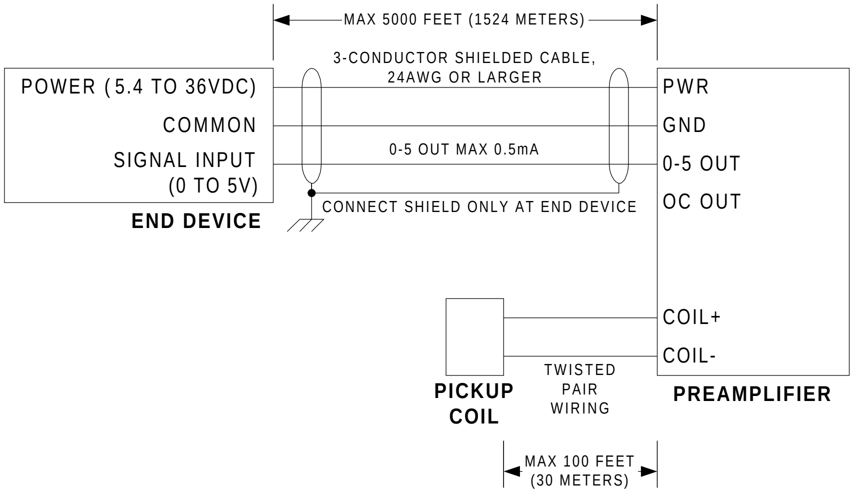

Figure 1: 0-5V Output Wiring

The 0-5V output is not suitable if the end device has a threshold greater than 4.2V and/or its input current exceeds 0.5mA. Figure 2 below shows an alternate field wiring configuration, using the Preamp OC (open-collector) output. This output is actually driven by a FET (Field Effect Transistor), and is properly called an open-drain configuration. Because the Preamp output works the same as an open collector output, the more familiar term is used. This output swings between 0V and a pullup voltage.

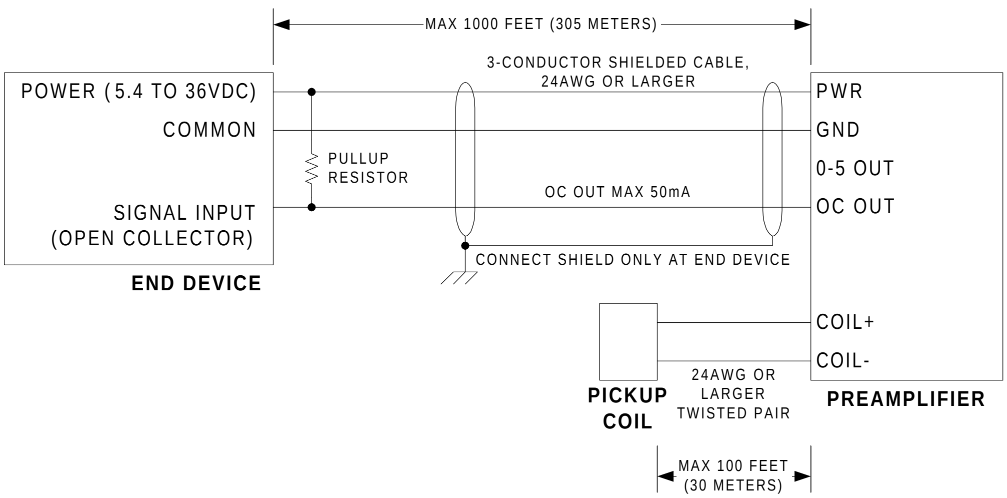

Figure 2: OC Output

The OC OUT FET is turned on when the 0-5V output is at the 5V level. When the FET is turned on, OC OUT is connected to COMMON through a resistance of less than 10 ohms. When the FET is turned off (0-5V output at the 0V level), OC OUT is essentially an open circuit. A single power supply can provide both power and the pullup voltage. Note that while the pullup voltage has the same range as the power supply voltage, the two do not have to be the same. For example, the power supply may be 12V and the pullup voltage 24V, or vice-versa.

2.1 Choosing a Pullup Resistor

A pullup resistor is required when using the OC output. A 2K ohm, 3W resistor will serve most applications. Some rudimentary analysis is necessary to identify the optimum resistor for a given application. A qualified engineer or technician should review the selection to ensure compliance with Preamp and end device specifications.

The OC output is conservatively rated to sink a maximum of 50mA. This sets a lower limit on the pullup resistor value versus the power supply voltage, as illustrated in Figure 3 below.

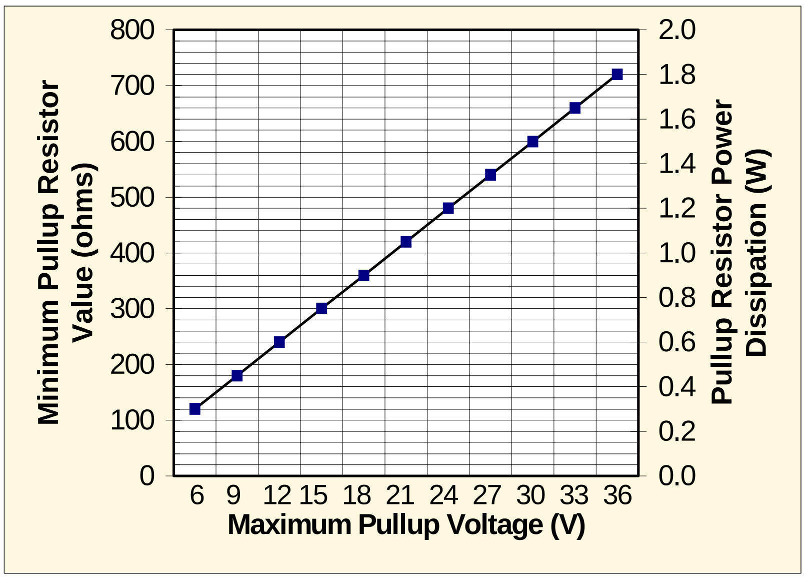

Figure 3: Pullup Resistor Parameters

The right axis in Figure 3 shows the power dissipation through the pullup resistor. Locate the resistance value on the left axis then find the corresponding power dissipation directly across from the resistance value. For example, at 24V the minimum pullup resistor value is 480 ohms and the power dissipation is 1.2W. The pullup resistor should be rated for at least 2-3 times this value. Normal power dissipation averages half the indicated value when the output is switching, but if the meter stops turning or is disconnected, the OC output may remain in a state where dissipation is continuous.

A practical upper limit on the pullup resistor value is dictated by output rise time. When the FET turns off, the pullup resistor causes OC OUT to rise toward the pullup voltage. Rise time is how long it takes for OC OUT to go from 10% to 90% of the pullup voltage after the FET turns off. The corresponding value, fall time, measures the time for OC OUT to go from 90% to 10% of the pullup voltage when the FET turns on. Fall time is always much less than rise time, and is not affected by the pullup resistor value.

For most applications, rise time depends on the pullup resistor value, cable length, and end device input capacitance. An end device input designed to accept "high-speed" signals (up to 5KHz for the Preamp) typically has negligible input capacitance. Figure 4 predicts the approximate rise time versus cable length with a 2K ohm pullup resistor, excluding end device input capacitance.

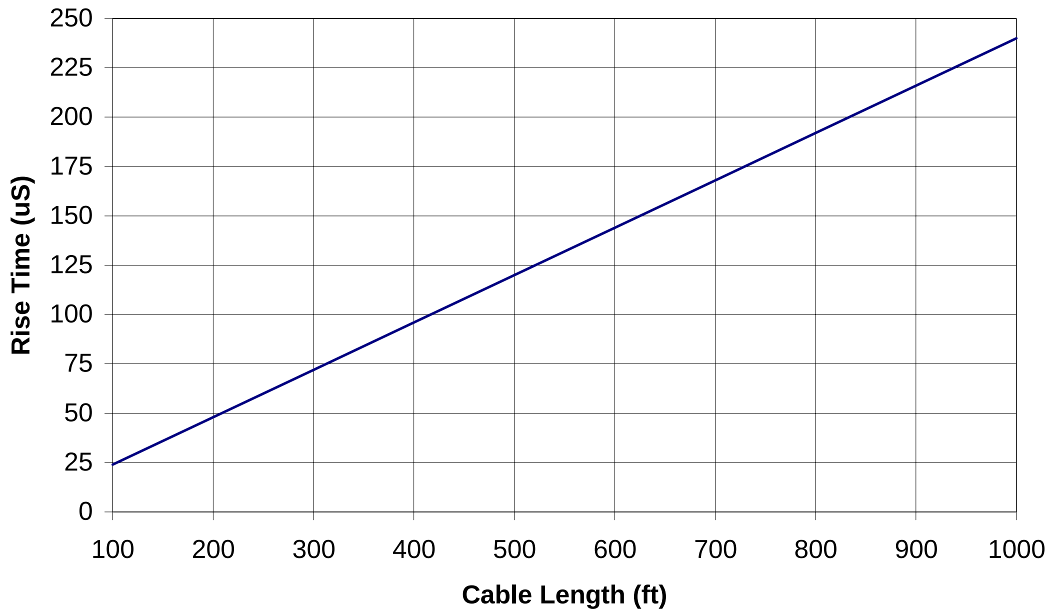

Figure 4: Rise Time vs. Cable Length (2K Pullup)

Every 6nF of end device input capacitance is equivalent to 100 feet of additional cable length when using Figure 4. For pullup resistor values other than 2K ohms, or for cable lengths not shown in the chart, use the following formula:

$t_R = 0.12 * R * L$ where

t_R is the predicted rise time in uS
R is the pullup resistor value in K ohms
L is the cable length in feet

The maximum acceptable rise time depends on the end device input characteristics and the highest expected signal frequency. Consult the end device documentation to determine if a maximum rise time is specified for the input used with OC OUT.

The maximum rise time allowed should be the lesser of 1) the end device rating, and 2) the value given by the following calculation:

$t_{MAX} = 0.3 / f$ where

t_{MAX} is the maximum acceptable rise time in S
f is the maximum turbine meter output frequency in Hz

For example, if the maximum frequency expected from the meter is 4KHz, the rise time should not exceed 0.3 / 4000 = 75uS. Referring to Figure 4, we see that the maximum cable length for 75uS rise time with a 2K pullup is about 300 feet. If we need to use 1000 feet of cable, we can calculate the required pullup resistance using the following formula:

$R_P = 2 * L_1 / L_2$ where

R_P is the new pullup value in K ohms
L_1 is the length from Figure 4
L_2 the desired length

From the above formula, we determine that R_P = 2 * 300 feet / 1000 feet = 0.6K or 600 ohms. We refer to Figure 3 and determine that the maximum allowable pullup voltage with a 600 ohm resistor is 30V. If our application uses a pullup voltage of 12V, the power dissipation of the pullup resistor is $E^2 / R = 12^2 / 600 = 0.24$W. A 600 ohm 1W pullup resistor is a conservative choice. Average power dissipation of the pullup resistor during operation will be 0.24W / 2, or 0.12W.

3. INSTALLATION

Mount the Preamp inside a building or enclosure where it is not directly exposed to weather, as close as practical to the meter. If the Preamp will be exposed to significant sources of EMI, such as high-powered mobile radios or other nearby transmitters, the Preamp should be installed in a junction box which is mounted directly on the turbine meter as shown in Figure 5 below.

Figure 5: Recommended Mounting

All wiring to the end device (PWR, GND, and 0-5 OUT or OC OUT) should be routed through conduit in environments where high levels of EMI are expected.

Figure 6 below shows front and top views of the Preamp, approximately actual size.

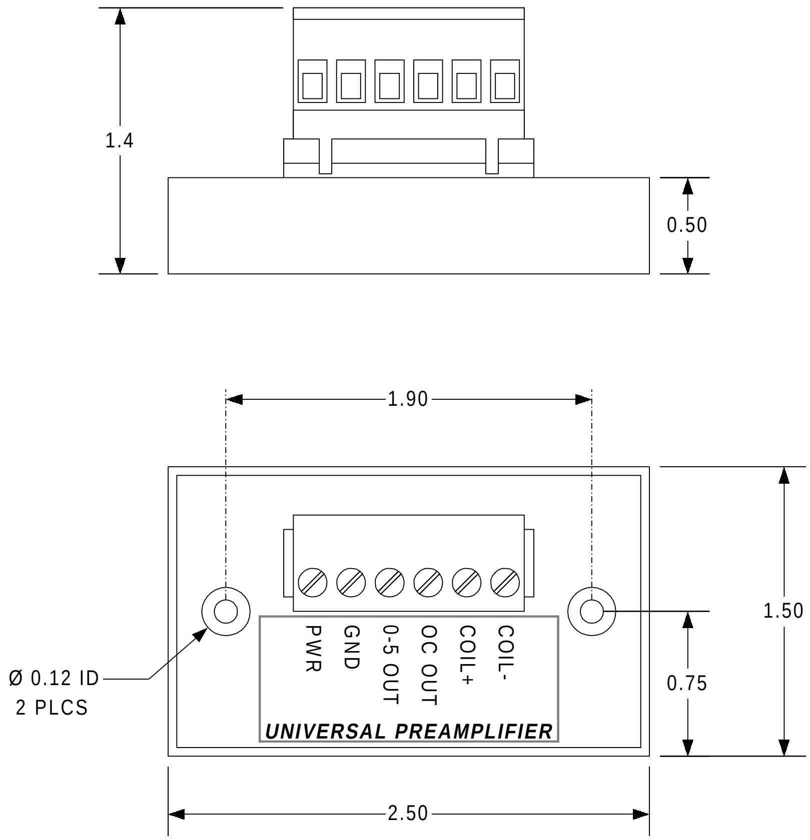

Figure 6: Dimensions

The Preamp is designed to fit in a standard 3” ID explosion-proof housing, with or without a mounting bracket.

4. ELECTRICAL CHARACTERISTICS

All specifications apply over the operating temperature range unless otherwise indicated.

4.1 Power Supply

The Preamp requires a DC power source to operate. The power supply positive output connects to the PWR terminal on the Preamp. The power supply return connects to the Preamp COMMON terminal. The COMMON terminal serves as a return path for power, 0-5 OUT, and OC OUT.

Power Supply Voltage (DC, operating)	5.4V min 36V max
Power Supply Current	0.7mA typ 1mA max

4.2 Coil Input

The two pickup coil leads connect to the Preamp COIL+ and COIL- terminals. The coil may have a third lead, typically connected to the coil housing. Do not connect this lead to the Preamp. The coil leads are interchangeable. Each coil input tolerates up to ± 36V relative to COMMON. The total voltage between COIL+ and COIL- should not exceed 36V.

Refer to Section 4.5 for a discussion of the coil input frequency response.

4.3 0 to 5V Output

The 0-5 OUT terminal swings between 0V and 5V nominally, at the same rate as the signal from the pickup coil. If no signal is present at the coil input, the output is stable at either 0V or 5V.

0-5 OUT Voltage (low)	0V min 0.5V max
0-5 OUT Voltage (high)	5.0V typ (no load) 4.8V typ (0.5mA load) 4.2V min 5.5V max
0-5 OUT Current (low)	0.5mA max
0-5 OUT Current (high)	-0.5mA max

If 0-5 OUT is connected to a power source due to a wiring error, the output may sink several amps for a few milliseconds before the protection circuit activates. After a few milliseconds, if the fault is still present, 0-5 OUT will stabilize at about 20mA. The output returns to normal operation within seconds after the fault is removed.

4.4 Open Collector Output

The OC OUT terminal actually uses an open-drain configured FET (Field Effect Transistor). When 0-5 OUT is high, the FET is turned on, and when 0-5V is low, the FET is turned off.

OC OUT Leakage	< 10uA typ 0.1mA max
OC OUT Resistance (on)	5 ohms typ (25° C) 10 ohms max
OC OUT Pullup Voltage	36V max
OC OUT Pullup Current	50mA max

OC OUT should connect to a power source through a pullup resistor. The resistor value must be selected to limit pullup current to 50mA or less. Refer to Section 2.1 for information about choosing a pullup resistor. If OC OUT is connected directly to a power source due to a wiring error, the output may sink several amps for a few milliseconds before the protection circuit activates. After the protection circuit activates, if the fault is still present, OC OUT will stabilize at about 20mA. The output returns to normal operation within seconds after the fault is removed.

4.5 Frequency Response

The output of the turbine meter pickup coil is approximately a sine wave. For a given frequency, the turbine meter output must reach a minimum amplitude in order for the Preamp to respond accurately. If the signal is below this minimum amplitude, the Preamp may not respond at all, or it may drop pulses on its output. If the signal equals or exceeds this minimum amplitude, the Preamp output will correspond to the input signal.

Figure 7 shows the minimum input amplitude versus frequency for the Preamp. The curve is produced by a simple formula: Amplitude = (0.06 * Frequency) + 1. Amplitude is expressed in mVrms, and frequency is expressed in Hertz.

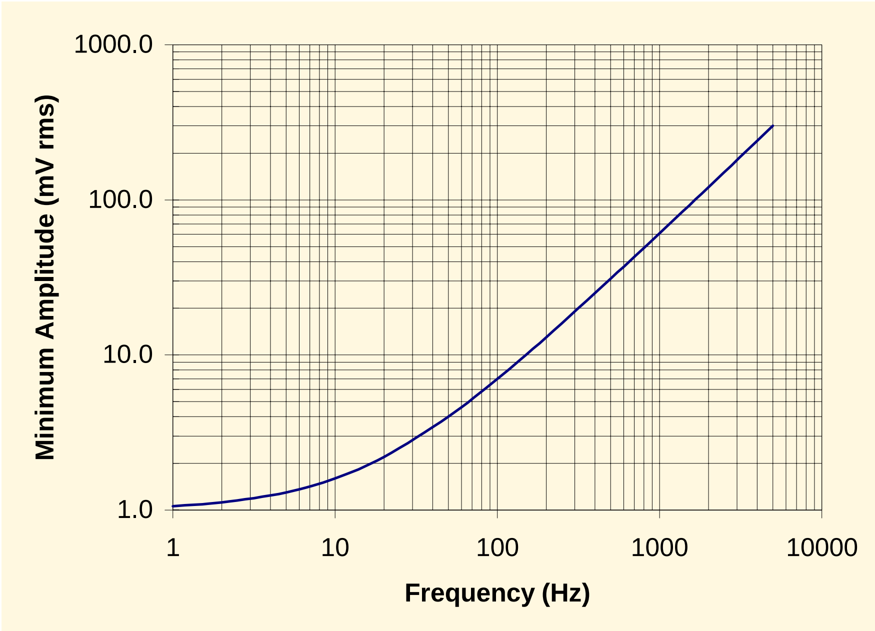

Figure 7: Frequency Response

5. ENVIRONMENT

Operating temperature range	-40 to +70° C
Operating humidity range	5% to 95% RH non condensing
Transient susceptibility	All field connected circuits are designed to meet the requirements of ANSI/IEEE C37.90.1-1989 (formerly IEEE 472) for surge withstand capability.
Vibration Effect	10 to 500 Hz at 1 g on any axis per SAMA PMC-31-1 without damage or impairment.
ESD susceptibility	Field connected circuits are designed to meet the requirements of IEC 801-2 for ESD withstand capability up to 10KV.
EMI compatibility	Designed to meet the susceptibility requirements of IEC 801-3 level 2 (3V/M) from 500KHz to 500MHz when installed per section 3 of this document. Designed to meet FCC Rules Part J, Subpart 15, Class A for radiated emissions.

Hazardous locations	Designed to meet NFPA and UL requirements for installation in Class I, Divisions 1 and 2, Groups C & D hazardous locations. Designed to fit in commonly available explosion-proof junction boxes.

While the Preamp itself is designed to meet the requirements for both nonincendive and intrinsically safe installations, it is the responsibility of the user to ensure that the combination of pickup coil, Preamp, end device, power supply, and wiring is suitable for the location.

The total Preamp capacitance is 70uF. It has no inductive components and no internal power sources. There is no significant temperature rise during normal operation.