Accuracy discussion—Accumetrics Digital Rotor Telemetry

Overview:
Accumetrics systems provide highly accurate/ easy to install and operate digital telemetry systems for rotor telemetry. The precision front end analog circuitry, combined with on-rotor digitizing aids in developing and maintaining high accuracy measurement.

Accumetrics' digital telemetry systems input low level signals from sensors, amplify the signals, anti-alias filter these signals, and 12 or 16 bit digitize the signals at high speed. The digital data is transmitted to a Receiver, where the signals are reconstructed to a large scale output corresponding precisely to the original millivolt sensor signal.

Accuracy Determination:
The overall accuracy of an Accumetrics digital telemetry system is determined by:

- **Analog amplifier (front-end) accuracy**. Instrumentation amplifiers are typically used to provide high signal integrity. Precision amplifier components are chosen for very low drift (especially temperature drift) and very good noise floor characteristics.
  Noise discussion: When the noise is uniformly distributed over the frequency spectrum (white noise), it may be characterized by a noise spectral density. The noise spectral density of a signal conditioning amplifier is typically specified in units of volts per square root Hertz. This is because the noise power is uniformly distributed over the frequency spectrum, not the noise voltage. The total noise contribution from a signal conditioner may be determined by multiplying the noise spectral density by the square root of the measurement bandwidth. Accumetrics systems typically exhibit very little noise.
- **Analog anti-alias filter accuracy**. Filtering is chosen to maintain signal integrity (frequency and amplitude information fidelity) while eliminating alias noise (high frequency signal information that could potentially be undersampled, thereby adding to the noise floor of the reproduced signal). The anti-alias filter sets the bandwidth of the system, and is typically chosen to be a conservative fraction of the sampling rate. Filters range from simple single-pole designs to 8 pole elliptical filter designs in Accumetrics' products.
- **Sampling system accuracy.** Accumetrics' telemetry digitizes with high resolution (12 and 16 bit), while sampling at conservatively high sample rates. For instance, an AT-5000 system (B Channel) typically digitizes at 11718 samples per second, with the anti-alias filter set to 1 kHz. Similarly, an AT-4400 system samples at 26000 samples per second, with an anti-alias filter setting of 2 kHz. These and our other systems far exceed Nyquist's requirement for greater than two points per cycle by providing enough samples per cycle for very accurate amplitude measurements.
- **Reconstruction accuracy of the digitized signal at the remote Receiver**. Precision components are used to reconstruct the signal at the remotely located Receiver (Note: the receiver can be hundreds of feet away, and the digitized signal will still be flawlessly transferred- no signal integrity degradation is realized). For torque and other fast signals, the output signal updates at the same rate as the digitized transmitter signal samples.
- **Data error through minimization of dropout.** Digital telemetry systems do not need tuning, and can maintain perfect data transmission. As the signals are transmitted in digital form, the data typically cannot be easily interfered with from other transmission sources (i.e. interference from other non-related FM transmitters). Accumetrics systems are often successfully used on extremely large motors and generators that subject our telemetry to high levels of interference.

Contrast to Analog-only telemetry systems:

Gain and Span drift: Analog telemetry systems also have front end analog amplifiers similar to those discussed above, and these amplifiers are subject to gain and span errors or drifts. Once amplified, these signals are passed through a process of modulating the signal on an RF carrier. Pulse width modulation, frequency modulation or some combination of these techniques are typically used. These processes are analog techniques that are subject to additional errors and calibration drifts. Since the inaccuracies of the modulation process is usually the limiting factor in overall accuracy, analog telemetry systems generally do not have the high accuracy available from high performance digital telemetry systems. Putting the best low drift front-end amplifier into an analog telemetry system therefore adds little value.

Bandwidth: The bandwidth of a digital telemetry system is determined by the cutoff frequency of the antialias filter and the digital sample rate. There is a frequent misconception that analog systems do not have a bandwidth limit because they do not sample the time signature. This is not the case. The process of modulating the data has an inherent bandwidth limit that has much the same effect as the digitizing process. It is important to fully understand the bandwidth limitations of any system, even when they are not fully specified.

Dropout: Any telemetry system can be affected by a dropout of the RF carrier. But analog systems become noisy when the RF signal strength becomes weak. Digital telemetry systems need only to detect the difference between a one and a zero to reproduce the signal perfectly. Therefore they can generally endure much weaker RF signals or higher levels of noise or interference than analog telemetry without producing any noise in the measurement signal. With good antenna layout, digital telemetry is generally fully immune to noise or interference.

Discussion of Accumetrics systems:

The AT-5000 battery powered telemetry system provides the most cost effective, low power and compact system with good overall performance. Filtering and drift characteristics generally compare with the best of analog telemetry systems.

The AT-4400 induction powered telemetry system provides exceptional signal accuracy, providing precision instrumentation circuitry with extremely low Zero Drift, Gain Drift, Linearity error, and Noise. The AT-4400's 16 bit resolution (<0.003% of Full Scale) helps to precisely define the signal, and is especially useful for working when analyzing averaged extremely low noise signals.

The AT-7000 multichannel induction powered 12 bit resolution telemetry systems use precision instrumentation component circuitry but additionally use 8 pole anti-alias elliptical filters to minimize noise levels. The focus of this product is in its modularity, which allows flexibility in sensor type and channel capacity.

Please contact Accumetrics for additional information.

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