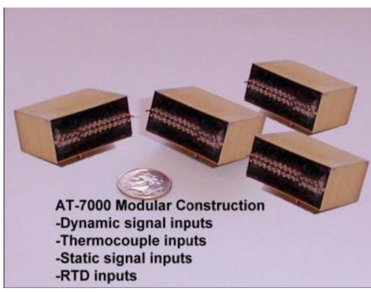
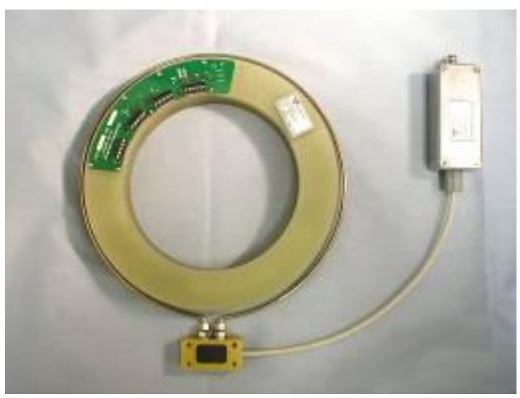
AT-7000 Theory of Operation

The modular architecture of the AT-7000 allows Accumetrics to configure systems for customer specific applications. Multichannel digital data acquisition modules are combined into a system to provide the specific number of channels that are required by the customer. The packaging of the modules is provided in clamp-on collars (or other mechanical configurations), and is tailored to the target application. This application note focuses on the 12 bit resolution, sequentially sampled AT-7000 products utilizing 6.78MHz for the induction power frequency. More advanced capabilities exist for the AT-7600 simultaneously sampled systems utilizing 16 bit resolution and 100 to 120 kHz for the induction power.

The following is a description of the modules and functional components within this system. Specific applications are configured with more or fewer modules and system options, depending upon the system requirements.





ROTATING COMPONENTS

Rotor Coil
This rotating winding functions as the secondary winding of an RF transformer. It receives RF energy from the stationary pick-up loop that is used to energize the transmitter. This coil also provides the transmission of data. It is typically embedded in the rotating collar or other structural element.

DAM (Dynamic Acquisition Module)
This four-channel module is designed primarily to interface with strain gages and other bridge type transducers. It interfaces directly with full bridges or bridge transducers, but can also be adapted to quarter bridges, accelerometers, or other sensor signals with special interface modules. Each DAM channel includes a precision instrumentation amplifier and an eight pole

elliptical filter. Data from each of these channels is multiplexed and digitized using a 12-bit digital to analog converter. The resulting data is passed to the Master Control and Telemetry Module via a digital bus. The sample rate and filter cut-off frequency is set up at the time of manufacture based upon the system configuration and user requirements.

Shunt Calibration Module
This module is used in conjunction with the DAM to provide a shunt calibration option for full bridge transducers.

Bridge Completion Module
This module is used in conjunction with the DAM to provide bridge completion resistors when sensor inputs come from quarter or half bridges. It also adds an "In-flight" shunt calibration feature for the bridges.

Current Source Module
This module is used in conjunction with the DAM to provide constant current sources required by some sensors such as ICP accelerometers.

TAM (Temperature Acquisition Module)
This module is an eight-channel data acquisition module designed primarily for monitoring thermocouples and cold junction temperatures. It typically operates at much lower sample rates then the DAM. Its flexible design allows reconfiguration at the time of manufacture for either internal or external compensation sensors, and either hardware or software cold junction compensation. The data from the module is passed to the Master Control and Telemetry Module over the digital bus.

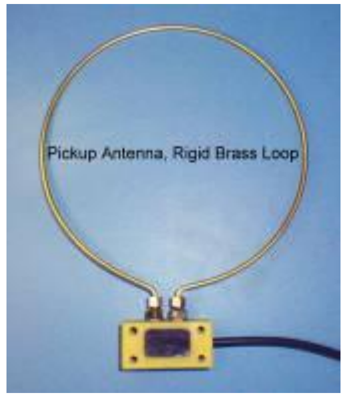
RTD Acquisition Module
This module is a four-channel data acquisition module designed to measure the temperature from RTD sensors. It provides constant current excitation and three wire connection to PT100 type RTD's. Like the TAM, it typically operates at lower sample rates. The data from this module is passed to the Master Control and Telemetry Module over the digital bus.

Voltage/Current/Ground Fault Leakage Current Module
This module is used to measure field voltages and currents in large electrical machines. It can be adapted to a variety of input interfaces including current shunts, voltage dividers, ground fault leakage current inputs, and others. Like the TAM, it typically operates at lower sample rates. The data from this module is passed to the Master Control and Telemetry Module over the digital bus.

Master Control and Telemetry Module
This module provides clock and timing signals to the data acquisition modules, and combines the digital data from these modules into a composite serial data stream. It modulates this stream on a radio frequency carrier for transmission off of the rotor. It also receives RF energy through the rotor coil to generate the power supplies needed for the transmitting electronics and external bridge excitation.

Application Specific Interface Board
This is a printed circuit board used to interface modules with sensor input terminations, and to provide other interconnections between the various rotor assembly modules. Special or uncommon sensor interface requirements that are not serviced by the standard modules described above can often be accommodated by special circuitry within this interface.

PICK-UP LOOP/ Stationary induction power/ data



This stationary loop is closely coupled to the rotor coil and serves as the primary winding to power rotating electronics. It also picks up the RF encoded digital data and passes it to the receiver.

A tuning enclosure (see small box on left picture, and the picture on the right) is typically mounted on the pickup, or within 18 inches of a pickup coil (with twisted pair wiring to the pickup, and coax connections for cabling to the receiver). The tuning enclosure provides minor adjustment for RF tuning changes due to nearby metal structures.

A tuned length of RG58 or similar coaxial cable connects the tuning enclosure to the receiver. The typical length is 24 feet.

RECEIVER ELEMENTS

The receiver unit is supplied as either a rack mount instrument or in a sealed NEMA12 (similar to IP65) enclosure when used in harsh industrial environments. The pictures below depict these two packaging options.

RF Induction Power Source
This function generates a radio frequency power signal, which is coupled to the rotor module through the stationary pick-up loop. This signal is amplified within the receiver to appropriate levels.

RF Receiver/Digital Control
This function recovers the modulated digital data from the rotor module(s) and interfaces with the modular digital to analog converter (DAC) boards and the serial or parallel computer interfaces.

Digital to Analog Converter (DAC) Boards
Four-channel digital to analog converter boards convert digital data from specific channels back to analog voltages. Typically, these provide an adjustable ±10-volt maximum output voltage. They can also be configured as 4-20 mA outputs.

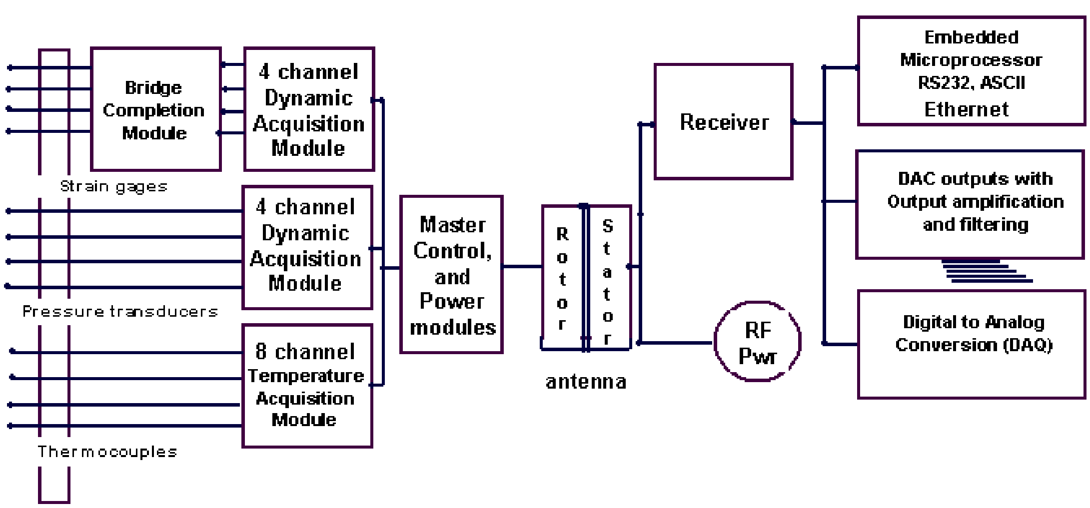
Microcomputer board/RS232 Interface/ Ethernet Interface
This optional interface is a small microcontroller board used for special functions. It performs linearization and software cold junction compensation for thermocouples and provides a digital serial computer interface.

- RS232: Because of the throughput limitations of RS232, this is typically used only for temperature data or other static sensors.
- Ethernet: For digital communication of dynamic data, a high speed embedded processor can provide high throughput Ethernet data.

Parallel Data Interface
This optional interface is designed to drive computer parallel I/O.

Power Supply
Several DC power levels are used to energize receiver circuitry.

Example of 16 Channel AT–7000 System



Accumetrics Associates, Inc.

AT-7000 SAMPLING STRATEGY

The AT-7000 combines all of the data from multiple Data Acquisition Modules into a composite digital data stream which is transmitted off the rotor. The maximum data throughput from the standard AT-7000 system is 52,969 data samples per second (for higher sample rate needs, see the AT-7600 system). The system's Master Control and Telemetry Module is configured at the time of manufacture for scanning through all sensor channels in a predefined sequence for a specified number of channels. When the system is configured with dynamic measurements only, the system samples all channels sequentially followed by one additional sample period which is reserved for receiver synchronization (referred to as the sync word). This full sampling sequence is referred to as a frame (see figure below). The resulting overall system sample rate for any particular sensor channel is given by the equation:

SR= 52,969 / (N+1)   (Dynamic channels only)
Where

SR=the sample rate for any dynamic channel (samples per second)
N= the number of dynamic channels

Dynamic Channels are always acquired through the Dynamic Acquisition Module (DAM). Other modules (Thermocouple Acquisition Module, RTD Acquisition Module or Voltage/Current Acquisition Module) are designed to acquire more slowly changing data. When these "static" acquisition modules are combined with DAM's, the sampling strategy employs a sub-frame. Here, the last sampling position before the sync word that would otherwise contain a dynamic channel is used for the subframe position. With the addition of the sub-frame data, the sample rate of the dynamic data is reduced to:

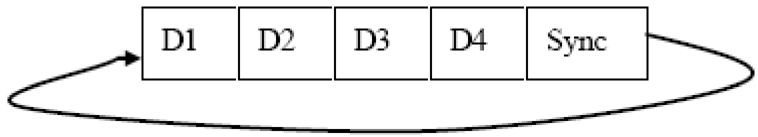
SR= 52,969 / (N+2) (for any combination of dynamic and static channels)
Where

SR=the sample rate for any dynamic channel (samples per second)
N= the number of dynamic channels (static channels are accounted for with the "N+2")

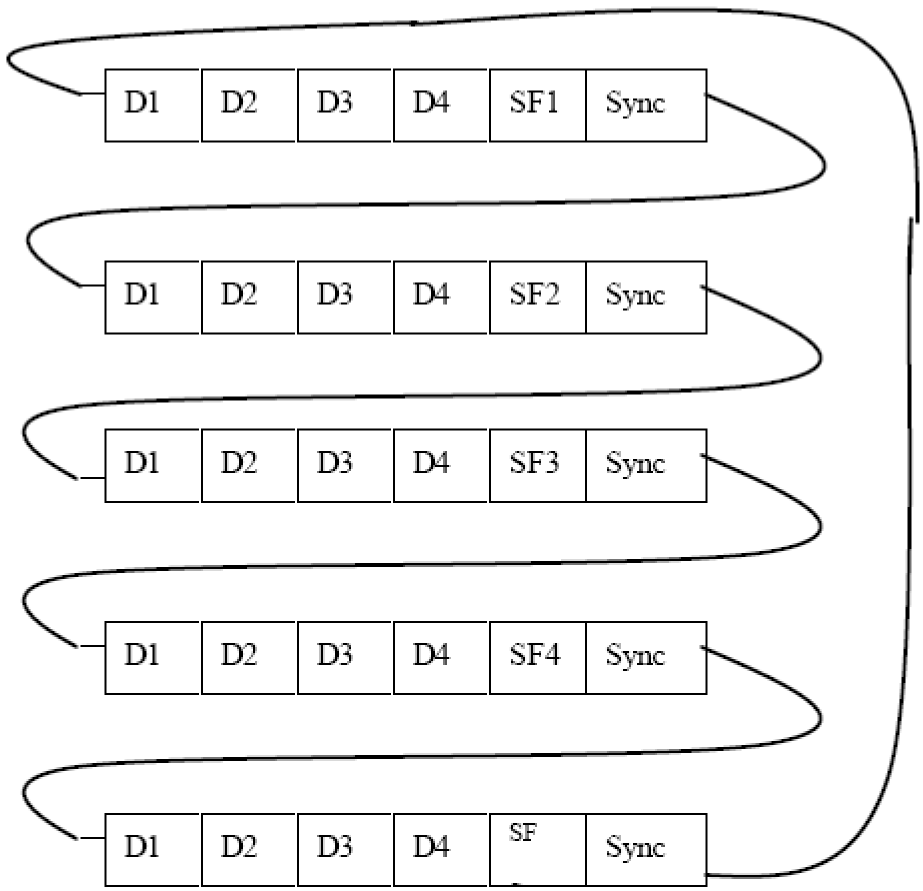
The last sample in the sub-frame is a sub-frame sync word that allows the receiver to synchronize on the sub-frame data. The rate at which the sub-frame data is sampled is equal to the dynamic data sample rate, divided by the total number of channels in the sub-frame. At times, the high speed of dynamic data sampling causes the sub-frame data to be sampled far higher than is required for truly static measurements. In that case, the receiver can be configured to provide a digital filtering or averaging algorithm, which reduces the effective sample rate and smoothes any dynamic affects in the data. This is particularly useful in reducing AC pickup in thermocouple measurements.

When AT-7000 Systems are configured with slowly changing data only, they are configured with simpler frame structures, not unlike those used for dynamic data only, except the overall sample throughput is reduced.

Frame Structure with Dynamic Data and Sub-frame for Static Data
AT-7000 Frame Structure



Frame Structure for Dynamic Data Only



Frame Structure with Dynamic Data and Subframe for Static Data

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