Wireless Airborne Instrumentation System™
WAIS™

INVOCON, INC., 19221 IH 45 South, Suite 530, Conroe, TX 77385, USA **System Specification – January 2000**

FEATURES

Spread Spectrum Radio Communications

Windows®95/98 Graphical User Interface Software (GUI)

GUI Programmable Network Configuration and Control

"Sliced" Architecture provides Increased System Flexibility and Low-cost Upgrades

Synchronized Network for Modal Analysis (Node to Node Synchronization ±300ns.)

85 kHz Aggregate Sample Rate 12 kHz Maximum per Channel

Powerful On-board 32-bit Microprocessor and 24-bit DSP

Standard and Custom Data Acquisition Modules Available

Advanced Power Saving Features for Extended Battery Operation

Operating Temperature Range –40 °C to +80 °C

Footprint: 3.5" x 5.5"

Height: 2.3" (4-channel unit), 3.2" (12-channel unit)

The Wireless Airborne Instrumentation System is a highly integrated remote data acquisition system for use in a wide variety of distributed sensor applications. Typical applications include modal analysis, condition-based maintenance, structural monitoring and manufacturing process control.

The system is based on a technology designed for the U.S. Military and Aerospace Flight Instrumentation Community to provide a fast, low-cost method of instrumenting high-performance military and aerospace vehicles for the purposes of flight testing. The system has the capability to provide a wireless or wired backbone for Prognostic Health Monitoring (PHM) in real or non-real time. Standard communication between units is accomplished via Spread Spectrum Radio Transceivers (SSRT) which provides up to 2Mbits of data throughput per second. An RS-485 serial bus between units provides an alternate means for communication. The ability to locate the data acquisition electronics near the sensor decreases setup costs and reduces "noise" induced on analog signals by long wires.

Each WAIS system provides synchronous bi-directional, spread-spectrum radio communications, data processing, signal conditioning and 12-bit A/D conversion for up to 64 distributed, simultaneously sampled, analog channels.

Data acquisition modules are currently available for voltage, current, and resistive output sensors. Custom modules for interfacing with alternate analog or digital transducers may be readily developed and integrated into the existing system.

The sliced architecture allows the system user to customize the data acquisition requirements for each location. To build a data acquisition unit, one simply starts with a power supply. Data acquisition modules are selected and "stacked" onto the power supply. Finally, the network communication and radio module are added to create a remote data-gathering unit. Programming of the units is accomplished remotely through a **Windows®95/98** graphical user interface.

System specifications may vary depending on application.

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SYSTEM DESCRIPTION

The system has the capability to collect real time data from up to 64 channels with an aggregate sample rate of 85 kHz at 12 bits. The data is output in analog or digital form at the Central Data Collection Unit. All channel parameters such as sample rate, filter bandwidth, offset, etc. are entered into a graphical user interface and sent to the Central Data Collection Unit (CDCU) via RS-232. The CDCU in turn transmits setup information to the Remote Data Gathering Units (RDGUs). Once the system has been programmed, the units will remember their parameters until reprogrammed. This feature guarantees system operation after power interruptions or complete power failure.

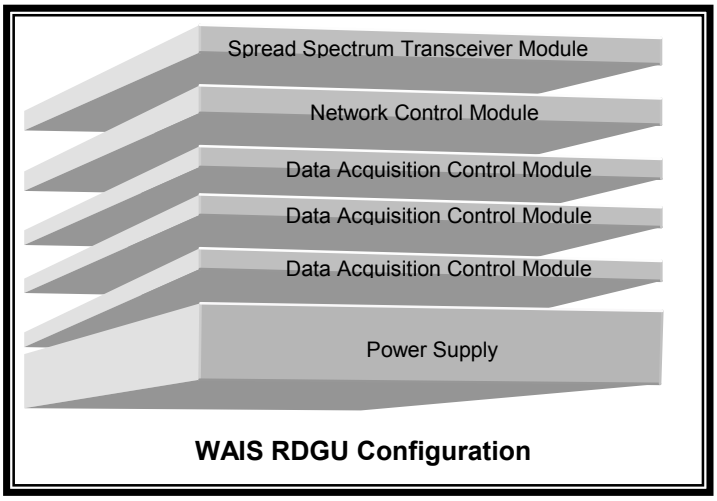
SYSTEM ORGANIZATION

The system consists of multiple Remote Data Gathering Units (RDGUs), and a Central Data Collection Unit (CDCU). Each RDGU contains all the electronics needed for acquiring analog signals from sensors, amplifying/filtering the sensor analog signals, converting the analog signals to digital, storing the digital data, processing the digital information for data reduction, and transmitting the data via the network to a central location. In addition to the data acquisition and transmission capabilities, for non-real time applications, each RDGU has the capability to act as a relay for any other RDGU in the network. The "sliced" architecture of the RDGUs and the CDCU provides long-term benefits to the system users such as flexibility, reusability, and low cost upgrades.

The Remote Data Gathering Unit consists of the following components:

- 1 Network Control Module (NCM) with Spread Spectrum Transceiver
- 1 (expandable to 3) 4-Channel Data Acquisition Control Module (DACM)
- 1 Power Supply Module

All modules within a given RDGU are connected by means of a parallel bus, which provides for data transfer, power control, and synchronization between modules.

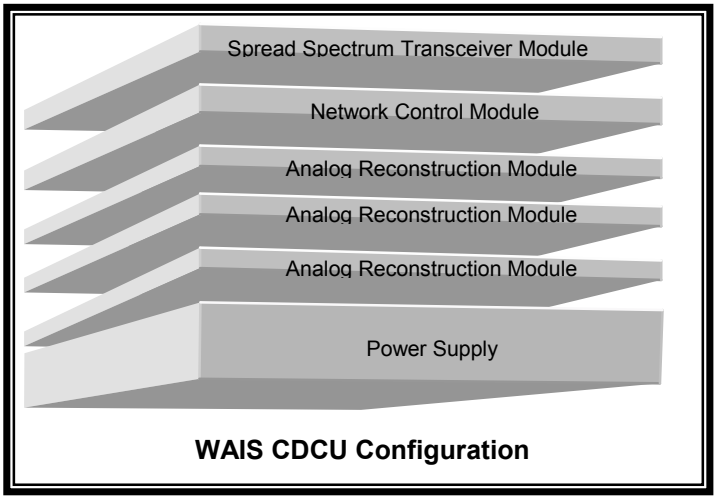


WAIS RDGU Configuration

The Central Data Collection Unit consists of the following components:

- 1 Network Control Module (NCM) with Spread Spectrum Transceiver Module
- 1 (expandable to 4) 16-Channel Analog Reconstruction Module (ARM)
- 1 Power Supply Module

All modules within a given CDCU are connected by means of a parallel bus, which provides for data transfer, power control, and synchronization between modules.



WAIS CDCU Configuration

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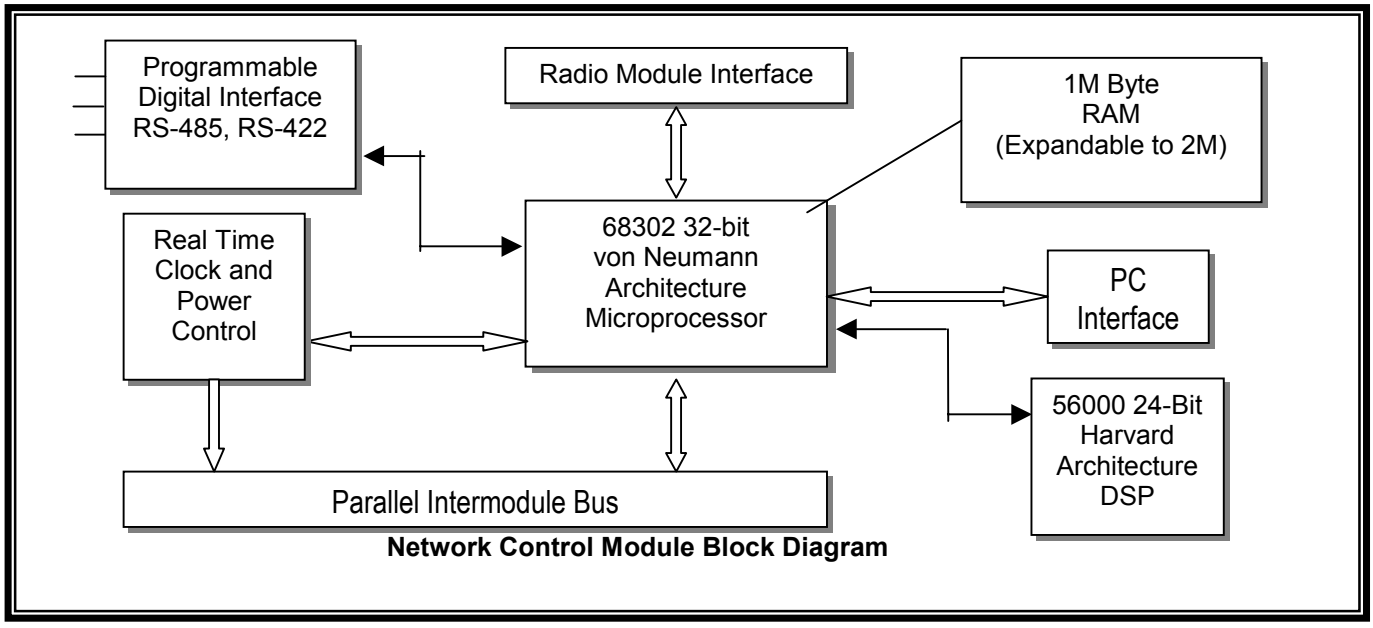
The CDCU is the system link to the Graphical User Interface. All front-end setup parameters and network timing constraints are generated by the GUI with system user input and subsequently sent to the CDCU. The CDCU is the network activity controller. Setup parameters are automatically sent via RF to the appropriate node. Once the setup is complete, the system is ready for operation. The following is a listing of some functions available using the GUI:

- Load, edit, and save setup
- Send information to CDCU
- Initiate "Quick Look" single channel data acquisition mode for immediate graphical display
- Hardware detect
- Series calibrate strain gage channels
- Network received signal strength indicator
- Available bandwidth indicator

NETWORK CONTROL MODULE

The Network Module includes the following features:

- High-speed 32-bit Microprocessor with on-board DSP for general purpose signal processing
- 10 Megabit/sec serial bus and Direct Memory Access (DMA) for high data transfer rates
- Programmable clock speeds enabling power control for non real-time systems.



Network Control Module Block Diagram

SPREAD SPECTRUM TRANSCEIVER MODULE

All WAIS units are linked via spread spectrum radio modules, each of which consists of a transceiver and an integral antenna. Current options include, but are not limited to, the following:

- 900 MHz ISM band transceiver, baseband data rate: 2 Mbit/sec
- 2.4 GHz ISM transceiver (under development), baseband data rate: 2 Mbit/sec
- 2.4 GHz ISM transceiver (under development), baseband data rate: 4 Mbit/sec

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NETWORK STRUCTURE

REAL TIME MODE

For applications where minimum latency is of prime importance, the WAIS can deliver synchronized data to a central location with a 200-millisecond delay. The Real Time Mode is primarily used in applications that require wireless data to interface to existing instrumentation systems, or the wireless data is used for control and/or feedback applications. Node-to-node synchronization is ± 300ns (1) and channel-to-channel synchronization within a node is ± 1ns.

A Time Division Multiplexed (TDM) scheme is used to transmit data from the RDGU to the CDCU. The Real Time Mode operates as follows: once every transmit cycle, the CDCU transmits a synchronization pattern which is used by the RDGUs for clock and transmit frame adjustment. The RDGU begins data acquisition and stores the data in a circular buffer. When the next synchronization pattern arrives, the RDGU transmits the data at a time determined by the system sample rate parameters. Once received by the CDCU, error checking is implemented to determine if retransmission is necessary. A portion of each transmit cycle is reserved for retransmissions; however, the total time available for retransmissions depends on the bandwidth or sample rates selected. Available sample rates include: 12.2kHz, 6.1kHz, 3.05kHz, 1.5kHz, 763Hz, 381Hz, 190Hz, 95Hz, 47Hz, and 23Hz.

(1) ADD APPROXIMATELY 1ns PER FOOT OF SEPARATION BETWEEN NODES FOR RF PROPAGATION DELAYS

NON-REAL TIME MODE

Non-Real Time Mode is a technique for acquiring distributed data from remote units after the data has been acquired. Relays may be used because clear paths between the RDGU and the CDCU do not always exist. The locations of remote data gathering units are driven entirely by the physical location of the phenomena to be monitored. RDGUs may be placed under fuel cells, in the tip of a tail cone, in the avionics bay, behind bulkheads or armor plating, in wing tips, in or out of pressurized compartments, etc. The system addresses the data path problem by causing each of the RDGUs to act as a relay for all other RDGUs in the system. These relay tasks do not conflict with the data gathering and communications chores occurring at each RDGU. All system control is automatic. Data messages are relayed through the system according to learned paths that are stored in the control memory of all RDGUs. The control memory of each RDGU is dynamic at all times. The units are always looking for new RDGUs that have been added to the system as well as looking for a communications failure that might signal a problem with a unit. When problems are detected, the learned paths are immediately modified to reflect the new situation.

Each member of the network is autonomous while performing its preprogrammed data recording and processing tasks. Each operates on a real time clock synchronized to the network periodically by a synchronization pattern transmitted by the CDCU. This is an important feature of the system since it is critical not only to acquire the data, but also to know when the data was obtained. With the RDGUs working independently, two or more could be ready to transmit at the same time. However, part of the "smart network" protocol is to test the transmission channel prior to transmitting data. If the channel is busy, the RDGU waits until the channel is clear. This does not destroy the timeliness of the data since the system preserves the exact time the data was recorded. This allows the operator to properly order the information in the database.

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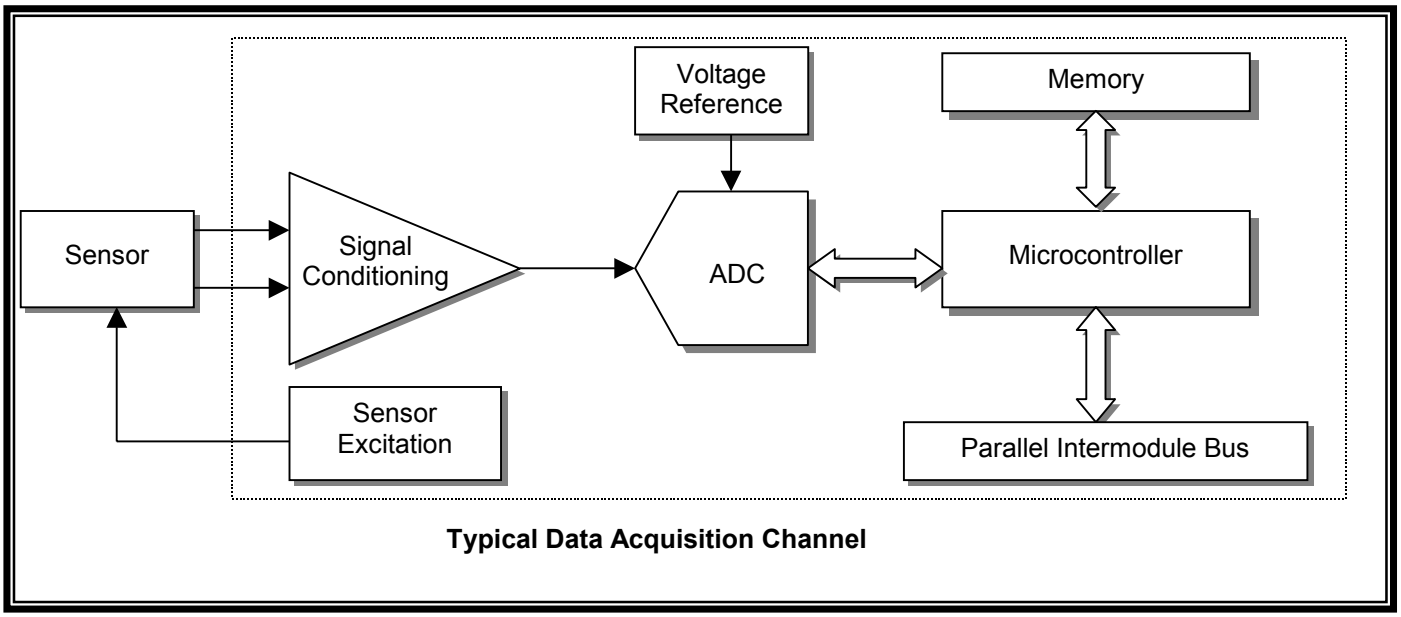
DATA ACQUISITION MODULES

The modular architecture implementation provides for very flexible, yet powerful data acquisition capabilities.



Typical Data Acquisition Channel

Each Data Acquisition Module utilizes a microcontroller to handle data buffering, and parallel communications with the Network Control Module (NCM).

SIGNAL CONDITIONING AND ANALOG-TO-DIGITAL CONVERSION

Several types of front-end signal conditioners are available including conditioners for strain gauges, piezoelectric accelerometers, pressure transducers, and temperature sensors. Each front-end module contains a dedicated analog-to-digital converter for each channel with a common clock enabling synchronization between channels. Available sample rates begin with the maximum rate per module successively dividing by two.

General Purpose Module

Each general purpose module includes 4 simultaneously sampled single-ended voltage input channels. Gain, sample rate, filter cutoff frequency, and channel offset are selectable under software control.

Strain Gauge Module

The strain gauge module provides 4 simultaneously sampled channels of strain gage measurements for quarter-bridge, half-bridge, and full-bridge circuit applications. Series calibration capabilities are provided for a quarter bridge configuration. Gain, sample rate, filter cutoff frequency, and offset are selectable by the user under software control.

Piezoelectric Accelerometer Module

The piezoelectric accelerometer module provides 4 simultaneously sampled channels of piezo data. Excitation is provided in the form of 3.5 milliamps constant current. Gain, sample rate, filter cutoff frequency, and offset are selectable by the user under software control.

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POWER SUPPLY

The power supply uses DC/DC conversion techniques to generate required voltages. The nominal input is 28 VDC. The supply produces isolated 28, 13, 7.2, and 5 Volts and is available for front-end modules via the intermodule bus.

FRONT END SPECIFICATIONS

4-CHANNEL GENERAL PURPOSE MODULE, IVC30-RDGU-GEN-4

PARAMETER	VALUE	UNITS
Resolution	12	Bits
Input Range	±10	Volts
Input Type	Single-Ended	-
Maximum Sample Rate	12.207	KHz
2 Pole Butterworth Filter	10 to 4340, 61 Steps	Hertz
Preamp Gain	1(2)	Volts/Volt
Programmable Gain	1,2,4,8	Volts/Volt
Offset Range	±5	Volts
Excitation	None	-
Size (including housing)	5.44 x 3.51 x 0.47	Inches
Power 12.0 Volts	170	mA
Power 5.0 Volts	65	mA
Weight	6.0	Ounce (oz.)

(2) MAY BE FACTORY SET 1 TO 1000

4-CHANNEL PIEZOELECTRIC ACCELEROMETER CONDITIONER MODULE, IVC30-RDGU-PZO

PARAMETER	VALUE	UNITS
Resolution	12	Bits
Input Range	±10	Volts
Input Type	Single Ended	-
Maximum Sample Rate	12.207	KHz
2 Pole Butterworth Filter	20 to 12k, 70 Steps	Hertz
Preamp Gain	Resistor Set 1 - 1000	Volts/Volt
Programmable Gain	1,2,4,8	Volts/Volt
Offset Range	±5	Volts/Volt
Excitation	3.5 mA Constant Current	mA
Size (including housing)	5.44 x 3.51 x 0.47	Inches
Power 12.0 Volts	185	mA
Power 5.0 Volts	70	mA
Power 28.0 Volts	16	mA
Weight	6.0	Ounce (oz.)

System specifications may vary depending on application.

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FRONT END SPECIFICATIONS (cont'd)

4-CHANNEL STRAIN GAUGE CONDITIONER MODULE, IVC30-RDGU-WHT-4

PARAMETER	VALUE	UNITS
Resolution	12	Bits
Input Range	±200	mV
Input Type	Differential	-
Maximum Sample Rate	12	KHz
2 Pole Butterworth Filter	10 to 4340, 61 Steps	Hertz
Preamp Gain	50	Volts/Volt
Programmable Gain	1,2,4,8	Volts/Volt
Offset Range	±5	Volts
Excitation	5.0 or 10.0 Constant Voltage	Volts
Size (including housing)	5.44 x 3.51 x 0.47	Inches
Power 12.0 Volts	305(3)	mA
Power 5.0 Volts	70	mA
Power 28.0 Volts	80(4)	mA
Weight	6.0	Ounce (oz.)

(3) INCLUDES 4 CHANNEL EXCITATION

(4) 28 V USED ONLY DURING CALIBRATION

OUTPUT MODULE SPECIFICATIONS

16-CHANNEL DIGITAL TO ANALOG MODULE, IVC30-CDCU-D/A-2

PARAMETER	VALUE	UNITS
Resolution	12	Bits
Output Range	±5, 0-5, 0-10	Volts
Output Type	Single ended	-
Maximum Update Rate/Channel(5)	12	kHz
2 Pole Butterworth Filter	1 to 4340, 63 Steps	Hertz
Size (including housing)	7.188 x 3.51 x 0.47	Inches
Power 15.0 Volts	120	mA
Power -15.0 Volts	120	mA
Power 7.2 Volts	510	mA
Weight	8.0	Ounce (oz.)

(5) MAXIMUM AGGREGATE UPDATA RATE IS 85 KHZ.

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POWER SUPPLY MODULE SPECIFICATIONS

POWER CONDITIONER MODULE, IVC30-RDGU-POW-2, MIL-704D COMPLIANT, ISOLATED

PARAMETER	VALUE	UNITS
Input Voltage	28	Volts
Input Voltage Range	18 – 40	Volts
Input Current @ 28V	0.65 typical, 1.2 Max[6][7]	Amps
Size (including housing)	5.44 x 3.51 x 0.965	Inches
Output Current @ 12.8 Volts	920[6]	mA
Output Current @ 5.0 Volts	225[6]	mA
Output Current @ 7.2 Volts	700[6]	mA
Output Current @ 28.0 Volts	250[6]	mA
Weight	18	Ounce (oz.)

(6) AT FULL LOAD WITH THREE DATA ACQUISITION MODULES INSTALLED AND RADIO IN TRANSMIT MODE

(7) ISOLATED DC/DC CONVERSION IS 80% EFFICEINT

POWER CONDITIONER MODULE, IVC30-RDGU-POW-NM3, NOT ISOLATED

PARAMETER	VALUE	UNITS
Input Voltage	28	Volts
Input Voltage Range	24-29	Volts
Input Current @ 28V	0.52 typical 1.0max[8]	Amps
Size (including housing)	5.44 x 3.51 x 0.965	Inches
Output Current @ 12.8 Volts	920[8]	mA
Output Current @ 7.2 Volts	225[8]	mA
Output Current @ 5.0 Volts	700[8]	mA
Output Current @ 28.0 Volts	250[8]	mA
Weight	11.5	Ounce (oz.)

(8) AT FULL LOAD WITH THREE DATA ACQUISITION MODULES INSTALLED AND RADIO IN TRANSMIT MODE

POWER CONDITIONER MODULE, IVC30-CDCU-POW-2, MIL-704 COMPLIANT, ISOLATED

PARAMETER	VALUE	UNITS
Input Voltage	28	Volts
Input Voltage Range	18 – 50	Volts
Input Current @ 28V	1.65 typical, 2.2 Max[9][10]	Amps
Size (including housing)	7.188 x 3.51 x 1.03	Inches
Output Current @ 15.0 Volts	800[9]	mA
Output Current @ -15.0 Volts	800[9]	mA
Output Current @ 7.2 Volts	700[9]	mA
Output Current 2 @ 7.2 Volts	2040[9]	mA
Weight	24	Ounce (oz.)

(9) AT FULL LOAD WITH FOUR D/A MODULES INSTALLED

(10) ISOLATED DC/DC CONVERSION IS 80% EFFICIENT

System specifications may vary depending on application.

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COMMUNICATIONS MODULE SPECIFICATIONS

NETWORK CONTROL MODULE, IVC30-RDGU-NET-3

PARAMETER	VALUE	UNITS
Communications Engine	MC68356	-
RAM	1	Mbyte
ROM	256	Kbyte
EEPROM	4	Kbyte
I/O	Radio, RS-232, RS485, 16 Bit Parallel	-
Power Control	Three Sleep Modes, 10.0, 1.0, 0.150	mA
Size (including housing)	5.44 x 3.51 x 0.47	Inches
Power	120mA @ 7.2 Volts, 355(11), 700(12)	mA
Weight	8.0	Ounce (oz.)

(11) INCLUDES 900 MHZ RADIO TRANSCEIVER IN RECEIVE MODE

(12) INCLUDES 900 MHZ RADIO TRANSCEIVER IN TRANSMIT MODE

915 MHZ SPREAD SPECTRUM RADIO MODULE SPECIFICATIONS

PARAMETER	VALUE	UNITS
Baseband Data Rate	2.0	Mbit/sec.
Output Power	250	mW
Size (including housing)	5.44 x 3.51 x 0.47	Inches
Power TX Mode	550	mA
Power RX Mode	235	mA
Weight	9.5	Ounce (oz.)

Inquiries regarding WAIS may be addressed to:

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