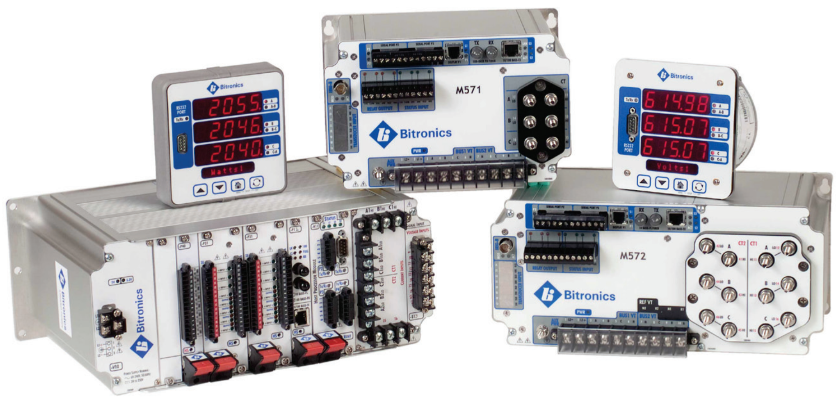
Bitronics

70 SERIES MEASUREMENT SYSTEM

DNP3 Protocol Manual



December 8, 2011
ML0026 Document Revision D

NovaTech®
Bitronics ◆ D/3 ◆ Orion

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70 SERIES FIRMWARE VERSION

The following table provides the most recent firmware and software versions. For best results, the Configurator version used should match with the firmware version. A complete list of firmware and software versions is provided on the 70 Series Utilities CD.

Firmware Versions						
Description	**Bios Version**	**DSP Firmware**	**Host Firmware**	**Configurator**	**Utilities CD**	**Release Date**
M870 Family						
Mx7x Product Release, New Hardware supported Dual Bus, Analog I/O	2.1/3.0*	1.210	2.050	2.31	2.43	03/24/06
Mx7x Updated Release	2.1/3.0*	"	2.060	2.32	2.44	04/14/06
Mx7x Updated Release	2.1/3.0*	1.240	2.120	2.39	2.50	10/01/06
M87x Updated Release	2.1/3.0*	1.240	2.150	2.41	2.52	12/18/06
M87x Product Release, Fault Location, Adjustable Sample Rate	3.4	1.30	2.170	2.43	2.56	12/21/07
M87x Product Release; Add Demand per phase for Watts, VAr, & VA. Configurator & Biview improvements w/ modems. Change to Digital I/O default watchdog contact (Configurator setup; not firmware dependent). Support new version of hardware on P3x, P4x modules.	3.40	1.30	2.18	3.00A	2.57	10/17/08
M87x Product Release: Added 1mHz accuracy on M87x. Improved poll rate from 500ms to 100ms for a single P40 transducer inputs module (M87x). Fault distance configuration is changed. Time sync with respect to DNP master is changed from the DNP master jamming the time to asking the master what time to jam. Increased waveform recording limit from 999 post trigger for longer recording.	3.40	1.31	2.19	3.02	2.58	09/30/2009
M87x Product Release, IEC61850 & SNTP; Avg 3-Ph Amps and Avg 3-Ph Volts	3.40	1.30	3.01.0	3.01	3.01	1/30/2009

Firmware Versions						
Description	Bios Version	DSP Firmware	Host Firmware	Configurator	Utilities CD	Release Date
M87x Product Release: Added 1mHz accuracy on M87x. Improved poll rate from 500ms to 100ms for a single P40 transducer inputs module (M87x). Fault distance configuration is changed. Time sync with respect to DNP master is changed from the DNP master jamming the time to asking the master what time to jam. Increased waveform recording limit from 999 post trigger for longer recording.	3.40	1.31	3.02	3.02	3.02	09/30/2009
M87x Product Release: Added virtual I/O to DR. Added Peak Fault Current Measurement. Improved password security. Added support for control characters for SMS.	3.40	1.31	3.04	3.04	3.04	10/15/2010
M87x Product Release: Added support for dual peak current input range M872 (S16, S17), IEEE C37.232 naming convention, periodic triggering, and 4 IEC 61850 buffered reports.	3.40	1.32	3.05	3.05	3.05	2/28/2011
M87x Product Release: Increased pre and post trigger times for DR recorders, modified base memory to 1MB	3.40	1.32	3.07	3.07	3.07	11/11/2011

* H10/H11

70 SERIES MANUAL SET

ML0021 M87X User Manual
ML0032 M57X User Manual
ML0022 70 SERIES UCA® Object Model
ML0024 70 SERIES Modbus Plus Module & Protocol
ML0025 70 SERIES Modbus Protocol
ML0026 70 SERIES DNP3 Protocol
ML0027 M870D Remote Display Manual
ML0033 M570Dx Remote Display Manual
ML0034 70 Series IEC61850® Protocol Manual

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SAFETY SECTION

Please refer to the M87x and M57x User Manuals, ML0021 and ML0032 respectively, for information regarding safety, installation, commissioning and decommissioning.

1.0 DNP INTERFACE

1.1 Description

The DNP network is a "MASTER" to "SLAVE" network; that is to say, one node asks a question and a second node answers. A NODE is a DNP device (RTU, Computer, M871, etc.) that is connected to the network. Each DNP NODE has an ADDRESS in the range of 0 to 65535, and it is this address that allows a MASTER to selectively request data from any other device. DNP uses the address 65535 for broadcast functions. Broadcast requests NEVER generate DNP responses.

The DNP implementation in the 70 SERIES IEDs conforms to all of the Harris IED (Intelligent Electronics Devices) implementation guidelines. All data items that are available from the 70 SERIES IEDs can be obtained via the **DNP READ CLASS 0** command. Individual items can also be read using **READ BINARY OUTPUT STATUS** or **READ ANALOG INPUT** or **READ COUNTER** or **READ BINARY INPUT STATUS** or **READ ANALOG OUTPUT STATUS** commands.

The Energy values can be reset to zero by issuing the **DIRECT OPERATE**, **DIRECT OPERATE NO ACKNOWLEDGE,** or **SELECT BEFORE OPERATE** by using the *CONTROL RELAY OUTPUT BLOCK Object, Variation 1, LATCH_ON*.

The Demand values can be reset by issuing the same **DIRECT OPERATE**, **DIRECT OPERATE NO ACKNOWLEDGE,** or **SELECT BEFORE OPERATE** command to the other points of this object using the *CONTROL RELAY OUTPUT BLOCK Object, Variation 1, LATCH_ON*.. Waveform and Disturbance Records can be triggered and digital outputs on the optional Digital I/O Module can be activated using these commands.

The CT and PT ratios, Current and Voltage Scale Factors, and various other configuration parameters can be changed by issuing **DIRECT OPERATE**, **DIRECT OPERATE NO ACKNOWLEDGE,** or **SELECT BEFORE OPERATE** by using the *ANALOG OUTPUT BLOCK* object. Due to the limited number of FLASH write cycles, scale factors SHOULD NOT be written continuously. Refer to Section 1.5 for more information on setting CT and PT ratios and Current and Voltage Scale Factors.

The **SELECT BEFORE OPERATE** arm timeout value is configurable from zero seconds to twenty-four hours.

1.2 DNP Address

Each DNP instrument responds to a single destination address in the range 0-65519. Each instrument on a DNP link must have a unique address. The 70 SERIES IEDs will allow any of the 65526 addresses to be selected. DNP instruments also use a GLOBAL address of 65535. Requests sent to the GLOBAL address cause the instrument to execute the function but not to respond.

1.3 Transaction Timing

The 70 SERIES IEDs complete a set of calculations approximately every cycle and calculations for volt and amp measurements every quarter cycle. The HOST CPU processor services the DNP ports by interrupts received from the corresponding serial ports. Incoming messages are parsed and responded to in approximately 30ms.

1.4 Object Format

The 70 SERIES IEDs report all static measurements via the use of three static objects. These objects include COUNTER (object 20, variations 1, 2, 5 and 6), ANALOG INPUT (object 30, variations 1, 2, 3 and 4) and BINARY INPUT (object 01, variations 1 and 2). These objects are read only and cannot be modified by DNP MASTER devices.

Parameters, such as configuration registers, that can be modified make use of the ANALOG OUTPUT STATUS (object 40, variation 2) object. DNP MASTER devices can read these points or modify their value via the *ANALOG OUTPUT BLOCK* (object 41, variation 2) command. Digital Outputs and all other pseudo output points (such as demand and energy resets) are reported using the BINARY OUTPUT STATUS (object 10, variation 2). BINARY OUTPUTs can be PULSED ON, PULSED OFF or LATCHED ON and LATCHED OFF by using the *CONTROL RELAY OUTPUT BLOCK* (object 12, variation 1, LATCH_ON) command.

The 70 SERIES IEDs are capable of reporting BINARY INPUT CHANGE (object 02, variations 1 and 2) events with and without time and ANALOG CHANGE EVENTS (object 32, variations 2 and 4) with and without time. Any BINARY INPUT can be configured to report as a CLASS-1, CLASS-2, or CLASS-3 BINARY INPUT CHANGE event and any ANALOG INPUT can be configured to report as a CLASS-1, CLASS-2, or CLASS-3 ANALOG CHANGE EVENT. Point, Class, Analog Deadband Values and Object Variation are all selectable by use of the 70 SERIES configuration utility software. The Object Variations are selectable by Object (not by point). All ANALOG CHANGE EVENTS can be configured to report with or without time, and all BINARY INPUT CHANGE objects can be configured to report with or without time.

The DNP protocol allows each device to determine the best method of data transfer. The 70 SERIES IEDs support this by selecting the most appropriate response variation when either the requested variation is 0 or a CLASS-0 read is requested. Both COUNTER and ANALOG INPUT objects allow optional flags to be used. If a value is requested as variation 0, the 70 SERIES IEDs respond as if the requested variation was for a 32-bit COUNTER or 16-bit ANALOG INPUT or 16-bit ANALOG OUTPUT STATUS.

When reading objects, the Health Check point (object 30, point 0) should always be read and checked before interpreting data, since some failure modes will cause erroneous data to be presented (See Section 1.8). The majority of the points are represented in Normalized 2's complement format. For conversion of the point data into engineering units, please refer to Section 1.6. For specifics concerning the correct command and its implementation, users are directed to the M87X or M57X User Manuals for the specific device that will request the data. Listed in section 1.4.1 are the point assignments for the 70 SERIES IEDs when using the Configurable or Single Feeder Configurable (SFC) selection (used for M571 and M871). Appendix A provides the Legacy or Bitronics Legacy

Fixed (BiLF) point set. NOTE: The 70 Series IEDs have a total of up to 6 different point sets (depending upon Configurator and fimrware versions). Please refer to the 70 Series Configurator DNP Points tab and click on the various options in the "Point Set" and "Points to Display" sections to see point assignments. For Configurator versions 2.27 or higher, the Point Sets on the left side of the box in the DNP Points Screen are all fixed sets whereas the ones on the right side of the box are all configurable to varying degrees (some have a fixed portion followed by a section where the user can select any of the measurements available in the 70 Series IEDs) Note also that unless otherwise specified, all points are READ ONLY.

1.4.1 Bitronics 70 SERIES IEDs DNP3 Point Assignments (Configurable/SFC (Single Feeder Configurable))

Bitronics 70 SERIES IEDs DNP3 Point Assignments												
	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:00		Health 0	T1		Bit-0	DSP Gain Cal Error	Data	0-Norm	1-Fail	1	
						Bit-1	DSP Offset Cal Error					
						Bit-2	SIM Gain Cal Error					
						Bit-3	SIM Offset Cal Error					
						Bit-4	SIM Phase Cal error					
						Bit-5	SIM Ratio Csum Error					
						Bit-6	User Ratio Csum Error					
						Bit-7	User Gain Csum Error					
						Bit-8	User Phase Csum Error					
						Bit-9	DSP Board ID Csum Error					
						Bit-10	SIM Board ID Csum Error					
						Bit-11	User TDD Csum Error					
						Bit-12	DSP Integrity Csum Error					
						Bit-13	DSP Stack Overflow					
						Bit-14	CT\VT Scaling Error					
						Bit-15	Protocol Config Error					
	AI:01		Health 1	T1		Bit-0	Reserved	Data	0-Norm	1-Fail	1	
						Bit-1	Reserved					
						Bit-2	Reserved					
						Bit-3	Reserved					
						Bit-4	Reserved					
						Bit-5	Reserved					
						Bit-6	Reserved					
						Bit-7	Reserved					
						Bit-8	Reserved					
						Bit-9	Reserved					
						Bit-10	Reserved					
						Bit-11	Reserved					
						Bit-12	Reserved					
						Bit-13	Reserved					
						Bit-14	Reserved					
						Bit-15	Reserved					
	AI:02		Amps A	T2	Amp Scale			Data	0	32767	((1/32768) *10*Amp Scale) A	
	AI:03		Amps B	T2	Amp Scale			Data	0	32767	((1/32768) *10*Amp Scale) A	
	AI:04		Amps C	T2	Amp Scale			Data	0	32767	((1/32768) *10*Amp Scale) A	
	AI:05		Amps N	T3	Amp Scale			Data	0	32767	((1/32768) *15*Amp Scale) A	
	AI:06		Amps Residual	T3	Amp Scale			Data	0	32767	((1/32768) *15*Amp Scale) A	

Bitronics 70 SERIES IEDs DNP3 Point Assignments

	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:07		Volts A	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:08		Volts B	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:09		Volts C	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:10		Volts N	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:11		Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:12		Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:13		Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:14		Volts A Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:15		Volts B Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:16		Volts C Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:17		Volts N Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:18		Volts AB Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:19		Volts BC Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:20		Volts CA Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
	AI:21		Watts A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) W	
	AI:22		Watts B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) W	
	AI:23		Watts C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) W	
	AI:24		Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *4500*Amp Scale * Volt Scale) W	
	AI:25		VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) vars	
	AI:26		VARs B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) vars	
	AI:27		VARs C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) vars	
	AI:28		VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *4500*Amp Scale * Volt Scale) vars	
	AI:29		VAs A	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *1500*Amp Scale * Volt Scale) VAs	
	AI:30		VAs B	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *1500*Amp Scale * Volt Scale) VAs	
	AI:31		VAs C	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *1500*Amp Scale * Volt Scale) VAs	
	AI:32		VAs Total Geometric	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *4500*Amp Scale * Volt Scale) VAs	
	AI:33		Power Factor A	T7				Data	-1000	1000	0.001	
	AI:34		Power Factor B	T7				Data	-1000	1000	0.001	
	AI:35		Power Factor C	T7				Data	-1000	1000	0.001	
	AI:36		Power Factor Total Geometric	T7				Data	-1000	1000	0.001	
	AI:37		Frequency Volts A	T8				Data	2000	8000	0.01 Hz	
	AI:38		Frequency Volts B	T8				Data	2000	8000	0.01 Hz	
	AI:39		Frequency Volts C	T8				Data	2000	8000	0.01 Hz	
	AI:40		Frequency Volts A Bus2	T8				Data	2000	8000	0.01 Hz	
	AI:41		Frequency Volts B Bus2	T8				Data	2000	8000	0.01 Hz	
	AI:42		Frequency Volts C Bus2	T8				Data	2000	8000	0.01 Hz	
	AI:43		System Frequency	T8				Data	2000	8000	0.01 Hz	
	AI:44		Phase Angle Volts A Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
	AI:45		Phase Angle Volts B Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
	AI:46		Phase Angle Volts C Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
	AI:47		Phase Angle Amps A Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	

Bitronics 70 SERIES IEDs DNP3 Point Assignments

	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:48		Phase Angle Amps B Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
	AI:49		Phase Angle Amps C Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
	AI:50		Phase Angle Volts A Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
	AI:51		Phase Angle Volts B Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
	AI:52		Phase Angle Volts C Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
	AI:53		Meter Type	T1		404	M87x Configurable reg.	Data	400	502	0	
						501	M57x Configurable reg.					
	AO:00		VA/PF Calc. Type	T1		1	Arithmetic	Setting	1	4	1	
						2	Geometric					
						3	3 Element (L-N)					
						4	2 Element (L-L)					
	AO:01		Volt Scale Factor	T10				Setting	1000	9999	1	
	AO:02		Volt Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:03		Amp Scale Factor	T10				Setting	1000	9999	1	
	AO:04		Amp Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:05		Xfmr Ratio Volts A	T10				Setting	1000	9999	1	
	AO:06		Xfmr Ratio Divisor Volts A	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:07		Xfmr Ratio Volts B	T10				Setting	1000	9999	1	
	AO:08		Xfmr Ratio Divisor Volts B	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:09		Xfmr Ratio Volts C	T10				Setting	1000	9999	1	
	AO:10		Xfmr Ratio Divisor Volts C	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:11		Xfmr Ratio Volts N	T10				Setting	1000	9999	1	
	AO:12		Xfmr Ratio Divisor Volts N	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:13		Xfmr Ratio Volts A Bus2	T10				Setting	1000	9999	1	
	AO:14		Xfmr Ratio Divisor Volts A Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:15		Xfmr Ratio Volts B Bus2	T10				Setting	1000	9999	1	
	AO:16		Xfmr Ratio Divisor Volts B Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:17		Xfmr Ratio Volts C Bus2	T10				Setting	1000	9999	1	
	AO:18		Xfmr Ratio Divisor Volts C Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:19		Xfmr Ratio Volts N Bus2	T10				Setting	1000	9999	1	
	AO:20		Xfmr Ratio Divisor Volts N Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:21		Xfmr Ratio Amps A	T10				Setting	1000	9999	1	
	AO:22		Xfmr Ratio Divisor Amps A	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:23		Xfmr Ratio Amps B	T10				Setting	1000	9999	1	
	AO:24		Xfmr Ratio Divisor Amps B	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:25		Xfmr Ratio Amps C	T10				Setting	1000	9999	1	
	AO:26		Xfmr Ratio Divisor Amps C	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:27		Xfmr Ratio Amps N	T10				Setting	1000	9999	1	
	AO:28		Xfmr Ratio Divisor Amps N	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:29		User Gain Volts A	T12				Setting	-32768	32767	1/16384	
	AO:30		User Gain Volts B	T12				Setting	-32768	32767	1/16384	
	AO:31		User Gain Volts C	T12				Setting	-32768	32767	1/16384	
	AO:32		User Gain Volts N	T12				Setting	-32768	32767	1/16384	
	AO:33		User Gain Volts A Bus2	T12				Setting	-32768	32767	1/16384	
	AO:34		User Gain Volts B Bus2	T12				Setting	-32768	32767	1/16384	
	AO:35		User Gain Volts C Bus2	T12				Setting	-32768	32767	1/16384	
	AO:36		User Gain Volts N Bus2	T12				Setting	-32768	32767	1/16384	
	AO:37		User Gain Amps A	T12				Setting	-32768	32767	1/16384	
	AO:38		User Gain Amps B	T12				Setting	-32768	32767	1/16384	
	AO:39		User Gain Amps C	T12				Setting	-32768	32767	1/16384	
	AO:40		User Gain Amps N	T12				Setting	-32768	32767	1/16384	
	AO:41		User Phase Correction Volts A	T8				Setting	-18000	18000	0.01 Degrees	

Bitronics 70 SERIES IEDs DNP3 Point Assignments

	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AO:42		User Phase Correction Volts B	T8				Setting	-18000	18000	0.01 Degrees	
	AO:43		User Phase Correction Volts C	T8				Setting	-18000	18000	0.01 Degrees	
	AO:44		User Phase Correction Volts N	T8				Setting	-18000	18000	0.01 Degrees	
	AO:45		User Phase Correction Volts A Bus2	T8				Setting	-18000	18000	0.01 Degrees	
	AO:46		User Phase Correction Volts B Bus2	T8				Setting	-18000	18000	0.01 Degrees	
	AO:47		User Phase Correction Volts C Bus2	T8				Setting	-18000	18000	0.01 Degrees	
	AO:48		User Phase Correction Volts N Bus2	T8				Setting	-18000	18000	0.01 Degrees	
	AO:49		User Phase Correction Amps A	T8				Setting	-18000	18000	0.01 Degrees	
	AO:50		User Phase Correction Amps B	T8				Setting	-18000	18000	0.01 Degrees	
	AO:51		User Phase Correction Amps C	T8				Setting	-18000	18000	0.01 Degrees	
	AO:52		User Phase Correction Amps N	T8				Setting	-18000	18000	0.01 Degrees	

1.4.2 DNP3 Calculation-Type Codes

Type	Value / Bit Mask	Description
T1		Unsigned 16-Bit Integer
T2		Signed 16-Bit Integer - 2's Complement - Saturation 10
		Float Value = ((Integer Value) / 32768) * Scale * 10)
		Example: 5.0 A stored as 16384 when Amp Scale = 1:1
T3		Signed 16-Bit Integer - 2's Complement - Saturation 15
		Float Value = ((Integer Value) / 32768) * Scale * 15)
		Example: 150 A stored as 16384 when Amp Scale = 20:1
T4		Signed 16-Bit Integer - 2's Complement - Saturation 150
		Float Value = ((Integer Value) / 32768) * Scale * 150)
		Example: 119.998 V stored as 26214 when Volt Scale = 1:1
T5		Signed 16-Bit Integer - 2's Complement - Saturation 1500
		Float Value = ((Integer Value) / 32768) * Scale * 1500)
		Example: -750.0 W stored as -16384 when Volt Scale = 1:1, Amp Scale 1:1
T6		Signed 16-Bit Integer - 2's Complement - Saturation 4500
		Float Value = ((Integer Value) / 32768) * Scale * 4500)
		Example: -90.0 kW stored as -8192 when Volt Scale = 20:1, Amp Scale 4:1
T7		Signed 16-Bit Integer - 2's Complement - 3 Decimal Places
		Example: -12.345 stored as -12345
T8		Signed 16-Bit Integer - 2's Complement - 2 Decimal Places
		Example: 123.45 stored as 12345
T9		Signed 16-Bit Integer - 2's Complement -1 Decimal Place
		Example: -1234.5 stored as -12345
T10		Unsigned 16-Bit Integer - Normalized Ratio
		ratio = (Normalized Ratio / Ratio Divisor)
		Example : 1.234, 12.34, 123.4, and 1234 are all stored as 1234
T11		Unsigned 16-Bit Integer - Ratio Divisor
		ratio = (Normalized Ratio / Ratio Divisor); valid Ratio Divisors are 1,10,100,1000
		Example: X.XXX stored as 1000, XX.XX stored as 100, XXX.X stored as 10
T12		Signed 16-Bit - 2's Complement - Saturation 2
		Gain Value = Integer Value /16384)
		Example: -0.250 stored as -4096
T13		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 10
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 10
		Example: 5.0 A stored as 3071 when Amp Scale 1:1
T14		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 150
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 150
		Example: 119.97 V stored as 3685 when Volt Scale 1:1
T15		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 1000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 1000
		Example: -500 W stored as 1023 when Volt Scale = 1:1, Amp Scale = 1:1
T16		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 3000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 3000
		Example: 349.10 kW stored as 3040 when Volt Scale = 6:1, Amp Scale = 40:1
T17		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 15
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 15
		Example: 11.79 A stored as 2369 when Amp Scale 5:1
T18		Unsigned 16-Bit Integer - 12 Bit Offset Binary -1 Decimal Place
		Float Value = ((Integer Value - 2047) / (10))
		Example: 121.4 degrees stored as 3261
T19		Unsigned 16-Bit Integer - 12 Bit Offset Binary -3 Decimal Place
		Float Value = ((Integer Value - 2047) / (1000))
		Example: 0.978 Power Factor stored as 3025
T20		Unsigned 16-Bit Integer - Bit Control/Status
		0' - stored as zero; '1' - stored as 65536
T21		Unsigned 16-Bit Integer - 3 Decimal Places
		Example: 54.321 stored as 54321
T22		Bit
		Example: 1-bit is set, 0-bit is clear

1.5 Configuration

1.5.1 Setting CT and VT Ratios

The 70 SERIES IEDs are capable of internally storing and recalling CT and VT ratios. The CT and VT ratios are written to ANALOG OUTPUTS over the DNP communication port, and are stored in non-volatile memory on the CT/VT Module. Each ratio is stored in two points, one for the Normalized Ratio and the other for the Ratio Divisor. Allowable constants for the normalized ratios are 1000 to 9999. The Ratio Divisors may be 1, 10, 100, or 1000 only. The number stored will be the high side rating of the CT Ratio or VT Ratio. Both a 500:5 ratio CT and a 100:1 CT will have a value of 100 stored. For example, to calculate a CT and VT ratio for Phase A from the data stored in the 70 SERIES IEDs, use the following equation:

$$Phase\,A\,CT_{RATIO} = \frac{Phase\,A\,CT\;Value(AO:21)}{Phase\,A\,CT\;\;Ratio\,Divisor\,(AO:22)}$$

$$Phase\,A\,VT_{RATIO} = \frac{Phase\,A\,VT\;Value(AO:05)}{Phase\,A\,VT\;\;Ratio\,Divisor\,(AO:06)}$$

The 70 SERIES IEDs calculate all measured quantities in primary units, unlike other Bitronics instruments (MultiComm and PowerPlex). The CT and VT ratio information is used to calculate these primary values. To force the 70 SERIES IEDs to report in secondary units, set the Scale Factor = to the CT or VT ratio, as appropriate.

Note: The Full Scale Integer Value of current and voltage reported by the 70 SERIES IEDs over DNP can be changed, see Section 1.5.2.

In the event of a CT/VT Ratio Checksum Failure, the value in the Normalized CT Ratio and Normalized VT Ratio points default to 1000, and the value in the CT Ratio Divisor and VT Ratio Divisor default to 1000. This results in a 1:1 CT Ratio and 1:1 VT Ratio.

> WARNING – TO PRESERVE SYSTEM PERFORMANCE, ONLY WRITE TO RATIO REGISTERS WHEN THE RATIOS NEED TO BE CHANGED.

1.5.2 Setting Current and Voltage Scale Factors

As detailed in Section 1.6, the data in the 70 SERIES IEDs DNP points is in Normalized 2's complement format. Measurements presented in this format do not have as much resolution as the 70 SERIES IED's internal floating-point values. Because of the wide dynamic range of the device inputs, the default full-scale integer representation of measurement values is a compromise that has been selected to accommodate typical system signal levels, while giving reasonable resolution. The maximum (or full scale) integer value that can be reported corresponds to some particular level of Amperes, Volts, Watts, etc.

The maximum full scale integer value of Amperes and Volts in the Normalized 2's complement format can be changed by means of the Current Scale Factor and Voltage Scale Factor ($I_{SCALE\ FACTOR}$ and $V_{SCALE\ FACTOR}$), which are modified by writing to the Normalized Scale Factor and Scale Factor Divisor (AO:01 to AO:04) points. *These Current Scale Factor and Voltage Scale Factor values are multipliers of the Default Full*

Scale values. To convert values reported in DNP points to engineering units, refer to Section 1.6. The default full-scale values for quantities are:

Quantity	Default Full Scale
Phase Current	10
Neutral Current	15
Voltages	150
Per-Phase Power (Watt, VAR, VA)	1500
Total Power (Watt, VAR, VA)	4500

$$I_{SCALE\ FACTOR} = \frac{Normalized\ Current\ Scale\ Factor\ (AO:03)}{Current\ Scale\ Factor\ Divisor\ (AO:04)}$$

$$V_{SCALE\ FACTOR} = \frac{Normalized\ Voltage\ Scale\ Factor\ (AO:01)}{Voltage\ Scale\ Factor\ Divisor\ (AO:02)}$$

The Current and Voltage Scale Factors are written to points AO:01 through AO:04 and are stored in non-volatile memory on the Host CPU Board. Each Scale Factor is stored in two points, one for the Normalized Scale Factor, and the other for the Scale Factor Divisor. Allowable constants for Normalized Scale Factors are 1000 to 9999. The Scale Factor Divisors may be 1, 10, 100, or 1000 only.

WARNING – TO PRESERVE SYSTEM PERFORMANCE, ONLY WRITE TO RATIO REGISTERS WHEN THE RATIOS NEED TO BE CHANGED.

1.5.2a Scale Factor Voltage Measurement Example

For example, the default full-scale value of voltage (points AI:07 to AI:20) is 150V, the default value of the Normalized Voltage Scale Factor (AO:01) is 1000, and the default value of the Voltage Scale Factor Divisor (AO:02) is 1000. Assume a system with a 1:1 VT Ratio. If it is desired to change the full-scale representation of volts to 300V (to accommodate a 208V input, for instance), change the value of the Normalized Voltage Scale Factor (AO:01) to 2000.

$$VOLTAGE\ Phase\ A-B = \frac{Value}{32768} \times 150 \times \frac{2000}{1000} = 300V$$

Note that since $V_{SCALE\ FACTOR}$ = 2, the values represented by the power quantity points will also be doubled.

Note that the full-scale representation of all Voltage measurements will also change. The scaling for Power quantities cannot be set independently, but will be the product of the Voltage and Current Scale Factors.

1.5.2b Scale Factor Current Measurement Example

Consider a system with a 2000:5 (400:1) CT, on which it is desired to measure the Phase A amperes. The Normalized CT Ratio (AO:21) would be set to 4000, the CT Ratio Divisor (AO:22) to 10. With the default settings for the Current Scale Factor, the maximum point value of "32767" would yield:

$$AMPEREs\,Phase\,A = \frac{Value(=32767)}{32768} \times 10 \times \frac{1000}{1000} = 10A$$

In other words, the integer value for Amperes would be at a maximum with only 10A flowing through the system primary conductors. To compensate for this, set the $I_{SCALE\ FACTOR}$ equal to the CT_{RATIO}. The Normalized Current Scale Factor (AO:03) would be set to 4000, and the Current Scale Factor Divisor (AO:04) to 10. If the maximum value of "32767" is returned in point AI:02, it is converted to Amperes as follows:

$$AMPEREs\,Phase\,A = \frac{Value}{32768} \times 10 \times I_{SCALE\ FACTOR} = \frac{32767}{32768} \times 10 \times \frac{4000}{10} = 4000A$$

If it is known that the maximum current on the circuit is not this high, and it is desired to set the full scale representation to 1200A for added resolution, the Normalized Current Scale Factor (AO:03) could be set to 1200, and the Current Scale Factor Divisor (AO:04) to 10. The maximum value returned (32767) would then be equal to:

$$AMPEREs\,Phase\,A = \frac{Value(=32767)}{32768} \times 10 \times \frac{1200}{10} = 1200A$$

1.5.3 Resetting Energy and Demands and Triggering Waveforms

The Energy and Demand registers can be reset by issuing a *CONTROL RELAY OUTPUT BLOCK, Variation 1, LATCH_ON* to the appropriate BINARY OUTPUT. Issuing a *CONTROL RELAY OUTPUT BLOCK* to a "Trigger" BINARY OUTPUT will trigger a Waveform or Disturbance Record. The 70 SERIES IEDs will store the record in the next available slot. All of these registers are user-defined; they are not part of the default 70 SERIES IED register set.

Reset / Trigger Functions
Reset Energy
Reset Demand Amps
Reset Demand Volts
Reset Demand Power
Reset Demand Harmonic
Trigger Waveform Recorder
Trigger Disturbance Recorder 1
Trigger Disturbance Recorder 2

1.5.4 Tag Register

The 70 SERIES IEDs provide a "TAG" BINARY OUTPUT for user identification purposes. An *ANALOG OUTPUT BLOCK* can be issued to this point to write a number from 1 to 65,535 in the tag register.

1.5.5 VA Calculation Type Register

The 70 SERIES IEDs can be configured to use one of several different methods to calculate Total VAs. Refer to the User Manual for an explanation of the different calculation types. The VA Calculation Type register (AO:00) is a READ/WRITE register.

VA Calculation Type	Register Value
Arithmetic	1
Geometric	2
Equivalent 3-element (WYE)	3
Equivalent 2-element (DELTA)	4

1.6 Converting Data to Engineering Units

As mentioned in Section 1.5, the majority of the data is stored in a normalized 2's complement format. When displaying these values at another location, it may be desirable to convert this format into engineering units. This conversion is readily accomplished using the following simple scaling equations:

BASIC EQUATION FOR NORMALIZED ANALOG INPUTS:

$$Engineering\,Units = \frac{Value}{32768} \times Default\ Full\ Scale_{SECONDARY} \times \frac{Normalized\ Scale\ Factor}{Scale\ Factor\ Divisor}$$

The **Value** referred to in the equations would be the value stored in the point that you wished to convert to engineering units. For example if you wanted to convert Phase A Amperes into engineering units, Value would be the value in ANALOG-INPUT point.

ENERGY is stored as 32-BIT values in static COUNTER points. Energy values are in units of PRIMARY kWh or kVARh.

FREQUENCY is stored as a single binary value that is the actual frequency times 100.

POWER FACTOR is stored as the value times 1000. Negative power factors indicate that the VARs are positive. The sign of the Power Factor is the inversion of the Exclusive-OR of the Watts and VARs (i.e. if either or both of the Watts or VARs are negative, then the Power Factor will be negative).

EQUATIONS for Fixed Data Point Set:

$$I_{SCALE\ FACTOR} = \frac{Normalized\ Current\ Scale\ Factor\ (AO:03)}{Current\ Scale\ Factor\ Divisor\ (AO:04)}$$

$$V_{SCALE\ FACTOR} = \frac{Normalized\ Voltage\ Scale\ Factor\ (AO:01)}{Voltage\ Scale\ Factor\ Divisor\ (AO:02)}$$

$$AMPEREs_{(Inst,\ Demand,\ Max)} = \frac{Value}{32768} \times 10 \times I_{SCALE\ FACTOR}$$

$$AMPEREs_{N\ (Inst,\ Demand,\ Max)} = \frac{Value}{32768} \times 15 \times I_{SCALE\ FACTOR}$$

$$VOLTs_{(Inst,\ Demand,\ Min,\ Max)} = \frac{Value}{32768} \times 150 \times V_{SCALE\ FACTOR}$$

$$WATTs(VARs)(VAs)_{TOTAL(Inst,\ Demand,\ Max,\ Max)} = \frac{Value}{32768} \times 4500 \times V_{SCALE\ FACTOR} \times I_{SCALE\ FACTOR}$$

$$WATTs(VARs)(VAs)_{PER\ PHASE(Inst)} = \frac{Value}{32768} \times 1500 \times V_{SCALE\ FACTOR} \times I_{SCALE\ FACTOR}$$

$$kWh\ (kVARh) = Value$$

$$FREQUENCY = \frac{Value}{100}$$

$$PF = \frac{Value}{1000}\ (-Lag, +Lead)$$

$$PHASE\ DIFFERENCE = \frac{Value}{10}\ (+Line\ Leading\ \mathrm{Ref})$$

All quantities reported in Primary Values. To force the 70 SERIES IEDs to report in secondary units, set the Scale Factor = to the CT or VT ratio, as appropriate.

The above equations provide answers in fundamental units (VOLTs, AMPs, WATTs, VARs, VAs and Hz). If the user desires other units such as KILOVOLTS, KILOWATTS or KILOVARS, the answers given by the equations should be divided by 1,000. If the user desires MEGAWATTS or MEGAVARS, the answers given by the equations should be divided by 1,000,000. Energy values are in units of kWh or kVARh.

1.7 Data Sets and Data Types

The 70 SERIES IEDs are shipped with a pre-defined set of data points and data types. These fixed points do not change, but may be augmented by adding additional points (and their data type), from the master listing. The List of Available Measurements may be found in the User Manual. The 70 SERIES Configurator is required to modify the data points.

For users who wish to use the 70 SERIES IEDs on systems configured for other Bitronics products, a Legacy point list may be selected. When selected, the Legacy point list will be substituted for the 70 SERIES IEDs fixed data points. This Legacy list cannot be modified, and will cause the 70 SERIES IEDs to emulate the response of a Bitronics MultiComm or PowerPlex unit. To use the 70 SERIES IEDs with a Bitronics Analog Output Converter (AOC), model NAO8103 or NAO8104, it will be necessary to select the Legacy point list.

1.7.1 Configuring the Class-0 Response

The Class-0 request is essentially a request to "give all data". Since the 70 SERIES IEDs is capable of providing a vast amount of data, provisions have been made to limit the response to this request. The 70 SERIES Configurator is required to change the Class-0 response. The Legacy Class-0 response is also configurable, and can return one of six pre-defined responses.

1.7.2 Configuring Class-1, Class-2 and Class-3 Events

BINARY INPUT points become BINARY INPUT CHANGE events by assigning the point to either the CLASS-1, CLASS-2, or CLASS-3 Data Object. ANALOG INPUT points become ANALOG CHANGE EVENTs by assigning the point to either the CLASS-1, CLASS-2, or CLASS-3 Data Object. This assignment is accomplished by simply moving the desired point(s) into the associated CLASS Data Object block via the 70 SERIES Configurator utility software (DNP Points configuration section).

When assigning ANALOG INPUTS a DEADBAND value must also be entered such that the ANALOG CHANGE EVENT will be generated whenever the last reported value changes by more than that DEADBAND amount. Any point may exist in any CLASS but it may only exist in one CLASS. All BINARY INPUTs can be assigned to BINARY INPUT CHANGE events. The 70 SERIES IEDs permit a maximum of forty ANALOG INPUTs to be assigned to ANALOG INPUT CHANGE events.

1.7.3 Time Sync

Pre-defined data points for status are used to indicate the current state for each of the various time synchronization methods possible on the 70 Series IEDs. These data points appear in the Bitronics Advanced Fixed (BAF) and Harmonic Advance Fixed (HAF) point sets. The 70 Series Configurator allows the user to modify the configuration of time sync parameters.

The following time sync points will return status values of '0' if a time sync master is inactive and '1' if a time sync master is active:
IRIG-B Time Sync, (UCA) Network Time Sync, SNTP Time Sync, DNP Time Sync.

1.7.4 Best Clock Source

The M87x or M57x determines the 'Best Clock Source' and returns a value to indicate the master that is synchronizing the time. This is based upon which time sync masters are active as determined from the Time Sync Data Points and which time sync master takes priority.

Best Clock source	Value
IRIG-B:	**2**
(UCA) Network Time Sync	**3**
SNTP	**4**
DNP	**5**
Manual time set	**0**

Refer to the IED User Manuals (M87x or M57x) for additional information on Time Sync clock source priority.

1.8 Health Check

The 70 SERIES IEDs have several self-tests built in to ensure that the instrument is performing accurately. The results of these self-tests are available in the Health Check register (AO:00), which is a simple 16-bit binary value. Each bit represents the results of a particular self-test, with "0" indicating the test was passed, and "1" indicating the test was failed. The definitions of the various self-tests are described in the User Manual. The following table lists possible faults that would be detected by the self-tests, how the fault is indicated, the effects of the fault, and any necessary corrective actions.

Bit #	Description	Effect	Default Value
0(LSB)	Factory gain calibration of Analog-Digital Signal Processor checksum error.	Unit will continue to function using default values, at reduced accuracy.	A/D Gain = 1
1	Factory offset calibration of Analog-Digital Signal Processor Module checksum error.	Unit will continue to function using default values, at reduced accuracy.	A/D Offset = 0
2	Factory gain calibration of Signal Input Module checksum error.	Unit will continue to function using default values, at reduced accuracy.	CT/VT Gain = 1
3	Factory offset calibration of Signal Input Module checksum error.	Unit will continue to function using default values, at reduced accuracy.	CT/VT Offset = 0
4	Factory phase calibration of Signal Input Module checksum error.	Unit will continue to function using default values, at reduced accuracy.	CT/VT Phase = 0
5	Factory defined internal ratios of Signal Input Module checksum error. (Type of Signal Input Module)	Unit will continue to function. Assumes -S10 Signal Input Module	Volts Ratio = 60 :1 Amps Ratio = 14.136 :1
6	User defined external transformer ratio checksum error.	Unit will continue to function using default values (i.e. w/o user ratios).	User CT = 5:5, VT = 1:1
7	User gain correction values checksum error.	Unit will continue to function using default values (i.e. w/o user gain).	User Gain = 1
8	User phase correction values checksum error.	Unit will continue to function using default values (i.e. w/o user phase).	User Phase = 0
9	Factory defined board ID for Analog-Digital Signal Processor Module checksum error.	Assumes default Analog-Digital Signal Processor Module.	Module -A10 (M87x)
10	Factory defined board ID for Signal Input Module checksum error.	Assumes default Signal Input Module.	Module -S1x (M87x)
11	User defined denominators for TDD measurement checksum error.	Assumes default TDD Denominator.	TDD Denom = 5A Secondary
12	DSP program integrity checksum error.	Host trips watchdog, unit reboots.	
13	DSP stack overflow.	Host trips watchdog, unit reboots.	
14	Invalid or missing Amp and/or Voltage Scale Factor.	Protocol will use default Scale Factor	Scale Factor = 1:1
15	Protocol configuration invalid.	IED uses default protocol configuration	70 SERIES default register set

1.9 Diagnostic Status LED

The Diagnostic LED is an indicator that shows the communications activity on the DNP port of the 70 SERIES IEDs. The Diagnostic LED is a bi-color LED (red/green) indicator that is located on the Front Panel Board adjacent to each serial port. The Diagnostic LED will flash red every time the 70 SERIES IED receives data via the associated port and will flash green whenever the 70 SERIES IED sends data over the associated serial port. If the LED does not flash RED when a message is sent to it from a MASTER, check the network for the following problems:

1. Cable open or short circuit

2. Defective termination

3. Incorrect DNP ADDRESS

4. Incorrect polarity of cable connections

1.10 Heartbeat State Counter

The 70 SERIES IEDs provide a Heartbeat State Counter Register that allows the user to determine the time between successive polls. This counter will increment by the number of milliseconds that have elapsed since the last time the data was updated. Another use of this register is as a visual indicator that the data is changing; it allows users of certain MMIs to identify disruption in the polling of the instrument. The Heartbeat State Counter is a full 32-bit counter that rolls over at 4,294,967,295 (4,294,967 seconds). The counter starts at zero on power-up, and is NOT stored in non-volatile memory.

1.11 Meter ID Register

The 70 SERIES IEDs provides an "ID" register for model identification purposes (AI:53).

2.0 DNP PROTOCOL

2.1 Introduction

DNP 3.0 (Distributed Network Protocol) is an open standard that was designed by Harris Controls Division and then placed in the public domain. DNP defines a command-response method of communicating digital information between a master and slave device. The electrical connection between devices is known as a bus. In DNP, two types of devices attach to the bus: master and slave devices. A master device issues commands to slaves. A slave device, such as a 70 SERIES IED, issues responses to master commands that are addressed to them. Each bus must contain exactly one master and may contain as many slaves as the electrical standards permit.

All devices on a bus must operate according to the same electrical standards (i.e. all must be RS-232C or all must be RS-485). RS-232C standards specify that only two devices may be connected to a bus (i.e. only one slave is allowed). RS-485 specifications allow up to 32 devices (31 slaves) on a bus.

Detailed information regarding DNP 3.0 is available in a document titled "Basic 4 Document Set" which can be obtained from the DNP Users Group. The remainder of this chapter provides a brief overview of the protocol as implemented in the 70 SERIES IEDs.

2.2 Overall Protocol Structure

DNP is a 3-layer protocol based upon the standard IEC 870-5 (Telecontrol Equipment and Systems - Transmission Protocols). The three layers comprise the Enhanced Performance Architecture (EPA) and is a subset of the more familiar ISO-OSI 7-layer protocol. The three layers are the physical, data link, and application layers. The physical layer is responsible for transmission of raw 8-bit bytes (octets) across the network medium. The data link layer is responsible for reliably maintaining connectivity between two devices. The application layer defines standardized messages that flow between devices. DNP further defines an extra layer known as the transport layer that allows very long messages to be broken down into smaller pieces.

2.3 DNP Request/Response Overview

The 70 SERIES IEDs DNP implementation supports a wide variety of messages. The most general method to extract information from a 70 SERIES IED is to issue a **READ CLASS-0** request. DNP devices respond with the points to be returned in the Class-0 response. See Section 1.71 for more details on Class-0 configuration. This allows the MASTER to retrieve all readings from the instrument and determine whether the output points are online (i.e. whether energy/demand resets or ratio setup requests can be honored). The 70 SERIES IEDs also allow READs of individual objects specifying all points (variation 6) or individual points (other variations). The 70 SERIES IEDs execute the energy clear function and demand resets using the **DIRECT OPERATE**, **DIRECT OPERATE NO ACKNOWLEDGE**, or **SELECT BEFORE OPERATE** functions with the *CONTROL RELAY OUTPUT BLOCK, Variation 1, LATCH_ON*. CT/PT ratio setups are made via **DIRECT OPERATE**, **DIRECT OPERATE NO ACKNOWLEDGE**, or **SELECT BEFORE OPERATE** to the *ANALOG OUTPUT BLOCK* object points. Configuration setups are also made via the **DIRECT OPERATE**, **DIRECT OPERATE NO**

ACKNOWLEDGE, or **SELECT BEFORE OPERATE** object. The DNP function code WRITE is also supported by the 70 SERIES IEDs.

A 70 SERIES IED will attempt to respond with the same object variation and qualifier as in the request. Exceptions to this rule include changing variation 0 to a specific variation, and changing qualifier code 6 to 0 or 6 to 1.

3.0 DNP3 over ETHERNET (TCP)

If the 70 SERIES IED is equipped with one of the Ethernet options, then it will respond to DNP3 commands via TCP. The 70 SERIES IEDs can simultaneously support DNP3, Modbus, and UCA2 protocols over the Ethernet link. The table below lists port assignments for all Ethernet based protocols supported by the 70 Series.

DNP	20000 (TCP, UDP)
	20, 21 (TCP)
Modbus	502 (TCP)
MMS (UCA & 61850)	102 (TCP)
SMTP (electronic mail)	25 (TCP)
	123 (UDP)
Telnet	23 (TCP)

3.1 DNP/IP

The DNP/IP (DNP Over TCP/IP and DNP Over UDP/IP) interface allows up to 16 DNP Masters to communicate with the 70 SERIES IEDs. Each remote IP host (Client) may communicate with the 70 SERIES Server via UDP or TCP. A Client may have multiple DNP Master addresses. Each Client has a distinct set of DNP Master addresses. Up to five filters for acceptable remote IP addresses may be set up (these may include wild-cards). The 70 SERIES IEDs reject requests from an IP address that is not included in the filter list.

Any DNP Master address will be accepted. Any DNP Slave address will be accepted with the restriction that all DNP Slave addresses from any particular Client must be the same.

After establishment of a TCP connection from a DNP Client, the 70 SERIES IEDs attempt to maintain contact by periodically sending REQUEST LINK STATUS messages. The device expects that each Master will maintain contact either by periodically polling the 70 SERIES IEDs or by responding to the REQUEST LINK STATUS messages with a RESPOND message. These messages are used as keep-alive messages.

DNP/IP has the following configuration parameters:

Send Keep Alive: This controls the minimum interval (in seconds) between outgoing messages from the 70 SERIES IEDs. If no data messages have been sent for this interval, a keep-alive message is sent. A value of zero stops the 70 SERIES IEDs from initiating keep-alive messages. A suggested default value for this is 10.

Max Send: This controls the number of keep-alive messages that will be sent without receiving a response from the Master before it is declared unresponsive, and the TCP connection closed. A suggested default for this value is 10.

Receive Keep Alive: This controls the maximum time between messages (in seconds) from the Master before the Master is declared unresponsive. When the 70 SERIES IEDs discover that all Masters on a TCP connection are unresponsive, the IED will close the TCP connection. Setting this value to zero stops the 70 SERIES IEDs from declaring Masters dead based on lack of messages from them. A suggested default for this value is either 0 or 30.

Num IP Filters: The number of IP filter values. It ranges from 0 to 5 where zero means that all IP addresses are accepted by the 70 SERIES IEDs. An IP address is accepted if it passes any filter.

IP Filter[0]: The value of first acceptable Internet Protocol filter in the form of "dotted decimal" notation. For example, the filter "192.168.0.1" (without quotes) would allow exactly one address through the filter and "192.168.*.*" would allow any address beginning with 192.168 to be accepted. A value of "*.*.*.*" would allow all addresses to be accepted.

IP Filter[1] through IP Filter[4]: Additional filter values.

3.1.1 IP Addressing

The TCP/IP stack needs to be configured with an IP address, a SUBNET mask, and a ROUTER (GATEWAY) address. It is very important that the network have no duplicate IP addresses. Configuration of the address may be accomplished by using UCA, by running the 70 SERIES Configurator, or via a front panel serial port using a terminal emulator such as HyperTerminal™ or ProComm™.

The units are pre-configured with an IP address / subnet mask/gateway address of:

192.168.0.254 / 255.255.255.0 / 192.168.0.1

3.2 DNP/IP Quick Tutorial

DNP/IP uses the concept of a Virtual Serial Port (VSP). An IP Client communicates with DNP/IP in the same way that a Client with a serial port would communicate over the DNP serial asynchronous protocol. Both UDP and TCP are "piped" into the 70 SERIES IEDs. UDP messages are examined for the source IP address and automatically attached to the physical connection that it previously used. TCP messages behave exactly the same way. Note that the source IP port number is not used in any way. TCP messages are sent over pre-established IP connections. The connection attachment request is accepted only if the connection attached to that IP address is unpopulated (it could have previously been attached to either a UDP or TCP port). TCP connections are de-populated (disconnected) under two conditions: (1) disconnection requests by the Client or (2) discovery that all Masters on the connection are unresponsive. A Client disconnection request is treated exactly as if every Master on the connection has become unresponsive. Note that TCP disconnection does not disassociate the individual Master addresses on that connector. The only way that this disassociation takes place is when the number of Client/Master address pairs exceeds 16. In this case, the Master that has least recently been sent a message is disassociated from the Client. Note that UDP communications are transient, they behave as if they were TCP connect/transaction/disconnect groups.

UDP and TCP share the same Virtual Serial Port (VSP). Upon a TCP disconnect, the UDP can take over all Master sessions. A TCP connection request can always take over for UDP data gram flow.

4.0 FILE TRANSFER

The 70 SERIES IEDs support the DNP file transfer implementation as described in the "Sequential File Transfer Objects" DNP Technical Bulletin. This document is a replacement for file transfer as described in the Basic 4 document set and is available from the DNP Users Group.

5.0 DNP3 EVENTS OVERVIEW

DNP3 provides for a method of reporting data only when it may be of interest to the application. This can significantly reduce the network bandwidth required by eliminating the redundant polling of data and only polling data when it changes enough to be consider relevant. When a change in a particular data value becomes relevant to the application, that change is called an event.

Events are pre-assigned to one of three CLASSes, (CLASS-1, CLASS-2, or CLASS-3). When an event occurs, the data point and OBJECT type are placed in a buffer and the event's specific CLASS BIT (BIT1, BIT2, or BIT3 of the first IIN octet) is set in the 70 SERIES IED's Internal Indications (IIN) field. DNP3 master devices monitor the IIN bits and will issue a specific CLASS-1, CLASS-2, or CLASS-3 poll when the respective CLASS IIN bit is set. The 70 SERIES IED will respond to the specific CLASS poll with all data buffered for the CLASS requested and than clear the associated CLASS IIN bit.

5.1 BINARY INPUT CHANGE Events

BINARY INPUT CHANGE events occur when a BINARY INPUT that is assigned to a CLASS-1, CLASS-2, or CLASS-3 Data Object changes states. Once the BINARY INPUT changes states, the specific BINARY INPUT point number and the new state value are placed in the BINARY INPUT EVENT BUFFER as a BINARY INPUT CHANGE event. The 70 SERIES IEDs can be configured to report The BINARY INPUT CHANGE data object in one of two VARATIONs, either BINARY INPUT CHANGE WITHOUT TIME (object 02, variation 1) or BINARY INPUT CHANGE WITH TIME (object 02, variation 2). All BINARY INPUT CHANGE events will be reported with the same configured variation. The default BINARY INPUT CHANGE variation (with or without time) can be set using the 70 SERIES Configurator utility software.

The 70 SERIES IEDs allocate the BINARY INPUT EVENT BUFFER size based on the number of configured DNP3 BINARY INPUTs. The buffer size is equivalent to 5 times the number of BINARY INPUTS. For example, a 70 SERIES IED with eight BINARY INPUTs would be able to buffer forty BINARY INPUT CHANGE events. If the buffer size is exceeded prior to being emptied by the CLASS poll, the oldest BINARY INPUT CHANGE event is purged from the buffer and is lost in order to make room for the most recent event. This buffer overflow status is reported to the DNP3 master by setting the BIT:3 of the second IIN octet in the Internal Indications field.

5.2 ANALOG CHANGE Events

ANALOG CHANGE events occur when an ANALOG INPUT that is assigned to a CLASS-1, CLASS-2, or CLASS-3 Data Object changes by more than its configured DEADBAND value since the last time it was reported. Once the ANALOG INPUT's value changes by more than the configured DEADBAND, the specific ANALOG INPUT point number and the new value are placed in the ANALOG CHANGE EVENT BUFFER as an ANALOG CHANGE EVENT. The 70 SERIES IEDs can be configured to report The ANALOG CHANGE EVENT Data Object in one of two Variations, either 16-BIT ANALOG CHANGE EVENT WITHOUT TIME (object 32, variation 2) or 16-BIT ANALOG CHANGE EVENT WITH TIME (object 32, variation 4). All ANALOG CHANGE EVENTS will be reported with the same configured VARIATION. The default ANALOG CHANGE EVENT variation (with or without time) can be set using the 70 SERIES Configurator utility software. The Configurator software is also used to set the DEADBAND value for each configured ANALOG CHANGE EVENT.

The 70 SERIES IEDs allocate the ANALOG CHANGE EVENT BUFFER size based on the number of configured DNP3 ANALOG INPUTs. The buffer size is equivalent to one more than number of configured ANALOG INPUTS. For example, a 70 SERIES IED with sixty four ANALOG INPUTs would be able to buffer sixty five ANALOG CHANGE events. If the buffer size is exceeded prior to being emptied by the CLASS poll, the oldest ANALOG CHANGE event is purged from the buffer and is lost in order to make room for the most recent event. This buffer overflow status is reported to the DNP3 master by setting the BIT:3 of the second IIN octet in the Internal Indications field.

The 70 SERIES IEDs allow for the ANALOG CHANGE EVENTs to operate in one of two modes, SOE mode or PRESENT mode. In SOE (Sequence of Events) mode, the ANALOG CHANGE EVENT buffering operates identical to the BINARY INPUT CHANGE events. In SOE mode all events remain in the ANALOG CHANGE EVENT BUFFER until the CLASS poll retrieves them or in the case of a buffer overflow they are forced out by newer events. In PRESENT mode, before a new ANALOG CHANGE EVENT is placed in the ANALOG CHANGE EVENT BUFFER, the buffer is checked to see if any other ANALOG CHANGE EVENTS are present in the buffer for the same point. If there are, the older ANALOG CHANGE EVENT (for the same point) is removed regardless of how much space remains in the buffer. The ANALOG CHANGE EVENT buffering mode is selectable by the 70 SERIES Configurator utility software.

6.0 DNP FROZEN COUNTER OBJECTS

The 70 Series IEDs with firmware v1.27 or later support the DNP3 FROZEN COUNTER Object. Each DNP3 BINARY COUNTER (OBJECT 20) Point configured will automatically have an associated FROZEN COUNTER (OBJECT 21) Point configured. The BINARY COUNTER and its associated FROZEN COUNTER will have the same point number (FROZEN COUNTER Point ‘0’ will contain the value frozen from BINARY COUNTER Point ‘0’).

The 70 Series IEDs will support the IMMEDIATE FREEZE (FC-07), IMMEDIATE FREEZE – NO ACKNOWLEDGEMENT (FC-08), FREEZE AND CLEAR (FC-09), and FREEZE AND CLEAR – NO ACKNOWLEDGEMENT (FC-10) Function Codes. Freeze commands and FROZEN COUNTERS can use any of the same QUALIFIERS and VARIATIONS as the BINARY COUNTERS.

Each DNP3 master communication session will have its own unique set of FROZEN COUNTERs. Once a DNP3 master initiates communication with the 70 Series IED, a communications session is established. This communication session allocates a dedicated set of FROZEN COUNTERs specifically for the new DNP3 master. When the new DNP3 master issues a FREEZE or FREEZE AND CLEAR command, only the FROZEN COUNTERs allocated for that DNP3 master are frozen (and cleared depending on the command). This allows multiple masters to maintain their own FROZEN COUNTERS and prevents one DNP3 master from inadvertently clearing another DNP3 master’s counter(s).

Upon session initialization, the FROZEN COUNTERS are initialized to zero. The FROZEN COUNTERs will continue to be read as zero until a FREEZE command is sent by the associated DNP3 master. If a FREEZE AND CLEAR command is sent the present count value will be stored in the FROZEN COUNTER and the running count of the FROZEN COUNTER value will be reset. By default, the FREEZE AND CLEAR COMMAND will NOT clear the associated BINARY COUNTER values. The BINARY COUNTER values for energy values will by default always match the energy measurements stored in the 70 Series IED database. This ensures that the energy measurements will always be reported the same regardless of protocol, port, or master device.
A hidden protocol configuration mode can be changed that modifies the way the FREEZE AND CLEAR command works. If the mode is changed the 70 Series IED will clear out the associated running counter and BINARY COUNTER when the FREEZE AND CLEAR command is issued. When the 70 Series IEDs are configured to operate in this mode and one DNP3 master issues a FREEZE AND CLEAR command, the energy measurements read from the BINARY COUNTERs will not longer match the energy measurements read by any other master (DNP3, Modbus, ModbusPlus, UCA) communicating with the same instrument. In this mode, the BINARY COUNTERs will be initialized and synchronized to the true energy measurements until the first FREEZE AND CLEAR command. After the first FREEZE AND CLEAR command synchronization to the true energy measurements is lost.

All FROZEN COUNTERs are volatile. As previously mentioned, the FROZEN COUNTERs are initialized to zero at start up. Any FROZEN COUNTERS that are part of a re-started communication session are initialed to zero as well. Any values frozen but not read prior to the 70 Series IED restarting or that were not read prior to the communication session closing are lost. BINARY COUNTERs are also resynchronized with the energy measurement values at system start up and session start up.

Sessions are closed automatically when the number of sessions per port is exceeded. Each serial port supports one communication session (or one DNP3 master). The 70 Series IED supports eighteen DNP3 communication sessions via Ethernet. If a message from a new DNP3 master is detected and the number of sessions for the associated port has been exceeded the existing communication session with the oldest activity for the associated port is closed (all FROZEN COUNTER values lost) and a new communications session is started (new FROZEN COUNTERs initialized to zero). The new master is identified on the serial ports by having a different SOURCE ADDRESS in the DATA LINK LAYER of the DNP3 command. The new DNP3 Ethernet masters are determined by different IP address.

APPENDIX A BITRONICS LEGACY DNP3 POINT ASSIGNMENTS

Bitronics Legacy DNP3 Point Assignments

Code	DNP Point	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:00	Health 0	T1		Bit-0	DSP Gain Cal Error	Data	0-Norm	1-Fail	1	
					Bit-1	DSP Offset Cal Error					
					Bit-2	SIM Gain Cal Error					
					Bit-3	SIM Offset Cal Error					
					Bit-4	SIM Phase Cal error					
					Bit-5	SIM Ratio Csum Error					
					Bit-6	User Ratio Csum Error					
					Bit-7	User Gain Csum Error					
					Bit-8	User Phase Csum Error					
					Bit-9	DSP Board ID Csum Error					
					Bit-10	SIM Board ID Csum Error					
					Bit-11	User TDD Csum Error					
					Bit-12	DSP Integrity Csum Error					
					Bit-13	DSP Stack Overflow					
					Bit-14	CT\VT Scaling Error					
					Bit-15	Protocol Config Error					
	AI:01	Amps A	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:02	Amps B	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:03	Amps C	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:04	Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:05	Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:06	Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:07	Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W	
	AI:08	VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars	
	AI:09	Watts A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W	
	AI:10	Watts B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W	
	AI:11	Watts C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W	
	AI:12	VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) vars	

Bitronics Legacy DNP3 Point Assignments

Code	DNP Point	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:13	VARs B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) vars	
	AI:14	VARs C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) vars	
	AO:00	Amp Scale Factor	T10				Data	1000	9999	1	
	AO:02	Volt Scale Factor	T10				Data	1000	9999	1	
	AI:19	Amps N	T3	Amp Scale			Data	0	32767	((1/32768) * 15 * Amp Scale) A	
	CT:0	Watt-Hrs Normal (High Word)	T1				Data	0	65536	65536 KiloWattHours	
	CT:1	Watt-Hrs Reverse (High Word)	T1				Data	0	65536	65536 KiloWattHours	
	CT:2	VAR-Hrs Lag (High Word)	T1				Data	0	65536	65536 KilovarHours	
	CT:3	VAR-Hrs Lead (High Word)	T1				Data	0	65536	65536 KilovarHours	
	AI:20	Frequency Volts A	T8				Data	2000	8000	0.01 Hz	
	AI:64	Volts A Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:71	Phase Angle Volts A Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
	AI:70	Frequency Volts A Bus2	T8				Data	2000	8000	0.01 Hz	
	CT:4	Heart Beat	T1				Data	0	65536	1 msec	
	AO:10	Unused	T1		0	spare unused register	Data	0	0	0	
	AI:21	VAs A	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs	
	AI:22	VAs B	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs	
	AI:23	VAs C	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs	
	AI:24	VAs Tot. Geom	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs	
	AI:25	Power Factor A	T7				Data	-1000	1000	0.001	
	AI:26	Power Factor B	T7				Data	-1000	1000	0.001	
	AI:27	Power Factor C	T7				Data	-1000	1000	0.001	
	AI:28	Power Factor Tot. Geom	T7				Data	-1000	1000	0.001	
	AI:15	Amp Scale Factor	T10				Setting	1000	9999	1	
	AI:16	Amp Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AI:17	Volt Scale Factor	T10				Setting	1000	9999	1	
	AI:18	Volt Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AI:29	Demand Amps A	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:30	Demand Amps B	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:31	Demand Amps C	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:32	Demand (Max) Amps A	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	

Bitronics Legacy DNP3 Point Assignments

Code	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:33		Demand (Max) Amps B	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:34		Demand (Max) Amps C	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A	
	AI:35		Demand Amps N	T3	Amp Scale			Data	0	32767	((1/32768) * 15 * Amp Scale) A	
	AI:36		Demand (Max) Amps N	T3	Amp Scale			Data	0	32767	((1/32768) * 15 * Amp Scale) A	
	AI:37		Demand Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:38		Demand Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:39		Demand Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:40		Demand (Max) Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:41		Demand (Max) Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:42		Demand (Max) Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:43		Demand (Min) Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:44		Demand (Min) Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:45		Demand (Min) Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:46		Demand Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W	
	AI:47		Demand (Max) Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W	
	AI:48		Demand (Min) Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W	
	AI:49		Demand VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars	
	AI:50		Demand (Max) VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars	
	AI:51		Demand (Min) VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars	
	AI:52		Demand VAs Total	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs	
	AI:53		Demand (Max) VAs Total	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs	
	AI:54		Demand (Min) VAs Total	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs	
	AI:55		Meter Type	T1		400 404 500 501	M87x Legacy register set M87x Configurable reg. M57x Legacy register set M57x Configurable reg.	Data	400	502	0	
	AI:56		Protocol Version	T21				Data	0	65536	0.001	
	AI:57		Factory Version Software	T21				Data	0	65536	0.001	
	AI:58		DSP Version	T21				Data	0	65536	0.001	
	AI:59		Volts N-G	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	

Bitronics Legacy DNP3 Point Assignments

Code	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AI:60		Volts A-B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:61		Volts B-C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:62		Volts C-A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:63		Volts N-G Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:65		Volts B Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:66		Volts C Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:67		Volts AB Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:68		Volts BC Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:69		Volts CA Bus2	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	BO:06		DIO#0 Output Point 1	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:07		DIO#0 Output Point 2	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:08		DIO#0 Output Point 3	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:09		DIO#0 Output Point 4	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:10		DIO#0 Output Point 5	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:11		DIO#0 Output Point 6	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:12		DIO#0 Output Point 7	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	BO:13		DIO#0 Output Point 8	T22		0	Relay Off	Setting	0	1	1	
						1	Relay Energized					
	AO:05		Unused Register	T1		0	spare unused register	Data	0	0	0	
	AO:14		VA/PF Calc. Type	T1		1	Arithmetic	Setting	1	4	1	
						2	Geometric					
						3	3 Element (L-N)					
						4	2 Element (L-L)					
	AO:15		DIO#0 Debounce	T1				Setting	0	65536	1 usec	
	AO:16		Log Interval	T1				Setting	0	720	1 min	
	AO:06		Tag Register	T1				Setting	0	65536	1	

Bitronics Legacy DNP3 Point Assignments

Code	DNP Point	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	BO:00	Reset Energy	T22		0	Normal	Setting	0	1	1	
					1	Reset Energy Counters					
	BO:01	Reset Demand Amps	T22		0	Normal	Setting	0	1	1	
					1	Reset Amp Demands					
	BO:02	Reset Demand Volts	T22		0	Normal	Setting	0	1	1	
					1	Reset Volt Demands					
	BO:03	Reset Demand Power	T22		0	Normal	Setting	0	1	1	
					1	Reset Power Demands					
	BO:04	Reset Demand Harmonic	T22		0	Normal	Setting	0	1	1	
					1	Reset Harmonic Demands					
	BO:05	Trigger Waveform	T22		0	Normal	Setting	0	1	1	
					1	Trigger Capture					
	AI:72	Demand Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:73	Demand Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:74	Demand Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:75	Demand (Max) Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:76	Demand (Max) Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:77	Demand (Max) Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:78	Demand (Min) Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:79	Demand (Min) Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AI:80	Demand (Min) Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V	
	AO:17	Xfmr Ratio Volts A	T10				Setting	1000	9999	1	
	AO:18	Xfmr Ratio Divisor Volts A	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:19	Xfmr Ratio Volts B	T10				Setting	1000	9999	1	
	AO:20	Xfmr Ratio Divisor Volts B	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:21	Xfmr Ratio Volts C	T10				Setting	1000	9999	1	
	AO:22	Xfmr Ratio Divisor Volts C	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:23	Xfmr Ratio Volts N	T10				Setting	1000	9999	1	
	AO:24	Xfmr Ratio Divisor Volts N	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:25	Xfmr Ratio Volts A Bus2	T10				Setting	1000	9999	1	
	AO:26	Xfmr Ratio Divisor Volts A Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:27	Xfmr Ratio Volts B Bus2	T10				Setting	1000	9999	1	
	AO:28	Xfmr Ratio Divisor Volts B Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	

Bitronics Legacy DNP3 Point Assignments												
Code	DNP Point		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
	AO:29		Xfmr Ratio Volts C Bus2	T10				Setting	1000	9999	1	
	AO:30		Xfmr Ratio Divisor Volts C Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:31		Xfmr Ratio Volts N Bus2	T10				Setting	1000	9999	1	
	AO:32		Xfmr Ratio Divisor Volts N Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:33		Xfmr Ratio Amps A	T10				Setting	1000	9999	1	
	AO:34		Xfmr Ratio Divisor Amps A	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:35		Xfmr Ratio Amps B	T10				Setting	1000	9999	1	
	AO:36		Xfmr Ratio Divisor Amps B	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:37		Xfmr Ratio Amps C	T10				Setting	1000	9999	1	
	AO:38		Xfmr Ratio Divisor Amps C	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:39		Xfmr Ratio Amps N	T10				Setting	1000	9999	1	
	AO:40		Xfmr Ratio Divisor Amps N	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:41		Xfmr Ratio Volts Aux1-Gnd	T10				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:42		Xfmr Ratio Divisor Volts Aux1-Gnd	T11				Setting	1000	9999	1	
	AO:43		Xfmr Ratio Volts Aux2-Gnd	T10				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:44		Xfmr Ratio Divisor Volts Aux2-Gnd	T11				Setting	1000	9999	1	
	AO:45		Xfmr Ratio Future Use	T10				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:46		Xfmr Ratio Divisor Future Use	T11				Setting	1000	9999	1	
	AO:47		Xfmr Ratio Future Use	T10				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:48		Xfmr Ratio Divisor Future Use	T11				Setting	1000	9999	1	
	AO:49		Xfmr Ratio Volts AuxDiff	T10				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:50		Xfmr Ratio Divisor Volts AuxDiff	T11				Setting	1000	9999	1	
	AO:51		Xfmr Ratio Amps Residual	T10				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
	AO:52		Xfmr Ratio Divisor Amps Residual	T11				Setting	1000	9999	1	

When connected to 2 Element (DELTA or 3-wire) systems, the Per-Element quantities may have no direct physical meaning.

NOTE: The 70 Series IEDs have a total of up to 6 different point sets (depending upon Configurator and fimrware versions). Please refer to the 70 Series Configurator DNP Points tab and click on the various options in the “Point Set” and “Points to Display” sections to see point assignments. For Configurator versions 2.27 or higher, the Point Sets on the left side of the box in the DNP Points Screen are all fixed sets whereas the ones on the right side of the box are all configurable to varying degrees (some have a fixed portion followed by a section where the user can select any of the measurements available in the 70 Series IEDs).

APPENDIX B BITRONICS DNP3 POINT ASSIGNMENTS FOR DFC AND BAF POINT SETS

	DFC (Dual Feeder Configurable)	
	Analog Inputs	Analog Outputs
0	Health	VT 1 Scale Factor
1	Health	VT 1 Scale Factor
2	Register Set	CT 1 Scale Factor
3	Meter Type	CT 1 Scale Factor
4	Firmware Version	VT 2 Scale Factor
5	RMS Amps A 1	VT 2 Scale Factor
6	RMS Amps B 1	CT 2 Scale Factor
7	RMS Amps C 1	CT 2 Scale Factor
8	RMS Amps A 2	Xfmr Ratio Volts A 1
9	RMS Amps B 2	Xfmr Ratio Volts A 1
10	RMS Amps C 2	Xfmr Ratio Volts B 1
11	RMS Volts A 1	Xfmr Ratio Volts B 1
12	RMS Volts B 1	Xfmr Ratio Volts C 1
13	RMS Volts C 1	Xfmr Ratio Volts C 1
14	RMS Volts N 1	Xfmr Ratio Volts N 1
15	RMS Volts AB 1	Xfmr Ratio Volts N 1
16	RMS Volts BC 1	Xfmr Ratio Volts A 2
17	RMS Volts CA 1	Xfmr Ratio Volts A 2
18	RMS Volts A 2	Xfmr Ratio Volts B 2
19	RMS Volts B 2	Xfmr Ratio Volts B 2
20	RMS Volts C 2	Xfmr Ratio Volts C 2
21	RMS Volts N 2	Xfmr Ratio Volts C 2
22	RMS Volts AB 2	Xfmr Ratio Volts N 2
23	RMS Volts BC 2	Xfmr Ratio Volts N 2
24	RMS Volts CA 2	Xfmr Ratio Volts R 1
25	RMS Volts R 1	Xfmr Ratio Volts R 1
26	RMS Volts R 2	Xfmr Ratio Volts R 2
27	RMS Watts A 1	Xfmr Ratio Volts R 2
28	RMS Watts B 1	Xfmr Ratio Amps A 1
29	RMS Watts C 1	Xfmr Ratio Amps A 1
30	RMS Watts Total 1	Xfmr Ratio Amps B 1
31	RMS VARs A 1	Xfmr Ratio Amps B 1
32	RMS VARs B 1	Xfmr Ratio Amps C 1
33	RMS VARs C 1	Xfmr Ratio Amps C 1
34	RMS VARs Total 1	Xfmr Ratio Amps N 1
35	RMS VAs A 1	Xfmr Ratio Amps N 1
36	RMS VAs B 1	Xfmr Ratio Amps A 2
37	RMS VAs C 1	Xfmr Ratio Amps A 2
38	RMS VAs Total 1	Xfmr Ratio Amps B 2
39	Power Factor A 1	Xfmr Ratio Amps B 2
40	Power Factor B 1	Xfmr Ratio Amps C 2

	DFC (Dual Feeder Configurable)	
	Analog Inputs	Analog Outputs
41	Power Factor C 1	Xfmr Ratio Amps C 2
42	Power Factor Total 1	Reserved for Xfmr Ratio Amps N 2
43	RMS Watts A 2	Reserved for Xfmr Ratio Amps N 2
44	RMS Watts B 2	User Gain Volts A 1
45	RMS Watts C 2	User Gain Volts B 1
46	RMS Watts Total 2	User Gain Volts C 1
47	RMS VARs A 2	User Gain Volts N 1
48	RMS VARs B 2	User Gain Volts A 2
49	RMS VARs C 2	User Gain Volts B 2
50	RMS VARs Total 2	User Gain Volts C 2
51	Reserved (returns 0)	User Gain Volts N 2
52	Reserved (returns 0)	User Gain Volts R 1
53	Meter Type	User Gain Volts R 2
54	Reserved (returns 0)	User Gain Amps A 1
55	Meter Type	User Gain Amps B 1
56	RMS VAs A 2	User Gain Amps C 1
57	RMS VAs B 2	User Gain Amps N 1
58	RMS VAs C 2	User Gain Amps A 2
59	RMS VAs Total 2	User Gain Amps B 2
60	Power Factor A 2	User Gain Amps C 2
61	Power Factor B 2	Reserved for User Gain Amps N2
62	Power Factor C 2	User Phase Correction Volts A 1
63	Power Factor Total 2	User Phase Correction Volts B 1
64	Frequency Volts A 1	User Phase Correction Volts C 1
65	Frequency Volts B 1	User Phase Correction Volts N 1
66	Frequency Volts C 1	User Phase Correction Volts A 2
67	Frequency Volts A 2	User Phase Correction Volts B 2
68	Frequency Volts B 2	User Phase Correction Volts C 2
69	Frequency Volts C 2	User Phase Correction Volts N 2
70	Frequency Volts R 1	User Phase Correction Volts R 1
71	Frequency Volts R 2	User Phase Correction Volts R 2
72	System Frequency	User Phase Correction Amps A 1
73	Reserved for System Frequency 2	User Phase Correction Amps B 1
74	Phase Angle Volts A 1 - 2	User Phase Correction Amps C 1
75	Phase Angle Volts B 1 - 2	User Phase Correction Amps N 1
76	Phase Angle Volts C 1 - 2	User Phase Correction Amps A 2
77	Phase Angle Volts A 1 - R 1	User Phase Correction Amps B 2
78	Phase Angle Volts B 1 - R 1	User Phase Correction Amps C 2
79	Phase Angle Volts C 1 - R 1	Reserved for User Phas Correction Amps N 2
80	Phase Angle Volts A 1 - R 2	VA/PF Calc. Type
81	Phase Angle Volts B 1 - R 2	Reserved (returns 0)
82	Phase Angle Volts C 1 - R 2	Reserved (returns 0)
83	Phase Angle RMS Amps A 1 Harmonic 01	Reserved (returns 0)
84	Phase Angle RMS Amps B 1 Harmonic 01	Reserved (returns 0)
85	Phase Angle RMS Amps C 1 Harmonic 01	Reserved (returns 0)
86	Phase Angle RMS Amps A 2 Harmonic 01	Reserved (returns 0)

	DFC (Dual Feeder Configurable)	
	Analog Inputs	Analog Outputs
87	Phase Angle RMS Amps B 2 Harmonic 01	Reserved (returns 0)
88	Phase Angle RMS Amps C 2 Harmonic 01	Reserved (returns 0)
89	Phase Angle RMS Volts A 1 Harmonic 01	Reserved (returns 0)
90	Phase Angle RMS Volts B 1 Harmonic 01	Reserved (returns 0)
91	Phase Angle RMS Volts C 1 Harmonic 01	Reserved (returns 0)
92	Phase Angle RMS Volts A 2 Harmonic 01	Reserved (returns 0)
93	Phase Angle RMS Volts B 2 Harmonic 01	Reserved (returns 0)
94	Phase Angle RMS Volts C 1 Harmonic 01	Reserved (returns 0)
95	Reserved (returns 0)	Reserved (returns 0)
96	Reserved (returns 0)	Reserved (returns 0)
97	Reserved (returns 0)	Reserved (returns 0)
98	Reserved (returns 0)	Reserved (returns 0)
99	Reserved (returns 0)	
100	Reserved (returns 0)	
101	Reserved (returns 0)	
102	Reserved (returns 0)	
103	Reserved (returns 0)	
104	Reserved (returns 0)	
105	Reserved (returns 0)	
106	Reserved (returns 0)	
107	Reserved (returns 0)	
108	Reserved (returns 0)	
109	Reserved (returns 0)	
110	Reserved (returns 0)	

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
00	Health	VT 1 Scale Factor	Reserved (returns 0)	DIO#0 Status Output Point 1	Heartbeat
001	Health	VT 1 Scale Factor	Reserved (returns 0)	DIO#0 Status Output Point 2	KWatt1-Hrs Normal
002	Register Set	CT 1 Scale Factor	Reserved (returns 0)	DIO#0 Status Output Point 3	KWatt1-Hrs Reverse
003	Meter Type	CT 1 Scale Factor	Reserved (returns 0)	DIO#0 Status Output Point 4	KVAR1-Hrs Lag
004	Firmware Version	VT 2 Scale Factor	Reserved (returns 0)	DIO#1 Status Output Point 1	KVAR1-Hrs Lead
005	RMS Volts A 1	VT 2 Scale Factor	Reserved (returns 0)	DIO#1 Status Output Point 2	KWatt2-Hrs Normal
006	RMS Volts B 1	CT 2 Scale Factor	Reserved (returns 0)	DIO#1 Status Output Point 3	KWatt2-Hrs Reverse
007	RMS Volts C 1	CT 2 Scale Factor	Reserved (returns 0)	DIO#1 Status Output Point 4	KVAR2-Hrs Lag
008	RMS Volts N 1	VA/PF Calc. Type	Reserved (returns 0)	DIO#2 Status Output Point 1	KVAR2-Hrs Lead
009	RMS Volts R 1	Xfmr Ratio Volts A 1	Reserved (returns 0)	DIO#2 Status Output Point 2	Reserved (returns 0)
010	RMS Volts R 2	Xfmr Ratio Volts A 1	Reserved (returns 0)	DIO#2 Status Output Point 3	Reserved (returns 0)
011	RMS Volts AB 1	Xfmr Ratio Volts B 1	Reserved (returns 0)	DIO#2 Status Output Point 4	Reserved (returns 0)
012	RMS Volts BC 1	Xfmr Ratio Volts B 1	Reserved (returns 0)	DIO#3 Status Output Point 1	Reserved (returns 0)
013	RMS Volts CA 1	Xfmr Ratio Volts C 1	Reserved (returns 0)	DIO#3 Status Output Point 2	Reserved (returns 0)
014	RMS Amps A 1	Xfmr Ratio Volts C 1	Reserved (returns 0)	DIO#3 Status Output Point 3	Reserved (returns 0)
015	RMS Amps B 1	Xfmr Ratio Volts N 1	Reserved (returns 0)	DIO#3 Status Output Point 4	Reserved (returns 0)
016	RMS Amps C 1	Xfmr Ratio Volts N 1	Reserved (returns 0)	DIO#4 Status Output Point 1	Reserved (returns 0)
017	RMS Amps N 1	Xfmr Ratio Amps A 1	Reserved (returns 0)	DIO#4 Status Output Point 2	Reserved (returns 0)
018	RMS Volts A 2	Xfmr Ratio Amps A 1	Reserved (returns 0)	DIO#4 Status Output Point 3	Reserved (returns 0)
019	RMS Volts B 2	Xfmr Ratio Amps B 1	Reserved (returns 0)	DIO#4 Status Output Point 4	
020	RMS Volts C 2	Xfmr Ratio Amps B 1	Reserved (returns 0)	DIO#5 Status Output Point 1	
021	RMS Volts N 2	Xfmr Ratio Amps C 1	Virtual Status Input 1	DIO#5 Status Output Point 2	
022	RMS Volts AB 2	Xfmr Ratio Amps C 1	Virtual Status Input 2	DIO#5 Status Output Point 3	
023	RMS Volts BC 2	Xfmr Ratio Amps N 1	Virtual Status Input 3	DIO#5 Status Output Point 4	
024	RMS Volts CA 2	Xfmr Ratio Amps N 1	Virtual Status Input 4	DIO#6 Status Output Point 1	
025	RMS Amps A 2	Xfmr Ratio Volts A 2	Virtual Status Input 5	DIO#6 Status Output Point 2	
026	RMS Amps B 2	Xfmr Ratio Volts A 2	Virtual Status Input 6	DIO#6 Status Output Point 3	
027	RMS Amps C 2	Xfmr Ratio Volts B 2	Virtual Status Input 7	DIO#6 Status Output Point 4	
028	Reserved for RMS Amps N 2	Xfmr Ratio Volts B 2	Virtual Status Input 8	Reserved (returns 0)	
029	RMS Watts A 1	Xfmr Ratio Volts C 2	Virtual Status Input 9	Reserved (returns 0)	
030	RMS Watts B 1	Xfmr Ratio Volts C 2	Virtual Status Input 10	Reserved (returns 0)	
031	RMS Watts C 1	Xfmr Ratio Volts N 2	Virtual Status Input 11	Reserved (returns 0)	
032	RMS Watts T 1	Xfmr Ratio Volts N 2	Virtual Status Input 12	Reserved (returns 0)	

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
033	RMS VARs A 1	Xfmr Ratio Amps A 2	Virtual Status Input 13	Reserved (returns 0)	
034	RMS VARs B 1	Xfmr Ratio Amps A 2	Virtual Status Input 14	Reserved (returns 0)	
035	RMS VARs C 1	Xfmr Ratio Amps B 2	Virtual Status Input 15	Reserved (returns 0)	
036	RMS VARs T 1	Xfmr Ratio Amps B 2	Virtual Status Input 16	Reserved (returns 0)	
037	RMS VAs A 1	Xfmr Ratio Amps C 2	Virtual Status Input 17	Reserved (returns 0)	
038	RMS VAs B 1	Xfmr Ratio Amps C 2	Virtual Status Input 18	Reserved (returns 0)	
039	RMS VAs C 1	Reserved for Xfmr Ratio Amps N 2	Virtual Status Input 19	Reserved (returns 0)	
040	RMS VAs T 1	Reserved for Xfmr Ratio Amps N 2	Virtual Status Input 20	Reserved (returns 0)	
041	Power Factor A 1	Xfmr Ratio Volts R 1	Virtual Status Input 21	Reset Energy	
042	Power Factor B 1	Xfmr Ratio Volts R 1	Virtual Status Input 22	Reset Demand Amps	
043	Power Factor C 1	Xfmr Ratio Volts R 2	Virtual Status Input 23	Reset Demand Volts	
044	Power Factor T 1	Xfmr Ratio Volts R 2	Virtual Status Input 24	Reset Demand Power	
045	RMS Watts A 2	Reserved (returns 0)	Virtual Status Input 25	Reset Demand Harmonic	
046	RMS Watts B 2	Reserved (returns 0)	Virtual Status Input 26	Reset Received [UCA] GOOSE Parameters **[NOTE: This is now referred to as GSSE]**	
047	RMS Watts C 2	Reserved (returns 0)	Virtual Status Input 27	WR1 Recorder Started	
048	RMS Watts T 2	Reserved (returns 0)	Virtual Status Input 28	WR2 Recorder Started	
049	RMS VARs A 2	Reserved (returns 0)	Virtual Status Input 29	DR1 Recorder Started	
050	RMS VARs B 2	Reserved (returns 0)	Virtual Status Input 30	DR2 Recorder Started	
051	RMS VARs C 2	Reserved (returns 0)	Virtual Status Input 31	Any Recorder Started	
052	RMS VARs T 2	Reserved (returns 0)	Virtual Status Input 32	WR1 Recorder Completed	
053	Meter Type	Reserved (returns 0)	Reserved (returns 0)	WR2 Recorder Completed	
054	Reserved (returns 0)	Reserved (returns 0)	Reserved (returns 0)	DR1 Recorder Completed	
055	Meter Type	Reserved (returns 0)	Reserved (returns 0)	Disturbance 2 Recorder Completed	
056	RMS VAs A 2	Reserved (returns 0)	Reserved (returns 0)	Any Recorder Completed	
057	RMS VAs B 2	Reserved (returns 0)	Reserved (returns 0)	Trigger WR1 Recorder	
058	RMS VAs C 2	Reserved (returns 0)	Reserved (returns 0)	Trigger WR2 Recorder	
059	RMS VAs T 2	Reserved (returns 0)	Reserved (returns 0)	Trigger DR1 Recorder	
060	Power Factor A 2	Reserved (returns 0)	Reserved (returns 0)	Trigger DR2 Recorder	
061	Power Factor B 2	Config Register 1	Reserved (returns 0)	Reserved (returns 0)	
062	Power Factor C 2	Config Register 2	Reserved (returns 0)	Reserved (returns 0)	
063	Power Factor T 2	Tag Register	Reserved (returns 0)	Reserved (returns 0)	
064	System Frequency		Reserved (returns 0)	Reserved (returns 0)	

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
065	Reserved for System Frequency 2		Reserved (returns 0)	Reserved (returns 0)	
066	Reserved (returns 0)		Reserved (returns 0)	Reserved (returns 0)	
067	Reserved (returns 0)		Reserved (returns 0)	Reserved (returns 0)	
068	Reserved (returns 0)		Reserved (returns 0)	Reserved (returns 0)	
069	Reserved (returns 0)		Reserved (returns 0)	Reserved (returns 0)	
070	Reserved (returns 0)		Reserved (returns 0)	Reserved (returns 0)	
071	Reserved (returns 0)			Reserved (returns 0)	
072	Reserved (returns 0)			Reserved (returns 0)	
073	Reserved (returns 0)			Reserved (returns 0)	
074	Reserved (returns 0)			Reserved (returns 0)	
075	Reserved (returns 0)			Reserved (returns 0)	
076	Reserved (returns 0)			Reserved (returns 0)	
077	Reserved (returns 0)			Virtual Status Output Point 1	
078	Reserved (returns 0)			Virtual Status Output Point 2	
079	Reserved (returns 0)			Virtual Status Output Point 3	
080	Reserved (returns 0)			Virtual Status Output Point 4	
081	System Frequency			Virtual Status Output Point 5	
082	Demand RMS Amps A 1			Virtual Status Output Point 6	
083	Demand RMS Amps B 1			Virtual Status Output Point 7	
084	Demand RMS Amps C 1			Virtual Status Output Point 8	
085	Demand RMS Amps N 1			Virtual Status Output Point 9	
086	Max Demand RMS Amps A 1			Virtual Status Output Point 10	
087	Max Demand RMS Amps B 1			Virtual Status Output Point 11	
088	Max Demand RMS Amps C 1			Virtual Status Output Point 12	
089	Max Demand RMS Amps N 1			Virtual Status Output Point 13	
090	Demand RMS Volts A 1			Virtual Status Output Point 14	
091	Demand RMS Volts B 1			Virtual Status Output Point 15	
092	Demand RMS Volts C 1			Virtual Status Output Point 16	
093	Demand RMS Volts N 1			Virtual Status Output Point 17	
094	Max Demand RMS Volts A 1			Virtual Status Output Point 18	
095	Max Demand RMS Volts B 1			Virtual Status Output Point 19	
096	Max Demand RMS Volts C 1			Virtual Status Output Point 20	
097	Max Demand RMS Volts N 1			Virtual Status Output Point 21	
098	Min Demand RMS Volts A 1			Virtual Status Output Point 22	

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
099	Min Demand RMS Volts B 1			Virtual Status Output Point 23	
100	Min Demand RMS Volts C 1			Virtual Status Output Point 24	
101	Min Demand RMS Volts N 1			Virtual Status Output Point 25	
102	Demand RMS Volts AB 1			Virtual Status Output Point 26	
103	Demand RMS Volts BC 1			Virtual Status Output Point 27	
104	Demand RMS Volts CA 1			Virtual Status Output Point 28	
105	Max Demand RMS Volts AB 1			Virtual Status Output Point 29	
106	Max Demand RMS Volts BC 1			Virtual Status Output Point 30	
107	Max Demand RMS Volts CA 1			Virtual Status Output Point 31	
108	Min Demand RMS Volts AB 1			Virtual Status Output Point 32	
109	Min Demand RMS Volts BC 1			Reserved (returns 0)	
110	Min Demand RMS Volts CA 1			Reserved (returns 0)	
111	Demand RMS Watts Total 1			Reserved (returns 0)	
112	Demand RMS VARs Total 1			Reserved (returns 0)	
113	Demand RMS VAs Total 1			Reserved (returns 0)	
114	Max Demand RMS Watts Total 1			Reserved (returns 0)	
115	Max Demand RMS VARs Total 1			Reserved (returns 0)	
116	Max Demand RMS VAs Total 1			Reserved (returns 0)	
117	Min Demand RMS Watts Total 1			Reserved (returns 0)	
118	Min Demand RMS VARs Total 1			Reserved (returns 0)	
119	Min Demand RMS VAs Total 1			Reserved (returns 0)	
120	Reserved for System Frequency 2			Reserved (returns 0)	
121	Demand RMS Amps A 2			WR1 Recorder Memory Low	
122	Demand RMS Amps B 2			WR2 Recorder Memory Low	
123	Demand RMS Amps C 2			DR1 Recorder Memory Low	
124	Reserved for Demand RMS Amps N 2			DR2 Recorder Memory Low	
125	Max Demand RMS Amps A 2			Any Recorder Memory Low	
126	Max Demand RMS Amps B 2			WR1 Recorder Active	
127	Max Demand RMS Amps C 2			WR2 Recorder Active	
128	Reserved for Max Demand RMS Amps N 2			DR1 Recorder Active	
129	Demand RMS Volts A 2			DR2 Recorder Active	
130	Demand RMS Volts B 2			Any Recorder Active	
131	Demand RMS Volts C 2			Reserved (returns 0)	
132	Demand RMS Volts N 2			Reserved (returns 0)	

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
133	Max Demand RMS Volts A 2			Reserved (returns 0)	
134	Max Demand RMS Volts B 2			Reserved (returns 0)	
135	Max Demand RMS Volts C 2			Reserved (returns 0)	
136	Max Demand RMS Volts N 2			Reserved (returns 0)	
137	Min Demand RMS Volts A 2			Reserved (returns 0)	
138	Min Demand RMS Volts B 2			Reserved (returns 0)	
139	Min Demand RMS Volts C 2			Reserved (returns 0)	
140	Min Demand RMS Volts N 2			Reserved (returns 0)	
141	Demand RMS Volts AB 2				
142	Demand RMS Volts BC 2				
143	Demand RMS Volts CA 2				
144	Max Demand RMS Volts AB 2				
145	Max Demand RMS Volts BC 2				
146	Max Demand RMS Volts CA 2				
147	Min Demand RMS Volts AB 2				
148	Min Demand RMS Volts BC 2				
149	Min Demand RMS Volts CA 2				
150	Demand RMS Watts Total 2				
151	Demand RMS VARs Total 2				
152	Demand RMS VAs Total 2				
153	Max Demand RMS Watts Total 2				
154	Max Demand RMS VARs Total 2				
155	Max Demand RMS VAs Total 2				
156	Min Demand RMS Watts Total 2				
157	Min Demand RMS VARs Total 2				
158	Min Demand RMS VAs Total 2				
159	Reserved (returns 0)				
160	Reserved (returns 0)				
161	Reserved (returns 0)				
162	Reserved (returns 0)				
163	Reserved (returns 0)				
164	Reserved (returns 0)				
165	Reserved (returns 0)				
166	Reserved (returns 0)				

BAF (Bitronics Advanced Fixed)					
	Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
167	Reserved (returns 0)				
168	Reserved (returns 0)				
169	Reserved (returns 0)				
170	Reserved (returns 0)				
171	Phase Angle Volts A 1- 2				
172	Phase Angle Volts B 1- 2				
173	Phase Angle Volts C 1- 2				
174	Phase Angle Volts A 1- R 1				
175	Phase Angle Volts B 1- R 1				
176	Phase Angle Volts C 1- R 1				
177	Phase Angle Volts A 1- R 2				
178	Phase Angle Volts B 1- R 2				
179	Phase Angle Volts C 1- R 2				
180	RMS Volts A 1				
181	RMS Volts B 1				
182	RMS Volts C 1				
183	RMS Volts N 1				
184	RMS Volts R 1				
185	RMS Volts R 2				
186	Frequency Volts A 1				
187	Frequency Volts B 1				
188	Frequency Volts C 1				
189	Frequency R 1				
190	Frequency R 2				
191	RMS Volts A 2				
192	RMS Volts B 2				
193	RMS Volts C 2				
194	RMS Volts N 2				
195	Frequency Volts A 2				
196	Frequency Volts B 2				
197	Frequency Volts C 2				
198	Reserved (returns 0)				
199	Reserved (returns 0)				
200	Reserved (returns 0)				

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
201	Reserved (returns 0)				
202	Reserved (returns 0)				
203	Reserved (returns 0)				
204	Reserved (returns 0)				
205	Reserved (returns 0)				
206	Reserved (returns 0)				
207	Reserved (returns 0)				
208	Reserved (returns 0)				
209	Reserved (returns 0)				
210	Reserved (returns 0)				
211	DSP Version				
212	Protocol Version				
213	Time Sync Error (msec)				
214	IrigB Time Sync (0 or 1)				
215	(UCA) Network Time (0 or 1))				
216	SNTP Time Sync (0 or 1)				
217	DNP Time Sync (0 or 1)				
218	Reserved (returns 0)				
219	Best Clock Source (0 thru 5)				
220	Reserved (returns 0)				
221	Reserved (returns 0)				
222	Reserved (returns 0)				
223	Reserved (returns 0)				
224	Reserved (returns 0)				
225	Reserved (returns 0)				
226	Reserved (returns 0)				
227	Reserved (returns 0)				
228	Reserved (returns 0)				
229	Reserved (returns 0)				
230	Reserved (returns 0)				
231	DIO#0 Input				
232	DIO#1 Input				
233	DIO#2 Input				
234	DIO#3 Input				

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
235	DIO#4 Input				
236	DIO#5 Input				
237	DIO#6 Input				
238	Reserved (returns 0)				
239	Reserved (returns 0)				
240	Reserved (returns 0)				
241	Reserved (returns 0)				
242	Reserved (returns 0)				
243	Reserved (returns 0)				
244	Reserved (returns 0)				
245	Reserved (returns 0)				
246	Reserved (returns 0)				
247	Reserved (returns 0)				
248	Reserved (returns 0)				
249	Reserved (returns 0)				
250	Reserved (returns 0)				
251	RMS Volts A 1				
252	RMS Volts B 1				
253	RMS Volts C 1				
254	Phase Angle RMS Volts A 1 Harmonic 01				
255	Phase Angle RMS Volts B 1 Harmonic 01				
256	Phase Angle RMS Volts C 1 Harmonic 01				
257	RMS Amps A 1				
258	RMS Amps B 1				
259	RMS Amps C 1				
260	Phase Angle RMS Amps A 1 Harmonic 01				
261	Phase Angle RMS Amps B 1 Harmonic 01				
262	Phase Angle RMS Amps C 1 Harmonic 01				
263	RMS Volts A 2				
264	RMS Volts B 2				
265	RMS Volts C 2				
266	Phase Angle RMS Volts A 2 Harmonic 01				
267	Phase Angle RMS Volts B 2 Harmonic 01				
268	Phase Angle RMS Volts C 2 Harmonic 01				

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
269	RMS Amps A 2				
270	RMS Amps B 2				
271	RMS Amps C 2				
272	Phase Angle RMS Amps A 2 Harmonic 01				
273	Phase Angle RMS Amps B 2 Harmonic 01				
274	Phase Angle RMS Amps C 2 Harmonic 01				
275	Reserved (returns 0)				
276	Reserved (returns 0)				
277	Reserved (returns 0)				
278	Reserved (returns 0)				
279	Reserved (returns 0)				
280	Reserved (returns 0)				
281	Reserved (returns 0)				
282	Reserved (returns 0)				
283	Reserved (returns 0)				
284	Reserved (returns 0)				
285	Reserved (returns 0)				
286	Reserved (returns 0)				
287	Reserved (returns 0)				
288	Reserved (returns 0)				
289	Reserved (returns 0)				
290	Reserved (returns 0)				
291	Impedance A 1				
292	Impedance B 1				
293	Impedance C 1				
294	Resistance A 1				
295	Resistance B 1				
296	Resistance C 1				
297	Reactance A 1				
298	Reactance B 1				
299	Reactance C 1				
300	Phase Angle A 1				
301	Phase Angle B 1				
302	Phase Angle C 1				

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
303	Impedance A 2				
304	Impedance B 2				
305	Impedance C 2				
306	Resistance A 2				
307	Resistance B 2				
308	Resistance C 2				
309	Reactance A 2				
310	Reactance B 2				
311	Reactance C 2				
312	Phase Angle A 2				
313	Phase Angle B 2				
314	Phase Angle C 2				
315	Reserved (returns 0)				
316	Reserved (returns 0)				
317	Reserved (returns 0)				
318	Reserved (returns 0)				
319	Reserved (returns 0)				
320	Reserved (returns 0)				
321	Reserved (returns 0)				
322	Reserved (returns 0)				
323	Reserved (returns 0)				
324	Reserved (returns 0)				
325	Reserved (returns 0)				
326	Reserved (returns 0)				
327	Reserved (returns 0)				
328	Reserved (returns 0)				
329	Reserved (returns 0)				
330	Reserved (returns 0)				
331	TI#1 Input 1				
332	TI#1 Input 2				
333	TI#1 Input 3				
334	TI#1 Input 4				
335	TI#1 Input 5				
336	TI#1 Input 6				

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
337	TI#1 Input 7				
338	TI#1 Input 8				
339	TI#2 Input 1				
340	TI#2 Input 2				
341	TI#2 Input 3				
342	TI#2 Input 4				
343	TI#2 Input 5				
344	TI#2 Input 6				
345	TI#2 Input 7				
346	TI#2 Input 8				
347	TI#3 Input 1				
348	TI#3 Input 2				
349	TI#3 Input 3				
350	TI#3 Input 4				
351	TI#3 Input 5				
352	TI#3 Input 6				
353	TI#3 Input 7				
354	TI#3 Input 8				
355	TI#4 Input 1				
356	TI#4 Input 2				
357	TI#4 Input 3				
358	TI#4 Input 4				
359	TI#4 Input 5				
360	TI#4 Input 6				
361	TI#4 Input 7				
362	TI#4 Input 8				
363	TI#5 Input 1				
364	TI#5 Input 2				
365	TI#5 Input 3				
366	TI#5 Input 4				
367	TI#5 Input 5				
368	TI#5 Input 6				
369	TI#5 Input 7				
370	TI#5 Input 8				

	BAF (Bitronics Advanced Fixed) Analog Inputs	Analog Outputs	Binary Inputs	Binary Outputs	Counters
371	TI#6 Input 1				
372	TI#6 Input 2				
373	TI#6 Input 3				
374	TI#6 Input 4				
375	TI#6 Input 5				
376	TI#6 Input 6				
377	TI#6 Input 7				
378	TI#6 Input 8				
379	TI#7 Input 1				
380	TI#7 Input 2				
381	TI#7 Input 3				
382	TI#7 Input 4				
383	TI#7 Input 5				
384	TI#7 Input 6				
385	TI#7 Input 7				
386	TI#7 Input 8				

Please note that the Bitronics HAF (Harmonics Advanced Fixed) Point Set is identical to BAF through point 386, but adds harmonics and phase angles for L-L and L-N voltages and for currents for all 63 harmonics through point 3271.

DNP V3.0
DEVICE PROFILE DOCUMENT

Vendor Name: **Bitronics LLC**	
Device Name: **Mx71**	
Highest DNP Level Supported: For Requests: **Level 2** For Responses: **Level 2**	Device Function: ☐ Master ☒ **Slave**
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported: For static (non-change-event) object requests, request qualifier codes 00 and 01 (start-stop), 07 and 08 (limited quantity), and 17 and 28 (index) are supported in addition to request qualifier code 06 (no range). Static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event object requests, qualifiers 17 or 28 are always responded. **16-bit Analog Change Events may be requested.** **The read function code for Object 50 (Time and Date), variation 1, is supported.** **Sequential file transfer, Object 70, variations 3 through 7, are supported.**	
Maximum Data Link Frame Size (octets): Transmitted: **292** Received **292**	Maximum Application Fragment Size (octets): Transmitted: **2048** Received **2048**
Maximum Data Link Re-tries: ☐ None ☐ Fixed ☒ **Configurable from 0 to 255**	Maximum Application Layer Re-tries: ☒ **None** ☐ Configurable
Requires Data Link Layer Confirmation: ☐ Never ☐ Always ☐ Sometimes ☒ **Configurable as: Never, Only for multi-frame messages, or Always**	
Requires Application Layer Confirmation: ☐ Never ☐ Always ☐ When reporting Event Data (Slave devices only) ☐ When sending multi-fragment responses (Slave devices only) ☐ Sometimes ☒ **Configurable as: "Only when reporting event data", or "When reporting event data or multi-fragment messages."**	

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DEVICE PROFILE DOCUMENT

Timeouts while waiting for:

Data Link Confirm: ☐ None ☐ Fixed at ____ ☐ Variable ☒ **Configurable.**
Complete Appl. Fragment: ☒ **None** ☐ Fixed at ____ ☐ Variable ☐ Configurable
Application Confirm: ☐ None ☐ Fixed at ____ ☐ Variable ☒ **Configurable.**
Complete Appl. Response: ☒ **None** ☐ Fixed at ____ ☐ Variable ☐ Configurable

Others: **Transmission Delay, configurable.**
Arm Select Timeout, configurable.
Application File Timeout, configurable.

Sends/Executes Control Operations:

WRITE Binary Outputs ☒ **Never** ☐ Always ☐ Sometimes ☐ Configurable
SELECT/OPERATE ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable
DIRECT OPERATE ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable
DIRECT OPERATE – NO ACK ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable

Count > 1 ☒ **Never** ☐ Always ☐ Sometimes ☐ Configurable
Pulse On ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable
Pulse Off ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable
Latch On ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable
Latch Off ☐ Never ☒ **Always** ☐ Sometimes ☐ Configurable

Queue ☒ **Never** ☐ Always ☐ Sometimes ☐ Configurable
Clear Queue ☒ **Never** ☐ Always ☐ Sometimes ☐ Configurable

Attach explanation if 'Sometimes' or 'Configurable' was checked for any operation.

Reports Binary Input Change Events when no specific variation requested:

☐ Never
☐ Only time-tagged
☐ Only non-time-tagged
☒ **Configurable**

Reports time-tagged Binary Input Change Events when no specific variation requested:

☐ Never
☒ **Binary Input Change With Time**
☐ Binary Input Change With Relative Time
☐ Configurable

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Sends Unsolicited Responses:	Sends Static Data in Unsolicited Responses:
☒ **Never** ☐ Configurable ☐ Only certain objects ☐ Sometimes (attach explanation) ☐ ENABLE/DISABLE UNSOLICITED Function codes supported	☒ **Never** ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation:	**Counters Roll Over at:**
☐ No Counters Reported ☐ Configurable ☒ **Default Object:** 20 **Default Variation:** 5 ☐ Point-by-point list attached	☐ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☒ **32 Bits** ☐ Other Value: _____ ☐ Point-by-point list attached

Sends Multi-Fragment Responses:

☒ **Yes**
☐ No

Sequential File Transfer Support:

Append File Mode	☐Yes	☒**No**	
Custom Status Code Strings	☐	Yes	☒ **No**
Permissions Field	☒**Yes**	☐No	
File Events Assigned to Class	☒	**Yes**	☐ No
File Events Send Immediately	☒	**Yes**	☐ No
Multiple Blocks in a Fragment	☒	**Yes**	☐ No
Max Number of Files Open	**1**		

Revision	Date	Changes	By
A	01/30/2009	Update Bitronics Name, Logo	E. Demicco
B	05/01/09	Updated logos and cover page	MarCom
C	09/18/09	Time Sync features: Added 1.7.3 & 1.7.4; Updated Appendix B with new data point assignments for AI:216, AI:217, AI:219 in BAF & HAF. Renamed data points AI:214 & AI:215. Revised issue date.	R. Fisher
D	12/8/11	Clarification on CONTROL RELAY OUTPUT BLOCK use	E. DeMicco

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