MultiHop Register Parameters

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Contents

Chapter 1 Input and Output Registers 3
Supported Modbus Function Codes 3

Chapter 2 Modbus Register Configuration 4
00000s Standard Physical Inputs 4
00100s and 00600s Remap Registers 4
Remap Registers or Register Aliasing 5
00500s Standard Physical Outputs 5
01000s Input Parameters 5
Switch Power Input Parameters 6
02000s Output Parameters 6
02950s Default Output Parameters 7
03000s Discrete Input Parameters 7
03300s Analog Input Parameters 8
Temperature Parameters 9
03500s Counter Input Parameters 10
03600s H-Bridge Output Parameters 10
03600s Switch Power Output Parameters 11
03700s Discrete Output Parameters 11
04000s Analog Output Parameters 12
04150s Initialization Controls 12
04400s Output Flash Pattern Parameters 13
04500s M-GAGE Parameters 13
04800s Ultrasonic Input Parameters 14
Configuration Examples 15
Configuring an Analog IN to use SP3 15
Configuring for Acclima SDI-12 Sensors 16
Configuring for Decagon 5T3 SDI-12 Sensors 16
Manufacturer Parameter Registers 16
Example: Storing a Model Number 17
Example: Parameters Stored as Numbers 17
Device and System Parameters 18
06000s Device Parameters 18
06050s Battery Monitoring Parameters 18
06360s Network System Binding 18
06400s Messages 18
06500s and 06800s Application Modes 18
06800s Push Registers 19
07000s Network Formation 20
07900s Client as a Server Network Registers 20

Chapter 3 Technical Notes 21
Network Information Registers 21
Forced Routing with MultiHop Radios 22
Determine the Firmware Version 22
Configure a Forced Routing from the Child Radio's LCD 22
Configure a Forced Routing using the Software 23
Remove a Forced Routing 23
..... 23
Enabling Deep Sleep Mode 23
Creating a Synchronous Counter from a Discrete Input on a MultiHop Radio 24
MultiHop Network Formation Tables 25
MultiHop Network Formation 25
Building MultiHop Formation Tables 25
Correlating Device Address to Modbus Address IDs 26
..... 26
Set the MultiHop Baud Rate to 1200 26
Set the MultiHop Baud Rate to 2400 27

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Chapter Contents

Supported Modbus Function Codes 3

Chapter 1 Input and Output Registers

Inputs (4xxxx)		Outputs (4xxxx)	
Register	Input #	Register	Output #
1	1	501	1
2	2	502	2
3	3	503	3
4	4	504	4
5	5	505	5
6	6	506	6
7	7	507	7
8	8	508	8
9	9	509	9
10	10	510	10
11	11	511	11
12	12	512	12
13	13	513	13
14	14	514	14
15	15	515	15
16	16	516	16

Supported Modbus Function Codes

The supported Modbus function codes are 3 (read multiple), 6 (write single), and 16 (write multiple).

All DX80 Modbus registers are defined as ‘holding registers’ in the 4xxxx address space. Some older PLCs use the register number space of 4xxxx to imply function code 3 for holding registers. For these systems, add 40000 to our register number and the PLC software uses the correct function code 3 to access our registers.

The supported Modbus function codes are defined below. For more information about Modbus, see www.modbus.org.

Function	Description
3	Reads the contents of a contiguous block of holding registers in a remote device. The request specifies the starting register address and the number of registers.
6	Writes a single holding register in a remote device. The request specifies the address of the register to be written and the single register of data.
16	Writes a block of contiguous holding registers in a remote device. The requested written values are specified in the request data field.

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Chapter Contents

00000s Standard Physical Inputs 4
00100s and 00600s Remap Registers 4
00500s Standard Physical Outputs 5
01000s Input Parameters 5
02000s Output Parameters 6
02950s Default Output Parameters 7
03000s Discrete Input Parameters 7
03300s Analog Input Parameters 8
03500s Counter Input Parameters 10
03600s H-Bridge Output Parameters 10
03700s Discrete Output Parameters 11
04000s Analog Output Parameters 12
04150s Initialization Controls 12
04400s Output Flash Pattern Parameters 13
04500s M-GAGE Parameters 13
04800s Ultrasonic Input Parameters 14
Configuration Examples 15
Manufacturer Parameter Registers 16
Example: Storing a Model Number 17
Example: Parameters Stored as Numbers 17
Device and System Parameters 18

Chapter 2 Modbus Register Configuration

Change the factory default settings for the inputs, outputs, and device operations using the device Modbus registers. To change parameters, set the data radio network to Modbus mode and assign the data radio a valid Modbus ID.

Generic input or output parameters are grouped together based on the device input or output number: input 1, input 2, output 1 etc. Operation type specific parameters (discrete, counter, analog 4 to 20 mA) are grouped together based on the I/O type number: analog 1, analog 2, counter 1, etc. Not all inputs or outputs may be available for all models. To determine which specific I/O is available on your model, refer to the Modbus Input/Output Register Maps listed in the device's datasheet. For more information about registers, refer to the MultiHop Product Instruction Manual (p/n 151317).

00000s Standard Physical Inputs

Registers 1 through 16 are the results registers for inputs 1 through 16.

For a list of the active results registers for your MultiHop radio, refer to your product's datasheet.

00100s and 00600s Remap Registers

Use these remap registers to map any I/O registers to a contiguous location to allow for easier access from a host system.

600s. Registers 601 through 616 contain the index of registers that are remapped.

100s. Registers 101 through 116 contain the values of the remapped registers.

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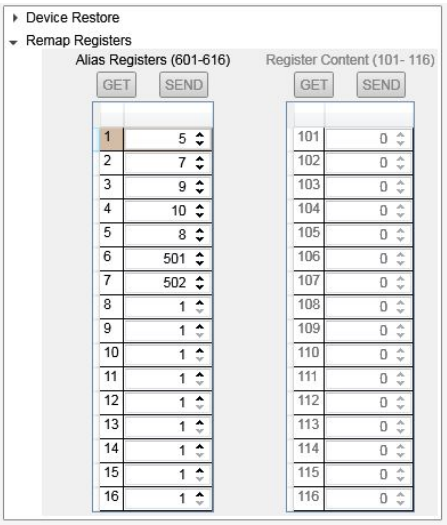
Remap Registers or Register Aliasing

Use the **Remap Registers** section of the **Configure Device** screen to map registers to contiguous register locations to optimize Modbus read/write functions.



1. Verify the desired MultiHop Radio **Address** is selected in **Configuration Address**.
2. Click the arrow next to **Remap Registers**.
3. Fill in the source registers you would like to alias. The **Alias Registers** rows 1 through 16 are the user-defined entries of addresses of the registers to alias (rearrange). This alias table is stored in the MultiHop radio register addresses 601 through 616. In the example, source registers addresses 5, 7, 9, 10, 8, 501, and 502 are entered into the table.

The aliased **Register Contents** are in registers 101 through 116. For this example, when a host system reads Modbus registers 101 through 107 of the MultiHop radio, the register contents come from register 5, 7, 9, 10, 8, 501 and 502.

00500s Standard Physical Outputs

Registers 501 through 516 are the results registers for outputs 1 through 16.

For a list of the active results registers for your MultiHop radio, refer to your product's datasheet.

01000s Input Parameters

Data radio inputs have the following generic parameters. These are not global parameters but are associated only with a particular input.

There are currently 16 separate inputs possible; the factory default settings are defined in the I/O specifications. Parameters for Input 1 are at 1001 through 1008. Parameters for input 2 are at 1051 through 1058. Each following input is offset from the previous one by 50 registers.

Parameter Registers for Inputs (4xxxx)									
1	2	3	4	5	6	7	8	9	Parameters
1001	1051	1101	1151	1201	1251	1301	1351	1401	Enable
1002	1052	1102	1152	1202	1252	1302	1352	1402	Sample Interval (high word)
1003	1053	1103	1153	1203	1253	1303	1353	1403	Sample Interval (low word)
1008	1058	1108	1158	1208	1258	1308	1358	1408	Out-of-Sync Enable

Enable

A 1 enables the input and a 0 to disable the particular input.

Out-of-Sync Enable

Set to one (1) to enable the input to continue operating when the device is out of sync with the client radio. Set to zero (0) to disable the input when the device is not synchronized to the client radio. The default value is one (1).

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Sample Interval (High Word)

The sample interval (rate) is a 32-bit value (requires two Modbus registers) that represents how often the data radio samples the input. The register value is the number of time units. For example, a Modbus register value of 125 (for a 900 MHz device) represents a sample interval of 5 seconds (125 x .040 seconds = 5 seconds). A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

Sample Interval (Low Word)

See Sample Interval (High Word).

1xx4 through 1xx7

See "Switch Power Input Parameters" on page 6.

Switch Power Input Parameters

The switch power input parameters are not global parameters but are associated only with a particular input.

There are currently 16 separate inputs possible; the factory default settings are defined in the I/O specifications. Switch power parameters for Input 1 are at 1004 through 1007. Switch power parameters for input 2 are at 1054 through 1057. Each following input is offset from the previous one by 50 registers.

Parameter Registers for Inputs (4xxxx)									
1	2	3	4	5	6	7	8	9	Parameters
1004	1054	1104	1154	1204	1254	1304	1354	1404	Switch Power Enable
1005	1055	1105	1155	1205	1255	1305	1355	1405	Switch Power Warm-up
1006	1056	1106	1156	1206	1256	1306	1356	1406	Switch Power Voltage
1007	1057	1107	1157	1207	1257	1307	1357	1407	Extended Input Read

Extended Input Read

The Extended Input Read is a bit field parameter that allows multiple inputs to be sampled with the same switch power parameters. If the bit field is set to 0x000F, the first four inputs are sampled after the switch power parameters are satisfied. If this parameter is set in the input 1 configuration registers, set inputs 2 through 4 to zero.

Switch Power Enable

The bit mask can select any number of switch power outputs 1 through 4. Switch power enable works with the warm-up and voltage parameters to define the switch power output. Some devices have only two switch power outputs. Refer to your model's datasheet to confirm which switch power outputs are active for your MultiHop radio.

- 0x0 - No switch power enabled
- 0x1 - Enable SP1
- 0x2 - Enable SP2
- 0x3 - Enable SP1 and SP2
- 0x4 - Enable SP3
- 0x8 - Enable SP4
- 0xC - Enable SP3 and SP4

Switch Power Voltage

The Switch Power Voltage parameter defines the output voltage of the switch power output. This parameter applies only to inputs using switched power. If switch power is not used with an input, use the Continuous Voltage parameter to control the voltage.

Output Voltage	Parameter Value	Output Voltage	Parameter Value
0 V	255	15 V	32
5 V	204	20 V	12
7 V	125	24 V	03
10 V	69		

Switch Power Warm-up

When the data radio supplies power to external sensors, the Switch Power Warm-up parameter defines how long power is applied to the external sensor before the input point is examined for changes. The register value is the number of time units.

A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

02000s Output Parameters

The following characteristics are configurable for each output.

Parameters for Output 1 start at 2001 through 2004. Parameters for output 2 start at 2051 through 2054. Each following output is offset from the previous one by 50 registers.

Parameter Registers for Outputs (4xxxx)									
1	2	3	4	5	6	7	8	9	Parameters
2001	2051	2101	2151	2201	2251	2301	2351	2401	Enable
2002	2052	2102	2152	2202	2252	2302	2352	2402	Flash Output Enable
2003	2053	2103	2153	2203	2253	2303	2353	2403	Flash Index

Continued on page 7

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Continued from page 6

Parameter Registers for Outputs (4xxxx)									
1	2	3	4	5	6	7	8	9	Parameters
2004	2054	2104	2154	2204	2254	2304	2354	2404	Out of Sync Enable

Enable

Set to 1 to enable the output; set to 0 to disable the output.

Flash Index

The Flash Index can have values 1, 2, 3, or 4. For a particular output, the Flash Index 1 through 4 select a certain output pattern as defined in registers 4401, 4411, 4421, or 4431.

Flash Output Enable

The Flash Output Enable, Flash Index, and Output Flash Pattern registers are all used to set up flashing patterns for indicator lights connected to the data radio. Set the Flash Output Enable register to 1 to enable the ability to select an output flash pattern; set to 0 to disable this feature. Select the output pattern using the Flash Index and Output Flash Pattern registers.

Out of Sync Enable

Set to one (1) to enable the output to continue operating when the device is out of sync with the client radio. Set to zero (0) to disable the output when the device is not synchronized to the client radio. The default value is one (1).

02950s Default Output Parameters

Several device conditions may be used to send outputs to their default state. Use these properties to define the device's default output conditions.

2951 Enable Default Out Of Sync

When a radio is "out of sync," it is not communicating with its parent radio.

Set this value to 1 to enable the default condition when the device is not communicating with its parent radio. Set to 0 to disable.

2952 Enable Default Communication Timeout

A "communication timeout" refers to the communication between the host system and this radio. Set this register to 1 to enable the default condition when the host has not communicated with this radio for the period of time defined by the Communication Default IO Timeout.

2953 Communication Default I/O Timeout (100 ms/Count)

This parameter defines the host timeout period in 100-millisecond increments. If a host does not communicate within this timeout period, the device outputs are set to the default values.

2954 Enable Default on Power Up

Setting this parameter to 1 sends the device outputs to their default condition when the radio is powered up. Set to 0 to disable this feature.

03000s Discrete Input Parameters

The Discrete Input Configuration parameters configure certain aspects of the data radio's discrete inputs.

Parameters for Discrete Input 1 start at 3001, and parameters for Discrete Input 2 start at 3021. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Discrete Inputs (4xxxx)				
IN 1	IN 2	IN 3	IN 4	Parameters
3001	3021	3041	3061	PNP/NPN
3002	3022	3042	3062	Sample High
3003	3023	3043	3063	Sample Low
3004	3024	3044	3064	Enable Latch on Change of State
3007	3027	3047	3067	Enable Discrete Input Time Active Counter
3008	3028	3048	3068	Discrete Input Time Active Count
3009	3029	3049	3069	Discrete Input Time Active Count
3013	3033	3053	3073	Enable Rising Edge
3014	3034	3054	3074	Enable Falling Edge
3015-3016	3035-3036	3055-3056	3075-3076	Digital Counter Value

Digital Counter Value

The 32-bit counter results are placed in registers 3015 and 3016 for input #1. To clear or preset the counter value, write a

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zero value or the preset value into registers 3015 and 3016. Cycling the power sets the counter values back to zero. The host system is responsible for saving the counter values in case of a power failure or power reset condition. A discrete input will not count when the device is not in sync with a parent MultiHop device. To allow for counting when out of sync, set configuration register 1008 to 1 for input #1.

Out of Sync Actions				
IN 1	IN 2	IN 3	IN 4	Description
1008	1058	1108	1158	Enable out-of-sync action. Set to 1 to enable, set to 0 to disable.

Discrete Input Time Active Count

These two registers contain the counter value. Register 3xx8 contains the high portion of the active counter and 3xx9 contains the low portion of the active counter. The counter stores a time value in 100 ms increments. This value is reset to zero when the power cycles off.

Enable Discrete Input Time Active Counter

The time active counter counts the time a discrete input is in the active state. Set to one (1) to enable the time counter; set to zero (0) to disable the counter. By default, this counter is enabled.

Enable Latch on Change of State

Writing a 1 to this register causes a data "push" (data transmitted to the client radio) on Change of State.

Enable Falling Edge

Enables the sync counter falling edge. Set to 1 to enable, set to 0 to disable.

Enable Rising Edge

Enables the sync counter rising edge. Set to 1 to enable, set to 0 to disable. To count on both rising and falling edges, set both the configuration registers to 1 to enable.

PNP or NPN

Set to 1 to define the input as a PNP (sourcing) input. Set to 0 to define the input as an NPN (sinking) input.

Sample High

The default value is 0, which disables this feature. The value range is 1 through 255. The Sample High parameter refers to the number of samples (1 through 255) a discrete input must be detected high (1) before it is considered to be a change of state.

Sample Low

The default value of 0 disables this feature. The value range is 1 through 255. The Sample Low parameter refers to the number of samples (1 through 255) a discrete input must be detected low (0) before it is considered to be a change of state.

03300s Analog Input Parameters

The following characteristics are configurable for each of the analog inputs.

Analog input parameters for input 1 start at 3301. Analog input parameters for input 2 start at 3321. Each following input is offset from the previous one by 20 registers.

Registers for Analog Parameters (4xxxx)				Parameters
IN 1 (3301-3320)	IN 2 (3321-3340)	IN 3 (3341-3360)	IN 4 (3361-3380)	
3301	3321	3341	3361	Maximum Analog Value
3302	3322	3342	3362	Minimum Analog Value
3303	3323	3343	3363	Enable Register Full Scale
3304	3324	3344	3364	Temperature Degrees C/F
3305	3325	3345	3365	Temperature Scaling
3306	3326	3346	3366	Thermocouple Type
3307	3327	3347	3367	Temperature Resolution
3308	3328	3348	3368	Threshold
3309	3329	3349	3369	Hysteresis
3310	3330	3350	3370	Delta
3311	3331	3351	3371	
3312	3332	3352	3372	
3313	3333	3353	3373	
3314	3334	3354	3374	
3315	3335	3355	3375	
3316	3336	3356	3376	Sample High
3317	3337	3357	3377	Sample Low
3318	3338	3358	3379	Change of State Push Enable
3319	3339	3359	3379	Median Filter Enable
3320	3340	3360	3380	Tau Filter

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Change of State Push Enable

Set to one (1) to enable push registers for this input. When the analog input changes state, the register value will be pushed to the client radio if this register is configured to be a push register.

Delta

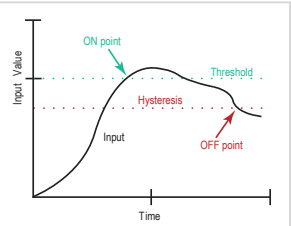
The delta parameter defines the change required between sample points of an analog input before the analog input reports a new value. To turn off this option, set the Delta value to 0.

Enable Register Full Scale

Set to 1 to enable a linear range from 0 to 65535 for specified input range. For a 4 to 20 mA input, a value of 0 represents 0 mA and 65535 represents 20 mA. Set this parameter to 0 to store input readings in unit-specific data. For example, the register data representing a 15.53 mA reading is 15530. For units of current (0 to 20 mA inputs), values are stored as µA (micro Amps) and voltage values are stored as mV (millivolts).

Hysteresis and Threshold

Threshold and hysteresis work together to establish the ON and OFF points of an analog input. The threshold defines a trigger point or reporting threshold (ON point) for a sensor input. When the input value is higher than the threshold, the input is ON. Hysteresis defines how far below the threshold the analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit's range.



In the example shown, the input is considered on at 15 mA. To consider the input off at 13 mA, set the hysteresis to 2 mA. The input will be considered off when the value is 2 mA less than the threshold.

Maximum Analog Value

The Maximum Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage input the register may contain 8000, for 8 volts.

Median Filter Enable

Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

Minimum Analog Value

The Minimum Value register stores the minimum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 4000, for 4 mA, or for a voltage input the register may contain 2000, for 2 volts.

Sample High and Sample Low

For analog inputs, the sample high parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold minus hysteresis before a signal is considered deactivated. The sample high and sample low parameters are used to avoid unwanted input transitions.

Tau Filter

Set to zero (0) to turn off the tau filter. Set to 1 (weakest filter) through 6 (strongest filter) to turn on the tau filter. (In the DX80 products, the Low Pass Filter is a combination of the median filter and the tau filter.)

Temperature Parameters

The following parameters are used to configure analog inputs involving temperature and are typically used to configure thermocouple or RTD inputs.

Registers for Analog Parameters (4xxxx)				Parameters
IN 1 (3301-3320)	IN 2 (3321-3340)	IN 3 (3341-3360)	IN 4 (3361-3380)	
3304	3324	3344	3364	Temperature Degrees C/F
3305	3325	3345	3365	Temperature Scaling
3306	3326	3346	3366	Thermocouple Type
3307	3327	3347	3367	Temperature Resolution

Temperature Degrees C/F

Set to 1 to represent temperature units in degrees Fahrenheit, and set to 0 (default) to represent temperature units in degrees Celsius.

Temperature Resolution

Thermocouples and RTDs may record temperatures in either high resolution (tenths of a degree) or low resolution (whole degree).

Write a 0 to select high resolution (default) or a 1 to select low resolution. Choosing high or low resolution changes the range of temperatures that can be written to the register.

Temperature Scaling

Set to 1 to store temperatures the same way as the DX80 devices (measured temp × 20) represent temperature.

Set to 0 (default) to store temperature values in tenths of a degree (measured temp × 10).

For example, if the measured temperature is 20.5 degrees, using a temperature scaling set to 1 would store the temperature value as 410; using a temperature scaling set to 0 would store the temperature as 205.

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Thermocouple Type

Write the listed value to this register to select a thermocouple type. The default configuration is set to a Type B thermocouple (0).

Value	Thermocouple Type	Value	Thermocouple Type	Value	Thermocouple Type
0	B	5	J	10	P

Continued on page 10

Continued from page 9

Value	Thermocouple Type	Value	Thermocouple Type	Value	Thermocouple Type
1	C	6	K	11	R
2	D	7	L	12	S
3	E	8	M	13	T
4	G	9	N	14	U

03500s Counter Input Parameters

The following parameters are configurable for the counter input.

Counter Input parameters for Counter Input 1 start at 3501 through 3505. Counter Input parameters for Counter Input 2 start at 3521 through 3525. Each following counter input is offset from the previous one by 20 registers.

Parameter Registers for Counter Inputs (4xxxx)	
IN 1	**Parameters**
3501	Enable Frequency/Event Counter
3502	Enable Read Counter State
3503	Set Preset Value
3504	Counter Preset Value
3505	Counter Preset Value

Counter Preset Value

Registers 3504 (high word) and 3505 (low word) contain the 32-bit value for presetting the counter. Write the ‘Counter Preset Value’ registers first, then use the ‘Set Preset Value’ register to execute the counter preset.

Enable Frequency/Event Counter

A counter input can be defined to calculate the frequency of the input in hertz or as a counter that increments with every input change (event counter) from 0 to 1 (for PNP inputs).

Set this parameter to 1 to configure the input to calculate frequency. Set to 0 to configure the counter to count input changes, for example, an event counter or totalizer. Because the counter is reset to zero when power is cycled to the device, it is up to the host system to save count data.

Enable Read Counter State

Manufacturing/test register only

Set Preset Value

Writing this value to 1 signals the data radio to preset the counter with the value stored in Modbus registers 3504 and 3505. When the task is complete, the value is written to 0.

03600s H-Bridge Output Parameters

The following parameters are configurable for the H-bridge outputs.

Parameters for H-bridge 1 start at 3604 through 3609. Parameters for H-bridge 2 start at 3624 through 3629. Each following H-bridge parameter set is offset from the previous one by 20 registers.

Parameter Registers for H-Bridge Outputs (4xxxx)	
H-Bridge 1	**Parameters**
3604	Enable H-Bridge
3605	H-Bridge Warmup Cap Time
3606	H-Bridge Active Current Time
3607	H-Bridge Switches
3608	H-Bridge Switches
3609	H-Bridge Booster Enabled When Active

Enable H-Bridge

Enable (1) or disable (0) the h-bridge inputs as needed.

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Disable the h-bridge inputs when using SDI-12 devices.

H-Bridge Active Current Time

Set how long, in 40 millisecond increments, the capacitor is switched into and supplying power to the solenoid circuit.

H-Bridge Switches

Use these two parameters as a bit mask to set the ON and OFF conditions of the h-bridge switch.

Continued from page 10

	DO4	DO3	DO2	DO1	SP4	SP3	SP2	SP1
3607 Rising Switch (ON)	0	0	1	0	0	0	0	1
3608 Falling Switch (OFF)	0	0	0	1	0	0	1	0

Continued on page 12

H-Bridge Warm-Up Cap Time

Similar to the switch power warm-up time, the h-bridge capacitor warm-up time is the time allotted, in 40 millisecond increments, to charge the capacitor used to activate the h-bridge and latching solenoid.

H-Bridge Booster Enabled When Active

To use this parameter, contact the applications engineers at Banner Engineering Corp. This parameter leaves the boost

voltage on while the capacitor discharges into the solenoid. While this can supply more power to the solenoid circuit, it may also brown-out the radio device.

03600s Switch Power Output Parameters

The Power Output Configuration parameters provide the basic operation for each power output. These parameters are not associated to specific inputs.

Efficient power management technology enables some FlexPower devices to include an internal power supply, called switch power (SP), that briefly steps up to power sensors that require more than 3.6 V DC power, such as 4 to 20 mA loop-powered sensors. When the switch power output cycles on, the voltage is stepped up to power the sensor for a specific time. The warmup time denotes how long the sensor must be powered before a reliable reading can be taken. After the warmup time has passed, the input reads the sensor, then the switch power shuts off to prolong battery life. The switch power voltage, warm-up time, and sample interval are configurable parameters.

Parameters for SP 1 start at 3601 through 3603. Parameters for SP 2 start at 3621 through 3623. Each following switch power is offset from the previous one by 20 registers.

Parameter Registers for Switch Power Outputs (4xxxx)				
SP1	**SP2**	**SP3**	**SP4**	**Parameters**
3601	3621	3641	3661	Continuous Voltage Setting
3602	3622	3642	3662	Default Output State
3603	3623	3643	3663	Hold Last State Enable

Continuous Voltage Setting

Use this voltage parameter to set the output voltage when supplying continuous power through the SP# terminals (not associated with inputs). The Continuous Voltage parameter cannot be used if any input uses switch power. To set a continuous voltage on the SP output, also turn on the default output condition “default on power up.” This will turn on this continuous voltage output when the radio powers up.

Output Voltage	Parameter Value	Output Voltage	Parameter Value
0 V	255	15 V	32
5 V	204	20 V	12
7 V	125	24 V	03
10 V	69		

Default Output State

The Default Output State parameter represents the default condition of the switch power output. When communication is lost to the host or the wireless link is lost for the I/O data radio, the data radio can set the outputs and switch power outputs in this default state.

When set to 0, the switch power is turned off. When set to 1, the switch power is set to the voltage established by the Continuous Voltage Setting.

Hold Last State Enable

Set Hold Last State Enable to 1 to set the switch power output to its last known value when communications are lost.

Set this parameter to 0 to disable the Host Last State Enable and use the Default Output State settings.

03700s Discrete Output Parameters

The following characteristics are configurable for each of the discrete outputs.

Parameters for Output 1 start at 3701 through 3703. Parameters for Output 2 start at 3721 through 3723. Each following input is offset from the previous one by 20 registers.

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Parameter Registers for Discrete Outputs (4xxxx)				
OUT 1	OUT 2	OUT 3	OUT 4	Parameters
3701	3721	3741	3761	Default Output State
3702	3722	3742	3762	Hold Last State Enable
3703	3723	3743	3763	Enable Switch Power Logic

Default Output State

The Default Output State parameter represents the default condition of the discrete output. When an error condition exists, the outputs are set to this user-defined output state, either a 0 or a 1.

Enable Switch Power Logic

Hold Last State Enable

Set the Hold Last State to 1 to set the output to its last known value before the error occurred. Set this parameter to 0 to disable the Hold Last State and use the Default Output State setting during an error condition.

04000s Analog Output Parameters

The following characteristics are configurable for each of the analog outputs.

Parameters for Analog Output 1 start at 4001 through 4005. Parameters for Analog Output 2 start at 4021 through 4025. Each following input is offset from the previous one by 20 registers.

Parameter Registers for Analog Outputs (4xxxx)				
OUT 1	OUT 2	OUT 3	OUT 4	Parameters
4001	4021	4041	4061	Maximum Analog Value
4002	4022	4042	4062	Minimum Analog Value
4003	4023	4043	4063	Enable Register Full-Scale
4004	4024	4044	4064	Hold Last State Enable
4005	4025	4045	4065	Default Output State

Default Output State

The Default Output State parameter represents the default condition of the analog output. When an error condition exists, the outputs are set to this 16-bit user-defined output state.

Enable Register Full-Scale

Set to 1 to enable a linear range from 0 to 65535 for the specified input range. For a 4 to 20 mA output, a value of 0 represents 4 mA and 65535 represents 20 mA. Set this parameter to 0 to store readings in unit-specific data. For example, the register data representing a 15.53 mA reading is 15530. For units of current (0 to 20 mA outputs), values are stored as µA (micro Amps) and voltage values are stored as mV (millivolts).

Hold Last State Enable

Set the Hold Last State to 1 to set the output to its last known value before the error occurred. Set this parameter to 0 to disable the Hold Last State and use the Default Output State setting during an error condition.

Maximum Analog Value

The Maximum Analog Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage output the register may contain 8000, for 8 volts.

Minimum Analog Value

The Minimum Analog Value register stores the minimum allowed analog value. The specific units of measure apply to register value. For example, the register may contain 4000, for 4 mA, or for a voltage output the register may contain 2000, for 2 volts.

04150s Initialization Controls

4151 Reset Device

Write a 1 to this register to trigger a device reset of the parameters selected by the next three registers.

4152 Default I/O Configuration

Returns all I/O configuration parameters to their factory default settings.

4153 Default System Parameters

Returns all system-level parameters to their factory default settings.

4154 Initialize Variables from the Serial Number

Returns all variables that are normally calculated (or seeded) from the serial number to values seeded from the serial number.

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04400s Output Flash Pattern Parameters

Setting the flash pattern establishes an on and off pattern that can be used for a discrete output or switch power.

Flash patterns are established by selecting specific timeslots to turn the output on or off. While originally the flash pattern was designed to turn on and off an indicator light, the flash pattern can be set for any discrete output or switch power. Each slot represents one frame size, which may vary from radio to radio. The default frame is 40 milliseconds. Users may configure up to four different flash patterns.

4401-4408 Flash Pattern Index 1.

4411-4418 Flash Pattern Index 2.

4421-4428 Flash Pattern Index 3.

4431-4438 Flash Pattern Index 4.

04500s M-GAGE Parameters

The following characteristics are configurable for the M-GAGE devices.

4501 Set Baseline

Write a 1 to this register to set the baseline. The baseline function of the M-GAGE stores the ambient magnetic field values of the X, Y, and Z axes as a baseline value. Once this baseline is established, any deviation in the magnetic field represents the presence of a ferrous object and will be reflected in the M-GAGE register. The more disruption in the magnetic field, the larger the M-GAGE register value.

4502 Disable Axes

A bit-wise register (0000). Write a one to disable the selected axis where bit 0 is the x axis, bit 1 is the y axis, and bit 2 is the z axis.

4503 Disable Compensation Median Filter

Write a 1 to this register to disable the compensation median filter.

4504 Disable Sensing Median Filter

Write a 1 to this register to disable the sensing median filter.

4505 Low Pass Filter

The filters T0 through T6 are parameter settings that define the degree of input digital signal filtering for analog inputs. T0 is the least amount of filtering. T6 is the highest filter setting and has the least fluctuation between readings. Write the following values to select a low pass (tau) filter.

Low Pass (Tau) Filter	Register Value	Low Pass (Tau) Filter	Register Value
T0	0	T4	4
T1	1	T5	5
T2	2	T6	6
T3	3		

4506 Sample High

The sample high counter parameter defines the number of consecutive samples the input signal must be above the threshold before a signal is considered active. The default value is 0, which disables this feature. The value range is 1 through 255. The Sample High parameter refers to the number of samples (1 through 255) a discrete input must be detected high (1) before it is considered to be a change of state.

4507 Sample Low

The default value of 0 disables this feature. The value range is 1 through 255. The Sample Low parameter refers to the number of samples (1 through 255) a discrete input must be detected low (0) before it is considered to be a change of state.

4509 Delta

Rate of change filter.

4510 Threshold and 4511 Hysteresis

Threshold and hysteresis work together to establish the ON and OFF points of an analog input. The threshold defines a trigger point or reporting threshold (ON point) for the M-GAGE™ input. The hysteresis value establishes how much below the active threshold (ON point) an analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit's range.

The M-GAGE's threshold and hysteresis ranges are 0 to 65,535.

The factory default threshold setting is 150 and the default hysteresis is 30 (the sensor detects an OFF condition at threshold minus hysteresis, or 150 - 30 = 120). With the default settings, once the magnetic field reading is above 150, an ON or "1" is stored in the lowest significant bit (LSB) in the Modbus register. When the M-GAGE reading drops below the OFF point (threshold minus hysteresis), the LSB of the Modbus register is set to "0."

To determine your threshold, take M-GAGE readings of the test objects at the distance they are likely to be from the sensor. For example, if a car reads 150, a bicycle 15, and a truck reads 250, setting the threshold to 200 will detect only trucks of a specific size. Magnetic field fluctuations vary based on the amount of ferrous metal present and the distance from the sensor.

4512 Baseline (Drift) Filter Time

Baseline filter time. When the Baseline Filter is on and the magnetic field readings are below the baseline filter threshold setting, an algorithm is used to slowly match the device's baseline to the current ambient magnetic field. This helps to account for the natural fluctuations in the magnetic field.

4513 Baseline (Drift) Filter Threshold

Baseline filter threshold is used with the baseline filter time to account for the natural fluctuations on the magnetic field.

4514 Baseline (Drift) Filter Tau

Baseline filter's low pass filter.

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4521 Baseline Difference Signal Value Total

A combination of the x-, y-, and z-axis baseline different signal values.

4522–4524 Baseline Difference Signal Value [x-axis]

4522 [x-axis]—The difference between the ambient magnetic field and the current magnetic field reading for the x axis.

4523 [y-axis]—The difference between the ambient magnetic field and the current magnetic field reading for the y axis.

4524 [z-axis]—The difference between the ambient magnetic field and the current magnetic field reading for the z axis.

4525–4527 Baseline Value

4525 [x-axis]—Ambient magnetic field reading for the x axis.

4526 [y-axis]—Ambient magnetic field reading for the y axis.

4527 [z-axis]—Ambient magnetic field reading for the z axis.

4528–4530 Raw Signal Value

4528 [x-axis]—The actual magnetic field reading for the x axis.

4529 [y-axis]—The actual magnetic field reading for the y axis.

4530 [z-axis]—The actual magnetic field reading for the z axis.

04800s Ultrasonic Input Parameters

The following characteristics are configurable for the ultrasonic input devices.

0001 Temperature Measured

Temperature is measured in 0.1 °C increments.

0002 Distance Measured

Distance is measured in mm.

The least significant bit indicates the threshold status
Value 65535 or 65534: Alarm, No Reflection Detected
Value 65533 or 65532: Alarm, Reflection Mismatch
Value 65531 or 65530: Alarm, Thermistor Error

1051 Enable

Write a 1 to enable the ultrasonic sensor. Write a 0 to disable.

1053 Sample Interval

The sample interval (rate) defines how often the data radio samples the input. The register value is the number of time units. For example, a Modbus register value of 125 (for a 900 MHz device) represents a sample interval of 5 seconds (125 × 0.040 seconds = 5 seconds).

A unit of time for a 900 MHz data radio is 40 milliseconds. A unit of time for a 2.4 GHz data radio is 20 milliseconds.

4801 Drive Pulses

Defines the number of cycles the transducer is pulsed.

4808 Receive Pulses

Defines the number of cycles that must be seen to recognize a reflection.

4810 Max Scale Value

The Maximum Value register stores the maximum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 20000, for 20 mA, or for a voltage input the register may contain 8000, for 8 volts.

4811 Min Scale Value

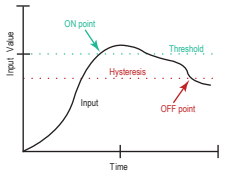
The Minimum Value register stores the minimum allowed analog value. The specific units of measure apply to the register value. For example, the register may contain 4000, for 4 mA, or for a voltage input the register may contain 2000, for 2 volts.

4812 Enable Register Full Scale

Set to 1 to enable a linear range from 0 to 65535 for specified input range. For a 4 to 20 mA input, a value of 0 represents 0 mA and 65535 represents 20 mA. Set this parameter to 0 to store input readings in unit-specific data. For example, the register data representing a 15.53 mA reading is 15530. For units of current (0 to 20 mA inputs), values are stored as µA (micro Amps) and voltage values are stored as mV (millivolts).

4813 Threshold and 4814 Hysteresis

Threshold and hysteresis work together to establish the ON and OFF points of an analog input. The threshold defines a trigger point or reporting threshold (ON point) for a sensor input. When the input value is higher than the threshold, the input is ON. Hysteresis defines how far below the threshold the analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit's range.



In the example shown, the input is considered on at 15 mA. To consider the input off at 13 mA, set the hysteresis to 2 mA. The input will be considered off when the value is 2 mA less than the threshold.

4815 Delta

The delta parameter defines the change required between sample points of an analog input before the analog input reports a new value. To turn off this option, set the Delta value to 0.

4816 Sample High and 4817 Sample Low

For discrete inputs, the sample high parameter defines the number of consecutive samples the input signal must be high before a signal is considered active. Sample low defines the number of consecutive samples the input signal must be low before a signal is considered low. The sample high and sample low parameters are used to create a filter to avoid unwanted input transitions. The default value is 0, which disables this feature. The value range is 1 through 255.

4818 Change of State Push Enable

Set to one (1) to enable push registers for this input. When the analog input changes state, the register value will be pushed to the client radio if this register is configured to be a push register.

4819 Median Filter Enable

Set to zero (0) to turn off the median filter. Set to one (1) to turn on the median filter.

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4820 Low Pass (Tau) Filter

Set to zero (0) to turn off the tau filter. Set to 1 (weakest filter) through 6 (strongest filter) to turn on the tau filter. (In the DX80 products, the Low Pass Filter is a combination of the median filter and the tau filter.) Write the following values to select a low pass (tau) filter.

Low Pass (Tau) Filter	Register Value	Low Pass (Tau) Filter	Register Value
T0	0	T4	4
T1	1	T5	5
T2	2	T6	6
T3	3		

4823 Window Range

Measured in mm.

When ultrasonic teach is active, the threshold is set to the distance measured minus the window range.

4825 Ultrasonic Teach

Write a 1 to initiate a threshold teach.

When ultrasonic teach is active, the threshold is set to the distance measured minus the window range.

4826 Invert Digital Logic

If the set distance measures below the threshold, the transition has an LSB of 1.

If the clear distance measures below the threshold, the transition has an LSB of 0.

4827 Boost Enable

Controls the ultrasonic transducer power level.

Set to 0 for low power level, a longer battery life, less noise, and a shorter range.
Set to 1 for higher power levels, a shorter battery life, more noise, and a longer range.

4828 Ultrasonic Sensitivity Control

Adjusts ultrasonic reflection sensitivity.

Write a 0 to disables the control feature
Start control at 0x8000 to match default
Control below 0x8000 is more sensitive
Control above 0x8000 is less sensitive

4831 Set Alarm as Logic 0

If set, an alarm is treated is if it is below the threshold.

If cleared, an alarm is treated is if it is above the threshold.

7909-7912 Push Registers

7909 Push Register 1 — Pushes the value of register 0002 (Distance Measured).

7910 Push Register 2 — Pushes the value of register 0001 (Temperature in 0.1 °C increments).

7911 Push Register 3 — Pushes the value of register 4813 (Current threshold setting).

7912 Push Register 4 — Pushes the value of register 4823 (Current teach window range).

Configuration Examples

Configuring an Analog IN to use SP3

Example 1: Enable the first analog input to power an external sensor using switched power 3 and change the parameters based on the requirements of the external sensor. This data radio model has analog 1 associated to input 5.

The parameters to adjust and their Modbus registers are:

- Sample interval (reg 1202 hi word, 1203 low word): Change from factory default of 1 second to 15 minute sample interval
- Switch Power Enable (reg 1204): Turn on switch power 3 for this input, using the bit mask
- Switch Power Warm-up (reg 1205): Based on the sensor requirements, turn on the switched power for a certain time before it is sampled.
- Switch Power Voltage (reg 1206): Set the voltage for the sensor operation.

The values to set in the registers are:

- Sample Interval: 15 min, (900 seconds)
- Switch Power Enable: 0x4
- Switched Power Warm-up: 1 second
- Switched Power Voltage: 15 Volts

Set the following registers to the values shown.

Modbus Register	Value	Description
1202	0	
1203	22,500	This register contains the number of 40 ms time units. 900 seconds ÷ 0.040 seconds = 22,500
1204	4	Enable switch power 3 for this input, see parameter description for bit mask
1205	25	Set warm-up time to 1 second, the register contains the number of 40 ms time units. 1 seconds ÷ 0.040 seconds = 25

Continued on page 16

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Continued from page 15

Modbus Register	Value	Description
1206	32	Set switch power voltage to 15 V

Configuring for Acclima SDI-12 Sensors

Acclima SDI-12 Parameter Registers

SDI-12 Device Register (Acclima)		Register Enable (1)	Decimal Point Move (0-7)	Move Right (0) or Left (1)	Signed (1) or Unsigned (0)	16 bit (0) or 32 bit (1)
1	Volumetric water content	ON	2	Left	Unsigned	32 bit
2	Temperature	ON	1	Left	Signed	32 bit
3	Soil Permittivity	ON	2	Left	Unsigned	32 bit
4	Soil Conductivity	ON	2	Left	Unsigned	32 bit

Acclima SDI-12 Results Registers

Acclima Register No.		Results Registers (high:low)	Integer Conversion Multiplier	Sample Reading	Actual Value
1	Volumetric water content	11101:11102	×100	0:124	1.24%
2	Temperature	11103:11104	×10	0:238	23.8 °C
3	Soil Permittivity	11105:11106	×100	0:402	4.02
4	Soil Conductivity	11107:11108	×100	0:123	1.23 dS/m

Configuring for Decagon 5T3 SDI-12 Sensors

Decagon SDI-12 Parameter Registers

SDI-12 Device Register (Decagon 5T3)		Register Enable (1)	Decimal Point Move (0-7)	Move Right (0) or Left (1)	Signed (1) or Unsigned (0)	16 bit (0) or 32 bit (1)
1	Volumetric water content	ON	2	Left	Unsigned	32 bit
2	Soil Conductivity	ON	2	Left	Unsigned	32 bit
3	Temperature	ON	1	Left	Signed	32 bit

Decagon SDI-12 Results Registers

Decagon Register No.		Results Registers (high:low)	Integer Conversion Multiplier	Sample Reading	Actual Value
1	Volumetric water content	11101:11102	×100	0:124	1.24%
2	Soil Conductivity	11103:11104	×100	0:123	1.23 dS/m
3	Temperature	11105:11106	×10	0:238	23.8 °C

Manufacturer Parameter Registers

The following are the device-specific and manufacturer parameters for the MultiHop radio devices. These registers are all within the 4xxxx range.

Strings stored in ASCII format are read as two characters per Modbus register. The lower-numbered Modbus register contains the right-most characters in the string. Within a given Modbus register, the upper byte contains the ASCII character that goes to the right of the character in the lower byte.

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04100s Manufacturing Information

Address (4xxxx)	Name	Format
4101–4104	Serial number, digits 1–8	ASCII, read only
4111–4113	Model number, digits 1–6	ASCII, read only
4121–4123	Production date, digits 1–6	ASCII, read only

04200s Device Name

Address (4xxxx)	Name	Format
4201–4209	Name characters 1-18	ASCII

04300s Software Information

Address (4xxxx)	Name	Format
4301–4303	RF firmware p/n	ASCII, read only
4304–4305	RF firmware version	ASCII, read only
4306–4308	RF EEPROM part number, digits 1–6	ASCII, read only
4309–4310	RF EEPROM version number, characters 1–3	ASCII, read only
4311–4313	LCD firmware p/n	ASCII, read only
4314–4315	LCD firmware version	ASCII, read only
4316–4318	LCD EEPROM part number, digits 1–6	ASCII, read only
4319–4320	LCD EEPROM version number, characters 1–3	ASCII, read only

06400s Message Parameters

Address (4xxxx)	Name	Format
6401	Device address	Hex
6402	Parent address	Hex, read only

Example: Storing a Model Number

For example, the model number 148691 is stored as shown below.

Address (4xxxx)	Name	Modbus Register Value (in hex)	Character Representation
4111	Model number digits 6-5	0x3139	1 9
4112	Model number digits 4-3	0x3638	6 8
4113	Model number digits 2-1	0x3431	4 1

Example: Parameters Stored as Numbers

Parameters stored as number values (not ASCII) read out directly as 16-bit values. Examples of parameters of this type include the Parent Address or Device Address.

Address (4xxxx)	Name	Value (in hex)	Value (decimal)
6401	Device address	0x002A	42
6402	Parent address	0x0023	35

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Device and System Parameters

06000s Device Parameters

6001 Is Client (Read Only)
Typically configured from the DIP switches, writing a 1 to this register sets the radio to be the MultiHop client radio.

6004 Is Repeater (Read Only)
Typically configured from the DIP switches, writing a 1 to this register sets the radio to be the MultiHop repeater radio.

06050s Battery Monitoring Parameters

Use the battery monitor parameters to monitor and set a threshold based on the incoming device voltage (on some models).

The incoming voltage is approximately 3.6 V DC from a battery input or 4.2 V DC from the 10 to 30 V DC input. These parameters allow users to determine which power source is powering the MultiHop device.

6051 Enable Battery Read
Set to zero to disable the battery read function. Set to 1 to enable the battery read function.

6052 Battery Read Sample Interval
Use this parameter to set the time interval at which the incoming voltage is read. Sample Interval (in seconds) = 0.040 seconds × 2^RegValue. Default register value: 9 (20 seconds).

6053 Battery Voltage Threshold
Use this parameter to define the incoming voltage threshold at which register 44061 will be set to a zero or one. Set this value in number of 100 mA increments. The default value is 38 (or 3.8 V).

6054 Hardware Reference Select
Use this parameter to allow for the correct calibration reference for different hardware platforms. Set to zero for 3.0 V PCB Vcc. Set to one for 3.3 V PCB Vcc. Default value is zero.

6061 Battery Threshold Reading
When zero (0), the incoming voltage is below the threshold defined by parameter 6053 (powered by battery). When one (1), the incoming voltage reading is above the defined threshold (powered by a solar panel or 10 to 30 V dc).

6062 Battery Voltage Reading
Actual incoming voltage reading in units of 100 mV.

06360s Network System Binding

6362-6363 Binding Mode Extended Pattern: Client to Children
Seeded from serial number. 32-bit value.

6364-6365 Binding Mode Extended Pattern: Child from Client
Seeded from serial number. 32-bit value.

06400s Messages

6401 Device Address (Read only)
The Device Address is seeded from serial number.

6402 Parent Address (Read only)
Device address of the parent radio. Normally this is automatically filled in when the child chooses a parent radio.

6403 Destination Address (Default)
Broadcast. Typically, the Destination Address is set to force a routing when the radios are operating in transparent mode. This default value (FFFF) broadcasts the message if the recipient is not in the routing table. Enter a specific destination address to force a routing. Default: 0xFFFF

6404 Destination Address (Current)
The Destination Address is where messages are routed to. This value is automatically filled in by the system.

6405 System Client Device Address
Stores the Device Address of the network's client radio.

6451 External Site Survey Control
To begin a Site Survey from a host system, write a one (1) to the child radio's 46451 register. After 100 data packets have been send between the parent and child radios, the system automatically writes a zero (0) to this register to end the Site Survey.

6452 Green Count
After the Site Survey is finished, the "green" signal strength count is written to this register on the child radio.

6453 Yellow Count
After the Site Survey is finished, the "yellow" signal strength count is written to this register on the child radio.

6454 Red Count
After the Site Survey is finished, the "red" signal strength count is written to this register on the child radio.

6455 Miss Count
After the Site Survey is finished, the number of "missed" data packets is written to this register on the child radio.

06500s and 06800s Application Modes

6502 Modbus Offset (Start)
The Modbus ID to start at for numbering devices. By default, begin numbering at 11.

6503 Modbus Number of Servers
The maximum number of Modbus servers. By default, the maximum number is 50, allowing IDs of 11 through 61 for network formation.

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6504 Modbus Server Destination Address Index 1, 6505 Modbus Server Destination Address Index 2, through 6553 Modbus Server Destination Address Index 50

These registers act as the conversion table between the Modbus ID (set by the rotary dials) and the Device Address (5-digit address derived from the serial number) of all Modbus server within the data radio network. This information is filled in by the system. For example, Address Index 1 will contain the device address of the first server in the network. This is ID 11 when using the default Modbus Offset.

6801 Modbus Rotary Switch BCD Disable

Defaults to decimal coding on the rotary switches, which means only rotary dial positions 0 through 9 are recognized. Default 0

6804 Modbus Address Override

Overrides the Modbus address specified on the rotary dials.

6805 Enable Modbus Nack

Controlled by the client radio. The client radio can determine if a device is in the radio network. If a device has dropped out of the network, the client will NACK the packet of data destined for that device to avoid having the host system spend time waiting for an acknowledgement. Default: 0

6808 Current Modbus Address

The ID as selected by the rotary dials. This register is populated automatically by the rotary dials.

6838 Network Parent Radio

Content of this register is the parent radio's device address for this child radio.

Writing to this register forces a child radio to communicate to the selected parent radio (forced routing). Write a zero (0) to this register to remove any forced routing.

06800s Push Registers

The following are the push register parameters for each radio. Push register values are stored on the radio client at registers 7909 through 7912, by MultiHop radio ID.

6831 Input Push Register 1

6832 Input Push Register 2, etc through 6850

For a server or repeater, these define which registers to push to the client device. This allows a server/repeater to send local input data back to the client without having to wait to be asked for the data.

The Modbus register value should be Modbus Register minus 40001. For example, to push register 40001, write a value of 40001 minus 40001, or 0. To push register 40002, write a value of 40002 minus 40001, or 1.

6871-6872 Push Register Report Interval

Push registers can report on a periodic interval or on change of state. The report interval establishes how often, in frames/slots, to push data to the client. 6871 is the high word and 6872 is the low word. This is typically a server or repeater parameter.

Set a periodic interval using 40 millisecond units. For example, to set the report interval to 1 minute (60 seconds ÷ 0.040 seconds = 1500 units), write a 0 to register 46871 = 0 and write a 1500 to register 46872.

Enable change of state reporting by writing a 1 to register 43004 for input 1 or register 43024 for input 2. Other inputs have different configuration registers to enable change of state reporting.

6873-6874 Client Sweep (Health Heartbeat) Interval

Works in conjunction with each server/repeater push register report interval (6871–6872) to create device status information in the client device. This allows the user to monitor the health of each device in the MultiHop network by defining how often the client should expect each repeater and server to push register values back to the cached copies in local storage on the radio client.

This health check should be at least 10 frames longer than the push register report interval. Use the registers to set a periodic interval using 40 millisecond units.

For example, to set the client sweep interval to 1 minute (60 seconds ÷ 0.040 seconds = 1500 units), write a 0 to register 6873 = 0 and write a 1500 to register 6874; register 6873 is the high word and register 6874 is the low word.

Read the individual status registers for each Modbus server device by sending a Modbus read command to the particular server device at register 7904. For example, to read the status register of server 24, send a Modbus read command to server ID 24 register address 7904, the contents will be either 0 (bad) or 1 (good). The individual status data can be read by device address (not Modbus address) starting at Modbus register 12701. The client radio register 12701 holds the number of devices in the system. The following registers 12702+ contain the status information for those devices.

A bit-packed version of the status data is available starting at register 12981. The client radio register 12981 holds the number of device in the system, register 12982 holds the status bit fields for devices 0-15, 12983 holds the status bit fields for devices 16-31.

When dealing with device addresses, device order is based on the order they first sync to the client device. That ordered list is stored starting at Modbus registers 7001 in the client radio. Modbus register 7001 holds the count of the number of devices in the network, with the following registers 7002 and greater holding the device address of the MultiHop radio. The order of this list defines how the status bits or words are stored in the client radio.

6875 Report Interval Random Modulus

The Report Interval Modulus parameter provides an offset to the report interval between 0 and the report interval modulus to minimize the collisions that occur if multiple radios are reporting back at the same time to the radio client.

Enter this parameter as the number of 40 millisecond frames for the offset. A value of 5 represents 200 milliseconds, or 5 × 0.040 seconds.

For example, if the reporting interval is set to every minute and the report interval modulus is set to 3, the report interval will be every minute to a maximum of every minute + 120ms (3 × 40ms).

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07000s Network Formation

Used by the client radio only, the Network Formation parameter values are populated as servers and repeaters join the radio network.

7001 Number of Devices in the Formation table
How many devices are in the network.

7002 Device Address Index 1
Device address for the first device that joins the network.

7003 Device Address Index 2
Device address for the second device that joins the network. A total of 50 devices may be a part of the radio network.

7302 Device MacTo Index 1
Device address for the first radio in the routing path to get to the device defined in index 1.

7303 Device MacTo Index 2
Device address for the first radio in the routing path to get to the device defined in index 2. A total of 50 devices may be a part of the radio network.

07900s Client as a Server Network Registers

The data stored in these registers act as a “window” into the push/poll registers.

These registers “cache” the register values associated with register 6807. When enabling push registers, the host system redirects the register reads to this register area (7909, 7910). The host still requests a specific server ID but with registers 7909 and 7910. The client data radio intercepts the read request and returns the cached data it collects from the push data.

7901 Device Address
Device address

7902 MacTo
Device address in the first step along the routing path to communicate with the device listed in register 7901.

7904 Status
-

7909 Push Register 0, 7910 Push Register 1, through 7924 Push Register 16
Contents of the push registers of the server listed in register 7901.

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Chapter Contents

Network Information Registers 21
Forced Routing with MultiHop Radios 22
Enabling Deep Sleep Mode 23
Creating a Synchronous Counter from a Discrete Input on a MultiHop Radio 24
MultiHop Network Formation Tables 25
Set the MultiHop Baud Rate to 1200 26
Set the MultiHop Baud Rate to 2400 27

Chapter 3 Technical Notes

Network Information Registers

The client device network table maintains three pieces of data for every device in the system: Device or MAC Address, Route MAC Address, and Route MACWhen. Repeater data radios contain this same network information about all child radios connected through it to the client device.

MAC Address

Unique identifier for a data radio. The MAC Address is the lower 16-bits of the serial number (also referred to as the Device Address).

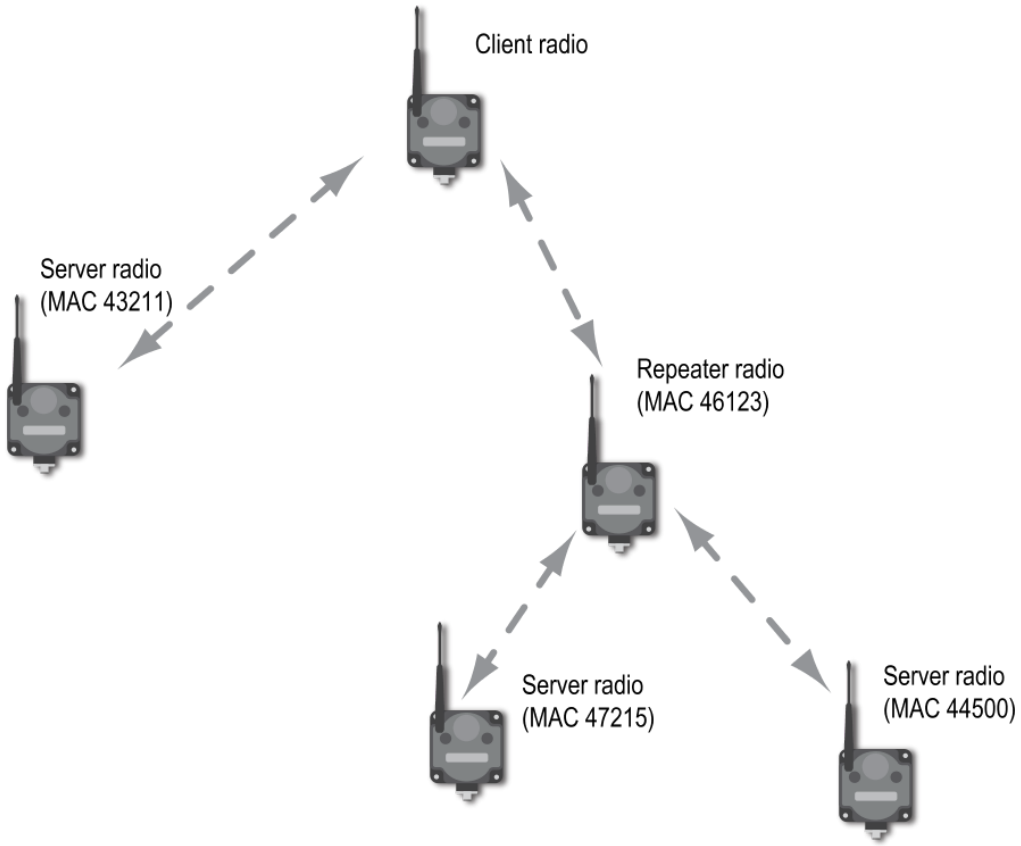
Route MAC Address

Connection information; lists the MAC Address of the first hop for a routed message from the parent. When the Route MAC Address and the MAC Address are the same, that device is directly linked to the parent device for whom the formation table is formed. (See examples below).

Route MACWhen

Defines how often this parent can communicate to the child specified by the Route MAC Address entry.

- Route MACWhen = 128. Every timing slot is available to talk to a device (there are a total of 128 communication slots).
- Route MACWhen = 4. The device is available for 4 of 128 timing slots. This setting is typically used for battery-powered devices.



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Network Formation Table for the Client			
Index	MAC Address (7002-7051)	Route MAC Address (7302-7351)	Route MACWhen (7602-7651)
1	43211	43211	128
2	44500	46123	32
3	47215	46123	32
4	46123	46123	32

Network Formation Table for the Repeater (Address 46123)			
Index	MAC Address (7002-7051)	Route MAC Address (7302-7351)	Route MACWhen (7602-7651)
1	47215	47215	4
2	44500	44500	4

Register 7001
Number of devices in the network formation table (MAC Address section)

Registers 7002–7051
Index 1 through index 50 for the MAC Address

Register 7301
Number of devices in the network formation table (Route MAC Address section)

Registers 7302–7351
Index 1 through index 50 for the device Route MAC Address

Register 7601
Number of devices in the network formation table (Route MACWhen section)

Registers 7602–7651
Index 1 through index 50 for the Route MACWhen

Register 6502
Modbus Offset. The starting Modbus ID for the wireless system is defined in the client device at register 6502. Factory default is set to 11.

Registers 6504–6553
Modbus ID to Device Address List. Register 6504 contains the MAC Address of the first wireless Modbus ID. The first wireless server ID, factory default is 11, is defined by register 6502. If register 6504 contains the MAC Address of Modbus 11, register 6505 contains the MAC Address of Modbus 12, et cetera.

The example table is shown with a starting Modbus ID of 11.

Register	Modbus ID	Device Address
6504	11	43987
6505	12	56109
6506	13	12354

Forced Routing with MultiHop Radios

The MultiHop forced routing feature allows users to define routing tree structures.

Users can define the parent radio device for some or all the server or repeater devices. As an added benefit, the sync time for the radios with forced routing decreases because the device doesn't spend time looking for multiple parent devices. Force the routing using the radio's LCD or the MultiHop Configuration Software.

RF firmware V3.1 or higher is required to enable this feature. Contact Banner Engineering to obtain the latest firmware revisions.

> **IMPORTANT:** The user must still bind all radios that communicate within the same wireless network. Forced routing only defines a parent device for a child radio (server or repeater).

Determine the Firmware Version

Use the MultiHop radio's LCD menu system to verify the radio's firmware version.

1. Press button 1 until you reach the **FCTRY** menu.
2. Press button 2 to enter the **FCTRY** menu.
   The LCD automatically displays all device information.
3. The firmware version is displayed as the **FMVER**.

Configure a Forced Routing from the Child Radio's LCD

Follow these steps to use the LCD menu system to configure force routing.

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1. Press button 1 until you reach the **DVCFG** menu (device configure menu).
2. Press button 2 to enter the **DVCFG** menu.
3. Press button 1 until the display shows **-PARNT**.
4. Press button 2.
5. Use button 1 to increment the digits and button 2 to move between digits. The first digit is always ZERO, the largest entered value will 65535.
6. Enter the parent device address (1 through 65535). Find the parent device address by viewing the LCD menu (**RUN › DADR**).
7. Press and hold down button 2 to enter the save option.
8. Select 'yes' or 'no' by using button 2 or button 1 to save the parent address.

Configure a Forced Routing using the Software

Follow these steps to use the MultiHop Configuration Software to configure force routing.

1. Use adapter cable **BWA-UCT-900** to connect a 1 Watt MultiHop radio to your computer.
2. Launch the MultiHop Configuration Software and connect to your client radio.
3. On the **Network** screen, enter the MultiHop Radio ID of the client radio and click **Read**.

   The network of repeater and server radios displays, along with the serial number, model number, and all versions. Verify the child radio you want to force a routing from has RF firmware v3.1 or higher.
4. On the **Register View › Write Registers** screen, enter the Modbus server ID (child) of the device to be force routed.
5. Enter `6368` in the **Starting Register** and enter the Parent Device Address in the **Value Register**. Click **Write registers**.
6. To verify the contents of the Read Register, enter `6368` and click **Read registers**. The route of the child should now be forced.

Remove a Forced Routing

To remove a forced routing using the child radio's LCD, follow the same procedure used to configure the forced route, but enter all zeros (0) for the **-PARNT** address.

To remove a forced routing using the MultiHop Configuration Software, follow the same procedure used to configure the forced route, but enter 00000 into Starting Register 6368. After the forced route is removed from the child radio, the network is still bound and the child radio automatically detects a path back to the client radio.

If you want to unbind the radio from the wireless network, follow these steps from the child radio:

1. Triple-click button 2 to put the device into binding mode.
2. When in binding mode, press and hold button 2 for 10 seconds. The radio automatically exits binding mode. The radio is now unbound from the network and must be re-bound to the client.

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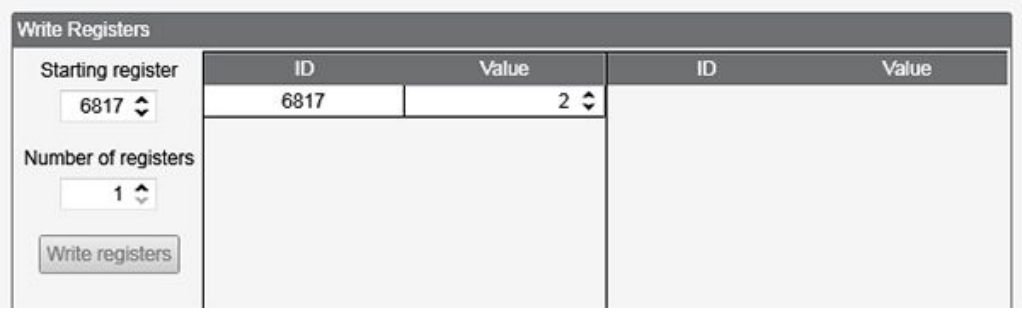
Enabling Deep Sleep Mode

Battery-powered radios can be stored in Deep Sleep mode to conserve battery power. During Deep Sleep, the radio does not communicate with or attempt to locate its parent radio and all I/O and switched power are inactive.

To enable Deep Sleep mode on a MultiHop radio, follow these steps.



1. Launch the MultiHop Configuration Software.
2. Go to the **Register View** screen.
3. Select the MultiHop device ID from the drop-down list.
4. In the **Write Register** section, enter 6817 as the **Starting register**.
5. Enter 1 as the **Number of registers**.
6. In the **Value** field, enter 2.
7. Click **Write registers**.

After enabling the ability to use Deep Sleep mode, enter Deep Sleep mode by holding down button 2 for 5 seconds. To wake the MultiHop radio from Deep Sleep mode, hold down button 2 for 5 seconds.

Creating a Synchronous Counter from a Discrete Input on a MultiHop Radio

On the MultiHop radios, a discrete input can be configured to create a totalizer counter. The counter will be a synchronous counter with a maximum sampling rate of 40 milliseconds for a 900 MHz radio or 20 milliseconds for 2.4 GHz radio.

There are three possible counter configurations:

- Count on rising edge (0 changing to a 1)
- Count on falling edge (1 changing to a 0)
- Count on both rising and falling edges

Discrete Input Counter Configuration Register Summary				
Input 1	**Input 2**	**Input 3**	**Input 4**	**Description**
43013	43033	43053	43073	Enable Sync Counter Rising edge. Set to 1 to enable, set to 0 to disable.
43014	43034	43054	43074	Enable Sync Counter Falling edge. Set to 1 to enable, set to 0 to disable.
43015, 43016	43035, 43036	43055, 43056	43075, 43076	32-bit counter value, write to preset

To count on both rising and falling edges, set both the configuration registers to 1 to enable.

The 32-bit counter results are placed in registers 43015 and 43016 for input 1. To clear or preset the counter value, write a zero value or the preset value into registers 43015 and 43016.

Cycling the power sets the counter values back to zero. The host system is responsible for saving the counter values in case of a power failure or power reset condition.

A discrete input will not count when the device is not in sync with a parent MultiHop device. To allow for counting when out of sync, set configuration register 41008 to 1 for input 1 (see the table below for other inputs).

Generic Input Configurations				
Input 1	**Input 2**	**Input 3**	**Input 4**	**Description**
41008	41058	41108	41158	Enable out-of-sync action. Set to 1 to enable, set to 0 to disable.

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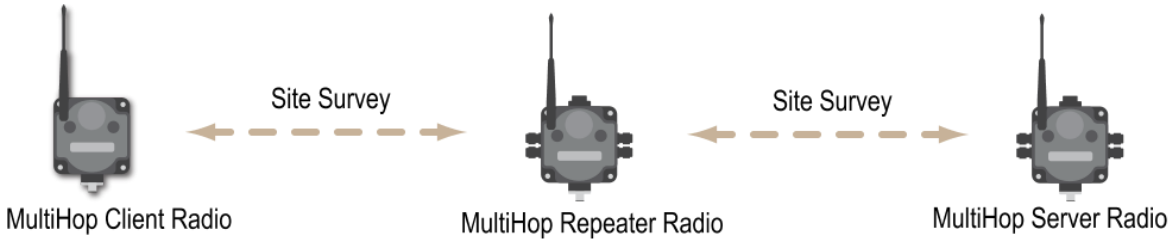
MultiHop Network Formation Tables

MultiHop Network Formation

At the root of the wireless network is the MultiHop radio client. The radio client contains the initial network routing data and the conversion data for the Modbus Address IDs. If the MultiHop radios are running in transparent mode (non-Modbus protocol), network routing information is not used and transactions are broadcast to the entire network.

As the MultiHop radios power up, all MultiHop radio repeaters or servers within range of the MultiHop radio client connect as children of the radio client, which serves as their parent. After radio repeaters synchronize to the radio client, additional radios within range of the repeater can join the network. The radios that synchronize to the repeater form the same parent/child relationship the repeater has with the radio client: the repeater is the parent and the new radios are children of the repeater.

The network formation continues to build the hierarchical structure until all MultiHop radios connect to a parent radio. A MultiHop radio can only have one designated parent radio.



After MultiHop radios are communicating with their parents, the network formation information is transmitted back to the radio client, creating a path that is stored in each parent radio's routing tables. Each parent radio stores only one link or step along a path to an end radio. The routing information for non-MultiHop Modbus server devices is stored as the devices are accessed by the host system.

Only the MultiHop radio client understands Modbus Address IDs. The conversion from Modbus Address ID to a MultiHop device address is done in the radio client as a Modbus message is received. After the Modbus Address ID to MultiHop device address conversion is determined, all network routing uses the device address, not the Modbus Address ID. A device address is similar to an Ethernet MAC address (sometimes the MultiHop device address is referred to as the MAC address).

Building MultiHop Formation Tables

As the network is formed, new device addresses are placed in the Network Formation Table in the MultiHop radio client (starting at register 47002). The new radios are stored in the order in which they synchronized to parent radios.

Register 47001 stores the number of radios in the Network Formation Table. Associated by position to the device address in the Network Formation Table is the routing data (starting at register 47302). The actual routing data is the next device address in the path to get to the end radio. The example below shows a Network Formation Table on the radio client for three radios in the network.

Register	Data	Description	Register	Data	Description
47001	03	Defines the number of radios in the network			
47002	54321	First device address in the network formation table	47302	54321	The same device address indicates that the target device is connected to this radio.
47003	12345	Second device address in the network formation table	47303	23456	A different device address indicates the first step in the route is going to device 23456.
47004	23456	Final device address in the network	47304	23456	Link indicates the device is connected to this parent radio.

Register 47302 is associated to register 47002 by its position in the table. Therefore, the link for the device address stored at register 47002 is stored in register 47302.

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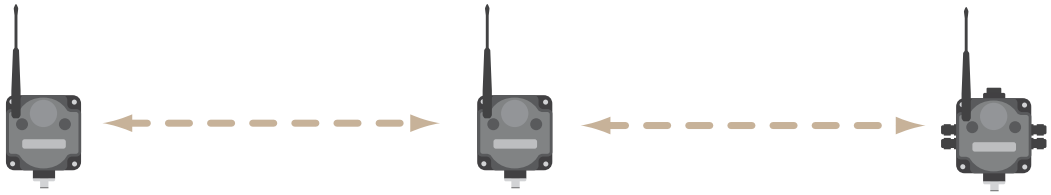

Client Radio, MultiHop ID 11
Address 54321

Repeater, MultiHop ID 14
Address 23456

Server, MultiHop ID 15
Address 12345

Correlating Device Address to Modbus Address IDs

The Modbus Address ID table defines the association from a Modbus Address ID to the MultiHop device address. (The Modbus Address ID for a MultiHop radio is usually defined by the rotary switches whereas the device address is a 5-digit number assigned by the factory.)

Register 46502 defines the Modbus Address ID offset for wireless Modbus servers. An ‘11’ in this register would mean that wireless Modbus server devices start at ID 11. Any messages referring to Modbus IDs 1 through 10 are ignored by the wireless devices.

Registers 46504 through 46604 store the MultiHop device addresses in order, starting with the Modbus ID defined by the offset register (46502). In the example below Modbus IDs 11, 14, and 15 are in the table. Register 46503 defines the maximum number of Modbus server for this system.

Register	MultiHop ID	Data	Description
46502		11	Wireless Modbus IDs start at 11
46503		50	The number of Modbus servers defined for the system
46504	11	54321	MultiHop device address 54321 is Modbus ID 11
46505	12	65535	Modbus ID 12 is not used
46506	13	65535	Modbus ID 13 is not used
46507	14	23456	Device address 23456 is Modbus ID 14
46508	15	12345	Device address 12345 is Modbus ID 15

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Set the MultiHop Baud Rate to 1200

The standard baud rate settings for the serial interface are 9600, 19200, and 38400. These are typically selected using the DIP switch settings on the MultiHop radio. A 1200 baud rate was implemented in firmware 1.3H and later.

To select a 1200 baud rate using the MultiHop Configuration Software, select the baud rate from the drop-down list. All other parameters are automatically changed to their appropriate value.

To select a 1200 baud rate by writing to Modbus registers, follow these steps:

1. Verify you have MultiHop firmware version 1.3H or later.
2. Set the DIP switches to select the custom baud rate.
   For most MultiHop radio models, the custom baud rate is selected using DIP switches 1 and 2.
3. Write Modbus register 46101 with 0x04 to select the baud rate timing for 1200 baud.
4. Write Modbus register 46105 with 0xFF (255) to select the maximum End-of-Message time value.
5. Write Modbus register 46109 with 1 to adjust the End-of-Message timeout when running this slow baud rate.
6. Cycle power on the device.

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Set the MultiHop Baud Rate to 2400

The standard baud rate settings for the serial interface are 9600, 19200, and 38400. These are typically selected using the DIP switch settings on the MultiHop radio. A 2400 baud rate was implemented in firmware 1.3H and later.

To select a 2400 baud rate using the MultiHop Configuration Software, select the baud rate from the drop-down list. All other parameters are automatically changed to their appropriate value.

To select a 2400 baud rate by writing to Modbus registers, follow these steps:

1. Verify you have MultiHop firmware version 1.3H or later.
2. Set the DIP switches to select the custom baud rate.
   For most MultiHop radio models, the custom baud rate is selected using DIP switches 1 and 2.
3. Write Modbus register 46101 with 0x0B to select the baud rate timing for 2400 baud.
4. Write Modbus register 46109 with 1 to adjust the End-of-Message timeout when running this slow baud rate.
5. Cycle power on the device.

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