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1 Input and Output Registers

<table>
<thead>
<tr>
<th>Inputs (4xxxx)</th>
<th>Outputs (4xxxx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register</td>
<td>Input #</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
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<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
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<tr>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

1.1 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](http://www.modbus.org).

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>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.</td>
</tr>
<tr>
<td>6</td>
<td>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.</td>
</tr>
<tr>
<td>16</td>
<td>Writes a block of contiguous holding registers in a remote device. The requested written values are specified in the request data field.</td>
</tr>
</tbody>
</table>
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 slave 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 Manual (p/n 151317).

2.1 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.

2.2 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.

2.2.1 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.

2.3 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.
2.4 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Inputs (4xxxx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>1001</td>
</tr>
<tr>
<td>1002</td>
</tr>
<tr>
<td>1003</td>
</tr>
<tr>
<td>1008</td>
</tr>
</tbody>
</table>

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 master radio. Set to zero (0) to disable the input when the device is not synchronized to the master radio. The default value is one (1).

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.

2.4.1 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Inputs (4xxxx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>1004</td>
</tr>
<tr>
<td>1005</td>
</tr>
<tr>
<td>1006</td>
</tr>
<tr>
<td>1007</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Output Voltage</th>
<th>Parameter Value</th>
<th>Output Voltage</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 V</td>
<td>255</td>
<td>15 V</td>
<td>32</td>
</tr>
<tr>
<td>5 V</td>
<td>204</td>
<td>20 V</td>
<td>12</td>
</tr>
<tr>
<td>7 V</td>
<td>125</td>
<td>24 V</td>
<td>03</td>
</tr>
<tr>
<td>10 V</td>
<td>69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

2.5 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Outputs (4xxxx)</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9  1001 2051 2101 2151 2201 2251 2301 2351 2401 Enable</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5 6 7 8 9  2002 2052 2102 2152 2202 2252 2302 2352 2402 Flash Output Enable</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5 6 7 8 9  2003 2053 2103 2153 2203 2253 2303 2353 2403 Flash Index</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5 6 7 8 9  2004 2054 2104 2154 2204 2254 2304 2354 2404 Out of Sync Enable</td>
<td></td>
</tr>
</tbody>
</table>

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 master radio. Set to zero (0) to disable the output when the device is not synchronized to the master radio. The default value is one (1).

2.6 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 I/O 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.

2.7 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Discrete Inputs (4xxxx)</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN 1</td>
<td>IN 2</td>
</tr>
<tr>
<td>3001</td>
<td>3021</td>
</tr>
<tr>
<td>3002</td>
<td>3022</td>
</tr>
<tr>
<td>3003</td>
<td>3023</td>
</tr>
<tr>
<td>3004</td>
<td>3024</td>
</tr>
<tr>
<td>3007</td>
<td>3027</td>
</tr>
<tr>
<td>3008</td>
<td>3028</td>
</tr>
<tr>
<td>3009</td>
<td>3029</td>
</tr>
<tr>
<td>3013</td>
<td>3033</td>
</tr>
<tr>
<td>3014</td>
<td>3034</td>
</tr>
<tr>
<td>3015-3016</td>
<td>3035-3036</td>
</tr>
</tbody>
</table>
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 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.

<table>
<thead>
<tr>
<th>Out of Sync Actions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN 1</td>
<td>IN 2</td>
</tr>
<tr>
<td>IN 3</td>
<td>IN 4</td>
</tr>
<tr>
<td>1008</td>
<td>1058</td>
</tr>
<tr>
<td>1108</td>
<td>1158</td>
</tr>
<tr>
<td>Enable out-of-sync action. Set to 1 to enable, set to 0 to disable.</td>
<td></td>
</tr>
</tbody>
</table>

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 master radio) on Change of State.

Enable Falling Edge
Enables the sync counter falling edge. Set to one (1) to enable, set to zero (0) to disable.

Enable Rising Edge
Enables the sync counter rising edge. Set to one (1) to enable, set to zero (0) to disable. To count on both rising and falling edges, set both the configuration registers to one (1) to enable.

PNP or NPN
Set to one (1) to define the input as a PNP (sourcing) input. Set to zero (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.

2.8 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.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>IN 1 (3301-3320)</th>
<th>IN 2 (3321-3340)</th>
<th>IN 3 (3341-3360)</th>
<th>IN 4 (3361-3380)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Analog Value</td>
<td>3301</td>
<td>3321</td>
<td>3341</td>
<td>3361</td>
</tr>
<tr>
<td>Minimum Analog Value</td>
<td>3302</td>
<td>3322</td>
<td>3342</td>
<td>3362</td>
</tr>
<tr>
<td>Enable Register Full Scale</td>
<td>3303</td>
<td>3323</td>
<td>3343</td>
<td>3363</td>
</tr>
<tr>
<td>Temperature Degrees C/F</td>
<td>3304</td>
<td>3324</td>
<td>3344</td>
<td>3364</td>
</tr>
<tr>
<td>Temperature Scaling</td>
<td>3305</td>
<td>3325</td>
<td>3345</td>
<td>3365</td>
</tr>
<tr>
<td>Thermocouple Type</td>
<td>3306</td>
<td>3326</td>
<td>3346</td>
<td>3366</td>
</tr>
</tbody>
</table>
### Registers for Analog Parameters (4xxxx)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Temperature Resolution</th>
<th>Threshold</th>
<th>Hysteresis</th>
<th>Delta</th>
<th>Sample High</th>
<th>Sample Low</th>
<th>Change of State Push Enable</th>
<th>Median Filter Enable</th>
<th>Tau Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN 1 (3301-3320)</td>
<td>3307</td>
<td>3327</td>
<td>3347</td>
<td>3367</td>
<td>3308</td>
<td>3328</td>
<td>3348</td>
<td>3368</td>
<td>3309</td>
</tr>
<tr>
<td>IN 2 (3321-3340)</td>
<td>3310</td>
<td>3330</td>
<td>3350</td>
<td>3370</td>
<td>3311</td>
<td>3331</td>
<td>3351</td>
<td>3371</td>
<td>3312</td>
</tr>
<tr>
<td>IN 3 (3341-3360)</td>
<td>3313</td>
<td>3333</td>
<td>3353</td>
<td>3373</td>
<td>3314</td>
<td>3334</td>
<td>3354</td>
<td>3374</td>
<td>3315</td>
</tr>
<tr>
<td>IN 4 (3361-3380)</td>
<td>3316</td>
<td>3336</td>
<td>3356</td>
<td>3376</td>
<td>3317</td>
<td>3337</td>
<td>3357</td>
<td>3377</td>
<td>3318</td>
</tr>
</tbody>
</table>

#### 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 master 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 4 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. Setting a threshold establishes an ON point. 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.)

**2.8 Temperature Parameters**

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

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

**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 x 20) represent temperature. Set to 0 (default) to store temperature values in tenths of a degree (measured temp x 10).

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

**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).

<table>
<thead>
<tr>
<th>Value</th>
<th>Thermocouple Type</th>
<th>Value</th>
<th>Thermocouple Type</th>
<th>Value</th>
<th>Thermocouple Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>B</td>
<td>5</td>
<td>J</td>
<td>10</td>
<td>P</td>
</tr>
<tr>
<td>1</td>
<td>C</td>
<td>6</td>
<td>K</td>
<td>11</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>7</td>
<td>L</td>
<td>12</td>
<td>S</td>
</tr>
<tr>
<td>3</td>
<td>E</td>
<td>8</td>
<td>M</td>
<td>13</td>
<td>T</td>
</tr>
<tr>
<td>4</td>
<td>G</td>
<td>9</td>
<td>N</td>
<td>14</td>
<td>U</td>
</tr>
</tbody>
</table>
2.9 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Counter Inputs (4xxxx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN 1 Parameters</td>
</tr>
<tr>
<td>3501 Enable Frequency/Event Counter</td>
</tr>
<tr>
<td>3502 Enable Read Counter State</td>
</tr>
<tr>
<td>3503 Set Preset Value</td>
</tr>
<tr>
<td>3504 Counter Preset Value</td>
</tr>
<tr>
<td>3505 Counter Preset Value</td>
</tr>
</tbody>
</table>

**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.

2.10 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.

<table>
<thead>
<tr>
<th>Parameter Registers for H-Bridge Outputs (4xxxx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-Bridge 1 Parameters</td>
</tr>
<tr>
<td>3604 Enable H-Bridge</td>
</tr>
<tr>
<td>3605 H-Bridge Warmup Cap Time</td>
</tr>
<tr>
<td>3606 H-Bridge Active Current Time</td>
</tr>
<tr>
<td>3607 H-Bridge Switches</td>
</tr>
<tr>
<td>3608 H-Bridge Switches</td>
</tr>
<tr>
<td>3609 H-Bridge Booster Enabled When Active</td>
</tr>
</tbody>
</table>

**Enable H-Bridge**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DO4</th>
<th>DO3</th>
<th>DO2</th>
<th>DO1</th>
<th>SP4</th>
<th>SP3</th>
<th>SP2</th>
<th>SP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3607 Rising Switch (ON)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3608 Falling Switch (OFF)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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.

2.10.1 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 requiring 5, 10, or 15 V power (e.g. 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 (4xxx) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| 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.

<table>
<thead>
<tr>
<th>Output Voltage</th>
<th>Parameter Value</th>
<th>Output Voltage</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 V</td>
<td>255</td>
<td>15 V</td>
<td>32</td>
</tr>
<tr>
<td>5 V</td>
<td>204</td>
<td>20 V</td>
<td>12</td>
</tr>
<tr>
<td>7 V</td>
<td>125</td>
<td>24 V</td>
<td>03</td>
</tr>
<tr>
<td>10 V</td>
<td>69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

2.11 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Discrete Outputs (4xxxx)</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT 1</td>
<td>OUT 2</td>
</tr>
<tr>
<td>3701</td>
<td>3721</td>
</tr>
<tr>
<td>3702</td>
<td>3722</td>
</tr>
<tr>
<td>3703</td>
<td>3723</td>
</tr>
</tbody>
</table>

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.

2.12 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.

<table>
<thead>
<tr>
<th>Parameter Registers for Analog Outputs (4xxxx)</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT 1</td>
<td>OUT 2</td>
</tr>
<tr>
<td>4001</td>
<td>4021</td>
</tr>
<tr>
<td>4002</td>
<td>4022</td>
</tr>
<tr>
<td>4003</td>
<td>4023</td>
</tr>
<tr>
<td>4004</td>
<td>4024</td>
</tr>
<tr>
<td>4005</td>
<td>4025</td>
</tr>
</tbody>
</table>

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 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.

2.13 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.

2.14 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.

2.15 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 amount of fluctuation between readings. Write the following values to select a low pass (tau) filter.

<table>
<thead>
<tr>
<th>Low Pass (Tau) Filter</th>
<th>Register Value</th>
<th>Low Pass (Tau) Filter</th>
<th>Register Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>0</td>
<td>T4</td>
<td>4</td>
</tr>
<tr>
<td>T1</td>
<td>1</td>
<td>T5</td>
<td>5</td>
</tr>
<tr>
<td>T2</td>
<td>2</td>
<td>T6</td>
<td>6</td>
</tr>
<tr>
<td>T3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 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.

4521 Baseline Difference Signal Value Total

A combination of the x-, y-, and z-axis baseline different signal values.
2.16 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 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 4 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. Setting a threshold establishes an ON point. 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.

![Graph showing threshold and hysteresis](image)

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 master 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.

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.

<table>
<thead>
<tr>
<th>Low Pass (Tau) Filter</th>
<th>Register Value</th>
<th>Low Pass (Tau) Filter</th>
<th>Register Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>0</td>
<td>T4</td>
<td>4</td>
</tr>
<tr>
<td>T1</td>
<td>1</td>
<td>T5</td>
<td>5</td>
</tr>
<tr>
<td>T2</td>
<td>2</td>
<td>T6</td>
<td>6</td>
</tr>
<tr>
<td>T3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 as if it is below the threshold.
If cleared, an alarm is treated as 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).

2.17 Configuration Examples

2.17.1 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.

<table>
<thead>
<tr>
<th>Modbus Register</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1202</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1203</td>
<td>22,500</td>
<td>This register contains the number of 40 ms time units. 900 seconds ÷ 0.040 seconds = 22,500</td>
</tr>
<tr>
<td>1204</td>
<td>4</td>
<td>Enable switch power 3 for this input, see parameter description for bit mask.</td>
</tr>
<tr>
<td>1205</td>
<td>25</td>
<td>Set warm-up time to 1 second, the register contains the number of 40 ms time units. 1 seconds ÷ 0.040 seconds = 25</td>
</tr>
<tr>
<td>1206</td>
<td>32</td>
<td>Set switch power voltage to 15 V. Value from table next to parameter description.</td>
</tr>
</tbody>
</table>
2.17.2 Configuring for Acclima SDI-12 Sensors

Table 1: Acclima SDI-12 Parameter Registers

<table>
<thead>
<tr>
<th>SDI-12 Device Register (Acclima)</th>
<th>Register Enable (1)</th>
<th>Decimal Point Move (0-7)</th>
<th>Move Right (0) or Left (1)</th>
<th>Signed (1) or Unsigned (0)</th>
<th>16 bit (0) or 32 bit (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Volumetric water content</td>
<td>ON</td>
<td>2</td>
<td>Left</td>
<td>Unsigned</td>
<td>32 bit</td>
</tr>
<tr>
<td>2 Temperature</td>
<td>ON</td>
<td>1</td>
<td>Left</td>
<td>Signed</td>
<td>32 bit</td>
</tr>
<tr>
<td>3 Soil Permittivity</td>
<td>ON</td>
<td>2</td>
<td>Left</td>
<td>Unsigned</td>
<td>32 bit</td>
</tr>
<tr>
<td>4 Soil Conductivity</td>
<td>ON</td>
<td>2</td>
<td>Left</td>
<td>Unsigned</td>
<td>32 bit</td>
</tr>
</tbody>
</table>

Table 2: Acclima SDI-12 Results Registers

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

2.17.3 Configuring for Decagon 5T3 SDI-12 Sensors

Table 3: Decagon SDI-12 Parameter Registers

<table>
<thead>
<tr>
<th>SDI-12 Device Register (Decagon 5T3)</th>
<th>Register Enable (1)</th>
<th>Decimal Point Move (0-7)</th>
<th>Move Right (0) or Left (1)</th>
<th>Signed (1) or Unsigned (0)</th>
<th>16 bit (0) or 32 bit (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Volumetric water content</td>
<td>ON</td>
<td>2</td>
<td>Left</td>
<td>Unsigned</td>
<td>32 bit</td>
</tr>
<tr>
<td>2 Soil Conductivity</td>
<td>ON</td>
<td>2</td>
<td>Left</td>
<td>Unsigned</td>
<td>32 bit</td>
</tr>
<tr>
<td>3 Temperature</td>
<td>ON</td>
<td>1</td>
<td>Left</td>
<td>Signed</td>
<td>32 bit</td>
</tr>
</tbody>
</table>

Table 4: Decagon SDI-12 Results Registers

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

2.18 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.

2.18 04100s Manufacturing Information

<table>
<thead>
<tr>
<th>Address (4xxxx)</th>
<th>Name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>4101–4104</td>
<td>Serial number, digits 1–8</td>
<td>ASCII, read only</td>
</tr>
<tr>
<td>4111–4113</td>
<td>Model number, digits 1–6</td>
<td>ASCII, read only</td>
</tr>
</tbody>
</table>
### 2.18 04200s Device Name

<table>
<thead>
<tr>
<th>Address (4xxxx)</th>
<th>Name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>4201–4209</td>
<td>Name characters 1-18</td>
<td>ASCII</td>
</tr>
</tbody>
</table>

### 2.18 04300s Software Information

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

### 2.18 06400s Message Parameters

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.

<table>
<thead>
<tr>
<th>Address (4xxxx)</th>
<th>Name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>6401</td>
<td>Device address</td>
<td>Hex</td>
</tr>
<tr>
<td>6402</td>
<td>Parent address</td>
<td>Hex, read only</td>
</tr>
</tbody>
</table>

### Storing a Model Number

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

<table>
<thead>
<tr>
<th>Address (4xxxx)</th>
<th>Name</th>
<th>Modbus Register Value (in hex)</th>
<th>Character Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4111</td>
<td>Model number digits 6-5</td>
<td>0x3139</td>
<td>1 9</td>
</tr>
<tr>
<td>4112</td>
<td>Model number digits 4-3</td>
<td>0x3638</td>
<td>6 8</td>
</tr>
<tr>
<td>4113</td>
<td>Model number digits 2-1</td>
<td>0x3431</td>
<td>4 1</td>
</tr>
</tbody>
</table>

### 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.

<table>
<thead>
<tr>
<th>Address (4xxxx)</th>
<th>Name</th>
<th>Value (in hex)</th>
<th>Value (decimal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6401</td>
<td>Device address</td>
<td>0x002A</td>
<td>42</td>
</tr>
</tbody>
</table>
2.19 Device and System Parameters

2.19.1 06000s Device Parameters

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

2.19.2 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.

2.19.3 06360s Network System Binding

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

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

2.19.4 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 Master Device Address
Stores the Device Address of the network’s master 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.

2.19.5 06500s and 06800s Application Modes

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

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

6504 Modbus Slave Destination Address Index 1, 6505 Modbus Slave Destination Address Index 2, through 6553 Modbus Slave Destination Address Index 50
These registers act as the translation table between the Modbus Slave ID (set by the rotary dials) and the Device Address (5-digit address derived from the serial number) of all Modbus slaves 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 slave in the network. This is Slave 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 master radio. The master radio can determine if a device is in the radio network. If a device has dropped out of the network, the master 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 Slave ID as selected by the rotary dials. This register is populated automatically by the rotary dials.

6831 Input Push Register Index 1, 6832 Input Push Register Index 2, etc
A total of 20 push register indices are available (up through 6850). For a slave or repeater, these define which registers to push to the master device. This allows a slave/repeater to send local input data back to the master without having to wait to be asked for the data.
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.

6871-6872 Push Register Report Interval
Establishes how often, in frames/slots, to push data to the master. Select values between 1 and $4.2 \times 10^2$ (1 to $FFFFF$). 6871 is the high word and 6872 is the low word. This is typically a slave or repeater parameter.

6873-6874 Health Heartbeat Time
The Health Heartbeat Time parameter works in conjunction with each slave/repeater push interval time (6871–6872) to create device status information in the master device. This allows the user to monitor the health of each device in the MultiHop network.

For example, if each slave/repeater push interval time is set to 60 seconds, the master Health Heartbeat Time should be set to a value two to three times greater (120 to 180 seconds). Every 180 second interval, the master device verifies a push message is received from each device. If a message is received, the status is good (1). If no message is received, the status is bad (0).

The Health Heartbeat Time register value is defined in MultiHop frames. The factory default for one frame is 40 ms. A value of 4500 in the 6874 is equal to 180 seconds (4500 × 0.040 seconds).

Read the individual status registers for each Modbus slave device by sending a Modbus read command to the particular slave device at register 7904. For example, to read the status register of slave 24, send a Modbus read command to slave ID 24 register address 7904, the contents will be either 0 (bad) or 1 (good).

A bit-packed version of the status data is available starting at register 12981. The master 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 master device. That ordered list is stored starting at Modbus registers 7001 in the master 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 master radio.

6875 Report Interval Random Modulus
The interval, in frames, that the report interval is offset by. This randomizes the reporting interval time so that devices set to the same report interval do not continuously collide when reporting push data.

2.19.6 07000s Network Formation
Used by the Master radio only, the Network Formation parameter values are populated as slaves 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.
2.19.7 07900s Master as a Slave 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 slave ID but with registers 7909 and 7910. The master 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 slave listed in register 7901.
3 Technical Notes

3.1 Network Information Registers

The Master 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 master 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.
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 Slave ID for the wireless system is defined in the master device at register 6502. Factory default is set to 11.

Registers 6504–6553

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

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

<table>
<thead>
<tr>
<th>Register</th>
<th>Slave ID</th>
<th>Device Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>6504</td>
<td>11</td>
<td>43987</td>
</tr>
<tr>
<td>6505</td>
<td>12</td>
<td>56109</td>
</tr>
<tr>
<td>6506</td>
<td>13</td>
<td>12354</td>
</tr>
</tbody>
</table>

3.2 Forced Routing with MultiHop Radios

Use the MultiHop forced route feature to create user-defined routing tree structures.

Users can define the parent radio device for some or all the slave 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. Forced Routing can be accomplished either through the radio’s LCD or by using the MultiHop Configuration Tool (MHCT). RF firmware V3.1 or higher is required to enable this feature. Contact Banner Engineering to obtain the latest Firmware Revisions.
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 (slave or repeater).

3.2.1 Determine the Firmware Version of a MultiHop Radio

Follow these steps to 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 display automatically displays all device information.
3. The firmware version is displayed as the FMVER.

3.2.2 Configure a Forced Routing from the Child Radio’s LCD

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

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 be 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.

3.2.3 Configure a Forced Routing using the MultiHop Configuration Tool (MHCT)

Follow these steps to use the MultiHop Configuration Tool 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 Tool and connect to your master radio.
3. On the Network screen, enter the MultiHop Radio ID of the master radio and click Read. The network of repeater and slave 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 Slave 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.
6. To verify the contents of the Read Register, enter 6368 and click Submit. The route of the child should now be forced.

3.2.4 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 Tool (MHCT), 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 master 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 Master.

3.3 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 Tool.
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.

3.4 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

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
<th>Input 3</th>
<th>Input 4</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>43013</td>
<td>43033</td>
<td>43053</td>
<td>43073</td>
<td>Enable Sync Counter Rising edge. Set to 1 to enable, set to 0 to disable.</td>
</tr>
<tr>
<td>43014</td>
<td>43034</td>
<td>43054</td>
<td>43074</td>
<td>Enable Sync Counter Falling edge. Set to 1 to enable, set to 0 to disable.</td>
</tr>
<tr>
<td>43015, 43016</td>
<td>43035, 43036</td>
<td>43055, 43056</td>
<td>43075, 43076</td>
<td>32-bit counter value, write to preset</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
<th>Input 3</th>
<th>Input 4</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>41008</td>
<td>41058</td>
<td>41108</td>
<td>41158</td>
<td>Enable out-of-sync action. Set to 1 to enable, set to 0 to disable.</td>
</tr>
</tbody>
</table>

3.5 MultiHop Network Formation Tables
3.5.1 MultiHop Network Formation

At the root of the wireless network is the MultiHop radio master. The radio master contains the initial network routing data and the translation 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 slaves within range of the MultiHop radio master connect as children of the radio master, which serves as their parent. After radio repeaters synchronize to the radio master, 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 master; 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 to their parents, the network formation information is transmitted back to the radio master, 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 slave devices is stored as the devices are accessed by the host system.

Only the MultiHop radio master understands Modbus Address IDs. The conversion from Modbus Address ID to a MultiHop device address is done in the radio master 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).

3.5.2 Building MultiHop Formation Tables

As the network is formed, new device addresses are placed in the Network Formation Table in the MultiHop radio master (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 master for three radios in the network.

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

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.
3.5.3 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 Slaves. An '11’ in this register would mean that wireless Modbus Slave devices start at Address ID 11. Any messages referring to Modbus Slaves 1 through 10 will be ignored by the wireless devices.

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

<table>
<thead>
<tr>
<th>Register</th>
<th>MultiHop ID</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>46502</td>
<td></td>
<td>11</td>
<td>Wireless Modbus Slave IDs start at 11</td>
</tr>
<tr>
<td>46503</td>
<td></td>
<td>50</td>
<td>The number of Modbus Slaves defined for the system</td>
</tr>
<tr>
<td>46504</td>
<td>11</td>
<td>54321</td>
<td>MultiHop device address 54321 is Modbus Slave ID 11</td>
</tr>
<tr>
<td>46505</td>
<td>12</td>
<td>65535</td>
<td>Modbus slave ID 12 is not used</td>
</tr>
<tr>
<td>46506</td>
<td>13</td>
<td>65535</td>
<td>Modbus slave ID 13 is not used</td>
</tr>
<tr>
<td>46507</td>
<td>14</td>
<td>23456</td>
<td>Device address 23456 is Modbus Slave ID 14</td>
</tr>
<tr>
<td>46508</td>
<td>15</td>
<td>12345</td>
<td>Device address 12345 is Modbus Slave ID 15</td>
</tr>
</tbody>
</table>

3.6 Setting 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 Tool, 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 DIP switches 1 and 2 to ON.
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.

3.7 Setting 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 Tool, 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 DIP switches 1 and 2 to ON.
   - Setting DIP switches 1 and 2 to ON selects the “custom” baud rate.
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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