

SDI-12 and the Sentek Enviroscan Soil Moisture Probe



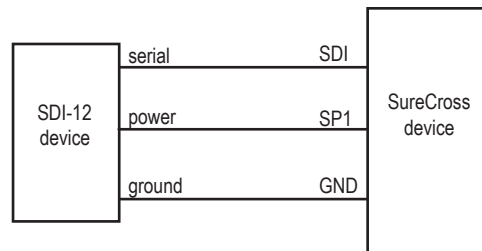
Technical Note

DX80DRM-H12 MultiHop Series SDI-12 Enabled Radio

Use the manufacturer's cable to connect the SDI-12 sensor to the computer. Use the manufacturer's software to change the sensor's SDI-12 address. Most manufacturers ship their sensor/probe units with an address of 0. The DX80DR9M-H12 radios are, by default, set to communicate with SDI-12 address 1 because address 0 is reserved as a broadcast method. Reference the sensor's instruction manual to determine how to read your sensor/probe address, adjust it, and determine readings.

Sensor Wiring

DC+ = Vin (SP1)
DC- = Gnd (GND)
Data = SDI-12 Data (SDI)



Configuring the Banner DX80DR9M-H12 with SDI-12 Protocol

The DX80DR9M-H12 MultiHop radio ships from the factory with the noted default register values. This allows you to connect one SDI-12 probe to the radio (refer to the radio's datasheet for the complete wiring of the sensor/probe). The radio queries the sensor/probe based on its default parameters. The radio can communicate with up to five probes (only one SDI-12 command per probe) or a combination of single/multiple probes (with multiple SDI-12 commands). Although the radio can communicate with up to five devices or provide five commands to a single or multiple devices (such as the xM!), by default the radio communicates with only one SDI-12 address or generates one M! command. Change the number of devices or commands enabled by modifying the "Enabling SDI-12 Section" in the registers list below.

For each of the five probes or five commands, there are up to twenty-four results registers (each result register has two 16-bit registers for a total potential number of registers of 24). Only results registers 1 through 9 are enabled since Mx! commands only support nine results. When using the DXM150 Controller, use the 32-bit floating point local registers as the destination for the radio's results. The 32-bit floating point local registers in the DXM150 controller range from 1001 to 1499.

Example — Five Sentek EnviroScan Probes to One Radio

To connect up to five probes, each reporting back the full capability of the probe, set the values in the enabling registers to M! (verify this with the probe manufacturer's documentation). Modify the addresses of the probes to represent SDI-12 addresses 1 through 5.

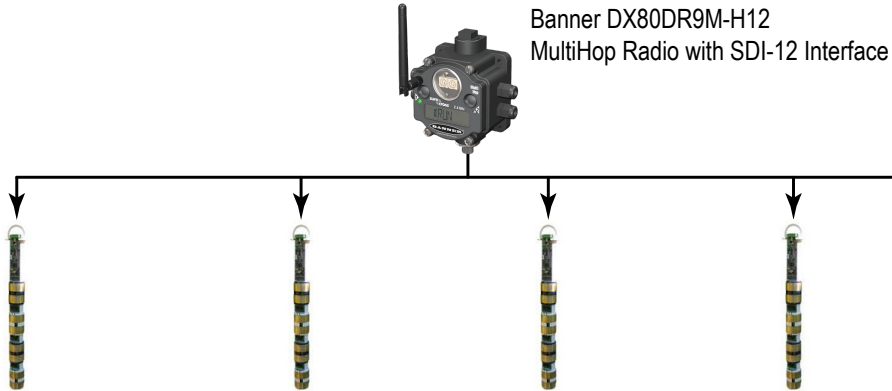


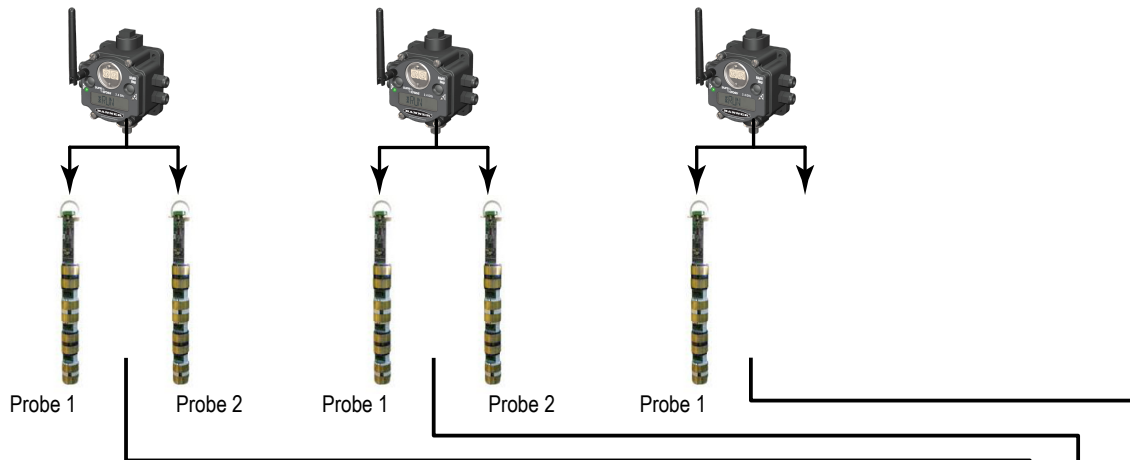
Table 1: Example of multiple probes (Using M! Command) - Example Results

Probe Address	Command			Results Registers											
	Mx! or Cx!	Definition	Probe #x, Sensor #	1	2	3	4	5	6	7	8	9	10	11	12
1	M!	Soil Moisture	#1, 1-5	1	1.1234	0.02	0.1234	0	-	-	-	-	-	-	-
2	M!	Soil Moisture	#2, 1-5	1	1.1234	0.02	0.1234	0	-	-	-	-	-	-	-
3	M!	Soil Moisture	#3, 1-5	24.994	24.528	24.98	24.5238	25.0956	-	-	-	-	-	-	-
4	M!	Soil Moisture	#4, 1-5	24.994	24.528	24.98	24.5238	25.0956	-	-	-	-	-	-	-
5	M!	Soil Moisture	#5, 1-5	24.994	24.528	24.98	24.5238	25.0956	-	-	-	-	-	-	-

The DX80DR9M-H12 can poll each of the five probes with the aM! command. The M-H12 can measure up to 12 soil moisture points per probe. With this arrangement, you cannot request more data using additional aM! commands because all the SDI-12 addresses or command registers are used.

Example — Five Sentek EnviroScan Probes to Three Radios

When both soil moisture and temperature data is required from each of the five probes, you must use more than one M-H12 radio. Modify the default settings to acknowledge the addresses of the probes and to make the proper commands.



Example of multiple probes with 6 Sensors (Using M! Commands) - Example Results

SDI-12 Probe Address	Command (M! or Cx!)	Command Definition	Probe #, Sensor #	Results Register #1	Results Register #2	Results Register #3	Results Register #4	Results Register #5	Results Register #6	Results Register #7	Results Register #8	Results Register #9	Results Register #10	Results Register #11	Results Register #12
1	M!	Soil Moisture	#1, 1-9	001.0000	001.1234	000.0200	000.1234	000.0000	-	-	-	-	-	-	-
1	M!1	Temperature	#1, 1-9	001.0000	001.1234	000.0200	000.1234	000.0000	-	-	-	-	-	-	-
2	M!	Soil Moisture	#2, 1-9	24.99402	24.52802	24.97996	24.52375	25.09555	-	-	-	-	-	-	-
2	M!1	Temperature	#2, 1-9	24.99402	24.52802	24.97996	24.52375	25.09555	-	-	-	-	-	-	-

Example of multiple probes with 6 Sensors (Using M! Commands) - Example Results

SDI-12 Probe Address	Command (M! or Cx!)	Command Definition	Probe #, Sensor #	Results Register #1	Results Register #2	Results Register #3	Results Register #4	Results Register #5	Results Register #6	Results Register #7	Results Register #8	Results Register #9	Results Register #10	Results Register #11	Results Register #12
1	M!	Soil Moisture	#1, 1-9	001.0000	001.1234	000.0200	000.1234	000.0000	-	-	-	-	-	-	-
1	M!1	Temperature	#1, 1-9	001.0000	001.1234	000.0200	000.1234	000.0000	-	-	-	-	-	-	-
2	M!	Soil Moisture	#2, 1-9	24.99402	24.52802	24.97996	24.52375	25.09555	-	-	-	-	-	-	-
2	M!1	Temperature	#2, 1-9	24.99402	24.52802	24.97996	24.52375	25.09555	-	-	-	-	-	-	-

Example of multiple probes with 6 Sensors (Using M! Commands) - Example Results

SDI-12 Probe Address	Command (M! or Cx!)	Command Definition	Probe #, Sensor #	Results Register #1	Results Register #2	Results Register #3	Results Register #4	Results Register #5	Results Register #6	Results Register #7	Results Register #8	Results Register #9	Results Register #10	Results Register #11	Results Register #12
1	M!	Soil Moisture	#1, 1-9	001.0000	001.1234	000.0200	000.1234	000.0000	-	-	-	-	-	-	-
1	M!1	Temperature	#1, 1-9	001.0000	001.1234	000.0200	000.1234	000.0000	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The DX80DR9M-H12 radio can poll each of the five probes with the aM! and aM! command. The data radios can store up to 12 soil moisture points or temperature points per probe. In this arrangement, use additional M-H12 radios to gather the results from the probes because the number of SDI-12 address and/or commands is too many for a single data radio to store.

Example — One Sentek EnviroScan Probe to One Radios

Using a single Sentek EnviroScan probe connected to a single MultiHop radio, the probe reports back soil moisture, salinity, temperature, and humidity readings using the aM!, aM2!, aM4!, and aM6! commands.



Probe Address	Command			Results Registers											
	Mx! or Cx!	Definition	Probe #x, Sensor #	1	2	3	4	5	6	7	8	9	10	11	12
1	M!	Soil Moisture	#1, 1-5	1	1.1234	0.02	0.1234	0	-	-	-	-	-	-	-
1	M2!	Salinity	#1, 1-5	1	1.1234	0.02	0.1234	0	-	-	-	-	-	-	-
1	M4!	Temperature	#1, 1-5	1	1.1234	0.02	0.1234	0	-	-	-	-	-	-	-
1	M6!	Humidity	#1, 1-5	1	1.1234	0.02	0.1234	0	-	-	-	-	-	-	-

The DX80DR9M-H12 can poll each of the five probes with the aM! command. The M-H12 can measure up to 12 soil moisture points per probe. With this arrangement, you cannot request more data using additional aM! commands because all the SDI-12 addresses or command registers are used.

The DXM Configurator Tool Register View screen list the results registers for the probe. In the example probe, there are five sensors and each sensor has two registers in the DX80DR9M-H12 (the results register list is referenced later in this document). The values represented are in floating point format.

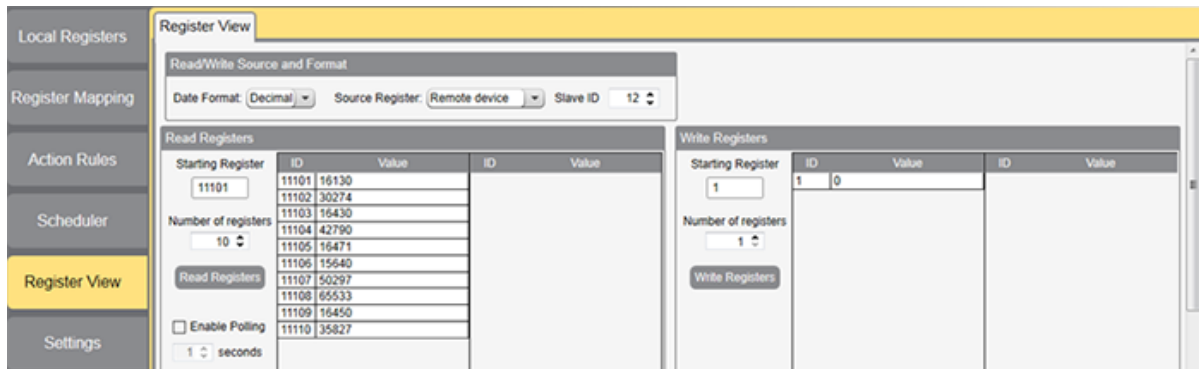


Figure 1. Sentek EnviroScan Results Registers using the DXM Configurator Tool

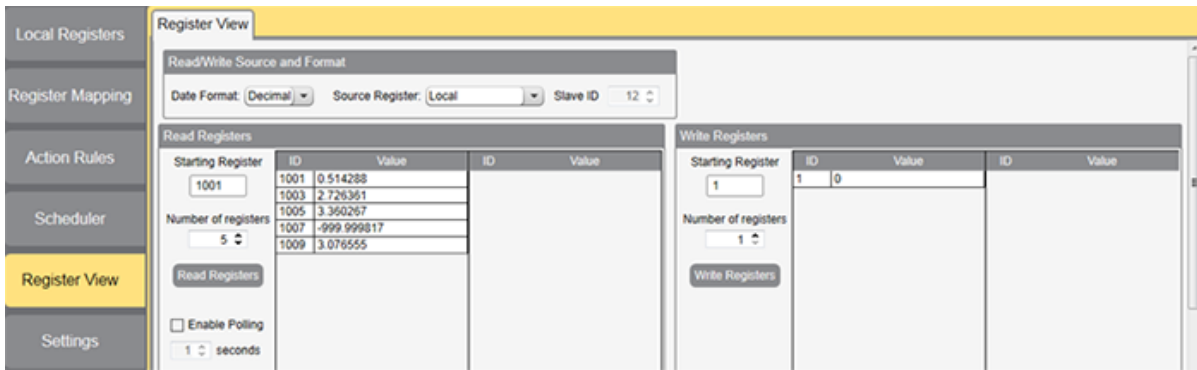


Figure 2. Sentek EnviroScan Local Registers using the DXM Configurator Tool

To compare values to the SDI-12 reader results or to view/store the value in a controller other than Banner Engineering's DXM150 Controller, convert the decimal values to hexadecimal values (via the "Data Type" field in the upper left corner) using a basic conversion tool. One example conversion tool is: <http://babbage.cs.qc.cuny.edu/IEEE-754.old/32bit.html>.

Excerpts from the M-H12 Datasheet

The following tables are included in the DX80DR9M-H12 datasheet. Refer to the datasheet for complete product information.

Register (4xxx)	Input #	Inputs	Units	I/O Range		Holding Register Representation		Terminal Block Labels
				Min. Value	Max. Value	Min. (Dec.)	Max. (Dec.)	
1	1	Discrete IN 1	-	0	1	0	1	DI1
2	2	Discrete IN 2	-	0	1	0	1	DI2
	...							
5	5	Analog IN 1 *	mA	0.0	20.0	0	65535	AI1
6	6							
7	7	Analog IN 2 *	mA	0.0	20.0	0	65535	AI3
8	8	Thermistor *	°F	-1638.3	1638.4	-32768	32767	AX2
9	9							
10	10							
11	11							
12	12	SDI-12 Device/CMD 5 *						SDI
13	13	SDI-12 Device/CMD 4 *						SDI
14	14	SDI-12 Device/CMD 3 *						SDI
15	15	SDI-12 Device/CMD 2 *						SDI
16	16	SDI-12 Device/CMD 1						SDI

* The factory default setting for SDI-12 devices 2 through 5, analog inputs 1 and 2, and the thermistor are disabled.

Register (4xxx)	Output #	Outputs	Units	I/O Range		Holding Register Representation		Terminal Block Labels
				Min. Value	Max. Value	Min. (Dec.)	Max. (Dec.)	
501	1	Discrete OUT 1	-	0	1	0	1	DO1
502	2	Discrete OUT 2	-	0	1	0	1	DO2
503	3	Switch Power 1						SP1
504	4	Switch Power 2						SP2

The Modbus configuration registers are listed. All registers are defined as Modbus holding registers. The factory default values are shown in parentheses. All values are in decimal, unless noted otherwise.

Device/CMD Configuration	Registers (Default Value)		
	Enable	Device Address	Device Command
SDI-12 Device/CMD 1	1751 (1)	11001 (49) ¹	11002 (10)
SDI-12 Device/CMD 2	1701 (0)	11201 (50)	11202 (10)
SDI-12 Device/CMD 3	1651 (0)	11401 (51)	11402 (10)
SDI-12 Device/CMD 4	1601 (0)	11601 (52)	11602 (10)
SDI-12 Device/CMD 5	1551 (0)	11801 (53)	11802 (10)

Device / Cmd Configuration	Registers (Default Value)						
	Enable	Device Address	Device Command	Sample Hi	Sample Low	Warmup Time	Voltage
SDI-12 Device/CMD 1	1751 (1)	11001 (49) ²	11002 (10)	1752 (0)	1753 (22500)	1755 (50)	1756 (148)
SDI-12 Device/CMD 2	1701 (0)	11201 (50)	11202 (10)	1702 (0)	1703 (22500)	1705 (50)	1706 (148)
SDI-12 Device/CMD 3	1651 (0)	11401 (51)	11402 (10)	1652 (0)	1653 (22500)	1655 (50)	1656 (148)
SDI-12 Device/CMD 4	1601 (0)	11601 (52)	11602 (10)	1602 (0)	1603 (22500)	1605 (50)	1606 (148)
SDI-12 Device/CMD 5	1551 (0)	11801 (53)	11802 (10)	1552 (0)	1553 (22500)	1555 (50)	1556 (148)

Device Address. Each SDI-12 device must have a unique device address. This parameter is the ASCII code for the device address. Valid device addresses are 0–9 and a–z that map to ASCII codes 48–57 and 97–122, respectively. The factory default addresses are:

- SDI-12 Device 1 uses ASCII code 49
- SDI-12 Device 2 uses ASCII code 50
- SDI-12 Device 3 uses ASCII code 51
- SDI-12 Device 4 uses ASCII code 52
- SDI-12 Device 5 uses ASCII code 53

Supported M! Commands		Supported C! Commands	
SDI -12 Command	Register Value	SDI -12 Command	Register Value
xM!	0 or 10	xC!	1 or 20
xM1!	11	xC1!	21
xM2!	12	xC2!	22
xM3!	13	xC3!	23
xM4!	14	xC4!	24
xM5!	15	xC5!	25
xM6!	16	xC6!	26
xM7!	17	xC7!	27
xM8!	18	xC8!	28
xM9!	19	xC9!	29

¹ The default device addresses 49 through 53 are in ASCII.

² The default device addresses 49 through 53 are in ASCII.

SDI-12 Device Result Registers

The result registers store all information received from the SDI-12 devices.

The registers are 16-bit registers and require two registers to store a 32-bit value. The factory default configuration defines the result registers as 32-bit registers, floating point format, and the first nine result registers are enabled for use. A host system reads the SDI-12 device data from these registers.

Result Registers	Register 1	Register 2	Register 3	Register 4	Register 5	Register 6
SDI-12 Device/CMD 1 Result Upper	11101	11103	11105	11107	11109	11111
SDI-12 Device/CMD 1 Result Lower	11102	11104	11106	11108	11110	11112
SDI-12 Device/CMD 2 Result Upper	11301	11303	11305	11307	11309	11311
SDI-12 Device/CMD 2 Result Lower	11302	11304	11306	11308	11310	11312
SDI-12 Device/CMD 3 Result Upper	11501	11503	11505	11507	11509	11511
SDI-12 Device/CMD 3 Result Lower	11502	11504	11506	11508	11510	11512
SDI-12 Device/CMD 4 Result Upper	11701	11703	11705	11707	11709	11711
SDI-12 Device/CMD 4 Result Lower	11702	11704	11706	11708	11710	11712
SDI-12 Device/CMD 5 Result Upper	11901	11903	11905	11907	11909	11911
SDI-12 Device/CMD 5 Result Lower	11902	11904	11906	11908	11910	11912

Result Registers	Register 7	Register 8	Register 9	Register 10	Register 11	Register 12
SDI-12 Device/CMD 1 Result Upper	11113	11115	11117	11119	11121	11123
SDI-12 Device/CMD 1 Result Lower	11114	11116	11118	11120	11122	11124
SDI-12 Device/CMD 2 Result Upper	11313	11315	11317	11319	11321	11323
SDI-12 Device/CMD 2 Result Lower	11314	11316	11318	11320	11322	11324
SDI-12 Device/CMD 3 Result Upper	11513	11515	11517	11519	11521	11523
SDI-12 Device/CMD 3 Result Lower	11514	11516	11518	11520	11522	11524
SDI-12 Device/CMD 4 Result Upper	11713	11715	11717	11719	11721	11723
SDI-12 Device/CMD 4 Result Lower	11714	11716	11718	11720	11722	11724
SDI-12 Device/CMD 5 Result Upper	11913	11915	11917	11919	11921	11923
SDI-12 Device/CMD 5 Result Lower	11914	11916	11918	11920	11922	11924