**Application Note**

Substation Automation and Protection Division

# REL 512 Connectivity With A Harris ® Westronics RTU Using DNP 3.0

*ABSTRACT: DNP 3.0 is a popular communication protocol in utility architectures. Interconnection of ABB Protective relays with a popular Remote Terminal Unit (RTU) is a common implementation using DNP 3.0. A common RTU is the HARRIS WESTRONICS ® D 20 RTU. This application note covers the connectivity issues encountered when implementing such an installation.*

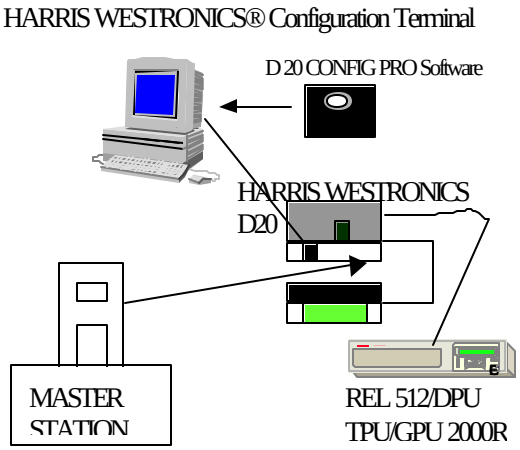
## *Sample Installation*

*A variety of DNP 3.0 protocol hosts allow for attachment to an ABB protective relay. The sample installation used for the purposes of this example is illustrated in Figure 1. One common implementation is shown in Figure 1 below. A Harris Westronics D20 can be attached to a protective relay from ABB allowing communication between an RTU device and a protective relay. However, certain configuration issues arise when implementing such architecture. Such topics arise as: hardware connectivity between the nodes, configuration of the devices (RTU and the Protective Relay), device protocol command compatibility and device configuration of the D20 database effectively allowing rapid update of parameters from the protective relay.*

*The ABB protective relays may be configured using a variety of techniques to decrease the amount of data passing between the D 20 RTU and the protective relay. The ability to model the point data base increases data throughput and leads to overall system optimization. Operator visualization and notification of field events occurs efficiently and rapidly with an optimally designed system.*

## *D 20 RTU Connectivity Philosophy*

Figure 1. Point to Point Topology




As shown in Figure 1, a configuration terminal is supplied by Harris Westronics® enabling configuration through an RS 232 port interface at the front of the microprocessor module on the D 20. The software is called “CONFIG PRO” and operates on a Windows operating system platform.

The CONFIG PRO ® software creates the control files which defines the active communication ports, physical remote unit mapping and logical remote unit mappings for the attached devices. Also the database points which are to be retrieved from the attached devices (in this case the protective relay) is mapped via the CONFIG PRO ® software.

The D 20, when powered- up for the first time has no configuration contained within the unit. A configuration must be developed and downloaded into the unit. As illustrated in figure 1, the configuration terminal is connected to the front port of the D 20’s microprocessor controller.

Figure 2 illustrates the ports available on the D 20. The unit has 8 ports located on the rear backplane of the unit. Seven of the ports are RS 232 while port 8 is a proprietary port configured with Harris XA 21 protocol. The Harris XA 21 protocol port interfaces the D 20 RTU to the Master SCADA station. The seven ports may be configured to communicate using DNP 3.0, or Modbus protocols. Both protocols are implemented as a master emulation designed to communicate to slave devices. The DNP 3.0 interconnection interface shall be examined within this application note. Each port, although with a point to point RS 232 interface, can be configured to communicate to multiple units attached to a port.
Another port is available for connection of the D 20 input output modules or peripheral boards. Figure 1 illustrates a single module (illustrated by the black/white/green boxes) connected to the microprocessor module. Several I/O modules may be multi-dropped along this RS 485 like interface. The D 20 Input Output Modules contain electronic circuitry allowing attachment of discrete input (breaker status …) output (pilot lights , control points…) Analog Inputs (Tap Positions, …) Analog Output (…….) physical devices which may be controlled by the RTU or by a SCADA host issuing commands to the D 20.

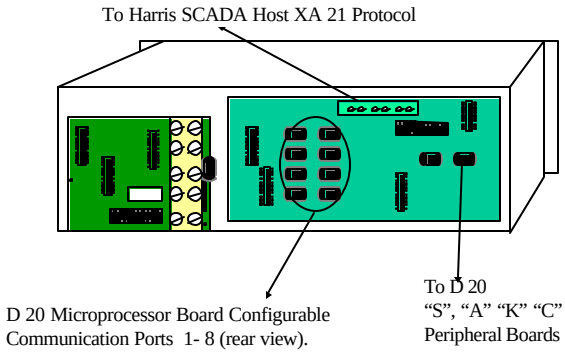



*Figure 2 – D 20 Device Port Layout (Rear Facing View)*

## *The ABB Communication Philosophy*

ABB protective relays are designed with the protocol already imbedded within the relay. ABB DPU 2000, 2000R, TPU 2000, TPU 2000R, GPU 2000R, and REL 512 protective relays have the ability to physically connect to a master node using RS 232 or RS 485 physical interfaces. No additional intermediate nodes ( such as data concentrators or port switches) are required. This advanced design capability allows for unit address-ability of up to 4095 (FFF HEX) DPU/TPU/GPUs or 65534 REL 512s , (address 65535 is the global address for all units). However, the physical interface restriction of RS 485 only allows for 32 devices ( 31 protective relays and one host device [D20]) to be interconnected. RS 232 allows for only point to point connectivity. If a multi-drop capability using RS 232 is required, short haul or long haul dedicated modems would have to be used to provide for multi-drop connectivity for over 32 devices.

ABB relays have a single port communicating using DNP 3.0. The parameters and port used are configurable via the communication parameters within the relay selected. Figure 3 illustrates the communication port locations.

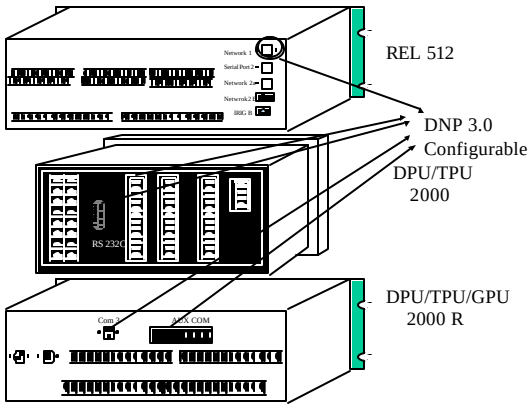



*Figure 3 - Communication Port Locations.*

The steps required allowing communication between the HARRIS D 20 and the ABB protective relays are as such:

- Configure the D 20
- Configure the ABB Protective Relay
- Send the DNP 3.0 commands.

This application note cannot be an all-inclusive note since parameterization and configuration of such systems can be very involved and lengthy. The purpose of this note is to describe some of the configuration philosophy required for the Harris Westronics D 20 unit thus allowing for connectivity to an ABB protective relay.

## *Harris D-20 Configuration Philosophy*

The D 20 has different applications which must be configured for a working system. Two of the applications configurations explained are:

Data Collection Application (DCA)
Data Process Application (DPA)

Once CONFIG PRO ® operation is initiated, a many configuration steps must be performed. A synopsis of the configuration steps follows:

### Create Project

All D 20 configurations must be initiated with a project file. This project file when configured becomes compiled and downloaded to the D 20. Some configuration parameters required are:

- Name
- Description
- D 20 RTU Type

Additional options are available to select the D 20 firmware types, and microprocessor used. The selections within this menu selection require no relay information to be entered.

## Create Datalink Process

Within the ALL APPLICATIONS section of the CONFIG PRO ® a window is available to configure each of the communication ports resident on the device. The Configuration numbers given to each entry are to be mapped to each of the 7 communication ports.

Within the DNP DATALINK section of this configuration process, the port connections for each of the nodes attached to the port are given. It is within this section that the physical port is attached to a table indicating the port characteristics. Some of the parameters which are configured are:

- Physical Port Number Attachment to soft CONFIG # Table Entry
- Baud Rate
- Port Timeouts
- Retries
- Data Link Layer Parameters (Confirmation, Retries and Timeout )
- Confirmations
- Handshaking (RTS/CTS)

This table shall be linked to other tables within the configuration process. The parameters within this window configuration selection include those which must be parameterized in the protective relay. It must be stressed that IED (i.e. ABB Protective Relays) device operability with the host is dependent upon the parameter compatibility contained within this screen.

## Device Collection Application Configuration

The philosophy of D 20 device configuration is that several applications operate concurrently within the RTU. Each application must be configured and each application must be bound and tied to the protocol port to send the data to the selected port (i.e. the SCADA Host). Each of the D 20's physical device I/O,as well as the communication ports, must be mapped to an application (DCA, DPA, …). A menu item is available to map this. The DCA DEVICE CONFIGURATION menu is selected which allows mapping of the configuration created (0 through 7) to be mapped to the individual devices connected to the port. Thus, the physical address of each individual IED is mapped in the DCA DEVICE CONFIGURATION menu. Therefore, 5 devices are to be multi-dropped on port number 1, each of the IED's node numbers are to be entered into this section of the configuration table.

## Bridgeman

The philosophy of software configuration is that all the configured tables to this point must be tied or "BRIDGED" together. The configuration utility allowing performance of this procedure is called "BRIDGEMAN". The configuration screens within "BRIDGEMAN" allows configuration of what data is obtained from which IED. Up until this point, the configuration has involved the physical layer (physical D 20 ports).

## Remote Application Table

The configuration table ties the task 0 though 7 (which is tied to the IED port entries) to the DCA configuration table.

CONFIG PRO ® menu items, which must be configured, are:

## Local AP Table

This entry configures the DNP 3.0 protocol requests to be sent from a MASTER ADDRESS (Source) to a REMOTE TABLE ADDRESS (Destination).

## Device Configuration Table

This table includes configuration information which parameterized the D 20 for:

- Multiple Command Generation
- Time Duration Between Time Synchronization between the D 20 RTU and IED
- Time Duration Between Polls
- Method of Polling
  1. Poll List
  2. Round Robin
  3. Poll By Exception (Unsolicited)

### System Point Database Configuration

The table referred to as the SYSTEM POINT DATABASE is the crucial table for attachment of the points required by the D 20 from the relay. Each point requested must be mapped to this database. Each input point retrieved and each output point required for control must be configured in this database. The database is configurable for three different point types:

- Digital Inputs
- Digital Outputs
- Analog Inputs

Each point configured within this screen is stored within the D 20 and it is assigned a memory address space. Thus, if a point is retrieved from the attached IED, it cannot be masked out. The retrieved point must be allocated a memory location even if it not used in the application.

The D 20 also has additional memory requirements for each point group as shown in figure 4.

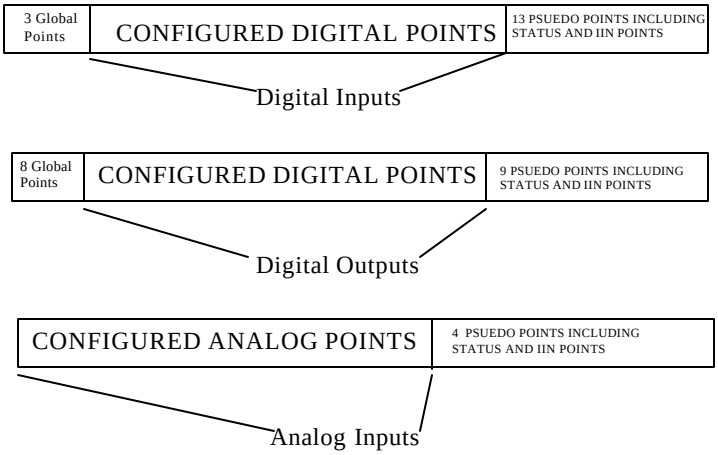



*Figure 4 – Data Storage Requriements For Each Entry In The System Point Database.*

## Compilation Of Database

The created tables must be compiled and downloaded to the D 20. After this step, the D20 should be obtaining data from each of the nodes attached to the D 20 ports.

## *Example DPU/TPU/GPU 2000R REL 512 Communication Parameterizations*

The DPU/TPU/GPU communication is parameterized via the Front Panel MMI interface or through the ECP (External Communication Program). Please consult the appropriate communication manuals for your selected ABB protective relay.

The parameters selected are as follows and mirror those which should be entered in the Create Datalink Process section described above.

The selected parameters for this application note are as follows:

| | |
|---|---|
| Unit Address | 5 |
| RP RS232 Baud | 9600 |
| RP RS 232 Frame | N 8 1 |
| RP RS485 Baud | 9600 |
| RP RS 485 Frame | N 8 1 |
| IRIG B | Enable ( Time Synch Via DNP Commands Enabled) |
| Parameter 1 | 40 (Inter-character Gap Timeout mS) |
| Parameter 2 | 30 (Data Link Layer Timeout in mS) |
| Parameter 3 | 0 (Data Link Layer Retries) |
| Parameter 4 | 200 ( Command Response Delay) |
| Parameter 5 | 254 (All Groups 0 – 7 Enabled) |
| Parameter 6 | 255 ( All Groups 8- 15 Enabled) |
| Parameter 7 | 255 ( All Groups 16- 24 Enabled) |
| Parameter 8 | 255 ( All Groups 25 – 32 Enabled) |
| Parameter 9 | 0 ( Reserved) |
| Parameter 10 | 0 (Reserved) |
| Mode Parameter 1 | Disabled (Data Link Layer Confirm) |
| Mode Parameter 2 | Disabled (Application Layer Confirm) |
| Mode Parameter 3 | Enabled ( DNP = RS 232) |
| Mode Parameter 4 | Disabled (RTS/CTS Handshake Confirms) |
| Mode Parameter 5 | Disabled (Enable/Disable of Auto Reset) |
| Mode Parameter 6 | Disabled (Reserved) |
| Mode Parameter 7 | Disabled (Reserved) |
| Mode Parameter 8 | Disabled (Reserved) |

The REL 512 is parameterized via a Hyperterminal ASCII emulation terminal. The attachment of the device and the PC terminal are illustrated in Figure 5.

There are five screens on presented for parameterization of the REL 512. The first screen presented for the DNP 3.0 “view settings” or “change settings” menu is presented as shown.

Mode=VIEW Active Group=1 Mon Oct 25 1999 13:25:00

[1] DNP Configuration #1
[2] DNP Configuration #2
[3] DNP Configuration #3

[4] DNP Configuration #4

Selection =>

The selections for DNP Configuration #1 is as follows:

DNP Protocol Configuration #1

```
          Device Address:      5
             Baud Rate:     9600
            Frame Type:     N,8,1
     Inter-char Gap Time:     0.05
Data Link Confirm Timeout:     3.0
      Data Link Retires:      2
        Transmit Delay:      20
      Class Zero Mask 1:       0
      Class Zero Mask 2:       0
      Class Zero Mask 3:       0
      Class Zero Mask 4:       0
      Class Zero Mask 5:       0
```

The parameters should match those entered in the CREATE DATALINK section of the D 20 CONFIG PRO ® process. The Class Zero Masks should be parameterized to mirror the database allocations in the D 20 SYSTEM POINT DATABASE.

DNP Configuration #2 screen is illustrated below:

DNP Protocol Configuration #2

```
   App Layer Fragment Size: 2048 Bytes
 App Layer Confirm Timeout:      5.0
Unsolicited Response Delay:       0
Unsolicited Rsp Dest Address:     0
    Class 1 Event Response:       0
    Class 2 Event Response:       0
    Class 3 Event Response:       0
    Data Link Confirm Mode:       0
```

The parameters for unsolicited response are not supported in the REL 512. The parameters for this feature are set to 0 as shown in Configuration #2 screen. Only the App Layer Confirm Timeout entries and the Data Link Confirm Mode entries are used. These parameters should mirror those entered in the D 20 DNP Datalink task and the Device Configuration Tables.

DNP Configuration #3 screen is illustrated below:

DNP Protocol Configuration #3

```
     RS-485 Duplex:     FULL
 App Layer Confirm:   DISABLE
      Transceiver:    RS-232
RS-232 Handshaking:     None
Local/Remote Input:  DISABLED
```

Receive LED on with: ANY CHAR
Time Synch Source: None
Time Synch Interval: 60
Control Point Paired: 0
Rollover Flag: 0

Configuration screen 3 allocates the physical interface characteristics. The most important parameters on this screen are RS 232 handshaking, and the transceiver parameterization being RS 232. The parameters should mirror those configured for the D 20 DNP Datalink Sections of CONFIG PRO ®.

DNP 3.0 Configuration Screen 4 is shown below:

DNP Protocol Configuration #4

load Current deadband: 5
load voltage deadband: 5
sequence Current deadband: 5
sequence voltage deadband: 5
watts deadband: 5
vars deadband: 5
power factor deadband: 5
deadband mask: 127
Binary input Default variation: VAR2
Binary input Change Default variation: VAR2
Binary Output Default variation: VAR2
Control Relay Output Block Default variation: VAR1
32 Bit Analog Default variation: VAR3
32 Bit Analog Change Default variation: VAR3

Configuration Screen 4 allows default assignment of Variation 0 variants for each of the DNP object classes. Also Object 30 Analog Input deadbands are assigned for Analog Change Detect reporting.

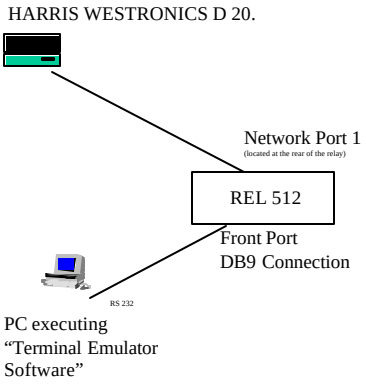



*Figure 5 - Physical Architecture for REL 512 communications with a Configuration terminal and the Harris Westronics ® D 20 RTU.*

*The method to configure Hyperterminal is a such:*

1. Connect a PC executing Hyperterminal or equivalent.ANSI terminal emulator to the front port of the relay. The default port configuration is 9600 bps, 8 data bits, no parity, one stop bit. No handshaking

is required. Cycle power to the unit. As the relay powers up, the DNP card should be recognized and the message “DNP Installed Vx.xx” should appear at the bottom right of the screen. Configure the terminal emulator program The cable is shown in figure 2. DEPRESS THE “ENTER “ key to initiate communications with the unit. NOTE: to navigate through the menu’s depress the key for the desired item. To navigate to a previous menu item, depress the “/” key. This allows for the forward and backward navigation through the menu selections.

2. Verify its address as node 5. From the REL512 Root Menu select
   (6) Password Functions,
   (1) Edit Configuration Settings
   (3) Comm Ports
   (4) DNP.
   (1) DNP Config #1

If its present address must be changed, it will take effect after rebooting the unit. The address should be checked each time new firmware has been downloaded to the relay. The factory default address for DNP is 5.

Consult the communication protocol document for port hardware port configuration options and menu selection options.

Cables required for connection of the D 20 to the RS 232 ports on the REL 512 or the DPU/GPU/TPU 2000R devices follow and are illustrated in Figures 6 and 7.

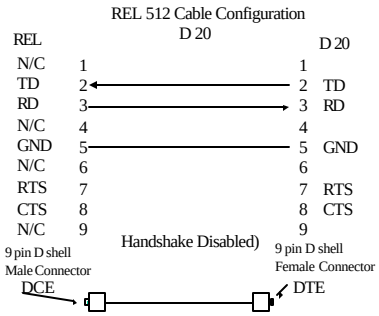



*Figure 6 - REL 512 to D 20 Cable Configuration*

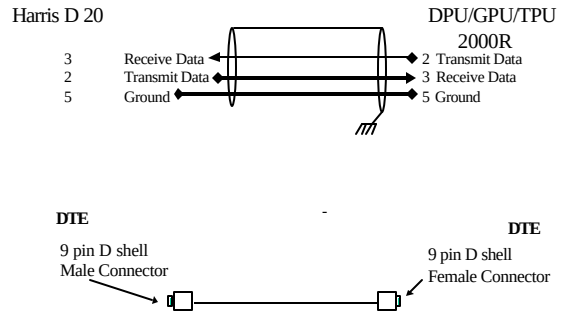



*Figure 7 - DPU TPU GPU Cable ToThe Harris Westronics D 20*

## *Configuration Issues*

The Harris D 20 requires that each point configured (along with the required pseudo-point returned with each group for a Class 0 scan) is allocated a memory location. It must be noted that this amount of data increases the overhead required to transmit the data to the SCADA host device. The amount of data can be reduced by decreasing the amount of groups enabled for Class 0 scan.

Another method for decreasing the amount of data is to have the D 20 request a Class 0 scan (commonly referred to as an integrity poll) every 15 minutes or so. Between integrity polls, the D 20 can issue polls to the slave device and monitor the IIN bits to determine if Class 1, 2, or 3 data is available for reporting. Class 3 data in may be masked using a technique defined as event masking. The event masking technique is described in the DPU 2000/2000R, TPU 2000/2000R or GPU 2000R DNP 3.0 Protocol Documents for each of the ABB products.

Class 3 data only reports the data points which have changed between scans. The D 20 would then update the point indices that have changed between scans. This technique keeps the amount of data transferred to a minimum. Thus, every 15 minutes, an integrity scan ( CLASS 0,1,2,3) would be issued and the entire database would be updated by the D 20. The “integrity” of the database would be maintained even though all points were not requested each and every point scan.

## *Conclusion*

The Harris D 20 and the ABB family of Distribution and Transmission Protective Relays are designed for seamless integration required in today’s automation systems. The incorporation of DNP 3.0 within both product lines allow for data access and control which was only the province of systems costing many times more

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