

12 DNP 3.0

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12.1 Introduction

DNP3 (Distributed Network Protocol) is a set of communications protocols used between components in process automation systems. Its main use is in utilities such as electric and water companies. It was developed for communications between various types of data acquisition and control equipment. It plays a crucial role in SCADA systems, where it is used by SCADA Master Stations (a.k.a. Control Centers), Remote Terminal Units (RTUs), and Intelligent Electronic Devices (IEDs). It is primarily used for communications between a master station and RTUs or IEDs. ICCP, the InterControl Center Communications Protocol (a part of IEC-608706), is used for intermaster station communications.

Elseta's DNP3 stack has both Master and Slave protocols implemented. Both of them can serve multiple serial (over physical RS485 line), TCP or TLS (over TCP) connections with high efficiency.

IEEE1815 defines 4 subset levels (14) that consist of the objects and function codes that must be supported by the master and outstation. Levels 13 are supported fully and level 4 is supported partially. To get more information about how DNP3 works and what capabilities are supported one should get a copy of the protocol specification and/or check the Slave Interoperability List/Configuration guides for both Master and Slave protocols.

 To set up TLS connection for both DNP3 Master and Slave, refer to sections Excel configuration and Certificates. All keys and certificates should be provided in the PEM format.

 If no configuration is set up, DNP3 Master and Slave services are not started.


12.2 DNP 3.0 Master

Default groups and variation sets are used to send commands. If slave devices support different groups and variations, they can be adjusted in Excel configuration. For more information check section [Excel configuration](#).

Configuring data points

To use DNP3 Master in WCC Lite, it has to be configured via an Excel configuration. This configuration contains two Excel sheets where parameters have to be filled in Devices and Signals.

DNP3 Master parameters for Devices tab

| Parameter | Type | Description | Required | | Default Value (when not specified) | Range | |
|-----------------------|---------|---|---------------|--|--|---|-------|
| | | | TCP/ TLS | Serial | | Min | Max |
| | | | |  | | | |
| name | string | User-friendly device name | Yes | Yes | | | |
| description | string | Description of a device | No | No | | | |
| device_alias | string | Alphanumeric string to identify a device | Yes | Yes | | | |
| enable | boolean | Enabling/disabling of a device | No | No | 1 | 0 | 1 |
| protocol | string | Protocol to be used ("dnp3 serial"/"dnp3 tcp" (case insensitive)) | Yes | Yes | | DNP3 TCP, DNP3 serial | |
| mode | string | Choosing between TCP, TLS and SERIAL modes. If the protocol provided DNP3 TCP mode defaults to tcp and if DNP3 serial is provided mode defaults to serial | No | No | TCP (for DNP3 TCP) SERIAL (for DNP3 serial) | TCP, TLS (for DNP3 TCP) SERIAL (for DNP3 serial) | |
| host | string | The IP address of the TCP slave device | Yes | - | | | |
| bind_address | string | The IP address of the network adapter used to connect to the slave device | No | No | 0.0.0.0 | | |
| port | integer | TCP communication port | No | No | 20000 | | |
| device | integer | Communication port ("PORT1" or "PORT2") | - | Yes | | | |
| baudrate | integer | Communication speed, bauds/s | - | No | 9600 | 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 | |
| databits | integer | Data bit count for communication | - | No | 8 | 6 | 9 |
| stopbits | integer | Stop bit count for communication | - | No | 1 | 1 | 2 |
| parity | string | Communication parity option | - | No | none | none, even, odd | |
| flowcontrol | string | Communication device flow control option. | - | No | none | none | |
| tls | boolean | Enable/disable the use of TLS | Yes (for TLS) | - | 0 | 0 | 1 |
| tls_local_certificate | string | Local certificate for TLS connection | Yes (for TLS) | - | | | |
| tls_peer_certificate | string | Certificate authority file for TLS connection | No (for TLS) | - | | | |
| tls_private_key | string | A file consisting of the private key for TLS connection | No (for TLS) | - | | | |
| max_rx_frag_size | integer | Maximum size of a received fragment. | No | No | 2048 | 0 | 2048 |
| destination_address | integer | Address of a master station | No | No | 1 | 0 | 65535 |
| source_address | integer | Address of a slave (local) station. | No | No | 1 | 0 | 65535 |

| | | | | | | | |
|-------------------------|-----------------|--|----|----|---------------------------------------|--------------|-----|
| unsol_classes | string | Defines which classes will have unsolicited actions on startup. (Example: "1,3,2") | No | No | no class | 1 | 3 |
| unsol_disable | bool | Disables unsolicited messages on startup. The parameter is going to be ignored if the unsol_classes parameter has any values assigned. | No | No | 0 | 0 | 1 |
| groups_scan_mask | integer | Bitmask for enabling separate group scans with x06 qualifier (all objects). The parameter value is converted into a binary number where each bit stands for a separate group. Bits indexes and the groups that they represent: 0 - Binary, 1 - Doublebit Binary, 2 - Binary Output Status, 3 - Counter, 4 - Frozen Counter, 5 - Analog, 6 - Analog Output Status, 7 - Octet String (Example: 115 (0111 0011) will trigger data polls for signals whose types are - Binary, Double-bit Binary, Frozen Counter, Analog, Analog Output Status) | No | No | 0 | 0 | 255 |
| groups_scan_interval | integer, string | The time between separate groups scans intervals in seconds. Set to 0 to disable. | No | No | 0 | 0 | |
| exception_scan_interval | integer, string | The time between exception scan (classes 1,2,3) intervals in seconds. Set to 0 to disable. | No | No | 0 | 0 | |
| integrity_scan_interval | integer, string | Time between integrity scan (classes 0,1,2,3) intervals in seconds (general interrogation). Set to 0 to disable. | No | No | 0 | 0 | |
| timesync_mode | string | Will override the master default setting for choosing the time sync procedure | No | No | NON-LAN (for Serial) LAN (for tcp) | LAN, NON-LAN | |
| time_sync_interval_sec | integer, string | Periodic time sync interval in seconds. If > 0 - time syncs are forced and periodic. If = 0 - time syncs react to IIN bits from the slave. If < 0 - time syncs are disabled. | No | No | | | |
| select_ms | integer | Select command timeout. Valid for all signals. | No | No | 10000 | | |
| timeout_ms | integer | Response timeout in milliseconds | No | No | 2000 | | |
| keep_alive_timeout | integer | The time interval for sending a keep-alive packet in seconds. | No | - | 60 | | |
| use_local_time | boolean | if enabled (1) communication uses system time instead of UTC. | No | No | 0 | 0 | 1 |

DNP3 Master parameters for the Signals tab

| Parameter | Type | Description | Required | | Default Value (when not specified) | Range | |
|--------------|---------|---|----------|-----|---------------------------------------|-------|-------|
| | | | TCP | RTU | | Min | Max |
| signal_name | string | User-friendly signal name | Yes | Yes | | | |
| device_alias | string | Device alias from a Devices tab | Yes | Yes | | | |
| signal_alias | string | Unique alphanumeric name of the signal to be used | Yes | Yes | | | |
| enable | boolean | Enabling/disabling a device | No | No | 1 | 0 | 1 |
| index | integer | Index of a signal. | Yes | Yes | | 0 | 65535 |
| log | boolean | Enable logging in the event log | No | No | 0 | 0 | 1 |

| | | | | | | | |
|-------------------|---------|--|--|--|---|--|---|
| signal_type | string | DNP3 signal type. (case insensitive) | Yes | Yes | | "binary", "doublebitbinary", "binaryoutputstatus", "binaryoutputcommand", "counter", "frozenscounter", "analogue", "analogoutputstatus", "analogoutputcommand", "timeandinterval", "octetstring" | |
| command_variation | integer | DNP3 command variation. <i>Supported variations depend on signal type and are provided in the table below</i> | Yes (for commands) | Yes (for commands) | | 0 | 4 |
| static_variation | integer | DNP3 command variation (). Supported variations depend on signal type and are provided in the table below. | Yes (for read signals) | Yes (for read signals) | | 0, 1, 2, 3, 4, 5, 6, 9, 10 | |
| event_variation | integer | DNP3 command variation. Supported variations depend on signal type and are provided in the table below. | Yes (for read signals) | Yes (for read signals) | | 0 | 8 |
| control_code | string | DNP3 control model code of CROB signal. TripClose and Pulse control model requires PulseOn/off times to be set | No | No | | LATCH, PULSE, TRIPCLOSE | |
| pulse_on_time_ms | integer | Pulse ON time in milliseconds, when using Pulse or TripClose control models must be set | Yes (for binary PULSE and TRIPCLOSE command codes) | Yes (for binary PULSE and TRIPCLOSE command codes) | | | |
| pulse_off_time_ms | integer | Pulse OFF time in milliseconds, when using Pulse or TripClose control models must be set | Yes (for binary PULSE and TRIPCLOSE command codes) | Yes (for binary PULSE and TRIPCLOSE command codes) | | | |
| class_num | integer | Class assignment of the signal. | No | No | 0 | 0 | 3 |
| operate_type | integer | Default command behaviour. If selected: "-1" - DirectOperateNoAck (FC=6), "0" - DirectOperate (FC=5), "1" - SelectBeforeOperate (FC=3). | No | No | 1 | -1 | 1 |
| job_todo | string | The device status signal can be configured by providing one of the given values. | No | No | | communication_status, device_running, device_error, unknown_error | |

Device status signals

To configure any device status signal for the DNP3 protocol additional job_todo column is required. For DNP3 master required parameters for status signal will be: **signal_name**, **device_alias**, **signal_alias**, **index**, **signal_type**, **event_variation** (1,2 or 3) and **job_todo**. There are 4 possible signals: communication_status, device_running, device_error, unknown_error. Each signal has 4 possible values and is based on the same logic. If the signal returns the value of 0, it means an unknown error has appeared, 1 - device or protocol connection is on and working properly, 2 - device is off or protocol is disconnected, 3 - error or service is down.

Command variations

| Signal Type | Available Command Variation | Default Command Variation |
|---------------------------------|-----------------------------|---------------------------|
| Binary Output Command (Group12) | 0, 1 | 1 |
| Analog Output Command (Group41) | 0, 1, 2, 3, 4 | 1 |

Static and Event variations

| Signal Type | Available Variations | Default Variations |
|----------------------|---|---|
| Binary | Static variation (Group1) 1, 2 Event variation (Group2) 1, 2, 3 | Static variation 2 Event variation 1 |
| Double Binary | Static variation (Group3) 2 Event variation (Group4) 1, 2, 3 | Static variation 2 Event variation 1 |
| Binary Output Status | Static variation (Group10) 1, 2 Event variation (Group11) 1, 2 | Static variation 2 Event variation 1 |
| Counter | Static variation (Group20) 1, 2, 5, 6 Event variation (Group22) 1, 2, 5, 6 | Static variation 1 Event variation 1 |
| Frozen Counter | Static variations (Group21) 1, 2, 5, 6, 9,10 Event variation (Group23) 1, 2, 5, 6 | Static variation 1 Event variation 1 |
| Analog | Static variation (Group30) 1, 2, 3, 4, 5, 6 Event variation (Group32) 1, 2, 3, 4, 5, 6, 7, 8 | Static variation 1 Event variation 1 |
| Analog Output Status | Static variation (Group40) 1, 2, 3, 4 Event variation (Group42) 1, 2, 3, 4, 5, 6, 7, 8 | Static variation 1 Event variation 1 |
| Time and Interval | Static variation (Group50) 1 | Static variation 1 |
| Octet String | Static variation (Group110) 0 Event variation (Group111) 0 | Static variation 0 Event variation 0 |

Debugging the DNP3 Master service

If the configuration for DNP3 devices is set up, a handler for the protocol will start automatically. If the configuration is missing or contains errors, the protocol will not start. It is done intentionally to decrease unnecessary memory usage.

DNP3 protocol runs a service called **dnp3-master**. If DNP3 does not work properly (e.g. no communication between devices, data is corrupted, etc.), a user can launch a debug session from the command line interface and find out why the link is not functioning properly. To launch a debugging session, a user should stop the **dnp3-master** process and run the **dnp3-master** command with respective flags as in the table given below.

Procedure for DNP3 Master protocol service debugging:

- **Step 1:** Service must be stopped by entering the following command into the wccite:

```
/etc/init.d/dnp3-master stop
```

- **Step 2:** After the service is stopped it must be started with the preferred configuration file (JSON files found in the /etc/ folder) and a debug level 7:

```
dnp3-master -c /etc/dnp3-master/dnp3master.json -d7
```

Additional output forming options described in the table below.

- **Step 3:** Once the problem is diagnosed normal operations can be resumed with the following command:

```
/etc/init.d/dnp3-master start
```

dnp3-master command line debugging options

| Option | Description |
|------------------|--------------------------|
| -h [-help] | Display help information |
| -V [-version] | Show version |
| -d <debug level> | Set debugging level |
| -c [-config] | Config path |
| -r [-redis] | Show Redis messages |

12.3 DNP 3.0 Slave

Default group and variation sets are used to send static and event values. If master devices support different groups and variations, they can be adjusted in Excel configuration. WCC Lite-supported variations are provided in *Static and Event variations* and *Command variations*.

DNP3 Slave parameters for Devices tab

| Parameter | Type | Description | Required | | Default Value (when not specified) | Range | |
|--------------|---------|--|-------------|-----|---------------------------------------|--|-----|
| | | | TCP/ TLS | RTU | | Min | Max |
| name | string | User-friendly device name | Yes | Yes | | | |
| description | string | Description of a device | No | No | | | |
| device_alias | string | Alphanumeric string to identify a device | Yes | Yes | | | |
| enable | boolean | Enabling/disabling of a device | No | No | 1 | 0 | 1 |
| protocol | string | Protocol to be used. | Yes | Yes | | dnp3 tcp slave dnp3 serial slave | |
| mode | string | Choosing between TCP, TLS and SERIAL modes. If the protocol is provided DNP3 TCP mode defaults to tcp and if DNP3 serial is provided mode defaults to SERIAL | No | No | TCP or SERIAL | TCP, SERIAL, TLS | |
| host | string | The IP address of the TCP slave device | Yes | - | | | |
| bind_address | string | The IP address of the network adapter used to connect to the slave device | No | - | 0.0.0.0 | | |
| port | integer | TCP communication port | No | - | 20000 | | |
| device | string | Communication port ("PORT1" or "PORT2") | - | Yes | | | |
| baudrate | integer | Communication speed, bauds/s | - | No | 9600 | 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600,115200 | |
| databits | integer | Data bit count for communication | - | No | 8 | 6 | 9 |
| stopbits | integer | Stop bit count for communication | - | No | 1 | 1 | 2 |
| parity | string | Communication parity option | - | No | none | none, even, odd | |
| flowcontrol | string | Communication device flow control option. | - | No | none | none | |

| | | | | | | | |
|------------------------|-----------------|---|---------------|----|----------|---|-------|
| tls | boolean | Enable/disable the use of TLS | Yes (for TLS) | - | 0 | 0 | 1 |
| tls_local_certificate | string | Local certificate for TLS connection | Yes (for TLS) | - | | | |
| tls_peer_certificate | string | Certificate authority file for TLS connection | No (for TLS) | - | | | |
| tls_private_key | string | A file consisting of the private key for TLS connection | No (for TLS) | - | | | |
| max_tx_frag_size | integer | Maximum size of a received fragment. | No | No | 2048 | 0 | 2048 |
| destination_address | integer | Address of a master station | No | No | 1 | 0 | 65535 |
| source_address | integer | Address of a slave (local) station. | No | No | 1 | 0 | 65535 |
| unsol_classes | string | Defines which classes will have unsolicited actions on startup. (Example: "1,3,2") | No | No | no class | 1 | 3 |
| time_sync_interval_sec | integer, string | Periodic time sync interval in seconds. If 0 < - time syncs are forced and periodic. If = 0 - time syncs react to IIN bits from the slave. If < 0 - time syncs are disabled. | No | No | 0 | 0 | |
| select_ms | integer | Select command timeout. Valid for all signals. | No | No | 10000 | | |
| timeout_ms | integer | Response timeout in milliseconds | No | No | 2000 | | |
| keep_alive_timeout | integer | The time interval for sending a keep-alive packet in seconds. | No | No | 60 | | |

DNP3 Slave parameters for Signals tab

| Parameter | Type | Description | Required | | Default Value (when not specified) | Range | |
|--------------|--------|---|----------|-----|------------------------------------|-------|-----|
| | | | TCP | RTU | | Min | Max |
| signal_name | string | User-friendly signal name | Yes | Yes | | | |
| device_alias | string | Device alias from a Devices tab | Yes | Yes | | | |
| signal_alias | string | Unique alphanumeric name of the signal to be used | Yes | Yes | | | |

| | | | | | | | |
|-------------------|-----------------|---|------------------------|------------------------|---|---|-------|
| enable | boolean | Enabling/disabling of a device | No | No | 1 | 0 | 1 |
| index | integer | Index of a signal. | Yes | Yes | | 0 | 65535 |
| log | boolean | Enable logging in the event log | No | No | 0 | 0 | |
| deadband | integer, string | Deadband for Analog, Analog Output Status, Counter, and Frozen Counter signals. | No | No | 0 | | |
| signal_type | string | DNP3 signal type. (case insensitive) | Yes | Yes | | "binary", "doublebitbinary", "binaryoutputstatus", "binaryoutputcommand", "counter", "frozencounter", "analog", "analogoutputstatus", "analogoutputcommand" | |
| command_variation | integer | DNP3 command variation. <i>Supported variations depend on signal type and are provided in the table below</i> | Yes (for commands) | Yes (for commands) | | 0 | 4 |
| static_variation | integer | Override default signal's static variation. Valid for Status mode signals. | Yes (for read signals) | Yes (for read signals) | | 0, 1, 2, 3, 4, 5, 6, 9, 10 | |
| event_variation | integer | Override default signal's event variation. Valid for Status mode signals. | Yes (for read signals) | Yes (for read signals) | | 0 | 8 |
| class_num | integer | Class assignment of this signal. | No | No | 0 | 0 | 3 |
| operate_type | integer | Default command behaviour. If selected: "-1" - DirectOperateNoAck (FC=6), "0" - DirectOperate (FC=5), "1" - SelectBeforeOperate (FC=3). | No | No | 1 | -1 | 1 |
| job_todo | string | The device status signal can be configured by providing one of the given values. | No | No | | communication_status, device_running, device_error, unknown_error | |

Device status signals

To configure any device status signal for DNP3 protocol additional job_todo column is required. For DNP3 slave required parameters for status signal will be: **signal_name**, **device_alias**, **signal_alias**, and **job_todo**. Job_todo value must be: **communication_status**. If the signal returns the value of 1 - the device or protocol connection is on and working properly, if 2 - the device is off or the protocol is disconnected.

Command variations

| Signal Type | Available Command Variation | Default Command Variation |
|---------------------------------|-----------------------------|---------------------------|
| Binary Output Command (Group12) | 0, 1 | 1 |
| Analog Output Command (Group41) | 0, 1, 2, 3, 4 | 1 |

Static and Event variations

| Signal Type | Available Variations | Default Variations |
|----------------------|--|---|
| Binary | Static variation (Group1) 1, 2 Event variation (Group2) 1, 2, 3 | Static variation 2 Event variation 1 |
| Double Binary | Static variation (Group3) 2 Event variation (Group4) 1, 2, 3 | Static variation 2 Event variation 1 |
| Binary Output Status | Static variation (Group10) 2 Event variation (Group11) 1, 2 | Static variation 2 Event variation 1 |

| | | |
|----------------------|---|---|
| Counter | Static variation (Group20) 1, 2, 5, 6 Event variation (Group22) 1, 2, 5, 6 | Static variation 1 Event variation 1 |
| Frozen Counter | Static variations (Group21) 1, 2, 5, 6, 9,10 Event variation (Group23) 1, 2, 5, 6 | Static variation 1 Event variation 1 |
| Analog | Static variation (Group30) 1, 2, 3, 4, 5, 6 Event variation (Group32) 1, 2, 3, 4, 5, 6, 7, 8 | Static variation 1 Event variation 1 |
| Analog Output Status | Static variation (Group40) 1, 2, 3, 4 Event variation (Group42) 1, 2, 3, 4, 5, 6, 7, 8 | Static variation 1 Event variation 1 |

Debugging the DNP3 Slave service

If the configuration for DNP3 devices is set up, a handler for the protocol will start automatically. If the configuration is missing or contains errors, the protocol will not start. It is done intentionally to decrease unnecessary memory usage.

DNP3 protocol runs a service called **dnp3-slave**. If DNP3 does not work properly (e.g. no communication between devices, data is corrupted, etc.), a user can launch a debug session from the command line interface and find out why the link is not functioning properly. To launch a debugging session, a user should stop the **dnp3-slave** process and run the **dnp3-slave** command with respective flags as in the table given below.

Procedure for DNP3 Master protocol service debugging:

- **Step 1:** Service must be stopped by entering the following command into the wccliite:

```
/etc/init.d/dnp3-slave stop
```

- **Step 2:** After the service is stopped it must be started with the preferred configuration file (JSON files found in the /etc/ folder) and a debug level 7:

```
dnp3-slave -c /etc/dnp3-slave/dnp3slave.json -d7
```

Additional output forming options described in the table below.

- **Step 3:** Once the problem is diagnosed normal operations can be resumed with the following command:

```
/etc/init.d/dnp3-slave start
```

dnp3-slave command line debugging options

| Option | Description |
|------------------|--------------------------|
| -h [-help] | Display help information |
| -V [-version] | Show version |
| -d <debug level> | Set debugging level |
| -c [-config] | Config path |
| -r [-redis] | Show Redis messages |