Technical Note

ProSoft TECHNOLOGY

IEC-60870-5-104 Server Tutorial

All ProSoft 104S products

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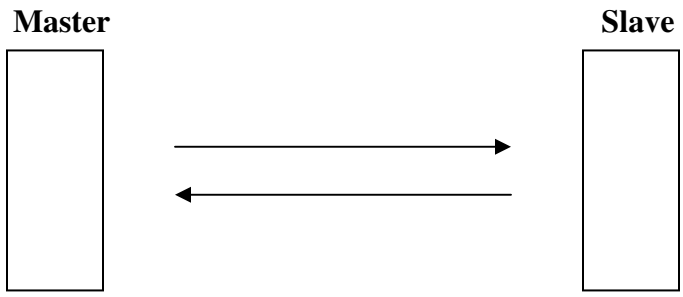
1. Introduction

The intent of this document is to offer a quick understanding of the IEC-60870-5-104 protocol while skipping the details of complex specification.

The IEC-60870-5-104 protocol applies to telecontrol equipment and systems with data transmission for monitoring and controlling geographically widespread processes. The protocol presents a combination of the IEC-60870-5-101 protocol and the transport functions provided by TCP/IP.

Any application with the IEC-60870-5-104 protocol will have a master (controlling station) and one or more slaves (controlled stations). The master will constantly monitor and control the data from each slave in the TCP/IP network.



The 104S module works as a IEC-60870-5-104 slave : it can send monitor data, receive commands or generate events to the master unit.

2. Module Address

The 104s module is identified at transport level (using the IP Address) and at application level (using the Common ASDU Address).

IP Address

The 104S module will be identified by a unique IP address in the TCP/IP network. The user should edit the WATTCP.CFG configuration file (or use the configuration tool) in order to enter a valid IP address. The file is listed as follows:

ProLinx Communication Gateways, Inc.
Default private class 3 address
my_ip=192.168.0.100
# Default class 3 network mask
netmask=255.255.255.0
# The gateway I wish to use
gateway=192.168.0.1
# some networks (class 2) require all three parameters
# gateway,network,subnetmask
# gateway 192.168.0.1,192.168.0.0,255.255.255.0

In this example the 104S module would be identified by IP address 192.168.0.100 in the IEC-60870-5-104 network.

Since there could be several devices in the same TCP/IP network, some applications may require a connection control (from which IP addresses the module may receive valid messages).

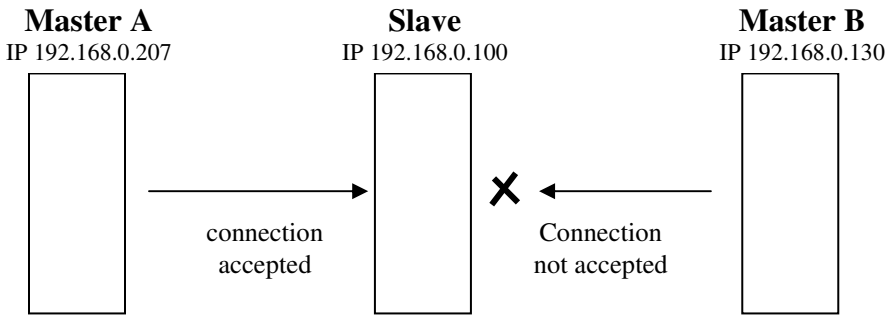
The user can restrict the units (IP addresses) from which the 104S module will accept connections using the following parameter:

Use IP List : 0 #Use IP list to validate connection (0=No, 1=Yes)

If this parameter is set as 1 (Yes), the module will only accept a connection from a master unit that is listed in the IP address list (to be configured by the user):

[IEC-870-5-104 IP ADDRESSES]
START
192.168.0.207
192.168.0.203
192.168.0.61
END

If the *Set IP List* parameter would be set to Y the module would only accept a connection from one of the three IP addresses listed above.



Common ASDU Address

At the application level, the module is identified by the Common ASDU Address that must match the CASDU sent by the master unit. ASDU means Application Service Data Unit and it is basically a data unit to transfer the information objects between the master and the slave.

If the master sends a message to a different CASDU the module will ignore the received command. The user can configure the Common ASDU Address for the 104S module through the following parameter in the configuration file:

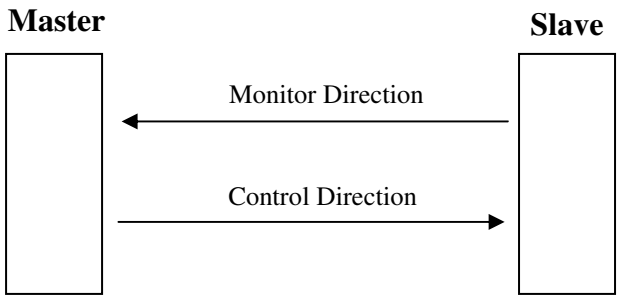
Common Address of ASDU : 1 #Range 0 to 65535

3. Monitor Direction and Control Direction

The protocol specification defines two directions of data: monitor direction and control direction. These directions are defined by the protocol specification as follows:

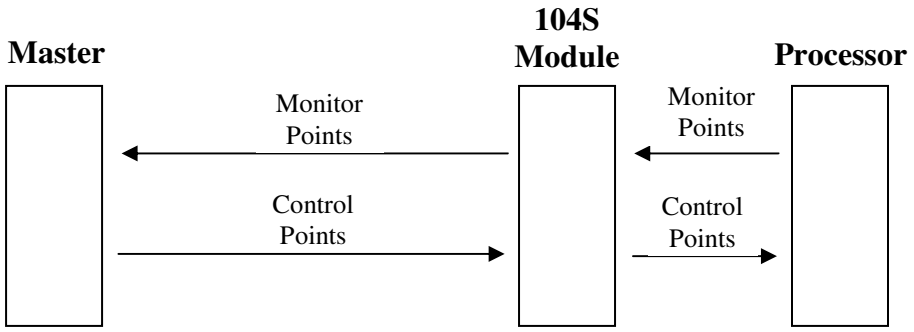
Monitor Direction: The direction of transmission from a slave to the master

Control Direction: The direction of transmission from the master to a slave



The points that are typically transferred from the slave to the master are also known as **Monitor Points** (or Monitor Information Objects). The points that are typically transferred from the master to the slave are also known as **Control Points** (or Command Information Objects).

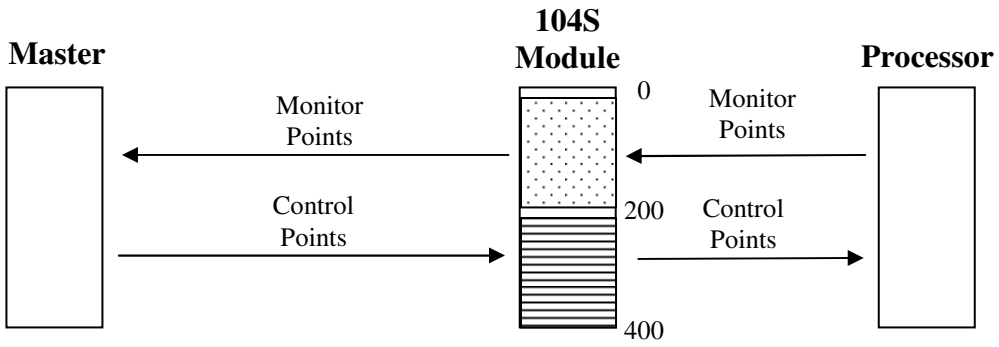
For In-Rack solutions (MVI46-104S, MVI56-104S, MVI71-104S or PTQ-104S) the control and monitor points would be transferred as follows:



The user must make sure that all points are configured in the correct location in the 104S module database in order to be properly updated from/to the processor.

For In-Rack solutions, it is strongly suggested that the user should configure the control points and monitor points in separate areas into the 104s module database.

For example, the 104S module can be configured to operate as follows:



So all monitor points would be located between database addresses 0 to 199 and all control points would be located between address 200 and 399. The backplane settings would also have to be configured in order to correctly update these database ranges.

4. Using Monitor Points

The following monitor points are supported by the 104S module:

Symbol	Description
M-SP-NA	Monitored Single-Points
M-DP-NA	Monitored Dual-Points
M-ST-NA	Monitored Step-Points
M-ME-NA	Monitored Measured Normalized-Points
M-ME-NB	Monitored Measured Scaled-Points
M-IT-NA	Monitored Counter-Points

Each monitor point is identified by its Information Object Address (it should be unique for each Common ASDU Address in the network). For each monitor point, the user should configure the following parameters:

Point # - This is the information object address of the point. It identifies the point in the network.

DB Address - This is the database location in the 104S module associated with the point.

Group(s) – This is the group definition for the point. It sets how the point will be polled by the master (cyclic or group interrogation). It can also be used to enable or disable the event generation for one specific point. The group parameter is discussed in the Data Communication section.

Deadband – Sets the deadband for each Measured point. If the value changes from more than the configured deadband , the module will generate an event for this point.

The monitor data types are described in the following table:

Data Type	Data Size	Addressing Type
M_SP_NA	1 bit	Bit
M_DP_NA	2 bits	Bit
M_ST_NA	1 byte	Byte
M_ME_NA	1 word	Word
M_ME_NB	1 word	Word
M_IT_NA	2 word	Double-Word

M_SP_NA Example

The monitored single-point uses one bit with bit-addressing. For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     100        1600   80000000
     101        1601   00000200
     102        1602   00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
100	Bit 0 of word 100
101	Bit 1 of word 100
102	Bit 2 of word 100

M_DP_NA Example

The monitored double-point uses two bits with bit-addressing. It typically represents the ON/OFF states where:

01 = OFF
10 = ON

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     200        3200   80000000
     201        3204   00000200
     202        3208   00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
200	Bit 0 of word 200
201	Bit 4 of word 200
202	Bit 8 of word 200

M_ST_NA Example

The monitored step-point uses one byte with byte-addressing.

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     300        40       80000000
     301        60       00000200
     302        81       00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
300	Low Byte of word 20
301	Low Byte of word 30
302	High Byte of word 40

M_ME_NA Example

The monitored measured normalized point uses one word with word-addressing. It uses a data representation defined by the protocol specification, where each bit represents a value as follows:

Bit	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Value	S	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Ex: a value of 4000hex is interpreted as 0.5

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     400         10       80000000
     401         12       00000200
     402         18       00000400
END
```

These points would be used as follows:

Inf. Object Address	**104s Module Database Address**
400	Word 10
401	Word 12
402	Word 18

M_ME_NB Example

The monitored measured scaled point uses one word with word-addressing.

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     500        10       80000000
     501        12       00000200
     502        18       00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
500	Word 10
501	Word 12
502	Word 18

M_IT_NA Example

The monitored integrated total point (counter) uses two words with double-word addressing.

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     600        20       80000000
     601        32       00000200
     602        52       00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
500	Words 40 and 41
501	Words 64 and 65
502	Word 104 and 105

5 - Using Control (Command) Points

The following control points are supported by the 104S module:

Symbol	Description
C_SC_NA	Single-Point Command
C_DC_NA	Dual-Point Command
C_RC_NA	Step-Point Command
C_SE_NA	Measured Normalized Point Command
C_SE_NB	Measured Scaled-Point Command

Each control point is identified by its Information Object Address (it should be unique for each Common ASDU Address in the network). For each monitor point, the user should configure the following parameters:

Point # - This is the information object address of the point. It identifies the point in the network.

DB Address - This is the database location in the 104S module associated with the point.

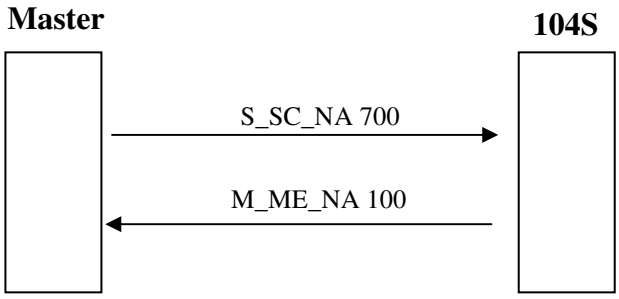
Monitor Point #–
Monitor DB Address- The user might (optionally) configure a monitor point to be sent by the 104S module when it receives the command for that specific point.

Example:

```
#                        Monitor  Monitor  Require
# Point #   DB Address   Point #  DB Addr   Select
# -------   ----------   -------  -------  -------
START
      700         3200       100     1600        0
END
```

So every time the module receives a command for single-command point 700 it would send a response containing a monitored single-point (information object address 100 with the value at bit-address 1600).

Require Select – This parameter selects the point requires a *Select* request before the *Operate* command.



Each monitor point type is discussed as follows:

The data types are described in the following table:

Data Type	Data Size	Addressing Type
C_SC_NA	1 bit	Bit
C_DC_NA	2 bits	Bit
C_RC_NA	1 byte	Byte
C_SE_NA	1 word	Word
C_SE_NB	1 word	Word

C_SC_NA Example

The single-point command uses one bit with bit-addressing. For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     100        1600   80000000
     101        1601   00000200
     102        1602   00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
100	Bit 0 of word 100
101	Bit 1 of word 100
102	Bit 2 of word 100

C_DC_NA Example

The monitored double-point uses two bits with bit-addressing. It typically represents the ON/OFF states where:

01 = OFF
10 = ON

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     200        3200   80000000
     201        3204   00000200
     202        3208   00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
200	Bit 0 of word 200
201	Bit 4 of word 200
202	Bit 8 of word 200

C_RC_NA Example

The step-point command uses one byte with byte-addressing.

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     300        40       80000000
     301        60       00000200
     302        81       00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
300	Low Byte of word 20
301	Low Byte of word 30
302	High Byte of word 40

C_SE_NA Example

The measured normalized point command uses one word with word-addressing. It uses a data representation defined by the protocol specification, where each bit represents a value as follows:

Bit	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Value	S	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Ex: a value of 4000hex is interpreted as 0.5

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     400         10       80000000
     401         12       00000200
     402         18       00000400
END
```

These points would be used as follows:

Inf. Object Address	**104s Module Database Address**
400	Word 10
401	Word 12
402	Word 18

C_SE_NB Example

The measured scaled point command uses one word with word-addressing.

For example, let's assume that the user has configured the following points:

```
# Point #   DB Address   Group(s)
# -------   ----------   --------
START
     500        10       80000000
     501        12       00000200
     502        18       00000400
END
```

These points would be used as follows:

Inf. Object Address	104s Module Database Address
500	Word 10
501	Word 12
502	Word 18

6 – Data Communication

The way that each monitored point is transferred from the 104S module and the master unit depends on how the *Group* parameter is configured for each point. The Group parameter is defined as follows:

GROUP CODE	DESCRIPTION
0x00000001	Interrogated by general interrogation (station or global)
0x00000002	Interrogated by group 1 interrogation
0x00000004	Interrogated by group 2 interrogation
0x00000008	Interrogated by group 3 interrogation
0x00000010	Interrogated by group 4 interrogation
0x00000020	Interrogated by group 5 interrogation
0x00000040	Interrogated by group 6 interrogation
0x00000080	Interrogated by group 7 interrogation
0x00000100	Interrogated by group 8 interrogation
0x00000200	Interrogated by group 9 interrogation
0x00000400	Interrogated by group 10 interrogation
0x00000800	Interrogated by group 11 interrogation
0x00001000	Interrogated by group 12 interrogation
0x00002000	Interrogated by group 13 interrogation
0x00004000	Interrogated by group 14 interrogation
0x00008000	Interrogated by group 15 interrogation
0x00010000	Interrogated by group 16 interrogation
0x00020000	Interrogated by general counter request
0x00040000	Interrogated by group 1 counter request
0x00080000	Interrogated by group 2 counter request
0x00100000	Interrogated by group 3 counter request
0x00200000	Interrogated by group 4 counter request
0x40000000	Disable event scanning of this point
0x80000000	Periodic/cyclic data returned from unit

For example, for the following configuration:

```
# Point #    DB Address    Group(s)
# -------    ----------    --------
START
     100          1600    80000002     # P1-PSHH -- Discharge pressure SD
END
```

Would imply that this point would be sent either during cyclic polls or when a General Interrogation request for group 1 occurs.

The module will periodically send all points configured for periodic/cyclic poll (0x80000000) at every x milliseconds, where x is configured by the user with the following parameter:

Cyclic data transmission : 20000 #Numb of milliseconds between cyclic updates

The user may also divide the monitored points into different groups, allowing the master to poll periodically only certain points. This also allows some points to be polled more frequently than others.

Obs: The user should configure the counter points (M_IT_NA) for general counter interrogation or group counter interrogations.

Example:

Let's suppose that the user configures the following data points:

```
[M_SP_NA_1 104]
# Point #    DB Address    Group(s)
# -------    ----------    --------
START
      100          1600    80000000 # Periodic Poll
      101          1601    00000002 # Group 1 Interrogation
      102          1602    00000002 # Group 1 Interrogation
      103          1603    00000004 # Group 2 Interrogation
END
```

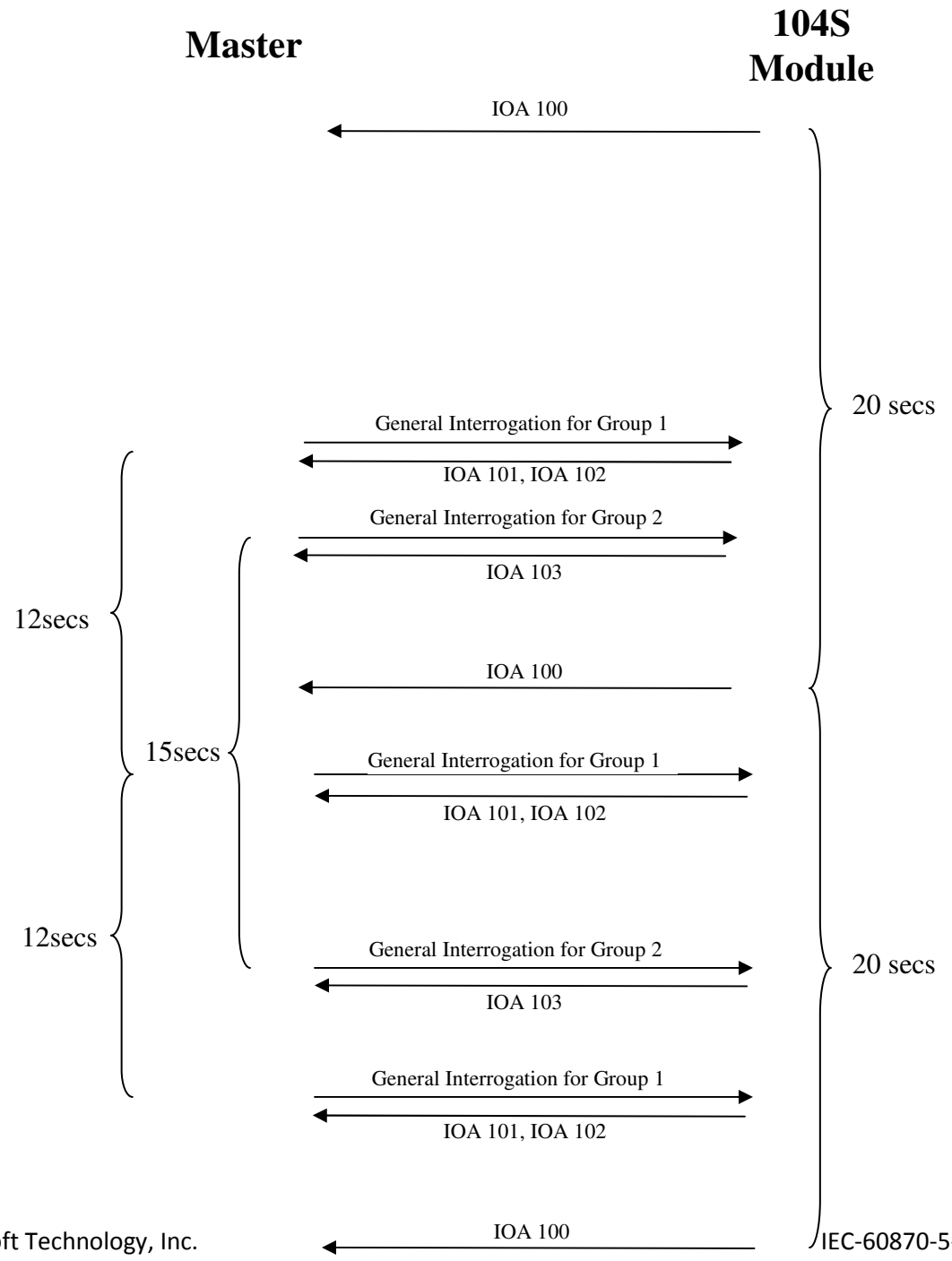
The Cyclic data transmission parameter is configured as follows:

Cyclic data transmission : 20000 #Numb of milliseconds between cyclic updates

Let's suppose that the master unit sends the following requests:

General Interrogation for Group 1 every 12 seconds
General Interrogation for Group 2 every 15 seconds

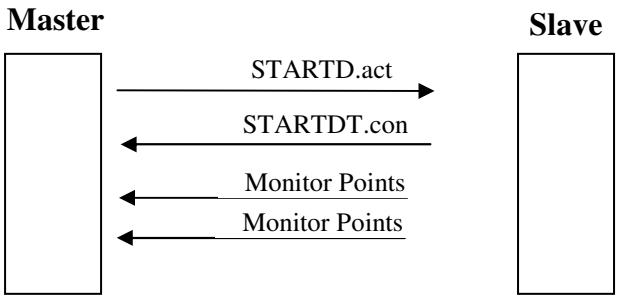
The following diagram shows how the communication would be performed between the master and the 104S module.



STARTDT & STOPDT

STARTDT (Start Data Transfer) and STOPDT (Stop Data Transfer) are used by the master to control the data transfer from the slave. When the connection is established, user data is not automatically enabled in the slave until it receives a STARTDT act request from the master. The slave should respond with a STARTDT con response to acknowledge the master request. Once this procedure is concluded, the slave can send monitor data to the master.

The master can interrupt the monitor data flow at any time sending a STOPDT act command to the slave.



In some circumstances the master unit may not support STARTDT and STOPDT messages. The module may also be tested with a simulator software that does not support these features. During these situations the user may want to disable the STARTDT and STOPDT features using the following parameter:

```
Override StartDT  :  1 #Used to ignore STARTDT/STOPDT state (0=No, 1=Yes)
```

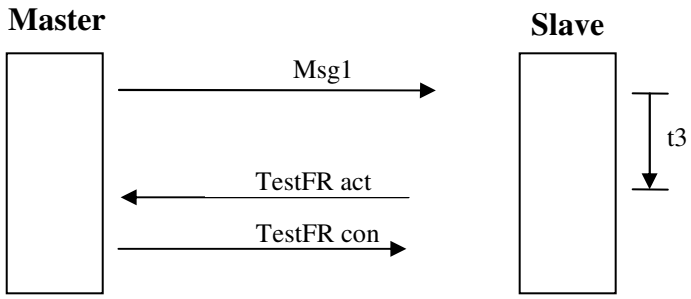
So if this parameter is set to 1 the module will ignore the STARTDT and STOPDT requests by the master unit.

TESTFR Requests

Connections that are unused (but opened) may be periodically tested in both directions by sending test messages (TESTFR=act) which are confirmed by the receiving station sending TESTFR=con messages. The 104S module can be configured to periodically send this message using the following parameter:

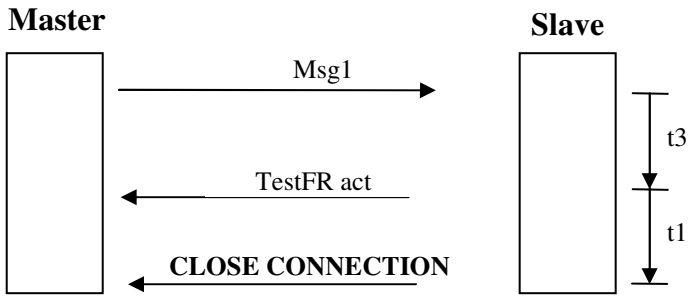
```
t3 timeout set value       :    30 #timeout for test frame on idle state
```

In the example above the module would send a TESTFR.ACT message 30 seconds after receiving the last message:



If the module does not receive the TESTFR.con message within a certain amount of time, it will timeout and close the connection. The user may configure the timeout period by using the following parameter:

t1 timeout set value : 15 #timeout of send or test ASDU



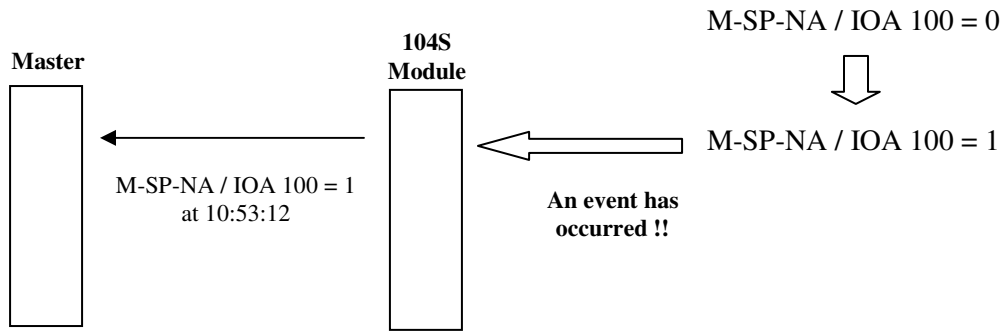
When closing the connection the module can be configured to clear all the messages in its queue. The following parameter is used to implement this task:

```
Clear queue on close:  1 #Clear the queue when connection closed (0=No, 1=Yes)
```

So the configuration above would cause to module to delete all pending messages/events while closing the connection to the master.

7. Events

In order to improve the communication efficiency, most applications will require the master to periodically poll for data changes with a higher priority than polling for monitor data. Every time a data changes the slave should send this information, typically with the date and time information on when it has occurred.



Deadbands

The monitored measured points (M_ME_NA and M_ME_NB) will only generate events if the data changes from more than the configured deadband value.

For example, let's suppose that the following point is configured:

```
[M_ME_NB_1 104]
#                                   Default
# Point #    DB Address    Group(s)  Deadband
# -------    ----------    --------  --------
START
      500           105   80000000       100
END
```

So, if the current value for this point is 130, it would only generate events if :

NEW VALUE is less or equal than 30
OR
NEW VALUE is greater or equal than 230.
The user can set the deadband for each monitored measured point through the configuration file.

The master may also dynamically change the deadband for each monitored point. The master may send one of the following commands:

Type	Command
110	Parameter of Measured Normalized Data (M_ME_NA)
111	Parameter of Measured Scaled Data (M_ME_NB)

The protocol specification explains that the qualifier value for these commands should be configured as:

Bits	Value	Description
1 to 6	0	Not Used
	1	**Threshold Value (Deadband)**
	2	Smoothing Factor (filter time constant) – Not Supported
	3	Low Limit Transmission of Measured Value
	4	High Limit Transmission of Measured Value
	5..31	Reserved
7	0	No Change
	1	Change
8	0	Operation
	1	Not in Operation

For the 104S module, the Low Limit and High Limit parameters cannot be changed by command, since these values are calculated as follows:

Low Limit = (LAST REPORTED VALUE) – Deadband
High Limit = (LAST REPORTED VALUE) + Deadband

These commands must be sent to a specific Information Object Address. The 104S module associates each monitor measured point with a parameter point through the following configuration parameters:

M_ME_NA Parameter Offset : 2000 #M_ME_NA IOA offset for parameter data
M_ME_NB Parameter Offset : 2000 #M_ME_NB IOA offset for parameter data

Example:

Supposing that the following monitored measured points are configured:

```
[M_ME_NA_1 104]
#
#                                  Default
# Point #    DB Address    Group(s)  Deadband
# -------    ----------    --------  --------
START
      400           100    80000000       100    # P1 suction pressure
      401           101    00000200       100    # P1 discharge pressure
      402           102    00000400       100    # P2 suction pressure
      403           103    00000800       100    # P2 discharge pressure
      404           104    00001000       100    # Station discharge pressure
END


[M_ME_NB_1 104]
#
#                                   Default
# Point #    DB Address    Group(s)  Deadband
# -------    ----------    --------  --------
START
      500           105    80000000       100
      501           106    00000200       100
      502           102    00000400         1
      503           103    00000800         1
      504           104    00001000         1
END
```

And supposing that the parameter points are configured as follows:

M_ME_NA Parameter Offset : 2000 #M_ME_NA IOA offset for parameter data
M_ME_NB Parameter Offset : 2000 #M_ME_NB IOA offset for parameter data

It would imply that the parameter points would be configured as follows:

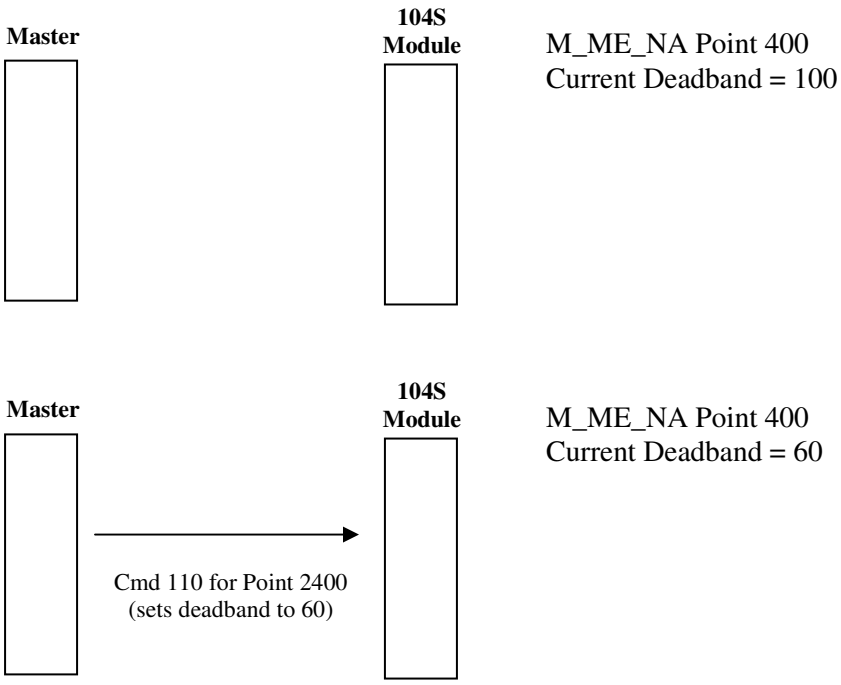
M_ME_NA

Monitored Measured Normalized Point	Associated Parameter Point
400	2400
401	2401
402	2402
403	2403
404	2404

M_ME_NB

Monitored Measured Normalized Point	Associated Parameter Point
500	2500
501	2501
502	2502
503	2503
504	2504

So, in order to send change the deadband for the M_ME_NA point 400, the master would send a command type 110 to point 2400:



Controlling the Generation of Events

Some applications may require that only some points should generate events. The application would only poll the current value for these points, although there would be no special interest on when these points change the values. Other applications may require that all configured points should generate events.

The 104S module offers a lot of flexibility for event control. The user may control if events will be generated at 3 different levels:

1- General (All Points)
2 – Data Type Level
3 – Point Level

General (All Points)

The user may control how frequently the module will scan the database for events using the following configuration parameter:

```
Event Scan delay     :      1 #MSec between event scanning (0-65535) 0=Disable
```

If this parameter is set to 0, the module will not generate events for any points. A non-zero value will configure how frequently the module will scan for events in the database.

Data Type Level

The user may configure if a data type should generate events or not. Each data type has a configuration parameter to control the generation of events:

```
M_SP_NA Scan Events  :      1 #0=No scanning, 1=scan for events
M_DP_NA Scan Events  :      0 #0=No scanning, 1=scan for events
M_ST_NA Scan Events  :      0 #0=No scanning, 1=scan for events
M_ME_NA Scan Events  :      0 #0=No scanning, 1=scan for events
M_ME_NB Scan Events  :      0 #0=No scanning, 1=scan for events
```

In the example above, only the M_SP_NA points would generate events.

Point Level

The user may configure if each point should generate events or not using the Group field for each point configuration. The user should set the value as 40000000 in order to disable the generation of events for that specific point.

```
[M_SP_NA_1 104]
#
# Point #    DB Address    Group(s)
# -------    ----------    --------
START
      100          1600    40000000    # P1-PSHH -- Discharge pressure SD
END
```

Time Information

Each event may also send the date and time when it has occurred. The 104S module supports the CP56 time format (as defined in the protocol specification). Basically, it contains the milliseconds, seconds, minute, hour, day, month and year when the event has occurred.

The 104S module may also be configured not to send any time information with each event for certain data types.

The following parameters may be used to control the time information for each data type:

M_SP_NA Time Type : 2 #0=None, 2=CP56 time
M_DP_NA Time Type : 2 #0=None, 2=CP56 time
M_ST_NA Time Type : 2 #0=None, 2=CP56 time
M_ME_NA Time Type : 2 #0=None, 2=CP56 time
M_ME_NB Time Type : 2 #0=None, 2=CP56 time
M_IT_NA Time Type : 2 #0=None, 2=CP56 time

Obs: The master should send a Time Synchronization command to the module in order to synchronize its date and time information

Event Report

Depending on several factors, a single point may generate multiple events before sending to the module. The 104S module can be configured to report all events for a specific point or sending only the last event that has occurred:

```
M_SP_NA Use Recent    :       0 #0=report multiple, 1=report single
M_DP_NA Use Recent    :       0 #0=report multiple, 1=report single
M_ST_NA Use Recent    :       0 #0=report multiple, 1=report single
M_ME_NA Use Recent    :       0 #0=report multiple, 1=report single
M_ME_NB Use Recent    :       0 #0=report multiple, 1=report single
```

FAQ – Frequently Asked Questions

1) Although there is communication between the master and the 104S module, the slave unit seems to ignore the commands or control points sent by the master.

Possible Solution:
Check if the 104s unit has the correct Common ASDU address that matches the one sent by the master unit.

2) There is no communication between the master and the module.

Possible Solution:
First of all, verify the *Use IP List* parameter value. If it is set to 1 (yes), make sure that the master unit uses one of the IP addresses selected on the valid IP list.

After that, make sure that the 104S module has the correct IP address.