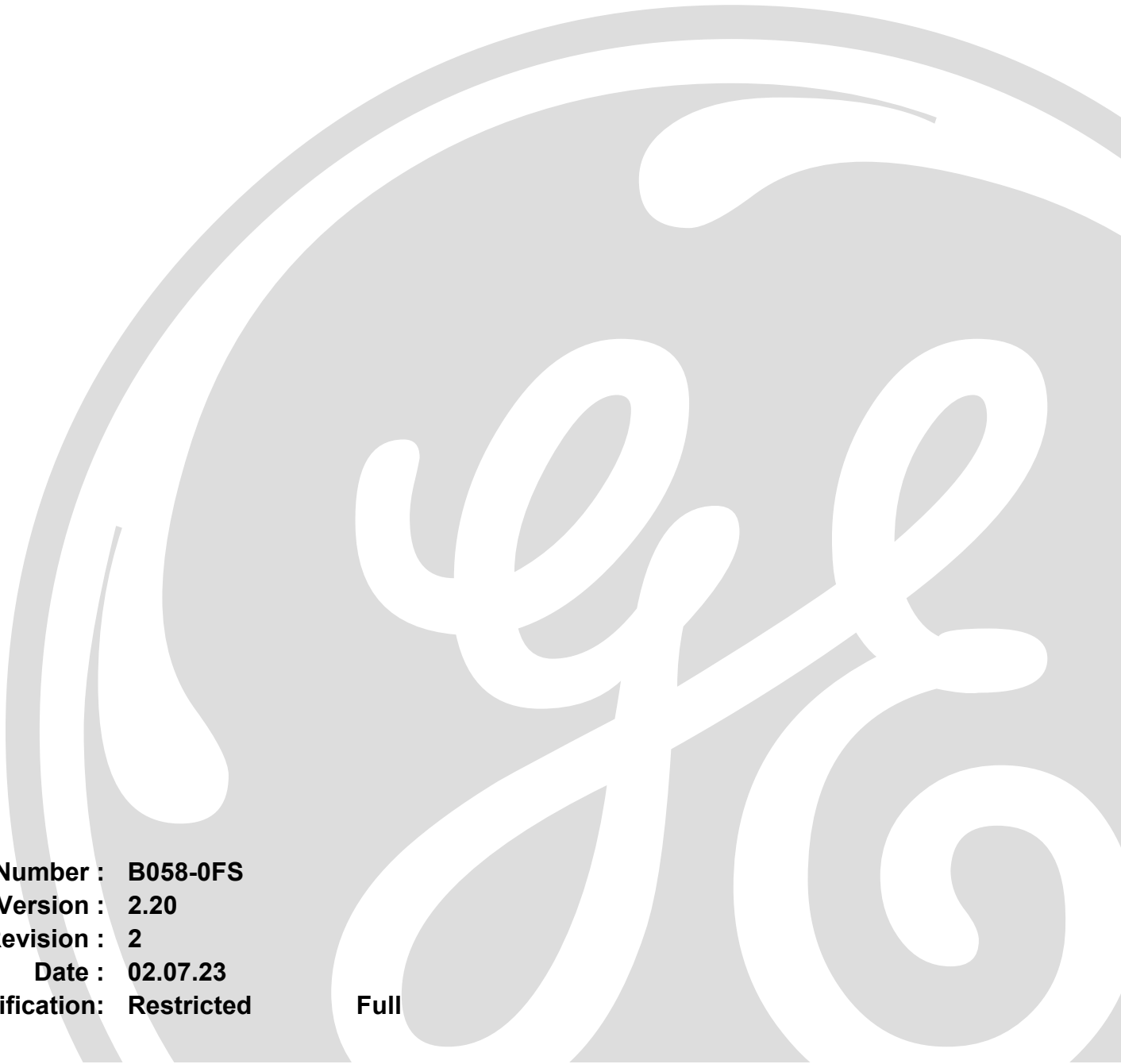
GE Energy Services

IEC 870-5 FT1.2 Primary Data Link
Functional Specification



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About this Specification

This specification establishes the software requirements for the IEC 870-5 FT1.2 Primary Data Link protocol to be used with the WESDAC remote terminal units (RTUs). It outlines specific requirements in terms of interface functions, processing requirements, design constraints, attributes, and other requirements.
This specification does not describe the IEC 870-5 data link protocol standard. *Appendix A:* does however outline the supported functions and *Appendix B:* provides a summary of some aspects of the protocol standard.

Additional Documentation

The following documents define the IEC 870-5 data link protocol.

- *IEC 870-5-1: 1990, Telecontrol equipment and systems - Part 5: Transmission protocols - Section one: Transmission frame formats.*
- *IEC 870-5-2: 1992, Telecontrol equipment and systems - Part 5: Transmission protocols - Section two: Link transmission procedures.*
- *IEC 870-5-5: 1995, Telecontrol equipment and systems - Part 5: Transmission protocols - Section five: Basic application functions.*
- *IEC 870-5-101: 1995, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 101: Companion standard for basic Telecontrol tasks.*
- *IEC 870-5-103: 1997, Telecontrol equipment and systems - Part 5: Transmission protocols - Section 103: Companion standard for the informative interface of protection equipment.*

Overview

This implementation of the IEC 870-5-1 FT1.2 Primary Data Link supports only the unbalanced version of the data link protocol layer, with the Data Link acting as a master communication device, initiating all data exchanges. In unbalanced mode, the controlling station is always primary, i.e. the initiator of a message dialog, and the controlled station is always secondary, only sending messages in response to primary station requests.
The Data Link supports the FT1.2 Transmission frame format with Hamming distance 4.

☞ **NOTE:** Throughout this document, the term Data Link, with initial capitals, is used to refer to this software. The term data link, with no capitals, is the generic term referring to any data communication at this protocol layer.

Product Perspective

The IEC 870-5-1 FT1.2 Primary Data Link formats outgoing application layer messages into data link frames and performs and controls message transmission to and reception from remote devices. The Data Link autonomously executes polling of remote devices for data. The Data Link is intended to be integrated in a modular software environment with one or more Data Collection Applications (DCAs) acting as Data Link users to provide basic SCADA functionality.
A general system overview is illustrated in *Figure 1*.

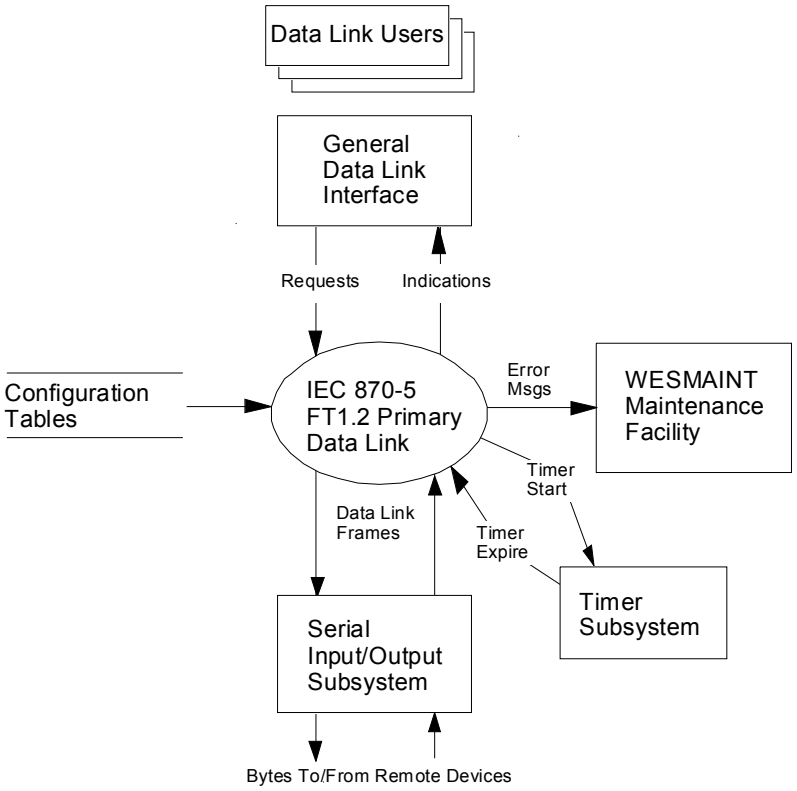


Figure 1 IEC 870-5 FT1.2 Primary Data Link Context

Product Functions

The IEC 870-5 FT1.2 Primary Data Link is designed to emulate a controlling (master) station. The major functions of this emulation are as follows:

- Provide transmission services using the IEC 870-5 FT1.2 frame format.
- Operate in unbalanced mode, i.e. act as a master station, supporting all functions defined in Appendix B:.
- Per Data Link instance, support communication with multiple remote devices over one communication line (serial link).
- Interface with the General Data Link to support communication with multiple Data Link users (DCAs) over multiple data link channels.
- Autonomously, execute polling of remote devices for data.
- Report on frame and communications errors.
- Keep communication statistics on a per device basis and report them to the Data Link user.

General Constraints

The IEC 870-5 FT1.2 Primary Data Link will operate under the following constraints:

- The Data Link always initiates communications with the remote device (i.e. unbalanced mode).
- A Data Link may communicate with multiple remote devices sharing the same communication channel, but each Data Link instance serves only one channel.
- Per Data Link instance, communication with only one Data Link user (DCA) is supported.
- As this Data Link implements unbalanced transmission mode, “group” addressing is not supported, refer to IEC 870-5-101 Section 6.2. Broadcast is still supported.
- The Data Link does not support switchover to a redundant transmission line.
- Available baud rates depend on the hardware platform.
- Response turn-around times depend on the speed and loading of the system.

Assumptions and Dependencies

Full implementation of some of the requirements stated herein will be dependent on the capabilities of the operating system. This specification assumes one of the following base systems:

- D20 Base System version 3.60 or higher.
- D25 Base System version 1.06 or higher.
- CCU Base System version 1.70 or higher.
- CPM Base System version 4.12 or higher.

Chapter 1: Specific Requirements

This chapter describes, in detail, the functional requirements of the IEC 870-5 FT1.2 Primary Data Link. These requirements are arranged into the following categories:

- Initialization Requirements.
- Functional Requirements.
- External Interface Requirements.
- Performance Requirements.
- Design Constraints.

The major functional requirement of the Data Link is to provide transmission services to higher layer applications. The detailed requirements of that function and other standard Data Link functions are outlined in the following sections.

1.1 Initialization Requirements

The initialization requirements of the IEC 870-5 FT1.2 Primary Data Link are outlined in the following sections.

1.1.1 Configuration Checking

All Data Link configuration parameters , refer to *Chapter 2: Configurable Parameters*, will be checked for validity. If any parameter is invalid, an appropriate error message will be generated.

1.1.1.1 Inputs

- A user request to open a Data Link (B020_dl_open).
- All configurable parameters specific to the IEC 870-5 FT1.2 Primary Data Link.

1.1.1.2 Processing

Upon reception of a user command to open a Data Link (B020_dl_open), which initiates the creation of a Data Link instance for a particular channel, the Data Link will verify that the contents of all its configuration parameters are valid and will not impair its operation.
The Data Link will check that:

- All required configuration tables exist.
- All records referenced by the configuration tables exist.
- All options have valid values.

If an invalid configuration is detected an appropriate error message will be logged to the WESMAINT Error Log and an error code returned to the user. If the error is not fatal, the Data Link will continue its initialization and provide as much functionality as possible.

1.1.1.3 Outputs

- Each error found will result in a single message logged to the WESMAINT Error Log. If any error is fatal, the Data Link will abort its start-up after logging as many error messages as possible.

1.1.2 Communication Initialization

The Data Link waits for the first request to send a user message to a specific remote device before initializing communication with that device and beginning to poll that device for spontaneously generated event data, refer to *Section 1.2.9 Autonomous Polling*.

1.1.2.1 Inputs

Communication initialization with a user application:

- A user request to open a Data Link (B020_dl_open).

Communication initialization with a remote device:

- The first user request to send a message (B020_dl_send) to a particular remote device after startup of the Data Link instance.
- RESPOND - STATUS OF LINK (FC 11) message, received in response to a REQUEST/RESPOND EXPECTED - REQUEST STATUS OF LINK (FC 9).
- Positive acknowledgment CONFIRM - ACK (FC 0) or single character ACK (0xE5), received in response to a SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7).
- Negative acknowledgment CONFIRM - NACK (FC 1) or single character NACK (0xA2), received in response to a SEND/CONFIRM - RESET OF REMOTE LINK (FC 0).

1.1.2.2 Processing

The initialization procedure is performed under two circumstances:

1. Upon reception of a request to open a Data Link, a Data Link instance is created which will be used to communicate with the remote device. No further initialization of the connection is preformed until the Data Link receives a user request for the remote device. The connection will be initialized immediately after the Data Link receives the first user request for the remote device, and before the Data Link attempts to send the user request. It should be noted that if the device initialization fails the user will be notified that the user request failed and the Data Link will then attempt to initialize the connection during the devices polling cycle.
2. After a communication failure in which the remote device failed to respond to a user request. The Data Link will attempt to initialize the connection with the remote device during the device's poll cycle.

In order to initialize the connections of devices compliant with either the IEC 870-5-5 or the IEC 60870-5-103 specifications, the initialization procedure is as follows:

- The Data Link issues a REQUEST/RESPOND EXPECTED - REQUEST STATUS OF LINK (FC 9) to the device to verify that the device is responding. This request is made in accordance with the IEC 870-5-5 initialization procedure.
    - If the expected response RESPOND - STATUS OF LINK (FC 11) is received, the Data Link checks if the DFC bit is set in the response packet. If the DFC bit is not set the Data Link transmits a SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7) to the same device for the purpose of message sequence synchronization. If the DFC bit is set the initialization is considered to have failed.
        - If a acknowledgment CONFIRM - ACK (FC 0) or single character ACK (0xE5) is received in response to the SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7) the initialization is considered to have completed successfully.
        - If no response is received to the SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7) request is received, the initialization is considered to have failed.
        - If a negative acknowledgment CONFIRM - NACK (FC 1) or single character NACK (0xA2) is received in response to the SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7) request the initialization is considered to have failed.
    - If the remote device does not respond to the REQUEST/RESPOND EXPECTED - REQUEST STATUS OF LINK (FC 9) within the allowed response time, the Data link will immediately, send a SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7), and wait for the response. This is done to make the initialization procedure compatible with devices using the IEC 60870-5-103 initialization procedure.
    - If the remote device responds to the SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7) with a CONFIRM - ACK (FC 0) or single character ACK (0xE5) the initialization is considered to have completed successfully.
    - If there is no response (neither ACK or NACK) is received within the configured timeout for the SEND/CONFIRM - RESET OF REMOTE LINK request then the initialization of the connection to the remote device is considered to have failed.

☞ **NOTE:** If a user request is received for a device for which attempts to reestablish communications are ongoing, the Data Link will act according to point 1 above, immediately sending the REQUEST/RESPOND EXPECTED - REQUEST STATUS OF LINK (FC 9) or SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 FC 7), which ever request is next to be executed for this device, as opposed to waiting until it is the device's turn in the poll cycle.

1.1.2.3 Outputs

Communication initialization with a user application:

- The return codes for the B020_dl_open function call are described in the General Data Link Interface Programmer's Guide.

Communication initialization with a remote device:

- Return codes for the B020_dl_send function call are described in the General Data Link Interface Programmer's Guide.
- To initialize communication with a remote device, the Data Link issues a REQUEST/RESPOND EXPECTED - REQUEST STATUS OF LINK (FC 9) and a SEND/CONFIRM - RESET OF REMOTE LINK (FC 0 or FC 7) to the device to verify that it is responding.
- The Data Link queues the message type B020_TX_STATUS and makes it available to the user application via the B020_dl_receive request, as listed in Section 1.2.8 Receive User Messages.
- The Data Link queues the message type B020_LINK_STATUS and makes it available to the user application via the B020_dl_receive request, as listed in Section 1.2.8 Receive User Messages.

1.2 Functional Requirements

The functional requirements of the IEC 870-5 FT1.2 Primary Data Link are outlined in the following sections.

1.2.1 External Interfaces

The IEC 870-5 FT1.2 Primary Data Link will act as a master device, always initiating communication with a remote device on a serial channel. The Data Link will accept requests from data link user applications.

1.2.1.1 Inputs

User application requests are received via the General Data Link Interface. The following General Data Link Interface function calls are supported:

- B020_dl_open

  Multiple Data Link users are not supported. Only one user application is supported per Data Link instance.
- B020_dl_close
- B020_dl_send

The following quality of service options are supported:
- B020_SEND_CONFIRM
- B020_SEND_NO_CONFIRM
- B020_QUERY (B020_RESPONSE is rejected with the error status set to B20_FAIL_OTHER)
- B020_EXPIRATION
- B020_GUARANTEED
- B020_BROADCAST
- B020_dl_cntrl

The following message type is supported:
- B020_ADD_DL_ADDRESS

The Data Link partially supports the following message type:
- B020_START_RESPONSE_TIMER, refer to Section 1.2.7 Link Control/Start Response Timer)

☞ **NOTE:** The Data Link will reject the B020_dl_cntrl function call with the error code B020_FAIL_NOT_SUPT when any function other than B020_START_RESPONSE_TIMER or B020_ADD_DL_ADDRESS is specified.

- B020_dl_receive

The Data Link supports the following message types:
- B020_RX_MSG
- B020_RX_TIMEOUT
- B020_TX_STATUS
- B020_LINK_STATUS
- B020_COMM_STATS

A remote device response is received from the same channel, via the Serial I/O Sub-system, on which the Data Link transmitted the request. All secondary messages listed in *Appendix B:* are supported.

1.2.1.2 Processing

The Data Link will accept requests from a user application, execute the requests and respond to the user application. Request execution may involve transmitting a request to a remote device and making the data received from the device in response to the request available to the user application.

1.2.1.3 Outputs

- The Data Link responds to a user request via the General Data Link Interface, indicating the success or failure of the command execution (for details refer to General Data Link Interface Programmer's Guide), and providing user data, if applicable.
- Primary requests to remote devices are transmitted via the Serial I/O Sub-system and are supported as listed in Appendix B:.

1.2.2 Format and Parse Frames

When transmitting or receiving frames, the Data Link uses the frame format shown in *Appendix B:*. This is the IEC 870-5 FT1.2 Data Link frame format, specified in the International Electrotechnical Commission's IEC 870-5 standard.

1.2.2.1 Inputs

The Data Link accepts:

- Primary user application requests to send a message to a remote device (B020_dl_send function call with quality of service B020_QUERY), which the Data link formats into FT1.2 transmission frames.
- Secondary responses from remote devices (frames with the PRM bit set to 0) as listed in *Appendix B:*.
- Single character ACK (0xE5) and NACK (0xA2) responses from remote devices.

1.2.2.2 Processing

This section describes the processing that is done on frames received from remote devices and frames sent to remote devices.

1.2.2.2.1 Frame Received From A Remote Device

The Data Link verifies that incoming fixed and variable frames are formatted correctly. An IEC 870-5 message never spans more than one data link frame. One frame may contain up to 255 user data bytes. Only frames of variable length contain ASDU information. If any of the following conditions are not met, the Data Link discards the incoming frame and increments the corresponding counter in the Statistics Table, refer to *Section 1.2.2.4 Frame Errors*.
Per frame:

- The START octet of a frame of fixed length must be 0x10.
- The number of octets received for a frame of fixed length must be equal to the configured Link Address Size plus 4 (1 START, 1 CONTROL, 1 CHECK SUM, 1 END octet).
- The START octets of a frame of variable length must be 0x68.
- The length of a frame of variable length must match the LENGTH fields plus 6 (2 START octets, 2 LENGTH octets, 1 CHECK SUM, 1 END octet).
- The PRM bit must be set to 0 as this Data Link implementation only accepts secondary responses.
- The FUNCTION CODE must reflect a valid response to the original request.
- The ADDRESS field must match the device address specified in the original request.
- The frame CHECK SUM must be correct.
- The END octet of a frame must be 0x16.
- The Data Link must receive all of the octets in a frame within a frame timeout.

☞ **NOTE:** If the Data Link discards a frame for any of the above reasons, it will continue to wait for a valid frame until either the Respond Message Timeout or the Confirm Message Timeout expires, as appropriate.

$$Frame\ Timeout = (Octet\ Transmit\ Time \times Octets\ in\ Frame) + Message\ Timeout$$

$$Octet\ Transmit\ Time = \frac{1\ start\ bit + 8\ data\ bits + 1\ parity + 1\ stop\ bit}{Configured\ Bits\ Per\ Second}\ Rounded\ up\ to\ nearest\ ms$$

For example, at 9600 bits/second, the octet transmit time is 1.15 milliseconds, rounded up to 2 milliseconds. The frame timeout for a maximum size message of 261 octets is therefore 522 milliseconds plus the configured Message Timeout.
The Data Link parses the ASDU contained in frames of variable length, removing the data START, LENGTH, CONTROL, ADDRESS, CHECK SUM and END characters from the frame.

1.2.2.2.2 User Data Frame to be Sent to A Remote Device

The user application supplies the information on whether to use the SEND/CONFIRM EXPECTED - USER DATA (FC 3) or SEND/NO REPLY EXPECTED - USER DATA (FC 4) function code by setting the quality of service option to either B020_SEND_CONFIRM or B020_SEND_NO_CONFIRM. To transmit a user data message, the Data Link formats an FT1.2 frame of variable length, adding the following information to the user data received via a B020_dl_send function call:

- The CONTROL octet.
- Setting the PRM bit to 1 to indicate a primary message.
- Setting the FCB and FCV bits to the appropriate values.

- Setting the FUNCTION CODE to the appropriate value.
- The ADDRESS field, setting its value to the destination address received in the B020_dl_send request. Broadcast messages must have all address bits set to 1.
- Two START octets, two LENGTH octets (incrementing the COUNT parameter value, passed in the B020_dl_send function by the user application, by 2 and writing it into each LENGTH field), calculates and adds the CHECK SUM octet and adds one END octet according to the FT1.2 frame format of variable length.

Frames, which are not initiated by a user application and sent by the Data Link to a remote, are always FT1.2 frame formats of fixed length. The fixed length is the sum of the configured Link Address Size plus 4 (1 START, 1 CONTROL, 1 CHECK SUM, 1 END octet).
A minimum of 33 line idle bits are required between two frames which requires the configurable Confirm Timeout and Respond Timeout values to be greater than 33 line idle bits. The Data Link calculates the minimum time to wait between sending consecutive frames based on the required 33 line idle bits and the configured baud rate. If the configurable Confirm Timeout and Respond Timeout happen to be less than the calculated minimum wait time, the minimum wait time will override the Confirm Timeout and Respond Timeout values. Details regarding the calculation of Confirm/Respond Timeout are given in IEC 870-5-2 Annex A.

1.2.2.3 Outputs

The Data Link:
- Transmits primary requests (frames with the PRM bit set to 1) to remote devices as listed in Appendix B:.
- Makes secondary responses available to be read by the user application (B020_dl_receive function call, message type B020_RX_MSG).

1.2.2.4 Frame Errors

The Data Link keeps one statistics table on a per channel basis. These tables reside in RAM. The table name is **B058STAx**, where **x** represents the channel number. For instance, the table name for channel 0 will be **B058STA0**. If any one of the following errors is encountered, the corresponding counter is incremented by one:
- Invalid START octet(s).
- Invalid frame length (i.e. invalid LENGTH fields in a frame of variable size or invalid number of octets in a frame of fixed length).
- Invalid PRM bit.
- Invalid FUNCTION CODE.
- Invalid ADDRESS.
- Invalid CHECK SUM.
- Invalid END octet.
- FRAME TIMEOUT.

Other run-time diagnostics include the following:

- SERIAL I/O error detected.
- Number of times the state of any one of the remote devices was set to COMMUNICATION FAILURE.
- Number of times the DFC bit was set in a remote response.
- CONFIRM TIMEOUT detected.
- RESPOND TIMEOUT detected.
- Number of TRANSMIT RETRIES were performed.
- Number of SEND/CONFIRM - RESET OF REMOTE LINK sent.
- Number of SEND/CONFIRM - USER DATA sent.
- Number of SEND/NO REPLY - USER DATA sent.
- Number of REQUEST FOR ACCESS DEMAND sent.
- Number of REQUEST/RESPOND - REQUEST STATUS OF LINK sent.
- Number of REQUEST/RESPOND - REQUEST USER DATA CLASS 1 sent.
- Number of REQUEST/RESPOND - REQUEST USER DATA CLASS 2 sent.
- Number of CONFIRM - ACK or single character ACK received.
- Number of CONFIRM - NACK or single character NACK received.
- Number of RESPOND - USER DATA received.
- Number of RESPOND - NACK received.
- Number of RESPOND - STATUS OF LINK OR ACCESS DEMAND received.

1.2.3 Open A Data Link

When the user requests to open a Data Link (B020_dl_open), a Data Link instance is created for communication with remote devices over a particular channel. The General Data Link Interface does not permit the user to send or receive data until the user opens the channel. The Data Link does not accept a request to open a Data Link if that Data Link instance is already created, i.e. multiple users are not supported.

1.2.3.1 Inputs

- A user request to open a Data Link (B020_dl_open). The user must specify the name **B058** as a part of the B020_dl_open function call.

More details concerning the parameters of the B020_dl_open function call can be found in the *General Data Link Interface Programmer's Guide*.

1.2.3.2 Processing

Upon reception of a request to open a Data Link, a Data Link instance is created to communicate with remote devices over a particular channel and Data Link specific configuration is validated, refer to *Section 1.1.1 Configuration Checking*).
The Data link waits for the first user request to send a message to a specific device before establishing communications with that device. Details are given in *Section 1.1.2 Communication Initialization*.

1.2.3.3 Outputs

- The Data Link indicates the success or failure of the request to open a Data Link to the user immediately. The return codes and parameters for the B020_dl_open function call are described in the General Data Link Interface Programmer's Guide.

1.2.4 Close A Data Link

When the user requests to close a Data Link (B020_dl_close), the specified Data Link instance is terminated.

1.2.4.1 Inputs

- A user request to close a Data Link (B020_dl_close).

For details, refer to the *General Data Link Interface Programmer's Guide*.

1.2.4.2 Processing

Closing a Data Link causes the Data Link to stop communicating with the remote devices over a particular channel. The Data Link discards any user messages that have not been transmitted.

1.2.4.3 Outputs

The return codes for the B020_dl_close function call are described in the *General Data Link Interface Programmer's Guide*.

1.2.5 Add Addresses

The Data Link permits the user to add one address per Data Link channel after the user has opened the channel for communication. Multiple users per Data Link channel are not supported.

1.2.5.1 Inputs

The user adds addresses by making a B020_dl_cntrl request with the service identifier B020_ADD_DL_ADDRESS. The input parameters of the B020_dl_cntrl request are found in the *General Data Link Interface Programmer's Guide*.

1.2.5.2 Processing

The data link accepts one request to add an address per Data Link channel. Any subsequent add address requests are rejected with B020_FAIL_OTHER.

1.2.5.3 Outputs

The return codes and parameters of the B020_dl_cntrl request are found in the *General Data Link Interface Programmer's Guide*.

1.2.6 Send User Messages

When a user requests to send user data to a remote device (B020_dl_send), the Data Link can either accept or reject a user message depending on the type of services specified by the user. When a user message is accepted by the Data Link, it will be queued for transmission at a later time. The user must have previously performed a B020_dl_open request or the General Data Link Interface will not accept the B020_dl_send request.

1.2.6.1 Inputs

From a user application:

- A user request to send a message to a remote station (B020_dl_send).

The following quality of service options are supported. Service options, which are not supported will be ignored by the Data Link:

- B020_SEND_CONFIRM/B020_SEND_NO_CONFIRM
- B020_QUERY (B020_RESPONSE is rejected with the error status set to B020_FAIL_OTHER)
- B020_EXPIRATION
- B020_GUARANTEED
- B020_BROADCAST

The Data Link supports the above quality of service options as follows:

- If the user specifies B020_SEND_CONFIRM service, the Data Link transmits the message as a SEND/CONFIRM EXPECTED - USER DATA (FC 3) frame.
- If the user specifies neither B020_SEND_CONFIRM nor B020_BROADCAST, the Data Link transmits the message as a SEND/NO REPLY EXPECTED - USER DATA (FC 4) frame.

- If the user specifies B020_QUERY service, the Data Link sets the PRM bit in the frame of the outgoing message to 1, indicating a query from a master station to a slave station. If the user specifies B020_RESPONSE (or neither service), the Data Link rejects the send request with error status B020_FAIL_OTHER.
- If the user specifies B020_EXPIRATION service, the Data Link will fail a message if the actual time of transmission of its first frame would exceed a specified expiration time.
- If the user specifies B020_GUARANTEED service, the Data Link attempts to send the frame of the message at the requested time.
- If the user specifies B020_BROADCAST service, the Data Link transmits the message using the IEC 870-5 broadcast address (all bits set to 1) as the destination address in a SEND/NO REPLY EXPECTED - USER DATA (FC 3) frame. The Data Link does not permit broadcast messages to be confirmed, i.e. it will reject the B020_dl_send request with error status B20_FAIL_OTHER, if both B020_BROADCAST and B020_SEND_CONFIRM are specified.

  The Data Link ignores the Service Access Point parameter of a B020_dl_send request. It truncates the 32-bit LAN address to the configured Data Link Address Size, using only the least significant bits.
  Refer to the *General Data Link Interface Programmer's Guide* for more details regarding the parameters of a B020_dl_send request.

From a remote device:

- Positive acknowledgment CONFIRM - ACK (FC 0) or single character ACK (0xE5), received in response to a SEND/CONFIRM EXPECTED - USER DATA (FC 3) frame.
- Negative acknowledgment CONFIRM - NACK (FC 1) or single character NACK (0xA2), received in response to a SEND/CONFIRM EXPECTED - USER DATA (FC 3) frame.
- RESPOND - USER DATA (FC 8), received in response to a REQUEST/RESPOND EXPECTED - REQUEST USER DATA 1 (FC 10) or 2 (FC 11).
- Negative acknowledgment RESPOND - NACK (FC 9) or single character NACK (0xA2), received in response to a REQUEST/RESPOND EXPECTED - REQUEST USER DATA 1 (FC 10) or 2 (FC 11).

1.2.6.2 Processing

If this is the first request to send a message to a particular remote device or communications with the device are currently marked as failed, the Data Link will first establish communications with the device and subsequently transmit the user data message as described in *Section 1.1.2 Communication Initialization*.
If the Data Link accepts a B020_dl_send request, it performs the following processing:

1. Validates the parameters of the send request.
2. Queues the frame for transmission to the device.
3. Returns a status code to the user indicating whether the request was successfully queued.

4. Waits until any frame transmission procedure in progress is complete, i.e. message transmission and, if applicable, receipt of confirmation or response, as well as a Class data poll request/response sequence which follows a user data frame send or send/confirm transmission, before selecting the next user data frame for transmission.

5. Selects a frame for transmission:

   - If another message is queued to the same device the previous message had been transmitted to, the Data Link selects the next message to this device. If no message is queued to the same device, the Data Link searches for the first device with a frame queued for transmission.

6. Formats the frame according to the protocol, as described in *Appendix B:*.

7. Waits for the physical serial link to become available.

8. Waits until the required time to transmit, if the user selected B020_GUARANTEED service. The Data Link does not transmit any other frames during this period.

9. If the user selected B020_EXPIRATION service, checks to ensure the present time does not exceed the expiration time. If the expiration time is exceeded, fails the entire message, and returns an error status to the user (message type B020_TX_STATUS with status B020_FAIL_EXPIRATION).

10. Transmits the frame.

11. After completing a user data frame transmission, the Data Link waits with timeout for a confirmation, if requested, from the device. If an invalid frame is received or a timeout occurs waiting for a confirmation, the Data Link retries sending the frame according to the configuration parameter *Transmit Retries*. The configured *Confirm Timeout* is the maximum idle time on the serial link before the Data Link must receive the first character of the confirmation. Otherwise, the Data Link continues to retransmit the original message to the remote device, without toggling the FCB bit, until either a valid confirmation is received from the device or the number of *Transmit Retries* is exhausted. In the case of the latter, the Data Link passes the user a communication error indication (message type B020_TX_STATUS with status B020_FAIL_CFM_TIMEOUT) and attempts to reestablish communications with the remote device as described in *Section 1.1.2 Communication Initialization*.

    If the Data Link receives a CONFIRM - NACK, single character NACK (0xA2) from a remote device, the Data Link queues a failed B020_TX_STATUS (B020_FAIL_DEV_BUSY) indication for the user and selects the next user data frame for transmission.
    Following a positive confirmation or, if no confirmation had been requested, following the transmission of the user data frame, the Data Link queues a B020_TX_STATUS message with B020_SUCCESS indication.
    Subsequently, the Data Link will send one Class 2 poll request to the same device, waiting with Respond Timeout for the device's response, which is followed by retries in the same fashion as a confirmation timeout.

- If this results in a communication error detection, the Data Link sets the B020_FAIL_CFM_TIMEOUT indication in message type B020_LINK_STATUS and

attempts to reestablish communications with the device as described in Section 1.1.2 Communication Initialization.

- If the remote device responds with a negative acknowledgement and ACD bit clear, i.e. the device has not yet finished processing the original user data request and also has no Class 1 data to report, the Data Link will repeat polling for Class 2 data (in this case toggling the FCB bit every time) until either a response other than a NACK/ACD = 0 has been received or the Reply Poll Count has been exceeded, refer to Figure 12 in Appendix B:. The latter condition will invoke the Data Link to notify the user application if the user requested the Data Link to install a timer for this particular B020_dl_send request, refer to Section 1.2.7 Link Control/Start Response Timer.

If the remote device responds with user data, it is parsed and queued as a B020_RX_MSG.

☞ **NOTE:** Whenever a remote device indicates that Class 1 data are available (ACD bit is set), the Data Link will immediately poll the device for Class 1 data until either the device has no more Class 1 data to report or the Reply Poll Count is exceeded, refer to *Figure 11* in *Appendix B:*.

The Reply Poll Count counts every Class 2 as well as Class 1 poll request issued after receiving a positive acknowledgment in response to a SEND/CONFIRM EXPECTED - USER DATA (3) message, whether the device responded to the Class poll with a negative acknowledgment or user data. Transmit Retries are not counted.
If Class 1 data were reported and Class 1 data polling finished before exhausting the Reply Poll Count, the Data Link will resume Class 2 data polling.
Class 1 and 2 data polling following a SEND/CONFIRM EXPECTED - USER DATA (3) is considered complete when either:

- The Reply Poll Count is exhausted, or
- After having received at least one user data message from the remote device, the device responds with a negative acknowledgment and ACD bit clear (no Class 1 or 2 data to report).

12. Repeats steps 4 through 11 until the Data Link has either successfully or unsuccessfully transmitted all queued user data frames.

When no more user frames are waiting to be transmitted, the Data Link resumes its standard Class 2 polling as described in *Section 1.2.9 Autonomous Polling*, starting with the next remote device to be polled when autonomous polling was interrupted.

1.2.6.3 Outputs

To the user application:

- The parameters returned from the B020_dl_send request are described in the General Data Link Interface Programmer's Guide.
- The Data Link returns B020_FAIL_OTHER under any of the following conditions:
  - The user requests the Data Link to send a zero-length message.
  - The user requests service option B020_RESPONSE.

  - The user requests both service options B020_SEND_CONFIRM and B020_BROADCAST together in one B020_dl_send request.
- The Data Link encountered a software error, such as being unable to allocate memory.
- The Data Link queues the message type B020_TX_STATUS and makes it available to the user application via the B020_dl_receive request, as listed in Section 1.2.8 Receive User Messages.
- If the B020_dl_send request was successful, the Data Link fills in the time-of-transmission and statistics fields of the B020_TX_STATUS indication as described in the General Data Link Interface Programmer's Guide.
- If the remote device responds with data to a Class poll, the Data Link queues the message type B020_RX_MSG and makes it available to the user application via the B020_dl_receive request, as listed in Section 1.2.8 Receive User Messages.
- The Data Link queues the message type B020_LINK_STATUS and makes it available to the user application via the B020_dl_receive request, as listed in Section 1.2.8 Receive User Messages.

To a remote device:
- SEND/CONFIRM EXPECTED - USER DATA (FC 3).
- SEND/NO REPLY EXPECTED - USER DATA (FC 4).
- REQUEST/RESPOND EXPECTED - REQUEST USER DATA 1 (FC 10).
- REQUEST/RESPOND EXPECTED - REQUEST USER DATA 2 (FC 11).

1.2.7 Link Control/Start Response Timer

When a user requests the Data Link to install a timer for a previously received B020_dl_send request, the Data Link will ignore the timer, but monitor for proper user data reception from the remote device in response to the user application command.
The user must have previously performed a B020_dl_send request which the Data Link has not finished executing at the time it receives the B020_dl_cntrl command. Otherwise, the Data Link will not accept the B020_dl_cntrl request to install a timer.

1.2.7.1 Inputs

- A user request to install a timer for a user initiated message to a remote device (B020_dl_cntrl).

The following function is partially supported:
- B020_START_RESPONSE_TIMER

1.2.7.2 Processing

If the Data Link accepts a B020_dl_send request with function B020_START_RESPONSE_TIMER, the Data Link will not install a timer. It will monitor the Class data request/response sequence following the SEND/CONFIRM EXPECTED - USER DATA (FC 3), which the Data Link received just prior to the B020_dl_cntrl request as follows:

- The Data Link will notify the user application by queuing a B020_RX_TIMOUT message, if the Reply Poll Count was exceeded and the remote device had responded with nothing but negative acknowledgments (i.e. no user data) to Class data poll requests.

If no timer installation was requested, the user would not be notified under the above condition.

1.2.7.3 Outputs

- The Data Link rejects any B020_dl_link requests for any function other than B020_START_RESPONSE_TIMER with the error status B020_FAIL_NOT_SUPT.

The Data Link queues the timeout indication as follows and makes it available to the user application via the B020_dl_receive request:

- Message type B020_RX_TIMEOUT, if the Reply Poll Count was exceeded and without having received any user data from the remote device.

1.2.8 Receive User Messages

The Data Link formats RESPOND - USER DATA (FC 8) frames received from remote devices into user messages. When the user makes a B020_dl_receive request, the Data Link passes the first of these messages to the user.

1.2.8.1 Inputs

From a remote device:

- RESPOND - USER DATA (FC 8) message, received in response to a REQUEST/RESPOND EXPECTED - USER DATA CLASS 1 (FC 10) or 2 (FC 11).
- Positive acknowledgement CONFIRM - ACK (FC 0) or single character ACK (0xE5), received in response to a SEND/CONFIRM EXPECTED - USER DATA (FC 3) frame.
- Negative acknowledgment CONFIRM - NACK (FC 1) or single character NACK (0xA2), received in response to a SEND/CONFIRM EXPECTED - USER DATA (FC 3) frame.

From a user application:

- A user request to receive a Data Link message (B020_dl_receive) which may be a message response from a remote device, the status of the communication link with a device or the status of a user initiated message transmission.
- The parameters of the B020_dl_receive request are described in the *General Data Link Interface Programmer's Guide*. The Data Link supports the B020_BLOCK and

B020_NO_BLOCK services. The Data Link ignores the Service Access Point parameter of a B020_dl_receive request.

1.2.8.2 Processing

- The Data Link performs the following processing when receiving user data messages from remote devices:
  - The Data Link verifies each frame received from a remote device as described in Section 1.2.2 Format and Parse Frames and discards the frame if it is invalid.

  ☞ **NOTE:** DFC bit is ignored by the Data Link.
  - In the event that a frame is received and then discarded the Data Link will continue to attempt to receive frames until a valid frame is received or the allowable timeout for the start of a frame has elapsed.
  - If the frame is a valid RESPOND - USER DATA (FC 8) frame, the Data Link parses the ASDU information from the frame. The Data Link queues a B020_RX_MSG message, containing the user data parsed from the device's response, for the user to retrieve with a B020_dl_receive request.
- The Data Link informs the user of the transmission status of a user initiated request by queuing a B020_TX_STATUS message type with an appropriate status code.
- The Data Link informs the user of the communications status changes by queuing a B020_LINK_STATUS message type with an appropriate status code.
- The Data Link informs the user of the current communication statistics by periodically queuing a B020_COMM_STATS message type per remote device.

1.2.8.3 Outputs

The Data Link queues user data messages parsed from poll responses received from remote devices, message transmission status as well as communication failures detected and makes them available to the user application via the B020_dl_receive request:

- Message type B020_RX_MSG with the following status indications:
  - B020_SUCCESS, i.e. user data from a remote device was successfully received and buffered.
  - B020_FAIL_BUF_OVR, if the message data exceeds the size of buffer supplied by the Data Link user.

This Data Link is a master device implementation supporting only unbalanced mode. Therefore, the mode indication in the message type B020_RX_MSG will always be set to B020_RESPONSE.
The Data Link queues the transmission status of a user initiated command as follows:

- Message type B020_TX_STATUS with the following status indications:

- B020_SUCCESS, if the user message was successfully transmitted and, if so requested, acknowledged by the remote device.
- B020_FAIL_DEV_BUSY, if the device responded with a negative acknowledgment, i.e. CONFIRM - NACK or single character NACK (0xA2).
- B020_FAIL_CFM_TIMEOUT, if no valid acknowledgment, if requested, had been received from a device within the configured number of *Transmit Retries*.
- B020_FAIL_EXPIRATION, if the user message could not be transmitted within the given expiry time.

The Data Link queues link status changes as follows:

- Message type B020_LINK_STATUS with the following status indication:
  - B020_FAIL_CFM_TIMEOUT, if the Data Link detects a communication error (if no valid acknowledgment had been received from a device within the configured number of Transmit Retries) while polling a device for Class data.

The Data Link queues communication statistics as follows:

- Message type B020_COMM_STATS

The parameters returned from a B020_dl_receive request are described in the *General Data Link Interface Programmer's Guide*.

1.2.9 Autonomous Polling

The Data Link will autonomously poll each remote device for data.

1.2.9.1 Inputs

From a remote device:

- RESPOND - USER DATA (FC 8).
- RESPOND - NACK REQUESTED DATA NOT AVAILABLE (FC 9) or single character NACK (0xA2).
- RESPOND - ACCESS DEMAND (FC 11).

1.2.9.2 Processing

The Data Link polls each remote device it has knowledge of, refer to *Section 1.1.2 Communication Initialization* in turn for Class 2 data, using the configured Polling Interval and Inter-Device Polling Delay. The Data link transmits only one Class 2 poll request per device per poll cycle, unless the device's response times out or is invalid.
Before changing to the next device to be polled, the Data Link performs a Quick Check, if enabled, to determine if any remote device has Class 1 data to report. Therefore, the algorithm has two steps as follows:

1. Standard Class 2 and 1 Polling:

If the remote's response times out after the configured *Respond Timeout* or is invalid, the Data Link retransmits the original message to the remote device, without toggling the FCB bit, until either a valid response is received from the device or the number of *Transmit Retries* is exhausted. In the case of the latter, the Data Link passes the user a communication error indication (message type B020_LINK_STATUS with status B020_FAIL_CFM_TIMEOUT), reestablishes communications with the failed device as described in *Section 1.1.2 Communication Initialization* and changes to the next device to be polled. After communications have been reestablished with a failed device and it is the previously failed device's turn to be polled, the Data Link resumes polling this device for Class 2 data.
If the remote device responds with a negative acknowledgement and ACD bit clear (no Class 1 data to report), indicating that the requested data is not available, the Data Link changes to the next device to be polled.
If the remote returns Class data, it is parsed and queued for the user application to be retrieved via the function call B020_dl_receive, refer to *Figure 13* in *Appendix B:*.

☞ **NOTE:** If any remote RESPOND frame indicates that Class 1 data is available (ACD bit is set to 1 in the Control field), the Data Link immediately polls the device for Class 1 data until either the remote has no more Class 1 data to report (ACD bit is set to 0 in the Control field) or the Maximum Poll Count has been exceeded. Only then will the Data Link proceed with the next remote device to be polled.
DFC bit is ignored by the Data Link.

2. Quick Check:

   The Data Link broadcasts a Request For Access Demand (FC 8).

   - If no Class 1 event had occurred, i.e. no response is received within the configured Respond Timeout, the Data Link resumes standard polling of the remote whose turn it is next according to the standard poll cycle.
   - If one remote device responds with RESPOND - ACCESS DEMAND (FC 11), i.e. it has Class 1 data to report, the Data Link polls this device for Class 1 data until either the remote has no more Class 1 data to report (ACD bit is set to 0 in the Control field) or the Maximum Poll Count has been exceeded. Then the Data Link resumes standard polling of the remote whose turn it is next according to the standard poll cycle, refer to *Figure 14* in *Appendix B:*.
   - If more than one remote device responded simultaneously, i.e. the Data Link detects frame collision, it will poll each device in turn for Class 1 data until either the remote has no more Class 1 data to report or the *Maximum Poll Count* has been exceeded. Then the Data Link resumes standard polling of the remote whose turn it is next according to the standard poll cycle, refer to *Figure 15* in *Appendix B:*.

Steps 1 and 2 (that is, if Quick Check is enabled) are performed in an infinite loop, interrupted only by the execution of a user application request or periodic queuing of communication statistics, refer to *Section 1.2.10 Communication Statistics* for details. If a user application

requests to send a command to a remote device, the polling sequence described above is interrupted following a response from a device or timeout of the current device poll for Class data. The user's request is executed as described in *Section 1.2.6 Send User Messages*.
When no more user frames are waiting to be transmitted, the Data Link resumes its standard Class 2 polling, starting with the next remote device to be polled when autonomous polling was interrupted.

1.2.9.3 Outputs

To a remote device:
- REQUEST/RESPOND EXPECTED - REQUEST USER DATA CLASS 1 (FC 10).
- REQUEST/RESPOND EXPECTED - REQUEST USER DATA CLASS 2 (FC 11).
- REQUEST FOR ACCESS DEMAND (FC 8).

To a user application:
- The Data Link queues user data messages parsed from poll responses as message type B020_RX_MSG and makes them available to the user application via the B020_dl_receive request, as listed in *Section 1.2.8 Receive User Messages*.
- The Data Link queues the message type B020_LINK_STATUS when detecting a communication failure (no valid acknowledgment had been received from a device within the configured number of *Transmit Retries*) and makes it available to the user application via the B020_dl_receive request, as listed in *Section 1.2.8 Receive User Messages*.

1.2.10 Communication Statistics

The Data Link keeps communication statistics and periodically reports them to the user application.

1.2.10.1 Inputs

- Requests sent to a remote device.
- Transmission retries.
- Communication failures, i.e. a device has not responded after the configured number of Transmit Retries.

1.2.10.2 Processing

The Data Link keeps the following communication statistics for each remote device it has knowledge of:
- Number of Transactions.
- Number of Retries.
- Number of Failures.

Per remote device, the Data Link periodically queues one B020_COMM_STATS message indicating the current counts for the communication statistics listed above. The counts are delta values, as the Data Link resets all counts to zero subsequent to passing the latest values to the user application.
For every remote device, B020_COMM_STATS messages are queued at a predefined minimum rate or, since the following sequences are not interruptible, after completion of an autonomous poll request/response or reply poll sequence.

1.2.10.3 Outputs

The Data Link periodically queues communication statistics collected for a remote device as message type B020_COMM_STATS and makes it available to the user application via the B020_dl_receive request, as listed in *Section 1.2.8 Receive User Messages*.

1.3 External Interface Requirements

The IEC 870-5 FT1.2 Primary Data Link will have a number of external interfaces. These are described in the following sections.

1.3.1 User Interface

The Data Link will provide a user interface in the form of configurable parameters and error messages. During startup, it will check its configuration for invalid values. Any errors found will logged be to the WESMAINT Error Log where they can be viewed through the facilities provided by the WESMAINT application.

1.3.2 Hardware Interfaces

The Data Link makes use of at least one serial communications port via the Serial I/O Sub-System. It requires a system containing non-volatile memory.

1.3.3 Software Interfaces

The Data Link will use the following software interfaces: the General Data Link Interface, for details refer to *Section 1.2.1 External Interfaces*, serial I/O, DBMR library, and WESMAINT.

1.3.3.1 General Data Link

The General Data Link provides a standard user interface to the IEC 870-5 FT1.2 Primary Data Link application.

1.3.3.2 Serial I/O Subsystem

The Data Link will use services supplied by the serial I/O Sub-System to facilitate serial communication with one or more remote devices.

1.3.3.3 WESMAINT

WESMAINT provides the basic user interface. The Data Link will log configuration error messages to the WESMAINT Error Log so they can be viewed through the services supplied by the WESMAINT interface.

1.3.4 Communication Interfaces

The serial I/O Sub-System to provide communication between itself and each remote device as per description in *Appendix B:*.

1.3.4.1 Character Format

The Data Link will support asynchronous serial communication with the following character configuration, *IEC 870-5-1 FT1.2 Section 6.2.4.2*:

- One start bit.
- Eight data bits.
- Even parity.
- One stop bit.

1.3.4.2 Baud Rates

Each communication channel controlled by the Data Link will operate at one of the following baud rates: 300, 600, 1200, 2400, 4800, 9600, or 19200. Available baud rates depend on the hardware platform.

1.4 Performance Requirements

The IEC 870-5 FT1.2 Primary Data Link design meets the performance requirements of minimal resource usage including:

- Number of Processes.
- Number of interprocess message exchanges.
- Amount of memory (SRAM, NVRAM, and EPROM).

1.5 Design Constraints

This section describes all constraints on the design and operation of the IEC 870-5 FT1.2 Primary Data Link.

1.5.1 Standards Compliance

This software complies with GE Energy Services Controls SCS Software Standards, Practices, Conventions, as well as the ISO 9000 Standards.
This software complies with the *General Data Link Interface Programmer' Guide*.

1.5.2 Hardware Limitations

The number of remote devices the Data Link can communicate with will be limited by available system resources (e.g. the number of communication ports, available memory).

Chapter 2: Configurable Parameters

This chapter discusses some of the parameters, which may be configured in the IEC 870-5 FT1.2 Primary Data Link. All configuration parameters belong to one category:

- General Communications Parameters.

The order of parameters does not imply a similar ordering in the Data Link configuration.

2.1 B058_CFG - General Communications Table

The following parameters can be configured for each Data Link instance:

- The name of the serial communication port to use.
- Baud rate for the communication port (300, 600, 1200, 2400, 4800, 9600, and 19200).
- Flags to enable/disable RTS, CTS and DCD.
- RTS pre- and post-transmission assert times in milliseconds.
- The time to wait after the DCD is asserted before beginning to receive data in milliseconds.
- Number of transmit buffers used by the Data Link to store messages, waiting to be retrieved by the user application.
- Number of receive buffers used by the Data Link for messages received from a user application, waiting their turn to be processed.
- Number of octets (1 or 2) in the data link address field.
- Amount of time for the Data Link to add to its calculated timeout within which an entire message frame must be received.
- RESPOND message timeout.
- CONFIRM message timeout.

- Maximum number of transmission retries before declaring communications with a remote device as failed.
- Polling interval to start over polling all devices in hours, minutes, seconds, and milliseconds.
- The time between end of poll of one device and start of poll of next device.
- While performing autonomous polling, maximum number of times to poll the same device for Class 1 data before changing to poll the next device.
- Flag to enable/disable Quick Check.
- Maximum number of times to poll for Class 2 and 1 data subsequent to receiving a positive acknowledgment in response to a user application request.
- The function code for the reset link request. To support 103 RESET_CU (FC 0) and RESET_FCB (FC 7) functionality, this configurable parameter is used to tell the data link which function code should be used when doing the reset link.

Appendix A:Interoperability Tables

In cases where several options are available, for example multiple lengths of address fields, the WESDAC RTU will be able to be configured to use the required value.

A.1 Network Configuration (IEC 870-5-101 Section 8.1)

Point to Point	Supported
Multi Point-Party Line	Supported
Multiple Point to Point	Supported
Multi Point Star	Supported

A.2 Physical Layer (IEC 870-5-101 Section 8.2)

Transmission Speed	Control Direction	Monitor Direction
100 bit/s	Not Supported	Not Supported
200 bit/s	Not Supported	Not Supported
300 bit/s	Supported	Supported
600 bit/s	Supported	Supported
1200 bit/s	Supported	Supported
2400 bit/s	Supported	Supported
4800 bit/s	Supported	Supported
9600 bit/s	Supported	Supported
19200 bit/s	Supported	Supported
38400 bit/s	Not Supported	Not Supported
56000 bit/s	Not Supported	Not Supported
64000 bit/s	Not Supported	Not Supported

Table 1 Physical Layer

A.3 Link Layer (IEC 870-5-101 Section 8.3)

- Frame format FT1.2 (*IEC 870-5-1 Section 6.2.4.2*) of fixed and variable length.
- Single character I, 0xE5, (*IEC 870-5-1 Section 6.2.4.2.3*) - used as a positive acknowledge.
- Single character II, 0xA2, (*IEC 870-5-1 Section 6.2.4.2.3*) - used as a negative acknowledge.
- Fixed CONFIRM time out interval (value is configurable).
- Fixed RESPOND time out interval (value is configurable).

A.3.1 Link Transmission Procedures

Balanced transmission	Not Supported
Unbalanced transmission	Supported

A.3.2

A.3.3 Address Field of The Link

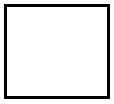
Not present (balanced transmission only)	Not Supported
One octet	Supported
Two octets	Supported
Structured	Supported
Unstructured	Supported
Maximum frame length	255

Appendix B:Protocol Summary

The following protocol summary shows only the details of the messages that are currently defined (i.e. those codes reserved for future use have not been listed).

B.1 Frame Formats

The diagrams below show the frame format used with 870-5. FT1.2 format as defined *in IEC 870-5-1*.
In the following diagrams fields marked are as follows:



Octet/Entity that is always present

Optional per system

Figure 2 Frame Format Used With 870-5. FT1.2 Format

Link Layer- Variable Length Packets

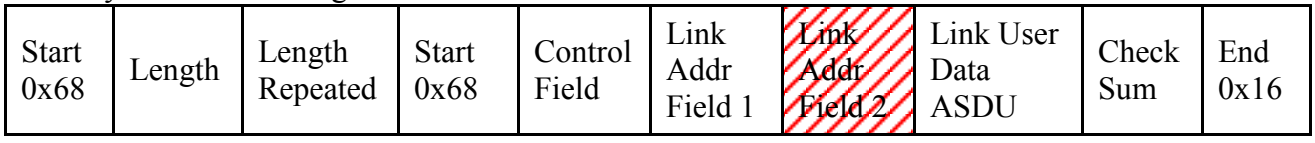


Figure 3 Link Layer – Variable Length Packets

☞ **NOTE:** IEC 870-5-1 specifies that there can only be one Application Data Service Unit per Frame.

Link Layer - Fixed Length Packets

Start 0x10	Control Field	Link Addr Field 1	Link Addr Field 2	Check Sum	End 0x16

Figure 4 Link Layer – Fixed Length Packets

☞ **NOTE:** 870-5-1 specifies that there is no application data in a fixed length message.

Link Layer - ACK character I (received only)

0xE5

Link Layer - NACK character II (received only)

0xA2

Figure 5 Link Layer ACK and NACK Characters

B.2 Link Layer Control Field

The link layer control field is defined in *IEC 870-5-2 Section 5.1.2*.

RES Reserved	PRM 1	FCB	FCV	Function Code				Primary (master) to secondary
	0	ACD	DFC	2^3	2^2	2^1	2^0	Secondary (slave) to primary

Figure 6 Link Layer Control Field

Where each of the fields is:

Field	Name	Value	Description
PRM	Primary	<1>	Master to Slave.
		<0>	Slave to Master.
FCB	Frame Count Bit	Alternates 0 Otherwise	Value alternates when FCV is set.
FCV	Frame Count Valid	<1>	FCB valid.
		<0>	FCB not valid.
ACD	Access Demand	<0>	No Class 1 data in slave.
		<1>	Class 1 data present in slave.
DFC	Data Flow Control	<0>	Slave can accept more messages.
		<1>	Slave cannot accept more messages.

Table 2 Link Layer Control Field

☞ **NOTE:** DFC bit is ignored by the Data Link.

B.2.1 Function Codes in Unbalanced Mode from the Primary (IEC 870-5-2 Section 5.2, Table 1)

Function Code	Frame Type	Description	Sets FCV
0	SEND/CONFIRM	Reset of remote link (RESET_CU).	
7	SEND/CONFIRM	Reset of remote link (RESET_FCB).	
1	SEND/CONFIRM (**Not Supported**)	Reset of user process.	
3	SEND/CONFIRM	User Data.	✔
4	SEND/NO REPLY	User Data.	
8	REQUEST for access demand	Expected response specifies access demand.	
9	REQUEST/RESPOND	Request status link.	
10	REQUEST/RESPOND	Request user data class 1.	✔
11	REQUEST/RESPOND	Request user data class 2.	✔

Table 3 Function Codes in Unbalanced Mode from the Primary

☞ **NOTE:** SEND/CONFIRM - RESET OF USER PROCESS (FC 1) is not supported.

B.2.2 Function Codes in Unbalanced Mode from the Secondary (IEC 870-5-2 Section 5.2, Table 2)

Function Code	Frame Type	Description
0	CONFIRM	ACK: Positive acknowledgment.
1	CONFIRM	NACK: Message not accepted, link busy.
8	RESPOND	User Data.
9	RESPOND	NACK: Requested data not available.
11	RESPOND	Status of link or access demand.

Table 4 Function Codes in Unbalanced Mode from the Secondary

IEC 870-5-2 details how various message transactions take place. Examples of various possibilities are given in this appendix below.

B.3 Examples of Message Exchanges

B.3.1 Communication Initialization - Request of Link Status

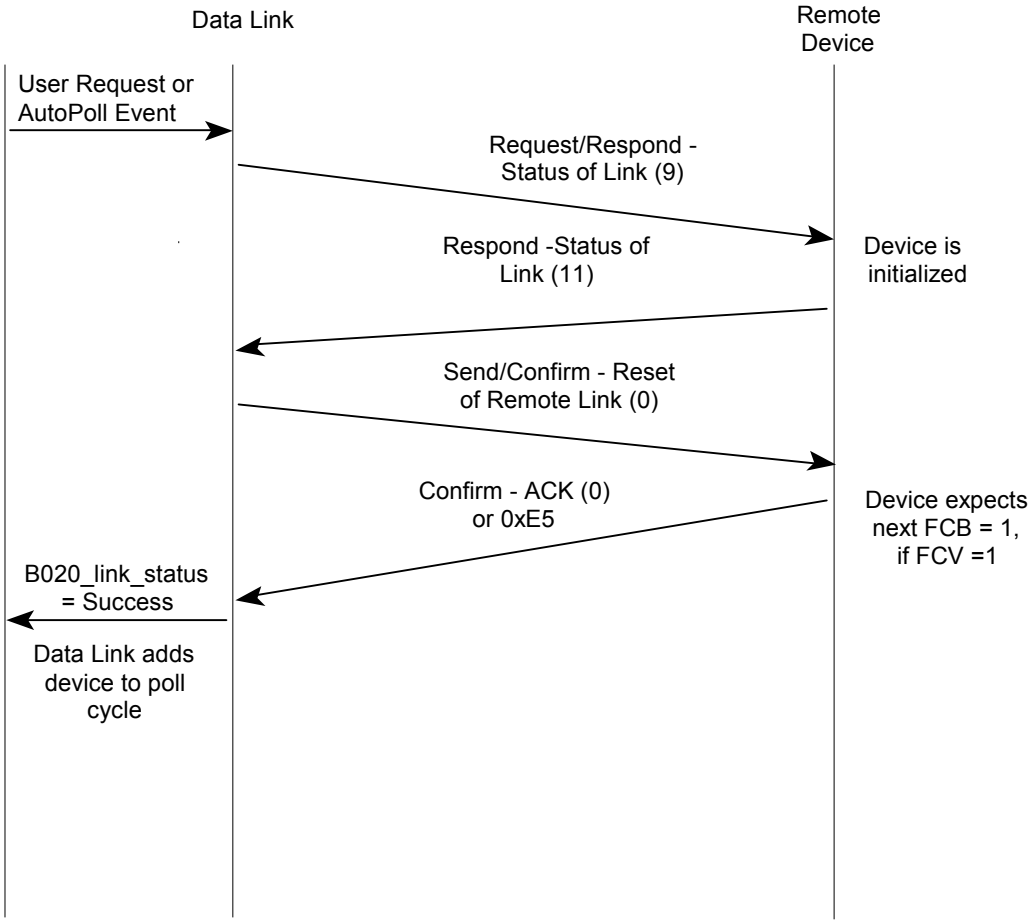


Figure 7 Successful Communication Initialization (a)

B.3.2 Communication Initialization - Reset Link

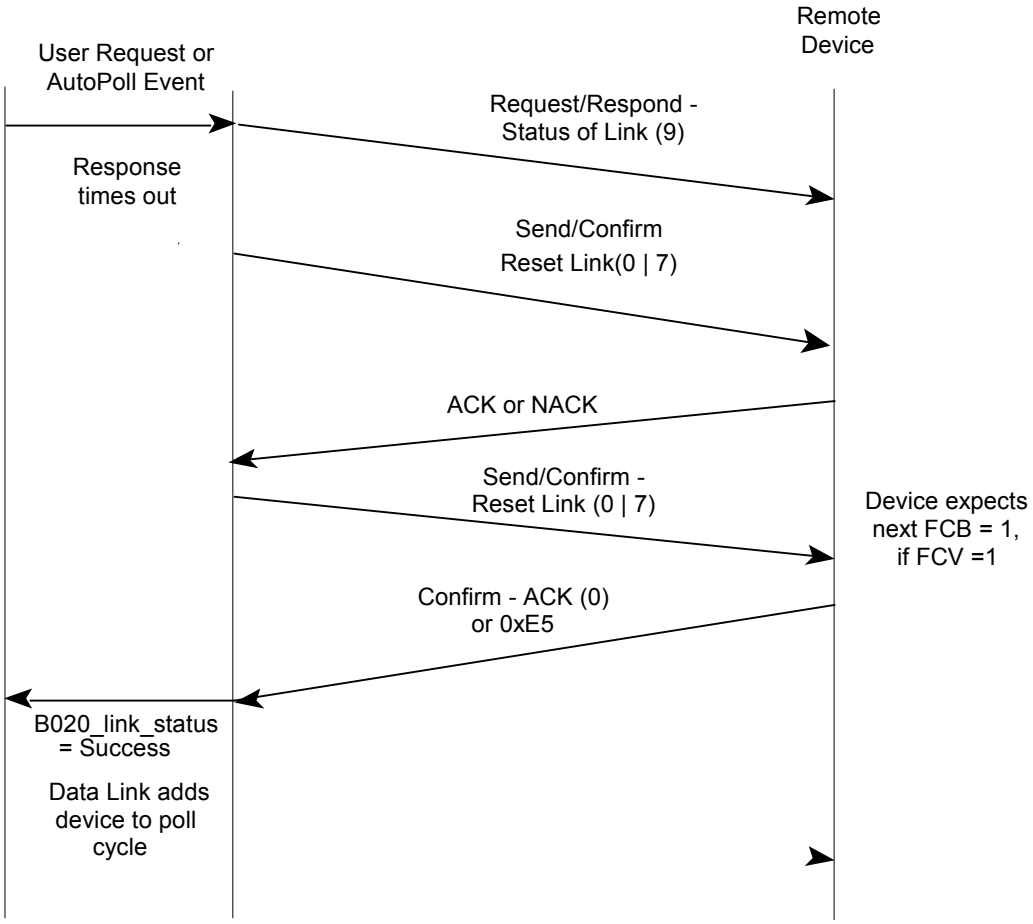


Figure 8 Successful Communication Initialization (b)

B.3.3 Communication Initialization - Failure

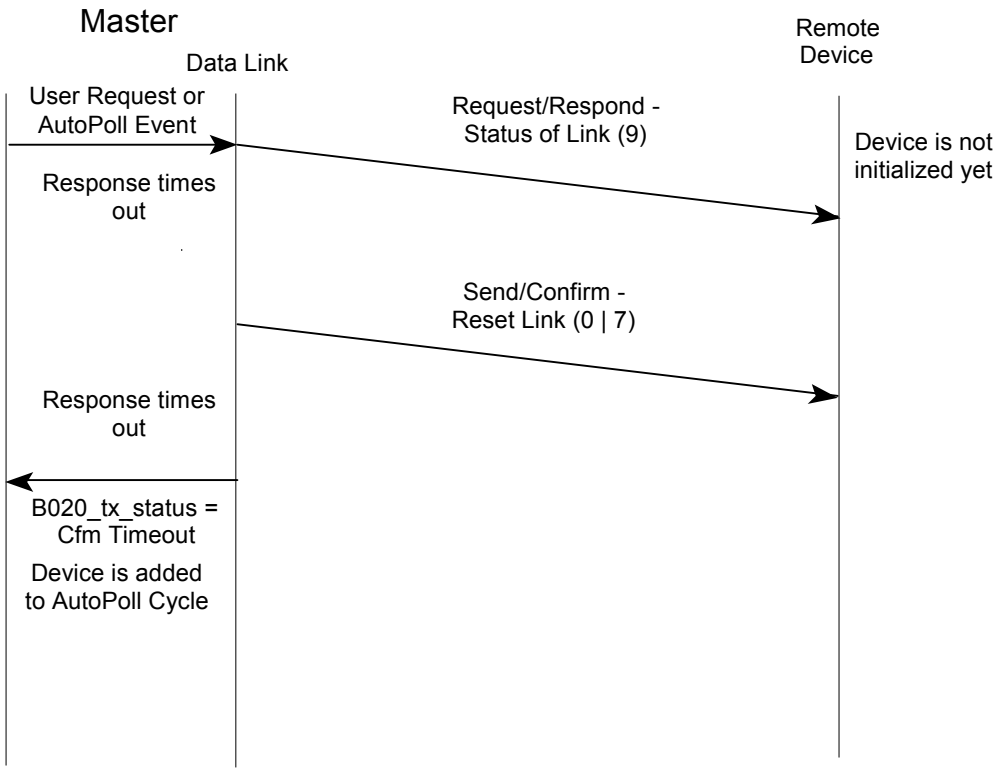


Figure 9 Unsuccessful Communication Initializations

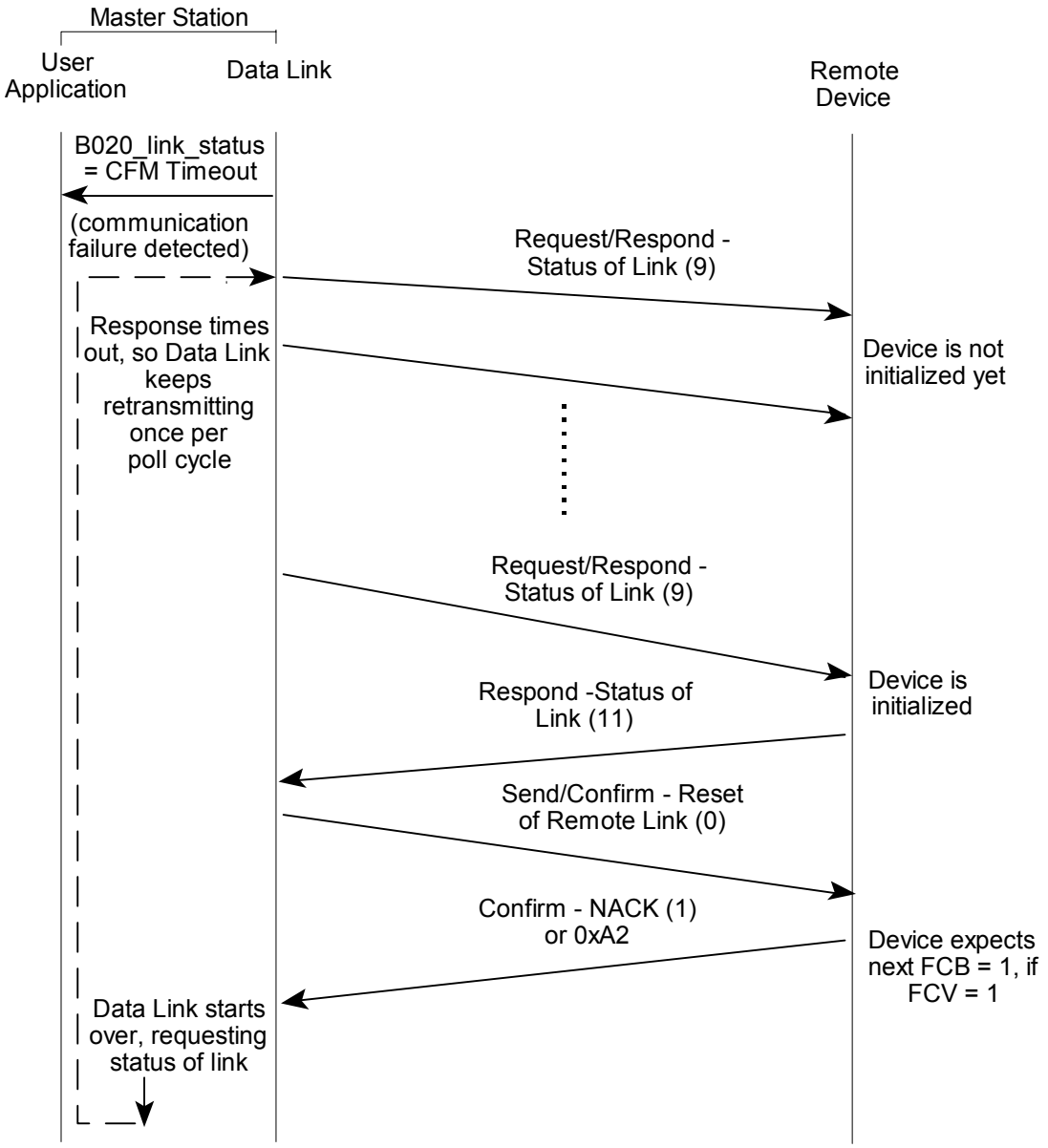
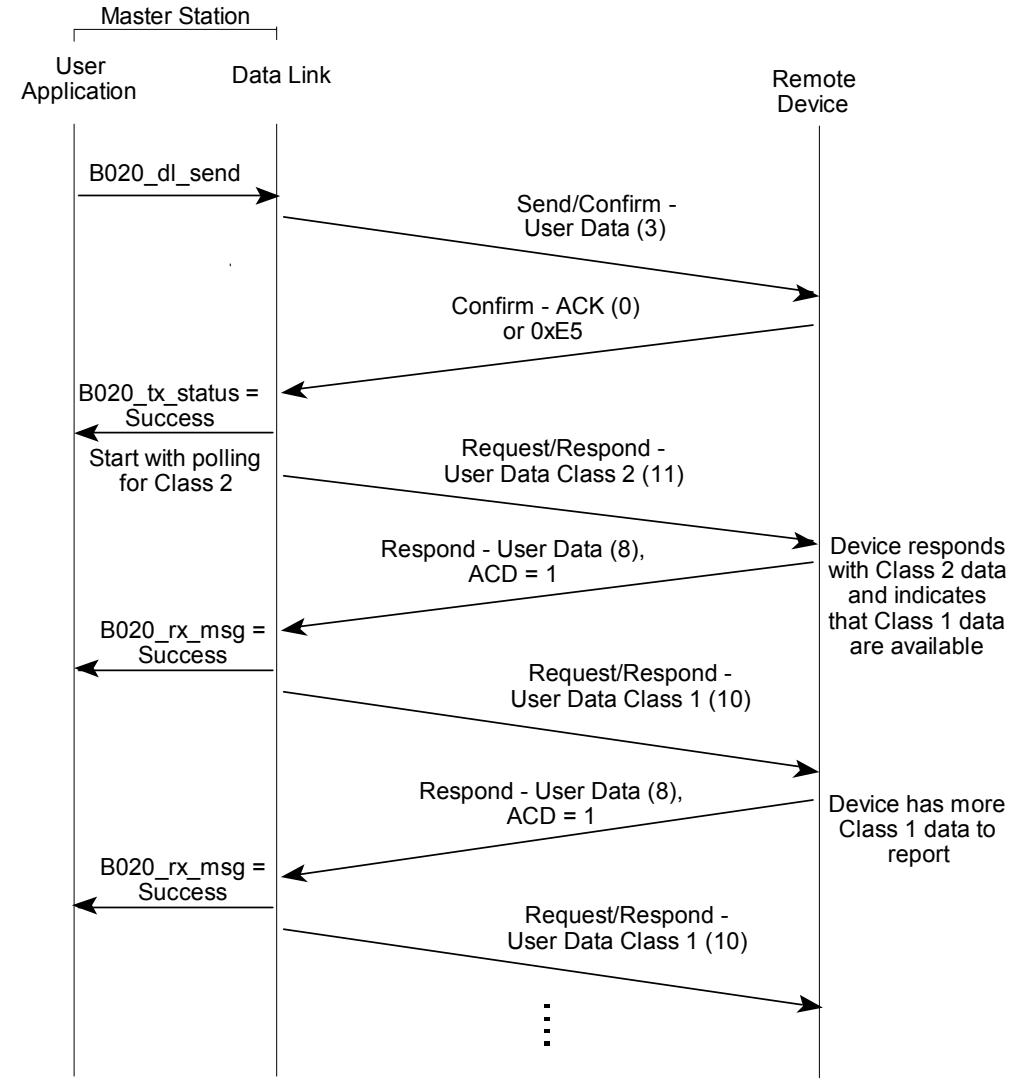


Figure 10 Communication Initialization With Confirm - NACK

B.3.4 Sending User Data Messages



The Data Link keeps requesting Class 1 data until either ACD = 0 or *Reply Poll Count* is exceeded. Once Class 1 polling is complete and the *Reply Poll Count* is not exhausted, the Data link resumes Class 2 data polling until either a NACK/ACD=0 is received or the *Reply Poll Count* exceeded.

Figure 11 Sending User Messages With Device Indicating Class 1 Data Available

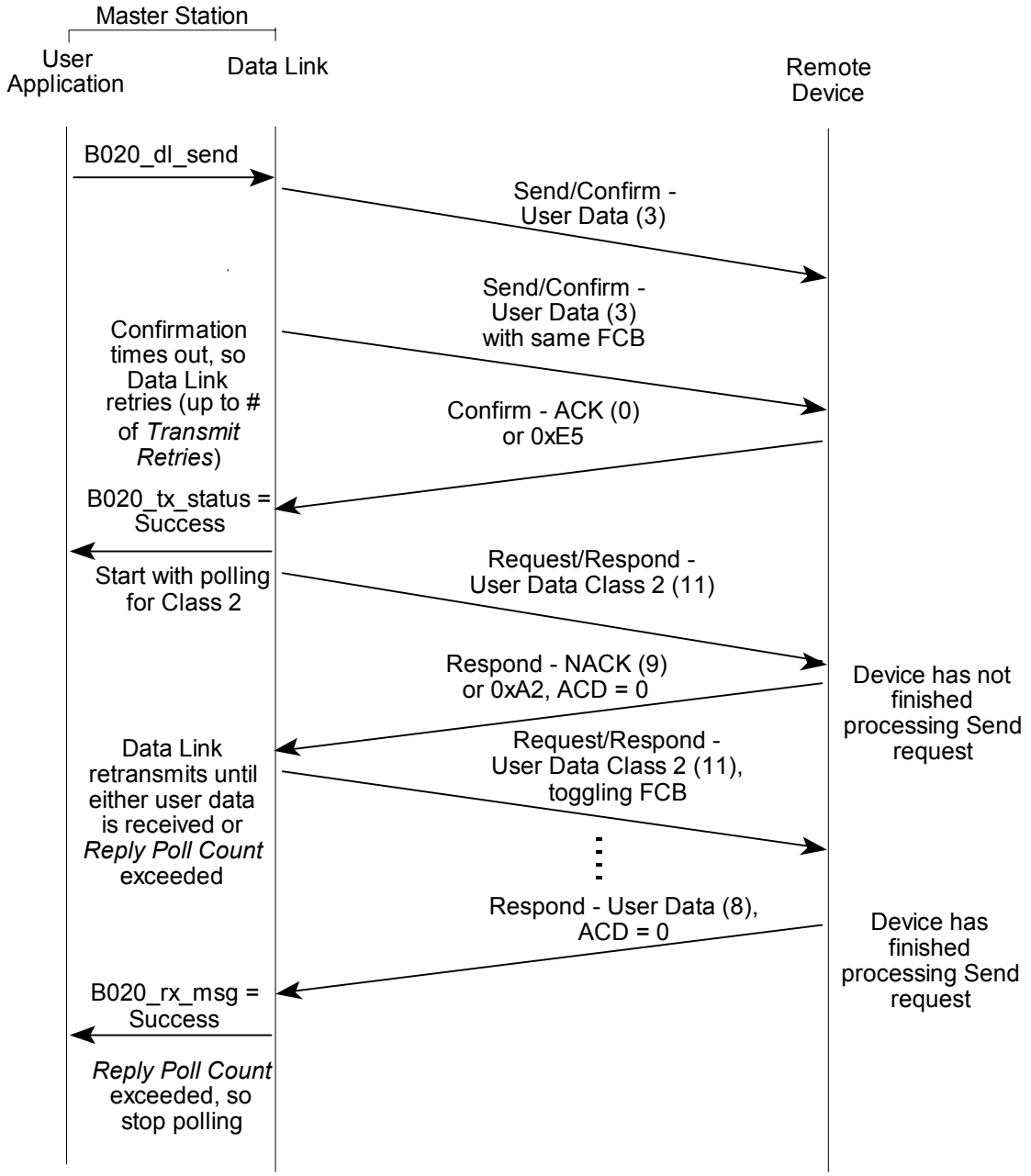


Figure 12 Sending User Messages With Respond - NACK

B.3.5 Autonomous Polling

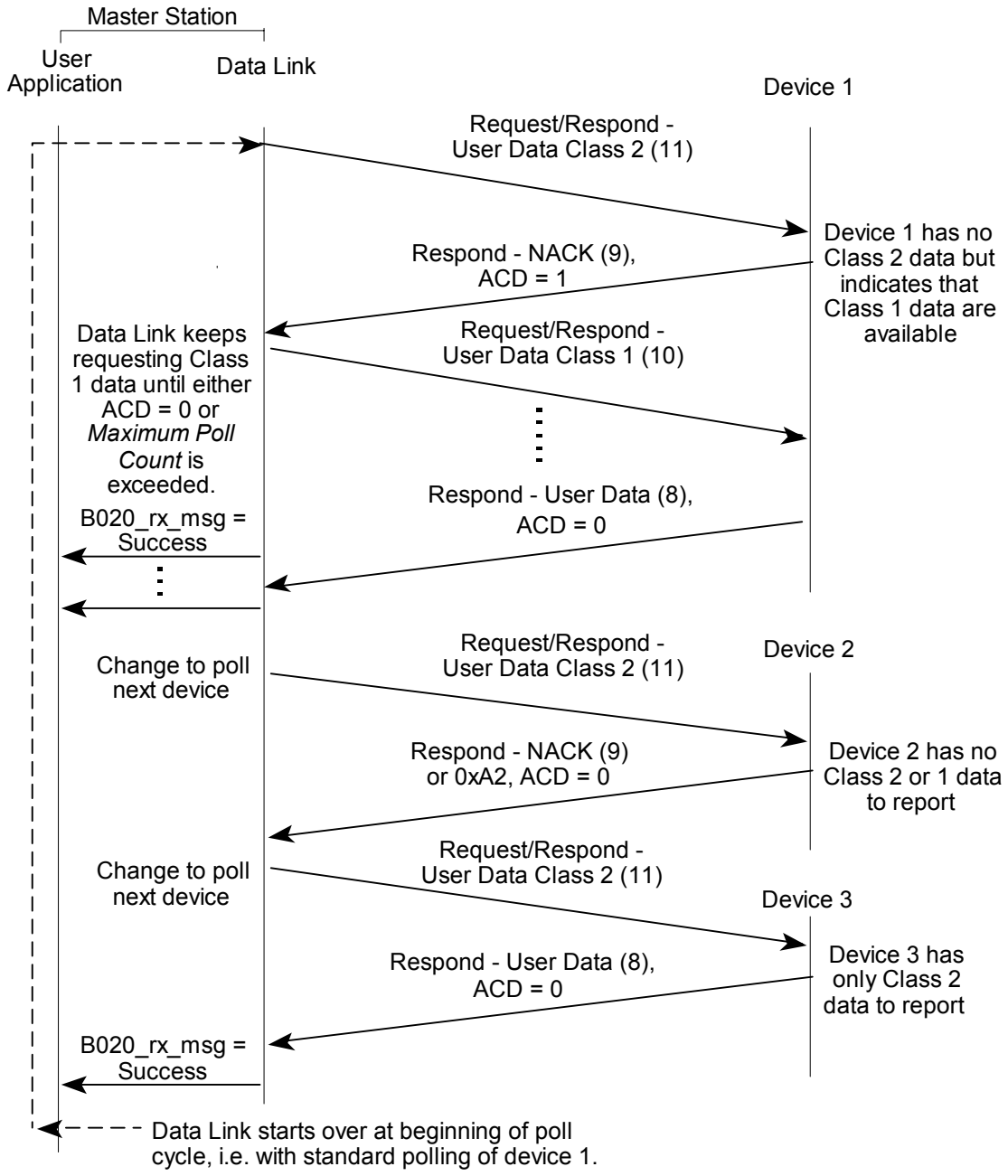


Figure 13 Autonomous Polling of 3 Devices Without Quick Check

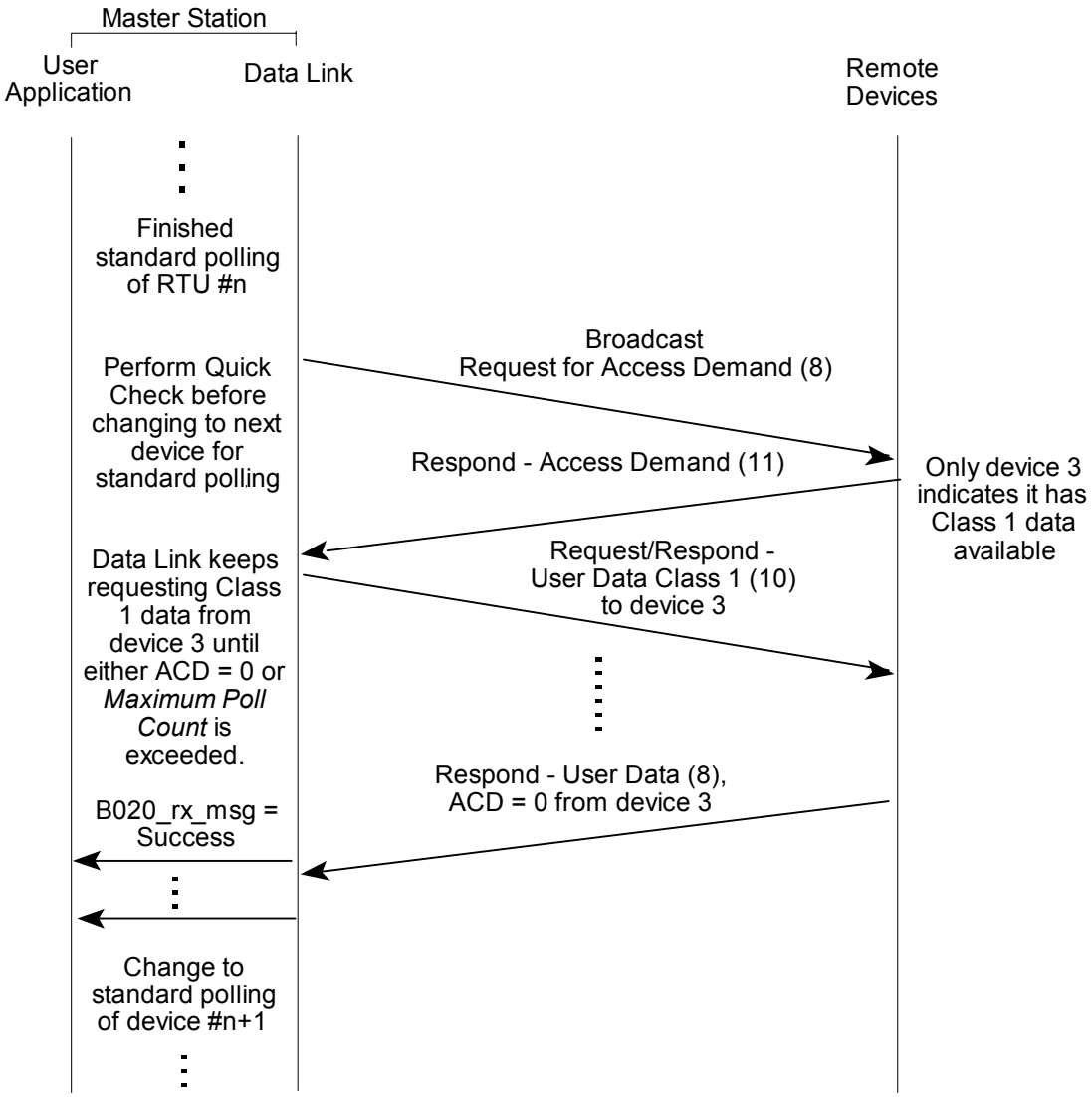


Figure 14 Quick Check With 1 Device Reporting Class 1 Data

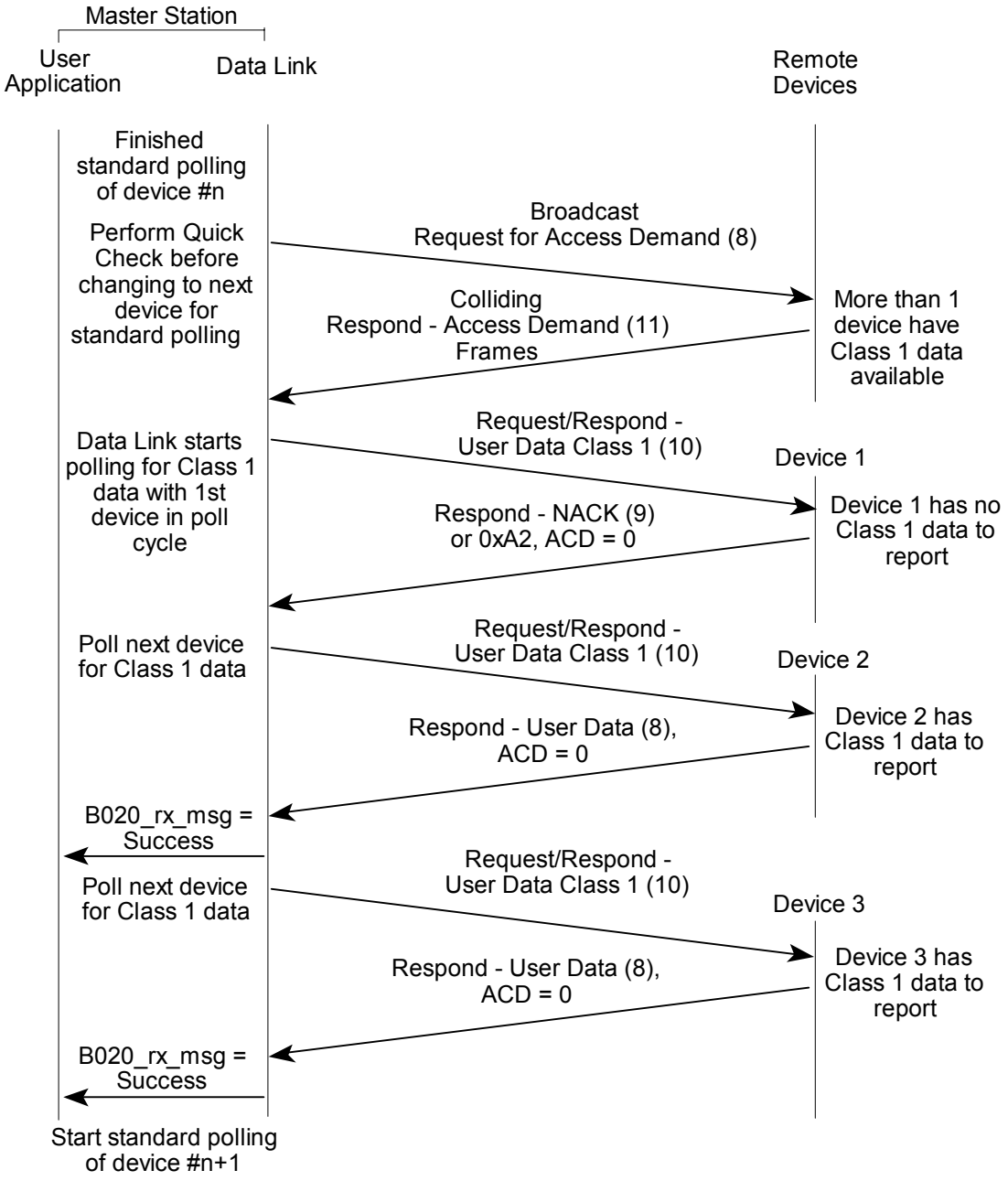


Figure 15 Quick Check With More Than 1 Device Reporting Class 1 Data