

Ensayos

Controlador DNP3 para la CIAA

Versión 0

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gridTICs

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Historial de revisiones

Nombre	Fecha	Descripción de los cambios	Versión
M. Sebastián Tobar	25/11/15	Emisión inicial	0

1. Objetivo

El objetivo de este documento es detallar las pruebas a efectuar en el controlador DNP3 desarrollado para CIAA para verificar su nivel de conformidad con el estándar.

2. Referencias

- IEEE Std 1815-2012 Standard for Electric Power Systems Communications - Distributed Network Protocol (DNP3)
- DNP3 Intelligent Electronic Device (IED) Certification Procedure Subset Level 1 – DNP Users Group

3. Procedimiento de ensayo

3.1 Verificaciones previas al ensayo

Antes de efectuar los ensayos, es necesario verificar la documentación y el equipamiento. En particular se debe verificar:

- Documento de perfil del dispositivo
- Dispositivo a ser testeado
- Diagramas de cableado para:
 - Alimentación
 - Comunicaciones
 - Señales de entrada

3.2 Herramientas

Las pruebas se realizarán utilizando las siguientes herramientas de software:

- Software SCADA con driver DNP3 maestro.
- Monitor de puerto serie
- Analizador de tramas DNP3

3.3 Condiciones de aceptación

Se ejecutarán las acciones detalladas en los apartados “Test Procedure”. En función de los resultados, la prueba tendrá dos resultados posibles:

Éxito ✓	Falla ✕
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4. Desarrollo

4.1 Link Layer

Any DNP device is required to passively implement all link layer services. Specifically, this means that a device need not request link layer service but must support any services requested by another device. For example:

- A device can choose not to request link layer confirms but MUST respond with a link layer confirm if requested to do so.
- A device can choose not to request link layer reset if it is using unconfirmed link services but MUST respond with a link layer confirm if a link layer reset is requested.
- A device must respond to all unconfirmed link requests (i.e. function codes 0, 4, 9) without a preceding link reset.

The following tests are designed to verify this functionality.

4.1.1 Reset Link and Passive Confirm support

4.1.1.1 Desired Behavior

The Device under test (DUT) must respond to a link reset with a link confirm.

- DUT must respond to application layer data requests using unconfirmed link services without requiring a link reset.
- DUT must not respond to application layer data requests using confirmed link services without a preceding link reset.
- DUT must respond to application layer data requests using confirmed link services after a link reset has been issued.
- DUT must acknowledge but not otherwise respond to requests with the wrong FCB.
- DUT must issue a data link reset if transmitting requests that require a data link confirm.

4.1.1.2 Test Procedure

- Cycle power to the DUT.
- Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xC4.
- Verify that the DUT responds with a valid message.

```

05 64 0B C4 04 00 08 00 DB F4 D3 C4 01 3C 01 06 76 37
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
05 64 24 44 08 00 04 00 95 51 C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 A3 C9
81 81 0A 02 00 00 07 01 01 01 01 01 01 01 01 C1 6B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 36

C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
01 01 01 01
FIR: 1 FIN: 1 SEQ: 0 LEN: 30

C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
01 01 01 01
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00]

001,002 Binary Input - With Flags, 8-bit start stop [0, 7]
[0] - value: 1 flags: 0x81
[1] - value: 1 flags: 0x81
[2] - value: 1 flags: 0x81
[3] - value: 1 flags: 0x81
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 1 flags: 0x81
[7] - value: 1 flags: 0x81

010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7]
[0] - value: 0 flags: 0x01
[1] - value: 0 flags: 0x01
[2] - value: 0 flags: 0x01
[3] - value: 0 flags: 0x01
[4] - value: 0 flags: 0x01
[5] - value: 0 flags: 0x01
[6] - value: 0 flags: 0x01
[7] - value: 0 flags: 0x01

```

Resultado

Éxito ✓

- d. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xF3.
- e. Verify that the DUT either sends a NACK with the DFC bit clear or does not respond.

```
05 64 0B F3 04 00 08 00 06 AF D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
```

Resultado

Éxito ✓

- f. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xD3.
- g. Verify that the DUT either sends a NACK with the DFC bit clear or does not respond.

```
05 64 0B D3 04 00 08 00 5B B7 D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
```

Resultado

Éxito ✓

- h. Issue a link reset using link control block 0xC0.
- i. Verify that the DUT responds with a link layer confirm (link control block 0x00).

```
05 64 05 C0 04 00 08 00 C6 89
Function: PRI_RESET_LINK_STATES Dest: 4 Source: 8 Length: 5

05 64 05 00 08 00 04 00 52 A9
Function: SEC_ACK Dest: 8 Source: 4 Length: 5
```

Resultado

Éxito ✓

- j. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xF3.
- k. Verify that the DUT responds with a link layer confirm and a valid application layer response.

```

05 64 0B F3 04 00 08 00 06 AF D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
05 64 05 00 08 00 04 00 52 A9 05 64 24 44 08 00 04 00 95 51 C0 C4 81 00 00 01 02 00
00 07 81 81 81 81 81 81 A3 C9 81 81 0A 02 00 00 07 01 01 01 01 81 81 01 01 BA 32
Function: SEC_ACK Dest: 8 Source: 4 Length: 5
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 36

C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
81 81 01 01
FIR: 1 FIN: 1 SEQ: 0 LEN: 30

C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
81 81 01 01
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00]

001,002 Binary Input - With Flags, 8-bit start stop [0, 7]
[0] - value: 1 flags: 0x81
[1] - value: 1 flags: 0x81
[2] - value: 1 flags: 0x81
[3] - value: 1 flags: 0x81
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 1 flags: 0x81
[7] - value: 1 flags: 0x81

010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7]
[0] - value: 0 flags: 0x01
[1] - value: 0 flags: 0x01
[2] - value: 0 flags: 0x01
[3] - value: 0 flags: 0x01
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 0 flags: 0x01
[7] - value: 0 flags: 0x01

```

Resultado

Éxito ✓

- l. Perform repeated requests of Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and alternating link control blocks 0xD3 and 0xF3.
- m. Verify that the DUT responds with a link layer confirm and a valid application layer response for each request.

```

05 64 0B D3 04 00 08 00 5B B7 D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
05 64 05 00 08 00 04 00 52 A9 05 64 24 44 08 00 04 00 95 51 C0 C4 81 00 00 01 02 00
00 07 81 81 81 81 81 81 A3 C9 81 81 0A 02 00 00 07 01 01 01 01 01 01 01 01 C1 6B
Function: SEC_ACK Dest: 8 Source: 4 Length: 5
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 36

C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
01 01 01 01
FIR: 1 FIN: 1 SEQ: 0 LEN: 30

C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
01 01 01 01
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00]

001,002 Binary Input - With Flags, 8-bit start stop [0, 7]
[0] - value: 1 flags: 0x81
[1] - value: 1 flags: 0x81
[2] - value: 1 flags: 0x81
[3] - value: 1 flags: 0x81
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 1 flags: 0x81
[7] - value: 1 flags: 0x81

010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7]
[0] - value: 0 flags: 0x01
[1] - value: 0 flags: 0x01
[2] - value: 0 flags: 0x01
[3] - value: 0 flags: 0x01
[4] - value: 0 flags: 0x01
[5] - value: 0 flags: 0x01
[6] - value: 0 flags: 0x01
[7] - value: 0 flags: 0x01

```

Resultado

Éxito ✓

- n. Issue a link reset using link control block 0xC0.
- o. Verify that the DUT responds with a link layer confirm (link control block 0x00).

05 64 05 C0 04 00 08 00 C6 89 Function: PRI_RESET_LINK_STATES Dest: 4 Source: 8 Length: 5
05 64 05 00 08 00 04 00 52 A9 Function: SEC_ACK Dest: 8 Source: 4 Length: 5

Resultado

Éxito ✓

- p. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xD3.
- q. Verify that the DUT responds with a link layer confirm (link control block 0x00) and no application response.

05 64 0B D3 04 00 08 00 5B B7 D3 C4 01 3C 01 06 76 37 Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11
D3 C4 01 3C 01 06 FIR: 1 FIN: 1 SEQ: 19 LEN: 5
C4 01 3C 01 06 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ
060,001 - Class Data - Class 0 - all objects
05 64 05 00 08 00 04 00 52 A9 Function: SEC_ACK Dest: 8 Source: 4 Length: 5

Resultado

Éxito ✓

- r. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xF3.
- s. Verify that the DUT responds with a link layer confirm and a valid application layer response.

```

05 64 0B F3 04 00 08 00 06 AF D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects

05 64 05 00 08 00 04 00 52 A9 05 64 24 44 08 00 04 00 95 51 C0 C4 81 00 00 01 02 00
00 07 81 81 81 81 81 81 A3 C9 81 81 0A 02 00 00 07 01 01 01 01 81 81 01 01 BA 32
Function: SEC_ACK Dest: 8 Source: 4 Length: 5
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 36

C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
81 81 01 01
FIR: 1 FIN: 1 SEQ: 0 LEN: 30

C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01
81 81 01 01
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00]

001,002 Binary Input - With Flags, 8-bit start stop [0, 7]
[0] - value: 1 flags: 0x81
[1] - value: 1 flags: 0x81
[2] - value: 1 flags: 0x81
[3] - value: 1 flags: 0x81
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 1 flags: 0x81
[7] - value: 1 flags: 0x81

010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7]
[0] - value: 0 flags: 0x01
[1] - value: 0 flags: 0x01
[2] - value: 0 flags: 0x01
[3] - value: 0 flags: 0x01
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 0 flags: 0x01
[7] - value: 0 flags: 0x01

```

Resultado

Éxito ✓

- t. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xF3.
- u. Verify that the DUT responds with a link layer confirm (link control block 0x00) and no application response.

```
05 64 0B F3 04 00 08 00 06 AF D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11
```

```
D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5
```

```
C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ
```

```
060,001 - Class Data - Class 0 - all objects
```

```
05 64 05 00 08 00 04 00 52 A9
Function: SEC_ACK Dest: 8 Source: 4 Length: 5
```

Resultado	Éxito ✓
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4.1.2 Request Link Status

4.1.2.1 Desired Behavior

- When issued a Request Link Status message, the DUT must respond with a valid Status of Link message.
- The DUT must ignore FCB when FCV = 0.

4.1.2.2 Test Procedure

- Cycle power to the DUT.
- Request a Link Status Frame using link control block 0xC9.
- Verify that the DUT responds with a valid link status message with link control block 0x0B or 0x1B.

05 64 05 C9 04 00 08 00 89 FF Function: PRI_REQUEST_LINK_STATUS Dest: 4 Source: 8 Length: 5
05 64 05 0B 08 00 04 00 11 99 Function: SEC_LINK_STATUS Dest: 8 Source: 4 Length: 5

Resultado

Éxito ✓

- Request a Link Status Frame using link control block 0xE9.
- Verify that the DUT responds with a valid link status message with link control block 0x0B or 0x1B.

05 64 05 E9 04 00 08 00 D4 E7 Function: PRI_REQUEST_LINK_STATUS Dest: 4 Source: 8 Length: 5
05 64 05 0B 08 00 04 00 11 99 Function: SEC_LINK_STATUS Dest: 8 Source: 4 Length: 5

Resultado

Éxito ✓

4.1.3 IR and FCV Bits

4.1.3.1 Desired Behavior

- The DUT must clear (set to zero) the DIR bit in each data link frame it transmits.
- The DUT must set the FCV bit to zero in all frames except SEND/CONFIRM User Data and SEND/CONFIRM Test Link. These frames are tested elsewhere.

4.1.3.2 Test Procedure

If the DUT is capable of requesting data link confirmations, configure it to NOT request data link confirmations.

- a. Cycle power to the DUT.
- b. Prepare and send a READ request for Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and a link control block 0xC4.
- c. Verify the response from the DUT uses data link control block 0x44 i.e. Unconfirmed User Data with the DIR bit not set and the FCV bit not set.

05 64 0B C4 04 00 08 00 DB F4 D3 C4 01 3C 01 06 76 37 Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11 D3 C4 01 3C 01 06 FIR: 1 FIN: 1 SEQ: 19 LEN: 5 C4 01 3C 01 06 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ 060,001 - Class Data - Class 0 - all objects
05 64 24 44 08 00 04 00 95 51 C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 A3 C9 81 81 0A 02 00 00 07 01 01 01 01 01 01 01 01 C1 6B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 36 C0 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01 01 01 01 01 FIR: 1 FIN: 1 SEQ: 0 LEN: 30 C4 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01 01 01 01 01 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00] 001,002 Binary Input - With Flags, 8-bit start stop [0, 7] [0] - value: 1 flags: 0x81 [1] - value: 1 flags: 0x81 [2] - value: 1 flags: 0x81 [3] - value: 1 flags: 0x81 [4] - value: 1 flags: 0x81 [5] - value: 1 flags: 0x81 [6] - value: 1 flags: 0x81 [7] - value: 1 flags: 0x81 010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7] [0] - value: 0 flags: 0x01 [1] - value: 0 flags: 0x01 [2] - value: 0 flags: 0x01 [3] - value: 0 flags: 0x01 [4] - value: 0 flags: 0x01 [5] - value: 0 flags: 0x01 [6] - value: 0 flags: 0x01 [7] - value: 0 flags: 0x01

Resultado

Éxito ✓

- d. If the DUT can generate REQUEST LINK STATUS, cause it to do so and verify none of these frames have the DIR or FCV bit set.

Resultado

N/A

- e. If the DUT can generate TEST LINK, cause it to do so and verify that these frames have the DIR bit clear and FCV bit set.

Resultado	N/A
-----------	-----

4.1.4 Data Link Rejects Invalid Frames

4.1.4.1 Desired Behavior

The DUT must detect errors due to transmission line errors or the incorrect functioning of other devices. It must therefore not respond, either at a data link layer or application layer, to frames that are otherwise valid but have one of the following errors:

- Incorrect start sequence
- Incorrect destination address
- Incorrect CRC
- Invalid function code
- Invalid FCV (Frame Count Valid) bit

For an invalid function code or invalid FCV, the DUT may also respond with LINK SERVICE NOT IMPLEMENTED.

NOTES:

These procedures do not test whether the DUT rejects frames having the DIR bit set incorrectly. Implementers of Slave IEDs must, however, clear this bit (0) in all their transmissions to aid monitoring their device's output on protocol analyzers. This is tested in section "DIR and FCV Bits".

It is optional whether devices choose to filter frames based on source address, and is therefore not tested here. The Device Profile Document indicates whether or not filtering is performed based on the source address.

4.1.4.2 Test Procedure – Primary Frames

Before performing the remainder of these tests:

- a. Cycle power to the DUT.
- b. Issue a link reset using link control block 0xC0.
- c. Verify that the DUT responds with a link layer confirm (link control block 0x00).
- d. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and link control block 0xF3.
- e. Verify that the DUT responds with a link layer confirm (link control block 0x00).
- f. Verify that the DUT responds with application layer data.
- g. To perform the remainder of this test, a general-purpose protocol analyzer capable of generating any sequence of data is necessary. If a DNP-specific protocol analyzer is being used for testing, it should be used to monitor the exchange between the general-purpose analyzer and the DUT.

4.1.4.2.1.1 Invalid Start Octets

- Prepare a READ request for Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and a link control block 0xD3.
- Modify the frame so it begins with an invalid initial start octet (e.g. 0x09) instead of 0x05.
- Modify the CRC of the data link layer header so the CRC is correct for the invalid start octet.
- Send the request.
- Wait several seconds.
- Verify that the DUT does not send a link layer confirm or application layer response.

09 64 0B F3 04 00 08 00 DE 47 D3 C4 01 3C 01 06 76 37

Resultado	Éxito ✓
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- Modify the frame so it begins with 0x05, but the second start octet is invalid (e.g. 0xff).
- Modify the CRC of the data link layer header so the CRC is correct for the invalid start octet.
- Send the request.
- Wait several seconds.
- Verify that the DUT does not send a link layer confirm or application layer response.

05 FF 0B F3 04 00 08 00 C9 10 D3 C4 01 3C 01 06 76 37

Resultado	Éxito ✓
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- Repeat this test once using different start octet values.

64 05 0B F3 04 00 08 00 CA 1D D3 C4 01 3C 01 06 76 37

Resultado	Éxito ✓
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4.1.4.2.2 Invalid Primary Function Code

- Prepare a READ request for Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and a link control block of 0xD3.
- Modify the frame so the control field contains the correct settings of the DIR, PRM, FCB and FCV fields, but has an invalid function code, e.g. 0xD5. Alter the CRC of the data link layer header so the CRC is correct for the invalid control field.

- c. Send the request.
- d. Wait several seconds.
- e. Verify that the DUT either does not send a link layer confirm, or responds with a valid LINK SERVICE NOT IMPLEMENTED frame (control field 0x0F).
- f. Verify that the DUT does not send an application layer response.

```
05 64 0B D5 04 00 08 00 4F 7D D3 C4 01 3C 01 06 76 37
Unknown PriToSec FUNCTION: INVALID
```

Resultado

Éxito ✓

- g. Repeat this test once with a different invalid function code

```
05 64 0B D6 04 00 08 00 45 18 D3 C4 01 3C 01 06 76 37
Unknown PriToSec FUNCTION: INVALID
```

Resultado

Éxito ✓

4.1.4.2.3 Invalid Destination Address

- a. Send a READ request to different address. Note: For devices that can be configured to represent multiple logical devices (i.e. can respond to requests directed to more than one address), ensure that the selected address is not one of the other valid addresses configured for the device.
- b. Wait several seconds.
- c. Verify that the DUT does not send a link layer confirm or application layer response.

```
05 64 0B D3 06 00 08 00 F2 7F D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 6 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5

C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
```

Resultado

Éxito ✓

- d. Repeat this test once with a different destination address.

```
05 64 0B D3 02 00 08 00 D9 A3 D3 C4 01 3C 01 06 76 37
Function: PRI_CONFIRMED_USER_DATA Dest: 2 Source: 8 Length: 11

D3 C4 01 3C 01 06
FIR: 1 FIN: 1 SEQ: 19 LEN: 5
```

```
C4 01 3C 01 06
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: READ

060,001 - Class Data - Class 0 - all objects
```

Resultado

Éxito ✓

4.1.4.2.4 Invalid CRC

- Prepare a READ request for Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and a link control block 0xD3.
- Modify the frame so the CRC of the data link layer header is incorrect.
- Send the request.
- Wait several seconds.
- Verify that the DUT does not send a link layer confirm or application layer response.

```
05 64 0B D3 04 00 08 00 5B B7 D3 C4 01 3C 01 06 76 37
CRC failure in header
```

Resultado

Éxito ✓

- Modify the frame so the CRC of the data link layer header is correct but the CRC of the application layer request is incorrect.
- Send the request.
- Wait several seconds.
- Verify that the DUT does not send a link layer confirm or application layer response.

```
05 64 0B D3 04 00 08 00 5B B7 D3 C4 01 3C 01 06 77 37
CRC failure in body
```

Resultado

Éxito ✓

- Repeat this test once with different incorrect CRC values.

```
05 64 0B D3 04 00 08 00 5B B7 D3 C4 01 3C 01 06 77 88
CRC failure in body
```

Resultado

Éxito ✓

4.1.4.2.5 Invalid FCV

- a. Prepare a READ request for Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and a link control block 0xC3, i.e. SEND/CONFIRM USER DATA, but with FCV=0 (incorrect).
- b. Send the request.
- c. Wait several seconds.
- d. Verify that the DUT does not send a link layer confirm or application layer response. The DUT may respond with a link layer frame with function code LINK SERVICE NOT IMPLEMENTED.

```
05 64 0B C3 04 00 08 00 C9 1D D3 C4 01 3C 01 06 76 37
Bad FCV for FUNCTION: PRI_CONFIRMED_USER_DATA
```

Resultado	Éxito ✓
-----------	---------

- e. Prepare a READ request for Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06 and a link control block 0xD4, i.e. SEND/NO CONFIRM USER DATA, but with FCV=1 (incorrect).
- f. Send the request.
- g. Wait several seconds.
- h. Verify that the DUT does not send a link layer confirm or application layer response. The DUT may respond with a link layer frame with function code LINK SERVICE NOT IMPLEMENTED.

```
05 64 0B D4 04 00 08 00 49 5E D3 C4 01 3C 01 06 76 37
Bad FCV for FUNCTION: PRI_UNCONFIRMED_USER_DATA
```

Resultado	Éxito ✓
-----------	---------

- i. Repeat steps e-h using the control blocks in the following table:

Code	Description	Notes
C2	Test Link	FCV = 0 incorrect
D0	RESET LINK	FCV=1 incorrect, FCB = 0 ignored
D9	Link Status Request	FCV=1 incorrect, FCB = 0 ignored

```
05 64 0B C2 04 00 08 00 CF 3E D3 C4 01 3C 01 06 76 37
Bad FCV for FUNCTION: PRI_TEST_LINK_STATES

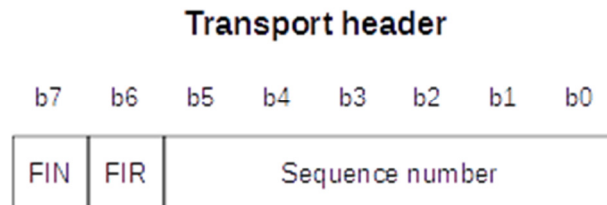
05 64 0B D0 04 00 08 00 51 D2 D3 C4 01 3C 01 06 76 37
Bad FCV for FUNCTION: PRI_RESET_LINK_STATES

05 64 0B D9 04 00 08 00 1E A4 D3 C4 01 3C 01 06 76 37
Bad FCV for FUNCTION: PRI_REQUEST_LINK_STATUS
```

Resultado	Éxito ✓
-----------	---------

4.2 Transport Layer

Whenever FIR, FIN and sequence numbers are referenced in this section they refer to the definitions present in the transport header which is reproduced here for convenience.



4.2.1 Desired Behavior

- If the DUT contains enough data to cause the reply to an application request to be larger than one Link Protocol Data Unit, it is required to,
 - a) Set the proper FIR and FIN bits.
 - b) Set the correct sequence information.
 - c) Distribute the data correctly.
 - d) Signify to the initiating station that the reply contains multiple LPDU's
 - e) Provide the appropriate information for assembly at the receiving station.
- If the device does not contain enough data, then the FIR and FIN bits must signify that there is only one LPDU in the reply.

4.2.2 Test Procedure

- a. Cycle power to the DUT.
- b. Request Class 0 data (Object 60 Variation 1) using Qualifier Code 0x06.
- c. Verify that the DUT responds with a valid message.

<pre> 05 64 0B C4 04 00 08 00 DB F4 C0 C1 01 3C 01 06 F9 73 Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11 C0 C1 01 3C 01 06 FIR: 1 FIN: 1 SEQ: 0 LEN: 5 C1 01 3C 01 06 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 1 FUNC: READ 060,001 - Class Data - Class 0 - all objects </pre>
<pre> 05 64 24 44 08 00 04 00 95 51 C0 C1 81 00 00 01 02 00 00 07 81 81 81 81 81 81 A2 52 81 81 0A 02 00 00 07 01 01 01 01 81 81 01 01 BA 32 Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 36 C0 C1 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01 81 81 01 01 FIR: 1 FIN: 1 SEQ: 0 LEN: 30 C1 81 00 00 01 02 00 00 07 81 81 81 81 81 81 81 81 0A 02 00 00 07 01 01 01 01 81 81 01 01 </pre>

```
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 1 FUNC: RESPONSE IIN: [0x00, 0x00]
```

```
001,002 Binary Input - With Flags, 8-bit start stop [0, 7]
```

```
[0] - value: 1 flags: 0x81
[1] - value: 1 flags: 0x81
[2] - value: 1 flags: 0x81
[3] - value: 1 flags: 0x81
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 1 flags: 0x81
[7] - value: 1 flags: 0x81
```

```
010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7]
```

```
[0] - value: 0 flags: 0x01
[1] - value: 0 flags: 0x01
[2] - value: 0 flags: 0x01
[3] - value: 0 flags: 0x01
[4] - value: 1 flags: 0x81
[5] - value: 1 flags: 0x81
[6] - value: 0 flags: 0x01
[7] - value: 0 flags: 0x01
```

Resultado	Éxito ✓
-----------	---------

- d. If the DUT's reply contains more than 249 octets then verify that the first response message sets the FIR bit to a one, the FIN bit is set to zero.

Resultado	N/A
-----------	-----

- e. Verify subsequent messages to assure that the FIR bit is zero, the FIN bit is zero, and the sequence number increments by one.

Resultado	N/A
-----------	-----

- f. Verify that the last message has the FIR bit is zero and the FIN bit is one, signifying the last data fragment, and the SEQ value increments by one.

Resultado	N/A
-----------	-----

- g. If the DUT's reply contains less than 250 octets in the Data Link Frame then the FIR bit is set to one and the FIN bit is also set to one.

Resultado	Éxito ✓
-----------	---------

4.3 Application Layer

4.3.1 Binary Output Status

The binary output status object represents the current state and status of the associated binary output. The status is an 8-bit flag field (repeated here for your convenience):

b0	ONLINE - 0=off-line, 1= on-line
b1	RESTART - 0=normal, 1= restart
b2	COMMUNICATION LOST - 0=normal, 1=lost
b3	REMOTE FORCED DATA - 0=normal, 1=forced
b4	LOCAL FORCED DATA - 0=normal, 1=forced
b5	0
b6	0
b7	STATE - 0, 1

4.3.1.1 Desired Behavior

- If the device supports binary outputs the device must respond to a Binary Output Status read request with a binary output status object (object 10 Variation 2) using qualifiers 0x00 or 0x01.
- If the device does not support binary outputs the device must respond to a Binary Output read request with a Null Response.
- Optionally, the device can return an error response with IIN2-1.

4.3.1.2 Test Procedure

- Issue a request for Object 10 Variation 0 using the all data qualifier 0x06.
- If the device supports binary outputs verify that the DUT responds with a Binary Output Status object (Object 10 Variation 2).
- Verify that the data is reported using either 8 bit start/stop indexing (qualifier 0x00) or 16 bit start/stop indexing (qualifier 0x01).

<pre> 05 64 0B C4 04 00 08 00 DB F4 C1 C2 01 0A 00 06 B8 6B Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 11 C1 C2 01 0A 00 06 FIR: 1 FIN: 1 SEQ: 1 LEN: 5 C2 01 0A 00 06 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 2 FUNC: READ 010,000 - Binary Output - Any Variation - all objects </pre>
<pre> 05 64 17 44 08 00 04 00 86 4B C0 C2 81 00 00 0A 02 00 00 07 01 01 01 01 01 01 77 FB 01 01 EF 62 Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 23 C0 C2 81 00 00 0A 02 00 00 07 01 01 01 01 01 01 01 01 FIR: 1 FIN: 1 SEQ: 0 LEN: 17 C2 81 00 00 0A 02 00 00 07 01 01 01 01 01 01 01 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 2 FUNC: RESPONSE IIN: [0x00, 0x00] 010,002 Binary Output - Output Status With Flags, 8-bit start stop [0, 7] [0] - value: 0 flags: 0x01 [1] - value: 0 flags: 0x01 [2] - value: 0 flags: 0x01 [3] - value: 0 flags: 0x01 [4] - value: 0 flags: 0x01 [5] - value: 0 flags: 0x01 [6] - value: 0 flags: 0x01 [7] - value: 0 flags: 0x01 </pre>

Resultado	Éxito ✓
-----------	---------

- If the device does not support binary outputs verify that the DUT responds with a Null Response. The device can optionally set IIN2-1.

Resultado	N/A
-----------	-----

- Verify that flag behavior complies with: “If not explicitly stated all tests imply verification that all points in a normal operating state are reported with all flag bits except the ONLINE bit clear and the ONLINE bit is set. Alternatively, verification that the object is reported with the “without flags” variation is also implied.”

Resultado	Éxito ✓
-----------	---------

4.3.2 Binary Outputs

If a device supports control outputs, it is required to be configurable to support all three modes of operation of control, namely Select Before Operate, Direct Operate, and Direct Operate No Acknowledgment. A device may be configurable to disable any subset of the modes. If a device has been configured to reject a particular mode, it must return a control status value of 4 (control operation not supported for this point).

It is the hosts' responsibility to determine the appropriate control mechanism. It is also the hosts' responsibility to perform select before operate control when it is unacceptable to have the control point operated more than once. This is typically a configuration item in the host and is the responsibility of the end user to configure properly.

It is the outstations' responsibility to perform the control operation if a correct control dialog has been issued from the host.

If the DUT is configurable in a manner such that points can be uninstalled or disabled, the device must be configured with at least one Binary Output point installed or enabled before proceeding with the test procedure.

4.3.2.1 Select Before Operate

Select before operate control is used under circumstances when it is absolutely imperative that the control point operate only once. An example of this is a recloser. The host first initiates the select portion of the dialog. The outstation then echoes the exact control request byte for byte to the host. Note that the encapsulation information need not match, but that the object, variation, qualifier, and all object data must match exactly. The host then sends the execute portion of the dialog. The object, variation, qualifier, and all object data must match exactly byte for byte the data sent in the select message. If this message matches the select message byte for byte and it is received within the configured acceptable delay between select and execute the outstation must operate the control point.

4.3.2.1.1 Desired Behavior

The following assumes that the device does not support control operations:

- If the device does not support control outputs, it must respond to a select with an Error Response setting IIN2-1.
- An Error Response with IIN2-2 set is an invalid response.
- No further testing in this section is necessary.

The following assumes that the device supports control operations:

- The maximum select to execute delay time must be specified in the Device Profile Document.
- The DUT responds to matching select and execute requests by echoing each request with the status field set to 0. The specified control operates.
- The DUT responds to selecting an uninstalled control point by returning an error response with IIN2-2 set and a status code of 4. The control point does not operate.
- The DUT responds to executing an installed control point after the configured acceptable select to execute delay by echoing the execute and setting the status field to 1 [Execute received after timeout]. The control point does not operate
- The DUT responds to a non-matching execute with a status field of 2 [No previous matching select] and does not operate the control under the following conditions:

- No prior select issued
- On time mismatch
- Off time mismatch
- Control code mismatch
- The DUT operates various selected control points.
- The DUT supports 8 and 16 bit point indexing.

The following assumes that the device supports control operations and were added as a result of Technical Bulletin TB2000-002 (Control Retries):

- The DUT must accept retries on the select portion of the control dialog that increment the application sequence number between retries. In this case the select-to-operate timer must be restarted after reception of each select.
- The DUT must accept retries on the select portion of the control dialog that do not increment the application sequence number between retries. In this case the select-to-operate timer must remain unaltered by the reception of each additional select.
- The DUT must reject any operate that does not:
 - contain an application layer sequence number that is exactly one greater (modulo 16) than the previously accepted select.
 - match the object portion of the select message byte for byte, excluding the application header.
- The DUT must accept retries on the operate portion of the control dialog that does not increment the application sequence number between retries. The DUT must echo the operate command but must not operate the control more than once.

The following assumes that the device does support control operations, however there are no control points installed/enabled:

- If the device does not have any control outputs installed, it must respond to a select with an Error Response setting IIN2-1 or IIN2-2.

4.3.2.1.2 Test Procedure

4.3.2.1.2.1 Binary Output, SBO, 0x28

- a. Issue a select using Object 12 Variation 1 to an installed point using 16 bit indexing (qualifier 0x28), a control code supported by the device and an appropriate on time/off time.
- b. If the device does not support control outputs, verify that the DUT responds with an Error Response with IIN2-1 set. End testing of Binary Output SBO.
- c. Verify that the DUT responds by echoing the select message exactly.
- d. Immediately issue a matching execute.
- e. Verify that the DUT echoes the execute.
- f. Verify that the selected control operates.

Resultado	Falla ✕
-----------	---------

4.3.2.1.2.2 Binary Output, SBO, 0x17

- Issue a select using Object 12 Variation 1 to a different installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- If the device does support control outputs, verify that the DUT responds by echoing the select message exactly.
- Immediately issue a matching execute.
- Verify that the DUT echoes the execute.
- Verify that the selected control operates.

```

05 64 18 C4 04 00 08 00 4A 1F D9 CA 06 0C 01 17 01 00 03 01 64 00 00 00 64 00 AD 04
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

D9 CA 06 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 25 LEN: 18

CA 06 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 10 FUNC: DIRECT_OPERATE_NR

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

4.3.2.1.2.3 Binary Output, SBO, To Uninstalled Point

- Issue a select using Object 12 Variation 1 to an uninstalled point using 16 bit indexing (qualifier 0x28) using a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by returning an error response with IIN2-2 set and a status code of 4.
- Verify that no control point operates.

Resultado

Falla ✗

4.3.2.1.2.4 Binary Output, SBO, Execute Issued After Timeout

- Issue a select using Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by echoing the select message exactly.
- Wait 1 second past the configured maximum select to execute delay time.
- Issue a matching execute and verify that the DUT echoes the execute with the control status field set to 1[Execute received after timeout].

e. Verify that no control point operates.

<pre> 05 64 18 C4 04 00 08 00 4A 1F C2 C3 03 0C 01 17 01 07 03 01 64 00 00 00 64 00 20 0A 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 C2 C3 03 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 2 LEN: 18 C3 03 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 3 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [7] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C3 81 00 00 0C 01 17 01 07 03 01 64 00 00 00 78 EF 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C3 81 00 00 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C3 81 00 00 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 3 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [7] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 18 C4 04 00 08 00 4A 1F C3 C4 04 0C 01 17 01 07 03 01 64 00 00 00 64 00 4D B8 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 C3 C4 04 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 3 LEN: 18 C4 04 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: OPERATE 012,001 Binary Command - CROB, 8-bit count and prefix [1] [7] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C4 81 00 00 0C 01 17 01 07 03 01 64 00 00 00 49 A8 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C4 81 00 00 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C4 81 00 00 0C 01 17 01 07 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [7] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>

Resultado

Éxito ✓

4.3.2.1.2.5 Binary Output, SBO, Execute to Different Point Than Select

- Issue a select to Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.

- b. Verify that the DUT responds by echoing the select message exactly.
- c. Immediately issue an execute to Object 12 Variation 1 to a different installed point using 8 bit indexing (qualifier 0x17), the same control code as the select, and the same on time/off time as the previous select.
- d. Verify that the DUT echoes the execute with the control status field set to 2 [No previous matching select].
- e. Verify that no control point operates.

<pre> 05 64 18 C4 04 00 08 00 4A 1F DB CC 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 AC 73 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 DB CC 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 FIR: 1 FIN: 1 SEQ: 27 LEN: 18 CC 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 12 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 CC 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 55 DE 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 CC 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 CC 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 12 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 18 C4 04 00 08 00 4A 1F DD CE 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 E6 07 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 DD CE 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 FIR: 1 FIN: 1 SEQ: 29 LEN: 18 CE 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 14 FUNC: OPERATE 012,001 Binary Command - CROB, 8-bit count and prefix [1] [2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C4 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 DA C7 64 00 00 00 02 BC 37 Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C4 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 02 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C4 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 02 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 4 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: NO_SELECT </pre>

Resultado

Éxito ✓

4.3.2.1.2.6 Binary Output, SBO, Execute On Time does not match Select On Time

- Issue a select using Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by echoing the select message exactly.
- Immediately issue a execute to Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), the same control code as the select, the on time incremented by 1 and the same off time as the previous select.
- Verify that the DUT echoes the execute with the control status field set to 2 [No previous matching select].
- Verify that no control point operates.

<pre> 05 64 18 C4 04 00 08 00 4A 1F C7 C8 03 0C 01 17 01 06 04 01 64 00 00 00 64 00 39 95 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 C7 C8 03 0C 01 17 01 06 04 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 7 LEN: 18 C8 03 0C 01 17 01 06 04 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 8 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [6] - code: 0x04 (LATCH_OFF) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C8 81 00 00 0C 01 17 01 06 04 01 64 00 00 00 47 7B 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C8 81 00 00 0C 01 17 01 06 04 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C8 81 00 00 0C 01 17 01 06 04 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 8 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [6] - code: 0x04 (LATCH_OFF) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 18 C4 04 00 08 00 4A 1F C8 C9 04 0C 01 17 01 07 04 01 64 00 00 00 64 00 7F C6 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 C8 C9 04 0C 01 17 01 07 04 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 8 LEN: 18 C9 04 0C 01 17 01 07 04 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 9 FUNC: OPERATE 012,001 Binary Command - CROB, 8-bit count and prefix [1] [7] - code: 0x04 (LATCH_OFF) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C9 81 00 00 0C 01 17 01 07 04 01 64 00 00 00 3D 4A 64 00 00 00 02 BC 37 Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C9 81 00 00 0C 01 17 01 07 04 01 64 00 00 00 64 00 00 00 02 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 </pre>

```

C9 81 00 00 0C 01 17 01 07 04 01 64 00 00 00 64 00 00 00 02
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 9 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[7] - code: 0x04 (LATCH_OFF) count: 1 on-time: 100 off-time: 100 status:
NO_SELECT

```

Resultado	Éxito ✓
-----------	---------

4.3.2.1.2.7 Binary Output, SBO, Execute Off Time does not match Select Off Time

- Issue a select using Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by echoing the select message exactly.
- Immediately issue an execute to Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), the same control code as the select, same on time as the previous select and the off time incremented by 1.
- Verify that the DUT echoes the execute with the control status field set to 2 [No previous matching select].
- Verify that no control point operates.

Resultado	Falla ✗
-----------	---------

4.3.2.1.2.8 Binary Output, SBO, Select with supported Code, Execute with different Code

- Issue a select using Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by echoing the select message exactly.
- Immediately issue an execute to Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code different from the previous select, and the same on time/off time as the previous select.
- Verify that the DUT echoes the execute with the control status field set to 2 [No previous matching select].
- Verify that no control point operates.

Resultado	Falla ✗
-----------	---------

4.3.2.1.2.9 Binary Output, SBO, Select 0x28, Execute 0x17

- Issue a select using Object 12 Variation 1 to an installed point using 16 bit indexing (qualifier 0x28), a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by echoing the select message exactly.
- Immediately issue an execute to Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and the same on time/off time as the previous select.
- Verify that the DUT echoes the execute with the control status field set to 2 [No previous matching select].
- Verify that no control point operates.

Resultado	Falla ✖
-----------	---------

4.3.2.1.2.10 Binary Output, SBO, Same Sequence Number Select Retries

- If the DUT does not have installed binary output points, skip this section.
- Issue a valid select to an installed binary output point.
- Verify that the DUT echoes the object portion of the select byte for byte.

<pre> 05 64 18 C4 04 00 08 00 4A 1F E6 C7 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 06 0B 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 E6 C7 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 38 LEN: 18 C7 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 7 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C7 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 36 CB 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C7 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C7 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 7 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>

Resultado	Éxito ✔
-----------	---------

- d. Issue the select again using the same application layer sequence number.
- e. Verify that the DUT echoes the object portion of the select byte for byte.

```

05 64 18 C4 04 00 08 00 4A 1F E6 C7 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 06 0B
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

E6 C7 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 38 LEN: 18

C7 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 7 FUNC: SELECT

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 C7 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 36 CB
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 C7 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

C7 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 7 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

- f. Issue a valid operate, incrementing the sequence number by 1 modulo 16.
- g. Verify that the DUT echoes the object portion of the operate byte for byte.
- h. Verify that the DUT operates the binary output.

```

05 64 18 C4 04 00 08 00 4A 1F EC CD 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 27 A5
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

EC CD 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 44 LEN: 18

CD 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 13 FUNC: OPERATE

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 CD 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 4D B0
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 CD 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

CD 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 13 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```


Resultado	Éxito ✓
-----------	---------

4.3.2.1.2.11 Binary Output, SBO, Incrementing Sequence Number Select Retries

- If the DUT does not have installed binary output points, skip this section.
- Issue a valid select to an installed binary output point.
- Verify that the DUT echoes the object portion of the select byte for byte.
- Issue the select again incrementing the application layer sequence number by 1 modulo 16.
- Verify that the DUT echoes the object portion of the select byte for byte.

<pre> 05 64 18 C4 04 00 08 00 4A 1F ED CE 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 53 E2 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 ED CE 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 45 LEN: 18 CE 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 14 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 CE 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 65 02 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 CE 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 CE 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 14 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 18 C4 04 00 08 00 4A 1F EE CF 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 DF 5A 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 EE CF 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 46 LEN: 18 CF 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 15 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 CF 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 7D 6C 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 CF 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 </pre>

CF 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 15 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS
05 64 18 C4 04 00 08 00 4A 1F EF C0 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 F9 4F 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 EF C0 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 47 LEN: 18 C0 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 0 FUNC: OPERATE 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS
05 64 1A 44 08 00 04 00 D3 29 C0 C0 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 07 8C 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C0 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C0 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 0 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS

Resultado

Éxito ✓

- f. Issue a valid operate, incrementing the sequence number by 1 modulo 16.
- g. Verify that the DUT echoes the object portion of the operate byte for byte.
- h. Verify that the DUT operates the binary output.

Resultado

Éxito ✓

4.3.2.1.2.12 Binary Output, SBO, Same Sequence Number Operate Retries

- a. If the DUT does not have installed binary output points, skip this section.
- b. Issue a valid select to an installed binary output point.
- c. Verify that the DUT echoes the object portion of the select byte for byte.

05 64 18 C4 04 00 08 00 4A 1F F4 C5 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 73 EC 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 F4 C5 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 52 LEN: 18
--

```

C5 03 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 5 FUNC: SELECT

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 C5 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 06 17
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 C5 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

C5 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 5 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

- d. Issue a valid operate, incrementing the sequence number by 1 modulo 16.
- e. Verify that the DUT echoes the object portion of the operate byte for byte.
- f. Verify that the DUT operates the binary output.

```

05 64 18 C4 04 00 08 00 4A 1F F5 C6 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 07 AB
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

F5 C6 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 53 LEN: 18

C6 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 6 FUNC: OPERATE

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 C6 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 2E A5
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 C6 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

C6 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 6 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

- g. Issue the operate again using the same application layer sequence number.
- h. Verify that the DUT echoes the object portion of the operate byte for byte.
- i. Verify that the DUT does not operate the binary output.

```

05 64 18 C4 04 00 08 00 4A 1F F5 C6 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 07 AB
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

F5 C6 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 53 LEN: 18

C6 04 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 6 FUNC: OPERATE

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 C6 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 2E A5
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 C6 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

C6 81 00 00 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 6 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

4.3.2.1.2.13 Binary Output, SBO, Incrementing Sequence Number Operate Retries

- a. If the DUT does not have installed binary output points, skip this section.
- b. Issue a valid select to an installed binary output point.
- c. Verify that the DUT echoes the object portion of the select byte for byte.

```

05 64 18 C4 04 00 08 00 4A 1F C8 C9 03 0C 01 17 01 02 03 01 64 00 00 00 64 00 9F 6E
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

C8 C9 03 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 8 LEN: 18

C9 03 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 9 FUNC: SELECT

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 C9 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 90 FB
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 C9 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

```

```

C9 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 9 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

- d. Issue a valid operate, incrementing the sequence number by 1 modulo 16.
- e. Verify that the DUT echoes the object portion of the operate byte for byte.
- f. Verify that the DUT operates the binary output.

```

05 64 18 C4 04 00 08 00 4A 1F C9 CA 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 EB 29
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

C9 CA 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 9 LEN: 18

CA 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 10 FUNC: OPERATE

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

05 64 1A 44 08 00 04 00 D3 29 C0 CA 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 B8 49
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 CA 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

CA 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 10 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

- g. Issue the operate again, incrementing the sequence number by 1 modulo 16.
- h. Verify that the DUT echoes the object portion of the operate byte for byte with a status code value of 2 (NO MATCHING SELECT).
- i. Verify that the DUT does not operate the binary output.

```

05 64 18 C4 04 00 08 00 4A 1F CA CB 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 67 91
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

    CA CB 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
    FIR: 1 FIN: 1 SEQ: 10 LEN: 18

    CB 04 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 00
    FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 11 FUNC: OPERATE

    012,001 Binary Command - CROB, 8-bit count and prefix [1]
    [2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

```

05 64 1A 44 08 00 04 00 D3 29 C0 CB 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 A0 27
64 00 00 00 02 BC 37
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

    C0 CB 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 02
    FIR: 1 FIN: 1 SEQ: 0 LEN: 20

    CB 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 02
    FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 11 FUNC: RESPONSE IIN: [0x00, 0x00]

    012,001 Binary Command - CROB, 8-bit count and prefix [1]
    [2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
NO_SELECT

```

Resultado

Éxito ✓

4.3.2.1.2.14 Binary Output, SBO, Sequence number checking

- a. If the DUT does not have installed binary output points, skip this section.
- b. Issue a valid select to an installed binary output point.
- c. Verify that the DUT echoes the object portion of the select byte for byte.

Resultado

Éxito ✓

- d. Issue a valid operate, incrementing the sequence number by anything but 1 modulo 16.
- e. Verify that the DUT echoes the object portion of the operate byte for byte with a status code value of 2 (NO MATCHING SELECT).
- f. Verify that the DUT does not operate the binary output.

Resultado

Falla ✗

- g. Issue a valid operate, incrementing the select sequence number by 1 modulo 16 to make sure the mismatched operate cleared the previous select.
- h. Verify that the DUT echoes the object portion of the operate byte for byte with a status code value of 2 (NO MATCHING SELECT).
- i. Verify that the DUT does not operate the binary output.

Resultado	Falla ✕
-----------	---------

4.3.2.2 Direct Operate with Acknowledge

4.3.2.2.1 Desired Behavior

The following behavior assumes that the device does not support control operation:

- If the device does not support control outputs, it must respond to a direct operate with an Error Response setting IIN2-1.
- An Error Response with IIN2-2 set is an invalid response.
- No further testing in this section is necessary.

The following behavior assumes that the device supports control operations:

- The DUT responds to a direct operate to an uninstalled data point by returning an Error response with IIN2-2 set and a status code of 4. The control does not operate.
- The DUT responds to a direct operate to an installed data point by echoing the direct operate and setting the status field to 0. The specified control operates.

The following behavior assumes that the device does support control operations, however there are no control points installed/enabled:

- If the device does not have any control outputs installed, it must respond to a direct operate with an Error Response setting IIN2-1 or IIN2-2.

4.3.2.2.2 Test Procedure

4.3.2.2.2.1 Binary Output, Direct Operate

- a. Issue a direct operate using Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- b. If the device does not support control outputs verify that the DUT responds with an Error Response with IIN2-1 set and end testing of this section.
- c. If the device does support control outputs verify that the DUT responds by echoing the direct operate message exactly with status field of 0.
- d. Verify that the specified control operates.

```
05 64 18 C4 04 00 08 00 4A 1F D1 C2 05 0C 01 17 01 00 03 01 64 00 00 00 64 00 64 16
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

D1 C2 05 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 17 LEN: 18
```

C2 05 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 2 FUNC: DIRECT_OPERATE 012,001 Binary Command - CROB, 8-bit count and prefix [1] [0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS
05 64 1A 44 08 00 04 00 D3 29 C0 C2 81 00 00 0C 01 17 01 01 00 00 10 00 00 00 56 C1 00 00 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C2 81 00 00 0C 01 17 01 01 00 00 10 00 00 00 00 00 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C2 81 00 00 0C 01 17 01 01 00 00 10 00 00 00 00 00 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 2 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [1] - code: 0x00 (NUL) count: 0 on-time: 16 off-time: 0 status: SUCCESS

Resultado	Éxito ✓
-----------	---------

4.3.2.2.2 Binary Output, Direct Operate to Uninstalled Point

- Issue a direct operate using Object 12 Variation 1 to an uninstalled point using 16 bit indexing (qualifier 0x28) using a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT responds by returning an Error response with IIN2-2 set and a status code of 4.
- Verify that no control operates.

Resultado	Falla ✗
-----------	---------

4.3.2.3 Direct Operate, No Acknowledge

4.3.2.3.1 Desired Behavior

- The DUT must not respond to in any way to the direct operate no acknowledge.
- If the device supports binary outputs and the operate message is correct then the binary output point must operate.

4.3.2.3.2 Test Procedure

4.3.2.3.2.1 Binary Output, Direct Operate, No Acknowledge

- Issue a Direct Operate, No Acknowledge using Object 12 Variation 1 to an installed point using 8 bit indexing (qualifier 0x17), a control code supported by the device and an appropriate on time/off time.
- Verify that the DUT does not respond.

- c. If the device does not support control outputs, end testing of this section.
- d. If the device does support control outputs, verify that the proper control point operates.

```

05 64 18 C4 04 00 08 00 4A 1F D9 CA 06 0C 01 17 01 00 03 01 64 00 00 00 64 00 AD 04
00 00 00 FF FF
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24

D9 CA 06 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 25 LEN: 18

CA 06 0C 01 17 01 00 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 10 FUNC: DIRECT_OPERATE_NR

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[0] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado	Éxito ✓
-----------	---------

4.3.2.3.2.2 Binary Output, Direct Operate, No Acknowledge, to an Uninstalled Point

- a. Issue a Direct Operate, No Acknowledge using Object 12 Variation 1 to an uninstalled point using 16 bit indexing (qualifier 0x28) using a control code supported by the device and an appropriate on time/off time.
- b. Verify that the DUT does not respond.
- c. Verify that no control operates.

Resultado	Falla ✗
-----------	---------

4.3.2.4 Control Code Support

4.3.2.4.1 Desired Behavior

The following assumes that the device supports control operations and were added as a result of Technical Bulletin TB2000-006 (CROB Control Codes):

- For complementary function indices, the Outstation must accept at least one of the following control code pairs:
 - 0x03 (Latch On/NUL) and 0x04 (Latch Off/NUL)
 - 0x41 (Pulse On/Close) and 0x81 (Pulse On/Trip)
- The outstation may optionally accept both forms of complementary control code pairs. If it does:
 - control codes 0x03 (Latch On/NUL) and 0x41 (Pulse On/Close) must perform the same function
 - control codes 0x04 (Latch Off/NUL) and 0x81 (Pulse On/Trip) must perform the same function

- For single function indices, the outstation must accept at least one of the following control codes:
 - 0x01 (Pulse On/NUL)
 - 0x03 (Latch On/NUL)
 - 0x04 (Latch Off/NUL)
 - 0x41 (Pulse On/Close)
 - 0x81 (Pulse On/Trip)
- If the outstation accepts more than one control code for a single function index, it must perform the same function for each control code it accepts.

4.3.2.4.2 Test Procedure

4.3.2.4.2.1 Binary Output, Single Function Support

- For any point that is tested below, determine what action should happen when the control executes.
- Issue a valid control sequence to the first installed single function binary output point using control code 0x03 (LatchOn/NUL).
- Verify the control operation in step a completes successfully.
- Issue a valid control sequence to the first installed single function binary output point using control code 0x04 (Latch Off/NUL).
- Verify the control operation in step a completes successfully.

<pre> 05 64 18 C4 04 00 08 00 4A 1F C5 C6 03 0C 01 17 01 06 03 01 64 00 00 00 64 00 3D E2 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 C5 C6 03 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 5 LEN: 18 C6 03 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 6 FUNC: SELECT 012,001 Binary Command - CROB, 8-bit count and prefix [1] [6] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 1A 44 08 00 04 00 D3 29 C0 C6 81 00 00 0C 01 17 01 06 03 01 64 00 00 00 1B 2B 64 00 00 00 00 00 5B Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26 C0 C6 81 00 00 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 0 LEN: 20 C6 81 00 00 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 6 FUNC: RESPONSE IIN: [0x00, 0x00] 012,001 Binary Command - CROB, 8-bit count and prefix [1] [6] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status: SUCCESS </pre>
<pre> 05 64 18 C4 04 00 08 00 4A 1F C6 C7 04 0C 01 17 01 06 03 01 64 00 00 00 64 00 61 E2 00 00 00 FF FF Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 24 C6 C7 04 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00 FIR: 1 FIN: 1 SEQ: 6 LEN: 18 C7 04 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00 </pre>

```

FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 7 FUNC: OPERATE

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[6] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS
05 64 1A 44 08 00 04 00 D3 29 C0 C7 81 00 00 0C 01 17 01 06 03 01 64 00 00 00 03 45
64 00 00 00 00 00 5B
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 C7 81 00 00 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

C7 81 00 00 0C 01 17 01 06 03 01 64 00 00 00 64 00 00 00 00
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 7 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[6] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
SUCCESS

```

Resultado

Éxito ✓

4.3.3 Cold Restart

4.3.3.1 Desired Behavior

- The device must respond to a Cold Restart request by sending a Time Delay response, restarting, and setting IIN1-7.

4.3.3.2 Test Procedure

- Issue a request for Cold Restart using Function Code 13, to the DUT.
- Verify the response is a Time Delay Fine or Coarse (Object 52 Variation 1 or Variation 2).

```

05 64 08 C4 04 00 08 00 8B 67 DE CF 0D C0 20
Function: PRI_UNCONFIRMED_USER_DATA Dest: 4 Source: 8 Length: 8

DE CF 0D
FIR: 1 FIN: 1 SEQ: 30 LEN: 2

CF 0D
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 15 FUNC: COLD_RESTART
05 64 1A 44 08 00 04 00 D3 29 C0 CB 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 A0 27
64 00 00 00 02 BC 37
Function: PRI_UNCONFIRMED_USER_DATA Dest: 8 Source: 4 Length: 26

C0 CB 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 02
FIR: 1 FIN: 1 SEQ: 0 LEN: 20

CB 81 00 00 0C 01 17 01 02 03 01 64 00 00 00 64 00 00 00 02
FIR: 1 FIN: 1 CON: 0 UNS: 0 SEQ: 11 FUNC: RESPONSE IIN: [0x00, 0x00]

012,001 Binary Command - CROB, 8-bit count and prefix [1]
[2] - code: 0x03 (LATCH_ON) count: 1 on-time: 100 off-time: 100 status:
NO_SELECT

```

Resultado	Éxito ✓
-----------	---------

- c. If the DUT requests an Application Layer Confirm send it before starting the wait period.
- d. Wait for a period of time longer than the time returned in step 2.
- e. Issue a request for Object 60 Variation 1.
- f. Verify that the device responds with IIN1-7 set indicating that the device has been restarted.

Resultado	Éxito ✓
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- g. Issue a Write using Object 80 Variation 1 with the qualifier 0x00. Use a start index of 7 and a stop index of 7, followed by the value 0.
- h. Verify that the device responds with a Null Response and that IIN1-7 is cleared.

Resultado	Éxito ✓
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5. Resumen

	Éxito	Fallo	N/A	Total	Porcentaje de cumplimiento
Enlace	26	0	2	28	100%
Transporte	2	0	3	5	100%
Aplicación	25	9	2	34	78%