Specification

Z-Wave Network Layer Test Specification

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REVISION RECORD

Doc. Rev	Date	By	Pages affected	Brief description of changes
0.3	2020/09/28	CSWG	ALL	Initial version
0.5	2020/11/27	CSWG	From 3.18 to 3.58	Many new test cases added
0.5.1	2020/12/20	CSWG	From 3.59 and forward	Added test cases for smartstart inclusion, controller roles and network maintenance
0.7	2021/02/26	CSWG	All	Added abbreviations References to tables and figures fixed Slave changed to End Node to match wording in network Layer Specification
0.8	2021/03/01	CSWG	None	WG review done. Revision updated to 0.8 for TC review.
0.9	2021/03/29	CSWG	Frontpage	Cleanup for Member Technical Review
1.0	2021/10/28	ZWA Board		Approved for publication

Table of Contents

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1   ABBREVIATIONS

Abbreviation	Explanation
ACK	Acknowledgement
AL	Always Listening
FL	Frequently Listening
MAC	Medium Access Control
MPDU	MAC Protocol Data Unit
NL	Non-Listening
NOP	No Operation
NPDU	Network Layer Protocol Data Unit
NWI	Network Wide Inclusion
PHY	Physical layer
S0	Security 0 Command Class.
S2	Security 2 Command Class.
SIS	SUC ID Server
SUC	Static Update Controller

2   INTRODUCTION

2.1   Purpose

To provide a set of tests that help verify compliance with the Network layer of the Z-Wave technology.

2.2   Audience and prerequisites

An RF sniffer hardware that can be tuned in on the valid frequencies for Z-Wave or a Z-Wave Zniffer module and PC Application. Z-Wave PC controller or equivalent to execute communication between the different nodes.

3   NETWORK-LAYER TEST CASE DESCRIPTIONS

3.1   General assumptions

The PHY and MAC layers are functional and follow the specification in [G.9959] and is verified by the set of tests in [PHY_TEST] and [MAC_TEST] respectively.

All components are defined by [NWK] and that document is the sole reference for the present Test Plan.

Services provided by the Network Layer shall be in accordance with requirement [NWK:0008.1].

Routing is assumed to be possible either by isolated routing boxes, physical distance or removing antennas from the final destination Node and the Primary Controller.

3.2   Frame Format – Routing information 2-channel frequencies

The Network Layer provides mesh routing functionality allowing to deliver messages through repeater nodes. These nodes can be found through special frames called Explorer Frames. Both types of frames should follow a specific type of format.

3.2.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End nodes.

3.2.2   Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove one of the End Nodes to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) frame to it.

3.2.3   Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater.

3.2.4   Pass Criteria

1. The frame sent to the repeater and then to the end node has Routed information (NWK:0009.1):
    a. The frame has the structure as Figure 4.2.
    b. The Frame Control field follows the structure as Figure 4.3
    c. The routed bit in the Frame Control field is set.
    d. The header type is set to 0x01 (singlecast).

3.2.5   Fail Criteria

1. The frame sent to the repeater and then to the end node has NO Routed information (NWK:0009.1):
    a. The frame Doesn't have the structure as Figure 4.2.
    b. The Frame Control field doesn't follow the structure as Figure 4.3
    c. The routed bit in the Frame Control field is NOT set.
    d. The header type is different from 0x01 (singlecast).

3.3 Frame Format – Routing information 3-channel frequencies

The Network Layer provides mesh routing functionality allowing to deliver messages through repeater nodes. These nodes can be found through special frames called Explorer Frames. Both types of frames should follow a specific type of format.

3.3.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.3.2 Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove one of the End Nodes to be one hop away. Send a frame to it.

3.3.3 Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater.

3.3.4 Pass Criteria

1. The frame sent to the end node has Routed information (NWK:0009.1):
   a. The frame has the structure as Figure 4.2.
   b. The Frame Control field follows the structure as Figure 4.4.
   c. The header type is set to 0x08 (Routed).

3.3.5 Fail Criteria

1. The frame sent to the end node has NO Routed information (NWK:0009.1):
   a. The frame Doesn't have the structure as Figure 4.2.
   b. The Frame Control field doesn't follow the structure as Figure 4.4.
   c. The header type is different from 0x08 (Routed).

3.4 Frame Format – Explorer frame 2 & 3-channel frequencies

The Network Layer provides mesh routing functionality allowing to deliver messages through repeater nodes. These nodes can be found through special frames called Explorer Frames. Both types of frames should follow a specific type of format.

3.4.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.4.2 Test Setup

1. Include the first End Node to PC Controller's network.
2. Disable it by removing power from it or put it out of range for the controller.
3. Include the second End Node to PC Controller's network.
4. Enable the first End Node (place it in close range). Place the second End Node one hop away from the Controller.
5. Send a singlecast with Payload 0x00 (NOP) to the first End Node to verify communication.
6. Send a singlecast with Payload 0x00 (NOP) to the second End Node to verify communication.

3.4.3 Test Result

5. The first End Node answers with an ACK frame.
6. The controller tries to reach the second End Node.
   a. Controller is unable to reach the second End Node directly and sends an explorer frame.
   b. The first End Node repeats this explorer frame and reaches the second End Node.
   c. Controller receives an "Explorer Search Result" frame.
   d. Controller Routes the singlecast to the Second End Node through the first one and Receives a Routed Ack.

3.4.4 Pass Criteria

1. The Explorer frames sent from the Controller, repeated by the First End Node and Answered as an "Explorer Search Result" from the second End Node have information about Routing (NWK:0009.1):
   a. The frame has the structure as Figure 4.2.
   b. The Frame Control field follows the structure as Figure 4.3
   c. The routed bit in the Frame Control field is set to 0x00.
   d. The Header type is 0x05 (Explorer).

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3.4.5   Fail Criteria

1. The Explorer frames have NO information about Routing (NWK:0009.1):
   a. The frame Doesn't have the structure as Figure 4.2.
   b. The Frame Control field doesn't follow the structure as Figure 4.3
   c. The routed bit in the Frame Control field is NOT 0x00.
   d. The header type is different from 0x05 (Explorer).

3.5   Frame Format – Routed NPDU 2-channel frequencies, Header format, Normal function

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.7 for 2-channel frequencies.

3.5.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.5.2   Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove one of the End Nodes to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.5.3   Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater.

3.5.4   Pass Criteria

1. On the routed frames, look for the Routing header: it should follow the structure of Figure 4.7
2. The frame sent to the repeater and then to the end node is sent as a singlecast (Header type 0x02) (NWK:000A.1, NWK:0180.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0013.1).
4. The field "Routed Speed Modified" is set to 0 (NWK:000B.1).
5. The "Extended Header" bit is set to 0 (NWK:0011.1).
6. The "R-Ack" (Routed Ack) is set to 0 (NWK:0015.1).
7. The "Direction" bit is set to 0 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds the value 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds the value 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. There is no "Destination Wake Up" field in the Routing Header (NWK:0023.1).
13. The DLPDU is 0x00 (NOP) (NWK:0034.1).
14. There is no RSSI Extended Header (NWK:0036.1).
15. The receiving node responds with an Acknowledgement frame using the same route (NWK:0183.1).
16. The delivery of a routed frame follows the basic diagram on Figure 4.59 (NWK:018D.1).

3.5.5 Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a singlecast (Header type 0x02) (NWK:000A.1, NWK:0180.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0013.1).
4. The field "Routed Speed Modified" is NOT set to 0 (NWK:000B.1).
5. The "Extended Header" bit is NOT set to 0 (NWK:0011.1).
6. The "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds a value different from 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds a value different from 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds more than one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. There is A "Destination Wake Up" field in the Routing Header (NWK:0023.1).
13. The routed frame does not include the corresponding Payload (NWK:0034.1).
14. The Routing frame does include RSSI extension (NWK:0036.1).
15. The receiving node responds with an Acknowledgement frame using a different route (NWK:0183.1).
16. The delivery of the routed frame does not follow the basic diagram Figure 4.59 (NWK:018D.1).
17. Variation outside of the allowed parameters causes successful results when they should not be.

3.6   Frame Format – Routed NPDU 3-channel frequencies, Header format, Normal function

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.8 for 3-channel frequencies.

3.6.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.6.2   Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove one of the End Nodes to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.6.3   Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater.

3.6.4   Pass Criteria

1. On the routed frames, look for the Routing header: it should follow the structure of Figure 4.8
2. The frame sent to the repeater and then to the end node is sent as a Routed (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0013.1).
4. The field "Routed Speed Modified" is not shown in the Zniffer and the corresponding bits of the frame are set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is set to 0 (NWK:0011.1).
6. In "Properties3", The "R-Ack" (Routed Ack) is set to 0 (NWK:0015.1).
7. The "Direction" bit is set to 0 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds the value 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds the value 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before "Properties 5", the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. In "Properties5" the "Destination Wake Up" field is set to 0x00 if the second End Node is AL and 0x02 if it's a FL (NWK:0024.1, NWK:0025.1).
13. The DLPDU is 0x00 (NOP) (NWK:0034.1).
14. There is no RSSI Extended Header (NWK:0036.1).

15. The receiving node responds with an Acknowledgement frame using the same route (NWK:0183.1).
16. The delivery of a routed frame follows the basic diagram on Figure 4.60 (NWK:018E.1).

3.6.5   Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a Routed (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0013.1).
4. The field "Routed Speed Modified" is shown in the Zniffer or its corresponding bits on the frame are NOT set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is NOT set to 0 (NWK:0011.1).
6. In "Properties3", the "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds a value different from 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds a value different from 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds more than one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. In "Properties5" the "Destination Wake Up" field is NOT set to 0x00 if the second End Node is AL NOR 0x02 fi it's a FL (NWK:0024.1, NWK:0025.1).
13. The routed frame does not include the corresponding Payload (NWK:0034.1).
14. The Routing frame does include RSSI extension (NWK:0036.1).
15. The receiving node responds with an Acknowledgement frame using a different route (NWK:0183.1).
16. The delivery of a routed frame doesn't follow the basic diagram on Figure 4.60 (NWK:018E.1).
17. Variation outside of the allowed parameters causes successful results when they should not be.

3.7   Frame Format – Routed ACK NPDU 2-channel frequencies, Header format, Normal function

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.7 for 2-channel frequencies.

3.7.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.7.2   Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove one of the End Nodes to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.7.3   Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater.

Routed Ack for an AL and a FL Node are exactly the same.

3.7.4   Pass Criteria

1. On the routed Ack frames, look for the Routing header: it should follow the structure of Figure 4.7
2. The frame sent to the repeater and then to the Controller is sent as a singlecast (Header type 0x02) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0013.1).
4. The field "Routed Speed Modified" is set to 0 (NWK:000B.1).
5. The "Extended Header" bit is set to 1 (NWK:0011.1).
6. The "R-Ack" (Routed Ack) is set to 1 (NWK:0016.1).
7. The "Direction" bit is set to 1 (NWK:0018.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds the value 0 (NWK:001A.1, NWK:001C.1, NWK:001D.1).
10. The second frame sent, in its "Hops" field holds the value 0x0F (NWK:001A.1, NWK:001E.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. There is no "Destination Wake Up" field in the Routing Header (NWK:0023.1).

13. In "Properties5", the "Extended Header Tye" field is set to 0x01 (Incoming Routed RSSI Type) (NWK:0026.1, NWK:002D.1).
14. The "Extended Header Body Length" is set to 4 (NWK:002C.1, NWK:0030.1).
15. The "Extended Header Body" field is structured as Figure 4.10 (NWK:002F.1).
16. In the first Routed Ack frame all 4 Bytes are set to 0x7F (NWK:0031.1, NWK:0039.1).
17. In the second Routed Ack frame the RSSI value is updated and set to a value according to Table 4.4 (NWK:0032.1, NWK:0033.1, NWK:0039.1).
18. The Routed Ack frames hold no DLPDU (NWK:0037.1).
19. The Routed Ack holds no "Destination Wake Up Extension" field (NWK:0038.1).

3.7.5   Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a singlecast (Header type 0x02) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0013.1).
4. The field "Routed Speed Modified" is NOT set to 0 (NWK:000B.1).
5. The "Extended Header" bit is NOT set to 0 (NWK:0011.1).
6. The "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds a value different from 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds a value different from 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds more than one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. There is A "Destination Wake Up" field in the Routing Header (NWK:0023.1).
13. In "Properties5", the "Extended Header Tye" field is NOT set to 0x01 (Incomming Routed RSSI Type) (NWK:0026.1, NWK:002D.1).
14. The "Extended Header Body Length" is NOT set to 4 (NWK:002C.1, NWK:0030.1).
15. The "Extended Header Body" field does NOT follow the structure from Figure 4.10 (NWK:002F.1).
16. In the first Routed Ack frame any Byte is different from 0x7F (NWK:0031.1, NWK:0039.1).
17. In the second Routed Ack frame the RSSI value is unchanged (NWK:0032.1, NWK:0033.1, NWK:0039.1).
18. The Routed Ack frames hold some type of DLPDU (NWK:0037.1).
19. The Routed Ack holds "Destination Wake Up Extension" field (NWK:0038.1).
20. Variation outside of the allowed parameters causes successful results when they should not be.

3.8 Frame Format – Routed ACK NPDU 3-channel frequencies, Header format, Normal function

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.8 for 3-channel frequencies.

3.8.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.8.2 Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove one of the End Nodes to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.8.3 Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater.

Routed Ack for an AL and a FL Node are exactly the same.

3.8.4 Pass Criteria

1. On the routed Ack frames, look for the Routing header: it should follow the structure of Figure 4.8
2. The frame sent to the repeater and then to the Controller is sent as a Routed (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0013.1).
4. The field "Routed Speed Modified" is not shown in the Zniffer and the corresponding bits of the frame are set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is set to 1 (NWK:0011.1).
6. In "Properties3", The "R-Ack" (Routed Ack) is set to 1 (NWK:0016.1).
7. The "Direction" bit is set to 1(NWK:0018.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds the value 0 (NWK:001A.1, NWK:001C.1, NWK:001D.1).
10. The second frame sent, in its "Hops" field holds the value 0x0F (NWK:001A.1, NWK:001E.1)
11. In the Zniffer, before "Properties 5", the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. In "Properties5" the "Destination Wake Up" field is not present (NWK:0038.1).
13. The is no DLPDU (NWK:0037.1).

14. In "Properties5", the "Extended Header Type" field is set to 0x01 (Incoming Routed RSSI Type) (NWK:0026.1, NWK:002D.1).
15. The "Extended Header Body Length" is set to 4 (NWK:002C.1, NWK:0030.1).
16. The "Extended Header Body" field is structured as Figure 4.10 (NWK:002F.1).
17. In the first Routed Ack frame all 4 Bytes are set to 0x7F (NWK:0031.1, NWK:0039.1).
18. In the second Routed Ack frame the RSSI value is updated and set to a value according to Table 4.4 (NWK:0032.1, NWK:0033.1, NWK:0039.1).
19. The first repeater (repeater 0) requests ACK MPDU (NWK:0182.1).

3.8.5 Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a Routed (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0013.1).
4. The field "Routed Speed Modified" is shown in the Zniffer or its corresponding bits on the frame are NOT set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is NOT set to 0 (NWK:0011.1).
6. In "Properties3", the "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds a value different from 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds a value different from 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds more than one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. In "Properties5" the "Destination Wake Up" field is present (NWK:0038.1).
13. There is DLPDU present with value of 0x00 (NOP) or otherwise (NWK:0037.1).
14. In "Properties5", the "Extended Header Type" field is set to 0x01 (Incoming Routed RSSI Type) (NWK:0026.1, NWK:002D.1).
15. The "Extended Header Body Length" is set to 4 (NWK:002C.1, NWK:0030.1).
16. The "Extended Header Body" field is structured as Figure 4.10 (NWK:002F.1).
17. In the first Routed Ack frame all 4 Bytes are set to 0x7F (NWK:0031.1, NWK:0039.1).
18. In the second Routed Ack frame the RSSI value is updated and set to a value according to Table 4.4 (NWK:0032.1, NWK:0033.1, NWK:0039.1).
19. The first repeater (repeater 0) doesn't request ACK MPDU (NWK:0182.1).
20. Variation outside of the allowed parameters causes successful results when they should not be.

3.9 Frame Format – Routed NPDU 2-channel frequencies, Header format, Routing to a FL Node

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.7 for 2-channel frequencies.

3.9.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
1 x AL End Node.
1 x FL End Node.

3.9.2 Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove the FL End Node to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.9.3 Test Result

2. Each End Node answers with an ACK frame. The Controller sends Wake up Beams to the FL End Node.
3. The singlecast is routed to the end node through the repeater. The repeater Beams to the FL Node and then sends the routed singlecast.

3.9.4 Pass Criteria

1. On the routed frames after the initial re-transmission, look for the Routing header: it should follow the structure of Figure 4.7
2. The frame sent to the repeater and then to the end node is sent as a singlecast (Header type 0x02) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0013.1).
4. The field "Routed Speed Modified" is set to 0 (NWK:000B.1).
5. The "Extended Header" bit is set to 1 (NWK:0012.1). [It will contain Wake Up information]. It **May** be set to 0 in the first attempt to reach the FL Node (NWK:0185.1) [No Wake Up Information].
6. The "R-Ack" (Routed Ack) is set to 0 (NWK:0015.1).
7. The "Direction" bit is set to 0 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds the value 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds the value 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before "Properties5", the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).

12. There is no "Destination Wake Up" field in the Routing Header (NWK:0023.1). [not used in 2-channels]
13. The "Properties5" field is configured following Table 4.3 (NWK:0026.1).
14. The "Extended Header Type" field is set to 0x00 (NWK:0027.1).
15. The "Extended Header Body Length" field is set to 1 (NWK:0028.1).
16. The "Extender Header Body" is configured following Figure 4.9 (NWK:0029.1).
17. The DLPDU is 0x00 (NOP) (NWK:0034.1).
18. The "Destination Wake Up" extension is required (NWK:0035.1, NWK:018F.1).
19. There is no RSSI Extended Header (NWK:0036.1).
20. The last repeater returns an Acknowledgement frame to the penultimate repeater (NWK:0181.1).

3.9.5   Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a singlecast (Header type 0x02) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0013.1).
4. The field "Routed Speed Modified" is NOT set to 0 (NWK:000B.1).
5. The "Extended Header" bit is NOT set to 0 (NWK:0012.1).
6. The "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds a value different from 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds a value different from 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds more than one NodeID value for 'Repeater 0' or a different NodeID from the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. There is A "Destination Wake Up" field in the Routing Header (NWK:0023.1).
13. The "Properties5" field is NOT configured following Table 4.3 (NWK:0026.1).
14. The "Extended Header Type" field is different than 0x00 (NWK:0027.1).
15. The "Extended Header Body Length" field is different than 1 (NWK:0028.1).
16. The "Extended Header Body" is NOT configured following Figure 4.9 (NWK:0029.1).
17. The DLPDU is Different from 0x00 (NOP) or is missing (NWK:0034.1).
18. The "Destination Wake Up" extension is missing (NWK:0035.1, NWK:018F.1).
19. The Routing frame does include RSSI extension (NWK:0036.1).
20. The Last repeater does not send an Acknowledgement frame to the penultimate repeater (NWK:0181.1).
21. Variation outside of the allowed parameters causes successful results when they should not be.

3.10   Frame Format – Routed NPDU 3-channel frequencies, Header format, Routing to a FL Node

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.8 for 3-channel frequencies.

3.10.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
1 x AL End Node.
1 x FL End Node.

3.10.2   Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove the FL End Node to be one hop away. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.10.3   Test Result

2. Each End Node answers with an ACK frame. The Controller sends Wake up Beams to the FL End Node.
3. The singlecast is routed to the end node through the repeater. The repeater Beams to the FL Node and then sends the routed singlecast.

3.10.4   Pass Criteria

1. On the routed frames after the initial re-transmission, look for the Routing header: it should follow the structure of Figure 4.7
2. The frame sent to the repeater and then to the end node is sent as a Routed (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0013.1).
4. The field "Routed Speed Modified" is not shown in the Zniffer and the corresponding bits of the frame are set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is set to 0 (NWK:0012.1).
6. In "Properties3", the "R-Ack" (Routed Ack) is set to 0 (NWK:0015.1).
7. The "Direction" bit is set to 0 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds the value 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds the value 1 (NWK:001A.1, NWK:001D.1)

11. In the Zniffer, before "Properties5", the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).

12. In "Properties5" the "Destination Wake Up" field is set to 0x02 if it's a FL (NWK:0024.1, NWK:0025.1).

13. The "Properties5" field is configured following Table 4.3 (NWK:0026.1).

14. The DLPDU is 0x00 (NOP) (NWK:0034.1).

15. There is no RSSI Extended Header (NWK:0036.1)

3.10.5 Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a Routed frame (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0013.1).
4. The field "Routed Speed Modified" is shown in the Zniffer or its corresponding bits on the frame are NOT set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is NOT set to 0 (NWK:0011.1).
6. In "Properties3", the "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The first frame sent, in its "Hops" field holds a value different from 0 (NWK:001A.1, NWK:001B.1).
10. The second frame sent, in its "Hops" field holds a value different from 1 (NWK:001A.1, NWK:001D.1)
11. In the Zniffer, before Properties 5, the Field "Repeaters" holds more than one NodeID value for 'Repeater 0' or a different NodeID from the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. In "Properties5", there is no "Destination Wake Up" field or it's not set to 0x02 (NWK:0024.1, NWK:0025.1).
13. The "Properties5" field is NOT configured following Table 4.3 (NWK:0026.1).
14. The DLPDU is Different from 0x00 (NOP) or is missing (NWK:0034.1).
15. The Routing frame does include RSSI extension (NWK:0036.1).
16. Variation outside of the allowed parameters causes successful results when they should not be.

3.11   Frame Format – Routed NPDU 2-channel frequencies, Header format, Routed error

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.7 for 2-channel frequencies.

3.11.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x AL End Node.

3.11.2   Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove power from one End Node. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.11.3   Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater. The repeater retransmits to the Node and then sends a Routed Error frame to the Controller after it can't reach the destination.

Routed Error for an AL and a FL Node are exactly the same.

3.11.4   Pass Criteria

1. On the Routed Error frame after the initial re-transmission, look for the Routing header: it should follow the structure of Figure 4.7
2. The Routed Error frame sent to the Controller is sent as a singlecast (Header type 0x01) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0014.1).
4. The field "Failed Hop" appears instead of "Routed Speed Modified" (NWK:000F.1).
5. The field "Failed Hop" displays the number of the Hop that did not get an acknowledgement for the routed frame (NWK:0010.1).
6. The "Extended Header Present" bit is set to 0 (NWK:0011.1).
7. The "R-Ack" (Routed Ack) is set to 0 (NWK:0015.1).
8. The "Direction" bit is set to 1 (NWK:0018.1).
9. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).

10. The Routed Frame, in its "Hops" field holds the value 0x0F (NWK:001C.1, NWK:001E.1).
11. In the Zniffer, before "Properties5", the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. There is no "Destination Wake Up" field in the Routing Header (NWK:0023.1). [not used in 2-channels]
13. The "Properties5" field is empty.
14. There is no DLPDU in the frame (NWK:003A.1).
15. There is no "Destination Wake Up" extension is required (NWK:003B.1).
16. There is no RSSI Extended Header (NWK:003C.1).
17. The first repeater (repeater 0) requests ACK MPDU (NWK:0182.1).
18. The repeater sending the Routed Error Frame sets the Source NodeID as the value of the Destination NodeID which delivery failed (NWK:0190.1).

3.11.5 Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a singlecast (Header type 0x01) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0014.1).
4. The field "Routed Speed Modified" appears instead of "Failed Hop" (NWK:000F.1).
5. The field "Failed Hop" displays a wrong number of the Hop that did not get an acknowledgement for the routed frame (NWK:0010.1).
6. The "Extended Header Present" bit is not set to 1 (NWK:0011.1).
7. The "R-Ack" (Routed Ack) is set to 1 (NWK:0015.1).
8. The "Direction" bit is set to 0 (NWK:0018.1).
9. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
10. The Routed Frame, in its "Hops" field holds a different value than 0x0F (NWK:001C.1, NWK:001E.1).
11. In the Zniffer, before "Properties5", the Field "Repeaters" Doesn't hold only one NodeID value for 'Repeater 0' which would be 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
12. The field "Destination Wake Up" is present in the Routing Header (NWK:0023.1). [not used in 2-channels]
13. The "Properties5" field is NOT empty.
14. There is a DLPDU field in the frame (NWK:003A.1).
15. The "Destination Wake Up" extension is present (NWK:003B.1).
16. The Routing frame does include RSSI extension (NWK:003C.1).
17. The first repeater (repeater 0) doesn't request ACK MPDU (NWK:0182.1).
18. The repeater sending the Routed Error Frame Doesn't set the Source NodeID as the value of the Destination NodeID which delivery failed (NWK:0190.1).
19. Variation outside of the allowed parameters causes successful results when they should not be.

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3.12 Frame Format – Routed NPDU 3-channel frequencies, Header format, Routed error

Routed NPDUs are used to transmit a frame when the sending node knows a route to the destination. They use a routing header described in Figure 4.8 for 3-channel frequencies.

3.12.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.12.2 Test Setup

1. Include both End Nodes to PC Controller's network.
2. Send a singlecast with Payload 0x00 (NOP) to each End Node to verify communication.
3. Remove power from one End Node. Send a singlecast frame with NPDU = 0x00 (NOP) to it.

3.12.3 Test Result

2. Each End Node answers with an ACK frame.
3. The singlecast is routed to the end node through the repeater. The repeater retransmits to the Node and then sends a Routed Error frame to the Controller after it can't reach the destination.
4. Routed Error for an AL and a FL Node are exactly the same.

Routed Error for an AL and a FL Node are exactly the same.

3.12.4 Pass Criteria

1. On the routed frames, look for the Routing header: it should follow the structure of Figure 4.8
2. The Routed Error frame sent to the Controller is sent as a Routed singlecast (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 1 (NWK:0014.1).
4. The field "Routed Speed Modified" is not shown in the Zniffer and the corresponding bits of the frame are set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is set to 0 (NWK:0011.1).
6. In "Properties3", The "R-Ack" (Routed Ack) is set to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0018.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is set to 1, since there is only 1 repeater (NWK:0019.1).

9. The Routed Frame, in its "Hops" field holds the value 0x0F (NWK:001C.1, NWK:001E.1).
10. In the Zniffer, before "Properties 5", the Field "Repeaters" holds only one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node) (NWK:001F.1, NWK:0020.1, NWK:0021.1).
11. There is no "Destination Wake Up" in "Properties5" (NWK:003B.1).
12. There is no DLPDU in the frame (NWK:003A.1).
13. There is no RSSI Extended Header (NWK:003C.1).

3.12.5 Fail Criteria

1. The Routed frames do not have a Routing Header.
2. The frame is not a Routed singlecast (Header type 0x08) (NWK:000A.1).
3. In the Zniffer in "Properties3", the "R-Err" (Routed Error) bit is set to 0 (NWK:0014.1).
4. The field "Routed Speed Modified" is shown in the Zniffer or its corresponding bits on the frame are NOT set to 0 (NWK:000E.1).
5. In "Properties2" the "Extended" bit is NOT set to 0 (NWK:0011.1).
6. In "Properties3", the "R-Ack" (Routed Ack) is set NOT to 0 (NWK:0015.1).
7. The "Direction" bit is set to 1 (NWK:0017.1).
8. In the Zniffer in "Properties4", the "Repeaters" field is NOT set to 1, since there is only 1 repeater (NWK:0019.1).
9. The Routed Frame, in its "Hops" field holds a different value than 0x0F (NWK:001C.1, NWK:001E.1).
10. In the Zniffer, before Properties 5, the Field "Repeaters" holds MORE than one NodeID value for 'Repeater 0' which is 2 (or the NodeID of the First End Node (NWK:001F.1, NWK:0020.1, NWK:0021.1).
11. There is "Destination Wake Up" included in "Properties5" (NWK:003B.1).
12. There is ANY type of DLPDU in the frame (NWK:003A.1).
13. There IS RSSI Extended Header (NWK:003C.1).
14. Variation outside of the allowed parameters causes successful results when they should not be.

3.13　Explorer Frames Format

Explore NPDUs are used to transmit a frame when the sending node does not know a route to the destination. They use the header format described in Figure 4.11. All Explorer type of frames shall abide to the format described in this Test Case. Each variation shall adjust its values as they are defined in the subsequent Test Cases.

3.13.1　Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.13.2　Test Setup

1. Include The first End Node to the Controller's network.
2. Remove power from the first End Node. Add the second End Node.
3. Return power to the first End Node. Create one hop in distance from the controller to the second End Node, using the first one as a repeater.
4. Send a singlecast to the second End Node from the Controller.
5. Observe the format of the explorer frame.

3.13.3　Test Result

1. First End Node is correctly included to the Controller's Network.
2. Second End Node is added to the Controller's Network and it does not count the first End Node as a neighbor.
4. Controller tries reaching out to the second End Node directly and when it doesn't reach, it starts sending explorer frames.
5. Explorer frame corresponds to the format defined in Figure 4.11

3.13.4　Pass Criteria

1. The version field consists of 3 bits and is set to 0x01 (NWK:003D.1).
2. The Command field consists of 5 bits and it's encoded according to Table 4.8 (NWK:003E.1).
3. The Direction bit indicates whether it's an outgoing or a returning frame (NWK:003F.1, NWK:0040.1, NWK:0041.1, NWK:0042.1).

4. The Source Routed bit shows if the Explore Frame contains a route to follow or if listening nodes shall repeat and add themselves when they forward the frame (NWK:0043.1, NWK:0044.1, NWK:0045.1).
5. The Stop Bit Indicates whether an AL node should repeat the frame or not (NWK:0046.1).
6. The Session Tx Random Interval field consists of 8 bits indicates how long should a node wait before repeating the Explore Frame (NWK:0047.1, NWK:0048.1, NWK:0049.1).
7. The TTL field consists of 4 bits and shows how many nodes can repeat the frame after the current transmission (NWK:004A.1, NWK:004B.1, NWK:004C.1).
8. The repeater count field consists of 4 bits, and it shows the number of repeaters for the Explore Frame (NWK:004D.1).
9. The Repeater 0 – 3 fields consist of 8 bits that show the Node ID of the Repeater position for each of the fields (NWK:004E.1, NWK:004F.1, NWK:0050.1, NWK:0051.1).

3.13.5 Fail Criteria

1. Any of the fields described misses its size, description and constraints.

3.14   Normal Explorer Frame

A normal explorer frame consists on the Explore Frame header with no specific payload.

3.14.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.14.2   Test Setup

1.   Include The first End Node to the Controller's network.
2.   Remove power from the first End Node. Add the second End Node.
3.   Return power to the first End Node. Create one hop in distance from the controller to the second End Node, using the first one as a repeater.
4.   Send a singlecast to the second End Node from the Controller.
5.   Observe the format of the explorer frame.

3.14.3   Test Result

1.   First End Node is correctly included to the Controller's Network.
2.   Second End Node is added to the Controller's Network and it does not count the first End Node as a neighbor.
4.   Controller tries reaching out to the second End Node directly and when it doesn't reach, it starts sending explorer frames.
5.   Explorer frame corresponds to the format defined in Figure 4.11

3.14.4   Pass Criteria

1.   The Normal Explore Frame follows the values in Table 4.9 (3.2.3.2).
2.   The version field consists of 3 bits and is set to 0x01 (NWK:003D.1).
3.   The Command field consists of 5 bits and it's set to 0x00 (NWK:003E.1).
4.   The Direction bit is set to 0, (NWK:003F.1, NWK:0041.1).
5.   The Source Routed bit is set to 0 (NWK:0043.1, NWK:0044.1).
6.   The Stop bit is set to 0 (NWK:0046.1).
7.   The Session Tx Random Interval field is more than 0, setting it to nwkRecommendedSessionTxRandomInterval (NWK:0047.1, NWK:0049.1).
8.   The TTL field starts with value of 4 and it decreases on each following Explore Frame (NWK:004A.1, NWK:004B.1).

9. The repeater count is set to 1 (NWK:004D.1).
10. Only the Repeater 0 field show the NodeID of the Repeater in the network, since there are no more nodes in the network (NWK:004E.1).
11. The frame may hold additional DLPDU payload (NWK:0053.1)

3.14.5 Fail Criteria

1. The version field is not set to 0x01 (NWK:003D.1).
2. The command field is different from 0x00 (NWK:003E.1).
3. The Direction bit is set to 1 (NWK:003F.1, NWK:0041.1).
4. The Source Routed bit is set to 1 (NWK:0043.1, NWK:0044.1).
5. The stop bit is set to 1 (NWK:0046.1).
6. The Session Tx Random Interval field is 0 (NWK:0047.1, NWK:0049.1).
7. The TTL field does not start with value of 4 nor decreases on each following Explore Frame (NWK:004A.1, NWK:004B.1, NWK:004C.1).
8. The repeater count is not set to 1 (NWK:004D.1).
9. The Repeater 0 field never shows the NodeID of the Repeater in the network. Other Repeater fields show a value different than 0, while there are no more repeaters in the network (NWK:004E.1).
10. Variation outside of the allowed parameters causes successful results when they should not be.

3.15   Inclusion Request Explore Frame

An Inclusion Request Explore Frame is used for Network Wide Inclusion and signal nodes of the network to include that the node broadcasting this frame is in Learning Mode and able to be included in the Network.

3.15.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.15.2   Test Setup

1. Include The first End Node to the Controller's network.
2. Create one hop in distance from the controller to the second End Node, using the first one as a repeater. Add the second End Node.
3. Send a singlecast to the second End Node from the Controller.

3.15.3   Test Result

1. First End Node is correctly included to the Controller's Network.
2. Second End Node initiates broadcasting Explore Autoinclusion frames.
   a. Once the First End Node receives the "Transfer Presentation" Broadcast from the Controller, it will be able to repeat incoming inclusion requests.
   b. There are two Explorer Autoinclusion frames before "Assign Node ID" is routed to the second End Node.
   c. Observe these two Autoinclusion frames.
3. The Controller routes through the First End Node to the second End Node successfully.

3.15.4   Pass Criteria

1. The Autoinclusion Explore Frame follows the values in Table 4.10 (3.2.3.3).
2. The Inclusion Request Explore Frame complies with Figure 4.13 (NWK:0055.1).
3. The version field consists of 3 bits and is set to 0x01 (NWK:003D.1).
4. The Command field consists of 5 bits and it's set to 0x01 (NWK:003E.1).
5. The Direction bit is set to 0, (NWK:003F.1, NWK:0041.1).
6. The Source Routed bit is set to 0 (NWK:0043.1, NWK:0044.1).
7. The Stop bit is set to 0 (NWK:0046.1).

8. The Session Tx Random Interval field is more than 0, setting it to nwkRecommendedSessionTxRandomInterval (NWK:0047.1, NWK:0049.1, NWK:0054.1).
9. The TTL field starts with value of 4 and it decreases on each following Explore Frame (NWK:004A.1, NWK:004B.1).
10. The repeater count is set to 1 (NWK:004D.1).
11. Only the Repeater 0 field show the NodeID of the Repeater in the network, since there are no more nodes in the network (NWK:004E.1).
12. After the 4 Repeaters field there are 4 bytes dedicated to hold the Home ID of the Node broadcasting this Explore frame (NWK:0056.1, NWK:0057.1).
13. The frame carries the Node Information Command Classes on its payload and nothing else (NWK:0058.1, NWK:0059.1).

3.15.5 Fail Criteria

1. The inclusion Request Explore Frame does not comply with Figure 4.13 (NWK:0055.1).
2. The version field is not set to 0x01 (NWK:003D.1).
3. The command field is different from 0x01 (NWK:003E.1).
4. The Direction bit is set to 1 (NWK:003F.1, NWK:0041.1).
5. The Source Routed bit is set to 1 (NWK:0043.1, NWK:0044.1).
6. The stop bit is set to 1 (NWK:0046.1).
7. The Session Tx Random Interval field is 0 or different to nwkRecommendedSessionTxRandomInterval (NWK:0047.1, NWK:0049.1, NWK:0054.1).
8. The TTL field does not start with value of 4 nor decreases on each following Explore Frame (NWK:004A.1, NWK:004B.1, NWK:004C.1).
9. The repeater count is not set to 1 (NWK:004D.1).
10. The Repeater 0 field never shows the NodeID of the Repeater in the network. Other Repeater fields show a value different than 0, while there are no more repeaters in the network (NWK:004E.1).
11. The Home ID of the Node broadcasting the Explore Frame is not shown after the Repeater fields (NWK:0056.1, NWK:0057.1).
12. The Frame does not carry the Node Information Command Classes on its payload or includes further information (NWK:0058.1, NWK:0059.1).
13. Variation outside of the allowed parameters causes successful results when they should not be.

3.16 Search Result Explore Frame

A Search Result Explore Frame is used to communicate what repeaters are available in order to reach a specific target node. Search Result Explore Frame is transmitted only in the return direction.

3.16.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.16.2 Test Setup

1. Include The first End Node to the Controller's network.
2. Remove power from the first End Node. Add the second End Node.
3. Return power to the first End Node. Create one hop in distance from the controller to the second End Node, using the first one as a repeater.
4. Send a singlecast to the second End Node from the Controller.
5. Observe after the Explorer Frames, there are two Explorer Search Result frames.

3.16.3 Test Result

1. First End Node is correctly included to the Controller's Network.
2. Second End Node is added to the Controller's Network and it does not count the first End Node as a neighbor.
4. Controller tries reaching out to the second End Node directly and when it doesn't reach, it starts sending explorer frames.
5. The format of the Explorer Search Result frames corresponds to the format defined in Figure 4.15.

3.16.4 Pass Criteria

1. The Search Result Explore Frame follows the values in Table 4.11 (3.2.3.4).
2. The Search Result Explore Frame complies with Figure 4.15 (NWK:005A.1).
3. The version field consists of 3 bits and is set to 0x01 (NWK:003D.1).
4. The Command field consists of 5 bits and it's set to 0x02 (NWK:003E.1).
5. The Direction bit is set to 1 (NWK:0040.1, NWK:0042.1).

6. The Source Routed bit is set to 1 (NWK:0043.1, NWK:0045.1).
7. The Stop bit is set to 1 (NWK:0046.1).
8. The Session Tx Random Interval field is more than 0 in the first frame setting it to nwkRecommendedSessionTxRandomInterval and set to 0 on the second frame (NWK:0047.1, NWK:0048.1).
9. The TTL field is set to 3 and it increases on each following Explore Frame (NWK:004A.1, NWK:004B.1).
10. The repeater count is set to 1 and then to 0 on the second frame (NWK:004D.1).
11. Only the Repeater 0 field show the NodeID of the Repeater in the network, since there are no more nodes in the network (NWK:004E.1).
12. After the 4 Repeaters field there is a one-byte field for the sending Node ID that should receive the Result of Explorer Search Frames (3.2.3.4.2.1).
13. After the Node ID field, there is a one-byte field for Frame Handle. Which is the sequence number of the normal Explore Frame for which the Search Result is returned (NWK:005B.1).
14. Following there are TTL result, Repeater Count result and four fields for Repeater Node IDs (3.2.3.4.2.3, 3.2.3.4.2.4, 3.2.3.4.2.5, 3.2.3.4.2.6, 3.2.3.4.2.7, 3.2.3.4.2.8).
15. There should not be any further payload in the Search Result Explore Frame (NWK:005C.1).

3.16.5 Fail Criteria

1. The Search Result Explore Frame does not comply with Table 4.11 (3.2.3.4).
2. The Search Result Explore Frame does not comply with Figure 4.15 (NWK:005A.1).
3. The version field does not consist of 3 bits or is not set to 0x01 (NWK:003D.1).
4. The command field is different from 0x02 (NWK:003E.1).
5. The Direction bit is set to 0 (NWK:0040.1, NWK:0042.1).
6. The Source Routed bit is set to 0 (NWK:0043.1, NWK:0045.1).
7. The stop bit is set to 1 (NWK:0046.1).
8. The Session Tx Random Interval field is 0 in the first frame or different to nwkRecommendedSessionTxRandomInterval and set to something different to 0 on the second frame (NWK:0047.1, NWK:0048.1).
9. The TTL field does not start with value of 4 nor decreases on each following Explore Frame (NWK:004A.1, NWK:004B.1).
10. The repeater count is not set to 1in the first repeaters nor 0 on the second one (NWK:004D.1).
11. The Repeater 0 field never shows the NodeID of the Repeater in the network. Other Repeater fields show a value different than 0, while there are no more repeaters in the network (NWK:004E.1).
12. There is no Node ID field, or it does not hold the same ID of the original sending node (3.2.3.4.2.1).
13. There is no o field for Frame Handle. Or it's different from the sequence number of the normal Explore Frame for which the Search Result is returned (NWK:005B.1).
14. TTL result, Repeater Count result and/or four fields for Repeater Node ID fields are missing in the Zniffer (3.2.3.4.2.3, 3.2.3.4.2.4, 3.2.3.4.2.5, 3.2.3.4.2.6, 3.2.3.4.2.7, 3.2.3.4.2.8).
15. The Frame carries further data in its payload (NWK:005C.1).
16. Variation outside of the allowed parameters causes successful results when they should not be.

3.17   Command Frames – No Operation Command Class

All frames commanding the Z-Wave network function and maintenance functionalities are constructed in a standard way.

3.17.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
1 x End Node.

3.17.2   Test Setup

1.   Include The End Node to the Controller's network.
2.   Send a singlecast to the End Node from the Controller with Payload = 0x00 (NOP).
3.   Remove the Node from the Controller's network.

3.17.3   Test Result

2.   Observe that the End Node answers with an Acknowledgement frame.
3.   The Node ID of the End Node goes back to zero and its Home ID is random.

3.17.4   Pass Criteria

1.   The singlecast command is constructed as described by Figure 4.17 (NWK:005D.1).
2.   The singlecast command has no additional encryption and has no additional payload from upper layers (NWK:005E.1).
3.   All Command classes from 0x00 – 0x1F are NWK command classes, so it's ID is within that interval (NWK:005F.2).
4.   The NOP frame is answered by the End Node regardless of the type of End Node. It has no payload (NWK:0060.1).
5.   It is used as a probing tool and it can be seen both in the inclusion process and in the exclusion process (NWK:0061.1).

3.17.5   Fail Criteria

1.   The singlecast command is NOT constructed as descrbed by Figure 4.17 (NWK:005D.1).
2.   The singlecast command has additional encryption or has additional payload from upper layers (NWK:005E.1).
3.   The command's class ID is higher than 0x1F (NWK:005F.2).
4.   The NOP frame is Not answered by some of the End Node types. It has more payload than its ID (NWK:0060.1).
5.   It is used missing in the inclusion process or in the exclusion process (NWK:0061.1).
6.   Any of the passing criteria is not met.
7.   Variation outside of the allowed parameters causes successful results when they should not be.

3.18   Command Frames – Z-Wave Protocol Command Class – Node Information Frame Command

All frames commanding the Z-Wave network function and maintenance functionalities are constructed in a standard way. This Command Class is used for Setup and Maintenance of Networks. The Node Information Frame command is used to advertise the capabilities of the sending node.

3.18.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC controller.
2 x End Nodes.

3.18.2   Test Setup

1. Include the First End Node to the Controller's network.
2. Send Node Information Frame from the second End Node (set it in learning Mode), but don't set the Controller in inclusion mode.
3. Make the Controller send out its own Node Information Frame.

3.18.3   Test Result

1. End Node is included successfully to the network.
2. The second End Node's NIF is broadcasted.
3. The Controller's NIF is broadcasted.

3.18.4   Pass Criteria

1. The inclusion singlecast commands are constructed as described by Figure 4.17 (NWK:005D.1).
2. The inclusion singlecast commands have no additional encryption and have no additional payload from upper layers (NWK:005E.1).
3. All Command classes from 0x00 – 0x1F are NWK command classes, so it's ID is within that interval (NWK:005F.2).
4. Z-Wave Protocol Command Class shall be supported by all nodes (NWK:0062.1).
5. The Node Information Frame Command is formatted as per Figure 4.20 (NWK:0063.1):
    a. The Protocol Version Field consists of 3 bits and it's formatted as per Table 4.14 (NWK:0064.1).
    b. Supported Speed (Max Baud Rate) field consists of 3 bits and should hold at least one of the values from Table 4.15 (NWK:0065.1).
    c. If Supported Speed is set to 0, a receiving node shall assume the lower Speed of 9.6 kbps (NWK:0066.1).
    d. The bits in this field follow channel configuration from [G.9959] (NWK:0067.1).
    e. Speed Extension field consists of 3 bits and signals if the node supports further Speeds. It's encoded as a bitmask following Table 4.16 (NWK:0068.1).
    f. The bits in this field comply with channel configuration from [G.9959] (NWK:0069.1).

g. The routing bit indicates if the node can repeat Routed Frames. It's set to 1 by AL Nodes and 0 by FL and NL nodes (NWK:006A.1).

h. A Controller shall assume that a node with Routing bit set to 1 and Listening bit set to 1 will repeat frames (NWK:006B.1).

i. Listening Bit advertises if the node Listens or Not. AL nodes shall set this field to 1 (NWK:006C.1).

j. Listening bit is set to 0 by NL and FL nodes (NWK:006D.1).

k. Security bit is set to 1 if the node supports secure communication either S0 or S2 (NWK:006E.1, NWK:006F.1).

l. The Controller bit determines if the emitting node is a Controller by setting it to 1, or if it's not by setting it to 0. This test has used only End Nodes so they should be set to 0 and the Routing End Node must be set to 1 (NWK:0070.1, NWK:0072.1).

m. The Specific Device Bit is set to 1 when the Specific Device Type byte-field is included in the Node Information Frame (NWK:0073.1).

n. The Routing End Node bit is set to 1 if the node is a End Node. If it's set to 1, the Node Information Frame does not include a Basic Device Type field. If it's set to 0, the Controller bit shall be set to 1 (NWK:0074.1, NWK:0075.1, NWK:0076.1).

o. The Beam Capability it indicates if the Node Can issue Wake Up Beams. The value 0 indicates the sending node cannot wake up FL nodes. The value 1 indicates that it does (NWK:0077.1).

p. The optional functionality bit indicates that the node supports additional application Command Classes to the mandatory minimum from [SDS10242]. A sending node should set this field to 1 (NWK:0078.1).

q. Basic Device Type is omitted since the controller field is set to 0 (NWK:007A.1)

r. The Generic Device Class Byte identifies what type of Generic Device the node is (NWK:007C.1).

s. The Specific Device Byte identifies what Specific device the node is (NWK:007D.1).

t. Command Class Bytes list the Supported Command Classes. It shall not be longer than 35 bytes. The Command Classes are in the range 0x21... 0xFFFF. Command Classes in the Range 0x00 ... 0x20 are not advertised (NWK:007E.1, NWK:007F.1).

6. Protocol version shall be set to 0x03 (NWK:0080.1, NWK:0081.1).

7. For the Second End Node, when it sends its NIF: Its format matches the one described in the Criteria 5.a – 5.t. And the Data of the NIF shall be forwarded to the upper protocol layer of the nodes within range (NWK:0082.1).

8. When the Controller sends its NIF, its format is mostly the same as 5.a – 5.t but for the following differences:

l. The Controller bit is set to 1 and the Node Information Frame includes a Basic Device Type field (NWK:0070.1, NWK:0071.1).

n. The Routing End Node field is set to 0, The Node Information Frame includes a Basic Device Type field and the Controller Bit is set to 1 (NWK:0075.1, NWK:0076.1).

q. Basic Device type is included because the Controller bit is set to 1. It is encoded according to Table 4.17 (NWK:0079.1, NWK:007B.1).

3.18.5 Fail Criteria

1. The inclusion singlecast commands are NOT constructed as described by Figure 4.17 (NWK:005D.1).
2. The inclusion singlecast commands have additional encryption or have additional payload from upper layers (NWK:005E.1).
3. The command's class ID of inclusion frames are higher than 0x1F (NWK:005F.2).
4. The device does not support Z-Wave Protocol Command Class (NWK:0062.1).
5. The Node Information Frame is not formatted as per Figure 4.20 (NWK:0063.1):
    a. The Protocol Version Field is either more or less than 3 bits or does not hold any value from Table 4.15 (NWK:0064.1).
    b. The Supported Speed (Max Baud Rate) field is either more or less than 3 bits or does not follow the values from Table 4.15 (NWK:0065.1).
    c. If the Supported Speed (Max Baud Rate) is set to 0, but the receiving node does not assume the lower Speed of 9.6 kbps (NWK:0066.1).
    d. The bits in this field do not comply with [G.9959] (NWK:0067.1).
    e. The speed extension field is either more or less than 3 bits in length. It is not encoded as a bitmask or does not follow Table 4.16 (NWK:0068.1).
    f. The bits in this field do not comply with channel configuration from [G.9959] (NWK:0069.1).
    g. The routing bit does not reflect if the node is either AL, or FL/NL (NWK:006A.1).
    h. The controller does not list the node correctly as AL or FL/NL after inclusion (NWK:006B.1).
    i. The End Node sets its Listening Bit to 0 if it's an AL node (NWK:006C.1).
    j. The End Node sets its Listening Bit to 1 if it's either an FL or NL node (NWK:006D.1).
    k. Security bit is not set to 1 if the node supports security S0 or S2 (listed in the Supported Command Classes) (NWK:006E.1, NWK:006F.1).
    l. The Controller bit is set to 1 and the Routing End Node bit is set to 0 (NWK:0070.1, NWK:0072.1).
    m. The Specific Device bit is set to 0 but there is a Specific Device field included in the NIF (NWK:0073.1).
    n. The routing End Node bit is set to 0 despite the node being a End Node. Or it includes a Basic Device Type field. Or if it is set to 0 and the Controller bit is also set to 0 (NWK:0074.1, NWK:0075.1, NWK:0076.1).
    o. The beam capability is not reflecting the capabilities of the End Node (NWK:0077.1).
    p. The optional functionality is set o 0 (NWK:0078.1).
    q. Basic Device Type is included despite the Node not being a Controller (NWK:007A.1).
    r. The Generic Device Class field is omitted, or it contains values not defined (NWK:007C.1).
    s. The Specific Device Byte is missing or does not identify the what the node is (NWK:007D.1).
    t. Command class bytes are more than 35 bytes. Or Their values are outside the range 0x21… 0xFFFF. Or it advertises Command Classes in the Range 0x00 … 0x20 (NWK:007E.1, NWK:007F.1).
6. Protocol version is not set to 0x03 (NWK:0080.1, NWK:0081.1).

7. For the Second End Node: Any of the Fail conditions from 5.a … 5.t are met. Or the Data of the NIF is not forwarded to the upper protocol layer of the nodes within range (NWK:0082.1).

8. When the Controller sends its NIF, its format met any of the failing conditions 5.a – 5.t with the following differences:

    l. The Controller bit is set to 1 AND Node Information Frame does include a Basic Device Type field and the Controller Bit is set to 1 (NWK:0070.1, NWK:0071.1).

    n. The Routing End Node field is set to 1, Or it is set to 0 and The Node Information Frame doesn't include a Basic Device Type, or the Controller Bit is set to 0 (NWK:0075.1, NWK:0076.1).

    q. Basic Device Type is not included despite of the Controller bit is set to 1. Or it's not encoded as per Table 4.17 (NWK:0079.1, NWK:007B.1).

9. Any of the passing criteria is not met.

10. Variation outside of the allowed parameters causes successful results when they should not be.

3.19   Command Frames – Z-Wave Protocol Command Class – Request Node Information Frame Command

This command is used to request a node to return a Node information Frame Command.

3.19.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
1 x End Node.

3.19.2   Test Setup

1. Include the First End Node to the Controller's network.
2. Send Request Node Information Frame to End Node.
3. Include the secondary Controller to the first Controller's network.
4. Send Request Node Information Frame to the Secondary Controller.
5. Send Request Node Information Frame to End Node as a multicast.
6. Sed Request Node Information Frame to the secondary Controller as a multicast.

3.19.3   Test Result

1. End Node is included successfully to the network.
2. The End Node answers with a Node Information Frame as a singlecast.
3. The Secondary Controller is included successfully to the network.
4. The Secondary Controller answers with a Node Information Frame as a singlecast.
5. The End Node does not answer the request that was sent as a multicast.
6. The secondary Controller does not answer the request that was sent as a multicast.

3.19.4   Pass Criteria

1. The singlecast command is constructed as described by Figure 4.17 (NWK:005D.1).
2. The singlecast command has no additional encryption and has no additional payload from upper layers (NWK:005E.1).
3. All Command classes from 0x00 – 0x1F are NWK command classes, so it's ID is within that interval (NWK:005F.2).
4. The Request Node Information Frame Command is formatted as per Figure 4.21 (NWK:0083.1).
5. This command is sent as a singlecast by default for both receiving nodes (NWK:0084.1).
6. The receiving node returns a Node Information Frame Command in response to the singlecast command and ignores it when it's sent as a multicast for both receiving nodes (NWK:0085.1).
7. The End Node answers with a Node Information Frame that follows the same format as described in Pass Criteria 5 of the previous Test Case.
8. The Controller answers with a Node Information Frame that follows the same format as described in Pass Criteria 8 in the previous Test Case.

3.19.5 Fail Criteria

1. The singlecast command is NOT constructed as descrbed by Figure 4.17 (NWK:005D.1).
2. The singlecast command has additional encryption or has additional payload from upper layers (NWK:005E.1).
3. The command's class ID is higher than 0x1F (NWK:005F.2).
4. The request Node Information Frame Command does not follow the format of Figure 4.21 (NWK:0083.1).
5. The command is sent as multicast by default for either receiving node (NWK:0084.1).
6. Either of the receiving nodes answers to the Request Node Information Command with a Node Information Frame regardless if it was sent as singlecast or multicast (NWK:0085.1).
7. The End Node answers with a Node Information Frame that meets any of the fail conditions from the Fail Criteria 5 in the previous Test Case.
8. The Controller answers with a Node Information Frame that meets any of the fail conditions from the Fail Criteria 8 in the previous Test Case.
9. Variation outside of the allowed parameters causes successful results when they should not be.

3.20   Command Frames – Z-Wave Protocol Command Class – Assign IDs Command

This command is used to assign NodeID and HomeID to the receiving node.

3.20.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
1 x End Node.

3.20.2   Test Setup

1. Include the End Node to the Controller's network.
2. Send Assign ID command to End Node as a singlecast.
3. Send Assign ID command to End Node as a multicast.
4. Include the secondary Controller to the first Controller's network.
5. Send Assign ID command to the secondary Controller as a singlecast.
6. Send Assign ID command to the secondary Controller as a multicast.
7. Remove the End Node from the Controller's network.
8. Remove the secondary Controller from the Controller's network.
9. Set Assign ID to be sent as multicast during inclusion.
10. Include the End Node to the Controller's network.
11. Include the secondary Controller to the first Controller's network.
12. Set Assign ID to be sent as singlecast during inclusion and set the NodeID value to be greater than 0xE8.
13. Include the End Node to the Controller's network.
14. Include the secondary Controller to the first Controller's network.
15. Remove all overrides on Assign ID command.
16. Include the End Node to the Controller's network.
17. Include the secondary Controller to the first Controller's network.
18. Set Assign ID to hold a value in its NodeID field to not be 0x00.
19. Remove the End Node from the Controller's network.
20. Remove the secondary Controller from the Controller's network.
21. Set Assign ID to hold a value in its HomeID field to not be 0x00.
22. Remove the End Node from the Controller's network.
23. Remove the secondary Controller from the Controller's network.

3.20.3   Test Result

1. End Node is included successfully to the Controller's Network.
2. End Node answers the command with an Ack frame only.
3. End Node ignores the multicast.
4. The secondary Controller is included successfully to the Controller's Network.
5. The secondary Controller answers the command with an Ack frame only.
6. The secondary Controller ignores the multicast.
7. End Node is removed from the network.

8. The secondary Controller is removed from the network.
10. The End Node ignores the "Assign ID" command sent as Multicast and inclusion fails.
11. The secondary Controller ignores the "Assign ID" command sent as Multicast and inclusion fails.
13. The End Node ignores the "Assign ID" command sent with NodeID set higher than 0xE8 and inclusion fails.
14. The secondary Controller ignores the "Assign ID" command sent with NodeID set higher than 0xE8 and inclusion fails.
16. End Node is included Successfully to the Network.
17. The secondary Controller is included successfully to the Network.
19. The End Node does not accept the change in its NodeID and remains in the Network with the same NodeID.
20. The seconday Controller does not accept the change in its NodeID and remains in the Network with the same NodeID.
22. The End Node does not accept the change in its HomeID and remains in the Network with the same NodeID and HomeID.
23. The seconday Controller does not accept the change in its HomeID and remains in the Network with the same NodeID and HomeID.

3.20.4 Pass Criteria

1. During inclusion of the End Node and the Controller, the "Assign ID" command is sent as a singlecast and follows the format as per Figure 4.22 (NWK:0086.1, NWK:0089.1).
2. The NodeID field of the command is not 0x00 and it's less than 0xE8 in both cases (NWK:0087.1).
3. The HomeID values are not displayed in the Zniffer but are found in the frame. They match the HomeID of the Network of the Controller in both cases (NWK:0088.1).
4. The End Node and the Secondary Controller accept both HomeID and NodeID as they have been put in learning mode and their inclusion is successful (NWK:008A.1).
5. The End Node and the Secondary Controller ignore the command once they have been included to the network and they are no longer in learning mode (NWK:008B.1).
6. When the nodes are removed, the NodeID and HomeID fields are set to 0x00 (NWK:0087.1, NWK:0088.1, NWK:008A.1).
7. The End Node and the Secondary Controller ignore the command when it's issued as a multicast (NWK:0089.1).
8. The End Node and the Secondary Controller ignore the Assign ID command when the NodeID field is set higher than 0xE8 (NWK:008C.1).
9. During exclusion the End Node and the Secondary Controller ignore the command when the NodeID field is not set to 0x00 (NWK:0087.1).
10. During exclusion the End Node and the Secondary Controller ignore the command when the HomeID field is not set to 0x00 (NWK:0088.1).

3.20.5 Fail Criteria

1. The "Assign ID" command does not comply with the specified formant nor it's sent as a singlecast by default (NWK:0086.1, NWK:0089.1).
2. The NodeID field is set to 0x00 during inclusion or it's higher than 0xE8 (NWK:0087.1).

3. The HomeId values don't match the HomeID of the Controller's network (NWK:0088.1).

4. The End Node and secondary Controller don't accept the command regardless of being set in learning mode (NWK:008A.1).

5. The End Node and secondary Controller change their Node ID or Home ID when receiving the "Assign ID" command after being included even if they are not in learning mode (NWK:008B.1).

6. The NodeID and HomeID are not set by default to 0x00 when removing the nodes (NWK:0087.1, NWK:0088.1, NWK:008A.1).

7. The nodes accept the "Assign ID" command when it's issued as multicast (NWK:0089.1).

8. The nodes accept values higher than 0xE8 for NodeID when being included (NWK:008C.1).

9. The nodes accept changing their NodeID to something other than 0x00 and remain in the same Network (NWK:0087.1).

10. The nodes accept changing their HomeID to something other than the HomeID of the Controller's Network while being excluded and retain their same NodeID (NWK:0088.1).

11. Variation outside of the allowed parameters causes successful results when they should not be.

3.21 Command Frames – Z-Wave Protocol Command Class – Find Nodes in Range Command – Regular function

This command is used to request the receiving node to find the nodes in direct range.

3.21.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
2 x AL End Node.
2 x FL End Node.
1 x NL End Node.

3.21.2 Test Setup

1. Include to the primary Controller's Network the first AL End Node.
2. Include the NL End Node to the network.
3. Include the first FL End Node to the network.
4. Include the secondary Controller to the network.
5. Remove power from the secondary Controller. Include the second AL End Node.
6. Include the second FL End Node.

3.21.3 Test Result

1. The first AL End Node is included to the Controller's Network. Observe in the Zniffer trace that Controller sends "Find nodes in Range" with Node ID 1 in the Mask Bytes. AL End Node sends a NOP frame to the primary Controller.
2. The NL node is included, observe in the Zniffer trace that Controller sends "Find nodes in Range" with Node ID 1 & 2 in the Mask Bytes. NL End Node sends a NOP frame to the primary Controller, it sends a NOP frame to the first End Node included.
3. The first FL End Node is included, observe in the Zniffer trace that Controller sends "Find nodes in Range" with Node ID 1 & 2 in the Mask Bytes. FL End Node sends a NOP frame to the primary Controller, it sends a NOP frame only to the first End Node (it doesn't try with the NL End Node).
4. The secondary Controller is included, observe in the Zniffer trace that Controller sends "Find nodes in Range" with Node ID 1 & 2 in the Mask Bytes. The secondary Controller sends a NOP frame to the primary Controller, it sends a NOP frame to the first End Node. It does not send anything to the NL End Node. The primary Controller sends one more "Find Nodes in Range" Command with Node ID 3, the secondary Controller it tries sending a NOP directly to the FL node, followed by a Wake up Beam and finally completing sending the NOP to the FL End Node.
5. The second AL End Node is included, observe in the Zniffer trace that Controller sends "Find Nodes in Range" with Node ID 1, 2 & 5 in the Mask Bytes. It sends a NOP frame to the primary Controller, it sends a NOP frame to the first End Node, it ignores the NL End Node and it tries reaching first the secondary Controller. Then the primary Controller sends a second "Find

Nodes in Range" command, the second AL End Node tries reaching the FL End Node (Node ID 3) with Wake Up beams.

6. The second FL End Node is included, observe in the Zniffer trace that Controller sends "Find nodes in Range" with Node ID 1, 2, 5 & 6 in the Mask Bytes. The second FL End Node sends a NOP frame to the primary Controller, it sends a NOP frame to the first AL End Node, it ignores the NL End Node and it tries reaching first the secondary Controller and finally to the second AL End Node. Then the primary Controller sends a second "Find Nodes in Range", the second FL Save tries reaching the first FL End Node with Wake Up beams and finally a regular NOP frame.

3.21.4 Pass Criteria

1. The "Find Nodes in Range" Command in all instances follows the format described by Figure 4.23 (NWK:008D.1).
2. The "Find Nodes in Range" command shall be sent as singlecast by default and it shall be ignored as a multicast. The "Node Bitmask" field shall not be set to 0 (NWK:009D.1, NWK:009E.1, NWK:00A1.1).
3. The first byte holds 2 reserved bits set to 0 in positions 6 & 5 (NWK:008E.1).
4. Speed Present bit is set to 0 (false) for the first frames and set to 1 (true) on the second frame when there is a FL node in the Network (NWK:008F.1 NWK:0090.1).
5. The Node Bitmask is displayed as "Mask Bytes". It holds the Nodes the receiving Node shall try to reach and no other values (NWK:0091.1).
6. The length of the Bitmask should match the number of bytes defined in the Bitmask Length (NWK:0092.1).
7. The Node Bitmask is a mask where each bit represents a node corresponding to the bit position, a bit set to 1 shall instruct the receiver to search for the node of matching number, set to 0 that it shall not, so that the First byte of this field represents nodes 1 … 8 (NWK:0093.1, NWK:0094.1, NWK:0095.1).
8. The Wake Up Time field is not displayed by the Zniffer, but it's preset in the frame structure. It's used to define whether the receiving node shall use a Wake Up beam and its duration. All nodes in the Node Bitmask field shall have the same Wake Up Time value (NWK:0096.1, NWK:0097.1).
9. Wake Up Time shall be present in the "Find Node in Range" Command and the receiving node shall validate it. If it's not present, a receiving node shall use the Wakeup Time value 0x00 (NWK:0098.1, NWK:0099.1).
10. The Data Rate field is not displayed but it's part of the frame's structure. It's used to set the speed of transmission during Neighbor discovery. It shall be set by default to 0x01 or be encoded as per Table 4.19. Its presence shall be verified by the receiving node and if it's not present, the default Data rate to be used should be that of value 0x01 (NWK:009A.1, NWK:009B.1, NWK:009C.1).
11. The receiving node shall issue NOP to all NodeIDs in the Node Bitmask field and return a "Command Complete" command to the node that requested the range test (NWK:009F.1).
12. All Z-Wave nodes shall keep a bitmask record of the last range test (NWK:00A0.1).

3.21.5 Fail Criteria

1. The "Find Nodes in Range" does not comply with the specified format (NWK:008D.1).

2. The command is sent as multicast by default or the "Node Bitmask" field is set to 0 (NWK:009D.1, NWK:009E.1, NWK:00A1.1).
3. The reserved bits are not set to 0 (NWK:008E.1).
4. The Speed Present bit don't correspond to the type of receiving nodes (NWK:008F.1, NWK:0090.1).
5. The Node Bitmask hold values that don't match to the NodeIDs the receiving node should try to reach (NWK:0091.1).
6. The length of the Node Bitmask doesn't match the number of bytes defined in Bitmask Length (NWK:0091.2).
7. The Node Bitmask is not used as a mask matching bit positions to NodeIDs. Or the bits set to 1 are ignored while the ones set to 0 are searched for OR the first byte in Node Bitmask fields is mapped to a different set of NodeIDs than 1 … 8 (NWK:0093.1, NWK:0094.1, NWK:0095.1).
8. The nodes defined in the command don't require or don't match the same Wake Up Time value (NWK:0096.1, NWK:0097.1).
9. Wake Up Time is not present in the "Find Node in Range" or it's not validated by the receiving Node. When missing, the Node does not use Wake Up Time value of 0x00 (NWK:0098.1, NWK:0099.1).
10. The Data Rate field is not set by default to 0x01 nor follows the Table 4.19 (NWK:009A.1, NWK:009B.1, NWK:009C.1).
11. The receiving node does not issue NOP frames to the NodeIDs in the Node Bitmask field or doesn't return a "Command Complete" command to the originating node (NWK:009F.1).
12. The Z-Wave node doesn0t keep a bitmask record of the last range test (NWK:00A0.1).
13. Variation outside of the allowed parameters causes successful results when they should not be.

3.22 Command Frames – Z-Wave Protocol Command Class – Find Nodes in Range Command – Overriding fields

This command is used to request the receiving node to find the nodes in direct range.

3.22.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
2 x AL End Node.
2 x FL End Node.
1 x NL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.22.2 Test Setup

1. Override the "Find Nodes in Range" command to be sent as a multicast.
2. Include to the primary Controller's Network the first AL End Node.
3. Override the "Find Nodes in Range" command to be sent as a singlecast. Set the "Node Bitmask" field to not include NodeID 1.
4. Include to the primary Controller's Network the first AL End Node.
5. Override the "Find Nodes in Range" command to set the "Bitmask Length" field to be more than 0x01.
6. Include to the primary Controller's Network the first AL End Node.
7. Remove overrides and include the first AL End Node.
8. Override the "Find Nodes in Range" command to set the "Node Bitmask" only with NodeID 1 enabled.
9. Include the NL End Node to the network.
10. Override the "Find Nodes in Range" command to set the "Node Bitmask" to only include NodeID of the NL node and to include the "Wake Up Time" field set to 0x01.
11. Include the first FL End Node to the network.
12. Override the "Find Nodes in Range" command to set the "Node Bitmask" to include NodeID of all the End Nodes and override it so that it does not include the "Wake Up Time" field.
13. Include the secondary Controller to the network.
14. Override the "Find Nodes in Range" command to set the "Node Bitmask" to only include NodeID of nodes not existing in the network and to include the "Wake Up Time" field set to 0x01.
15. Include the second AL End Node.
16. Override the "Find Nodes in Range" command to set the "Node Bitmask" to include NodeID of the first FL node "Wake Up Time" field set to 0x01 and the value of the "Data Rate" field to a value higher than 0x03.
17. Include the second FL End Node.

3.22.3 Test Result

2. The first AL End Node is not included to the Controller's Network.

4. The first AL End Node's inclusion fails.
6. The first AL End Node's inclusion fails.
7. The first AL End Node is included.
9. The NL End Node is included. The NL End Node does not send NOP frame to the first AL End Node.
11. The first FL End Node is included. It sends NOP frames to the primary Controller, the first AL End Node and the controller sends a second "Find Nodes in Range" command with only the NL NodeID. The first FL End Node tries sending Wake Up beams to the NL End Node. The NL End Node does not wake up and it returns a Node Range Info frame empty.
13. The secondary Controller tries reaching out to the AL End Node, the NL End Node and the FL End Node in the same Neighbors Test without using Beams. It returns to the Controller a "Node Range Info" frame including only NodeID of the Controller and the first AL End Node.
15. Upon receiving the "Find Nodes in Range" command, the second AL End Node begins trying to reach with NOP singlecasts and Wake Up beams to each of the NodeIDs listed in the "Node Bitmask" field. It returns a "Node Range Info" empty to the Controller.
17. The second FL node sends NOP singlecast to the Controller, the first AL End Node and secondary Controller successfully, it ignores the NL End Node and the controller sends a second "Find Nodes in Range" command with the "Data Rate" field set to a value higher than 0x03. The second FL End Node ignores this command.

3.22.4 Pass Criteria

1. The "Find Nodes in Range" Command in all instances follows the format described by Figure 4.23 (NWK:008D.1).
2. The "Find Nodes in Range" command sent as multicast is ignored as a multicast. The "Node Bitmask" field shall set to 0 is ignored and inclusion fails (NWK:009D.1, NWK:009E.1, NWK:00A1.1).
3. The receiving node tries to reach to the NodeIDs included in the "Node Bitmask" field and ignores any NodeID not included (NWK:0091.1).
4. The receiving nodes validate the Bitmask Length against the number of elements contained in the "Node Bitmask", if it doesn't match the frame is rejected (NWK:0092.1).
5. The receiving Node will not beam a NodeID if it's not included in the "Find Nodes in Range" including the "wake Up Time" field (NWK:0096.1, NWK:0097.1).
6. The "Data Rate" field shall not be set to a value higher than 0x03, frames that don't comply are ignored (NWK:009A.1, NWK:009B.1, NWK:009C.1).

3.22.5 Fail Criteria

1. If any of the pass criteria is not met (the expected behavior is not met, or the overrides produce a successful behavior in spite of being configured against it).

3.23 Command Frames – Z-Wave Protocol Command Class – Get Nodes in Range Command

The Get Nodes in Range command is used to request the list of direct range neighbors detected with the last range test.

3.23.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.23.2 Test Setup

1. Include the first End Node to the primary Controller's network.
2. Include the secondary Controller to the primary Controller's network.
3. Override the "Get Nodes in Range" to be sent as multicast.
4. Include the second End Node.
5. Remove the second End Node.
6. Override "Get Nodes in Range" to change its Command number from 0x05 to something different.
7. Include the second End Node.

3.23.3 Test Result

1. Observe in the Zniffer trace that once the Neighbor Range Test is finished, the Controller sends "Get Nodes in Range". The receiver answers with "Range Info" containing only the primary Controller.
2. Observe in the Zniffer trace that once the Neighbor Range Test is finished, the Controller sends "Get Nodes in Range". The receiver answers with "Range Info" containing the primary Controller and the first Save.
4. When the second End Node receives "Get Nodes in Range" as a multicast it ignores it and inclusion does not finish that step.
5. Second End Node is removed.
7. When the primary Controller tries to issue "Get Nodes in Range", it sends a command different from 0x03. The receiving Node does not respond sending a "Range Info" command.

3.23.4 Pass Criteria

1. The "Get Nodes in Range" command follows the format as Figure 4.25 and it's sent by default as singlecast (NWK:00A2.1, NWK:00A3.1).
2. The receivers validate the command and return a "Range Info" command in response (NWK:00A4.1).

3. When the command is sent as multicast or its number value is modified from 0x03, the receiver does not return a "Range Info" in response (NWK:00A2.1, NWK:00A5.1).

3.23.5 Fail Criteria

1. The "Get Node sin Range" command doesn't follow the specified format, or it is sent as multicast by default (NWK:00A2.1, NWK:00A3.1).
2. The nodes do not respond with a "Range Info" command in response (NWK:00A4.1).
3. The receiving nodes respond with "Range Info" even when the "Get Nodes in Range" command is sent multicast or its command number value is different from 0x03 (NWK:00A2.1, NWK:00A5.1).
4. Variation outside of the allowed parameters causes successful results when they should not be.

3.24   Command Frames – Z-Wave Protocol Command Class – Range Info Command

The Range Info command is used to advertise the list of direct range neighbors detected with the last range test.

3.24.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
1 x AL End Node.
1 x FL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.24.2   Test Setup

1. Include the AL End Node to the primary Controller's network.
2. Override the Range Info command in the secondary Controller so that it includes a Wakeup Time field with value 0x01. Include the secondary Controller
3. Send a singlecast NOP to the secondary Controller.
4. Remove overrides on the secondary Controller. Remove the secondary Controller from the network.
5. Override the Range Info frame to hold a Bitmask Length larger than 1. Include the secondary Controller.
6. Remove overrides on the secondary Controller. Remove the secondary Controller from the network.
7. Include the FL End Node. Observe the "Node Range Info" it sends to the primary Controller.
8. Override the "Node Range Info" frame on the secondary Controller to NOT include Wake UP Time. Include the secondary Controller.
9. Send a NOP frame from the secondary Controller to the FL End Node.
10. Remove the secondary Controller. Set its "Node Range Info" command to be set as multicast only.
11. Include the secondary Controller.

3.24.3   Test Result

1. During inclusion, the End Node responds to Get Nodes in Range with "Node Range Info" command.
2. After "Get Nodes in Range" command is received, the secondary Controller answers with a "Nodes in Range" command containing the Wake up Time byte. The primary Controller ignores this field.
3. The primary Controller sends the NOP to the secondary Controller directly without using wake up beams.

4. The secondary Controller is removed.
5. During inclusion, secondary Controller sends Range Info frame with a Bitmask Length value larger than 1. This frame is not accepted by the primary Controller since it doesn't match the actual contents of Node Bitmasks.
6. The secondary Controller is removed.
7. The FL End Node is included correctly. Its "Node Range Info" frame holds a "Node bitmask" field containing the primary Controller and the first AL End Node only.
8. The secondary Controller is included and its "Node Range Info" frame is overridden, so after it searches for the FL End Node with beams, it responds to the primary Controller with "Node Range Info" not including a Wake up Time field.
9. The secondary Controller beams to the FL End Node before delivering the NOP frame.
10. The secondary Controller is removed.
11. The secondary Controller issues "Node Range Info" as a multicast. The primary Controller does not send an ACK frame for this.

3.24.4 Pass Criteria

1. The Node Range Info commands follow the format from Figure 4.26 (NWK:00A6.1).
2. The Length in Bytes of the Node Bitmask field should be the same as the one defined by the "Bitmask Length" field (NWK:00A7.1).
3. The Node Bitmask is treated as a Mask and not as the direct NodeID values. The bits set as 1 indicate that the corresponding NodeID is within range of the node sending this frame. The first byte represents nodes 1…8 (NWK:00A8.1, NWK:00A9.1, NWK:00AA.1).
4. When the Wake-Up Time field is present, its value must be verified by the receiver. When it's not, the receiver assumes a value of 0x00 (NWK:00AB.1, NWK:00AC.1).
5. The Node Bitmasks holds the result of the last Range Test and not previous ones. If there were no Tests, the Node Bitmask field is set to 0x00 (NWK:00AD.1, NWK:00AE.1).
6. This command is only validated when it's sent as singlecast and not multicast (NWK:00AF.1).

3.24.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.25 Command Frames – Z-Wave Protocol Command Class – Command Complete Command

Used to advertise the completion of a given task.

3.25.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
1 x AL End Node.
1 x FL End Node.

We assume it's possible to override the fields of the command in advance to performing inclusion.

3.25.2 Test Setup

1. Include the AL End Node to the primary Controller's network. Look for the Command Complete frame.
2. Include the FL End Node to the network.
3. Include the secondary Controller to the network.
4. Remove the secondary Controller.
5. Override the Command Complete command so that it's sent as multicast. Include it again to the network.
6. Remove the secondary Controller.
7. Override the Command Complete command so that it's delayed for 5 seconds and holds a Sequence Number field that increases on each use. Include it again to the network.
8. Remove the secondary Controller.
9. Override the Command Complete command so that it holds a Sequence Number field that is unrelated to the previous one on each use. Include it again to the network.

3.25.3 Test Result

1. The AL End Node is successfully included. There is only 1 Command Complete frame.
2. The FL End Node is successfully included. There is only 1 Command Complete frame.
3. The secondary Controller is successfully included. There is 1 Command Complete frame after reaching for the primary Controller and the AL End Node and 1 after beaming for the FL End Node.
4. The secondary Controller is removed.
5. The secondary Controller tries to be included. It sends Command Complete as multicast and the frames are ignored.
6. Secondary Controller is removed.
7. The secondary Controller waits 5 seconds before sending "Command Complete" each time and the primary Controller waits during this period. The secondary Controller assigns consecutive Sequence Number values and inclusion is successful.
8. Secondary Controller is removed.

9. The secondary Controller assigns non-related Sequence Number values and those frames are ignored. Inclusion fails.

3.25.4 Pass Criteria

1. Command Complete follows the format from Figure 4.27 (NWK:0080.1).
2. When Command Complete is issued as multicast, it's ignored (NWK:0084.1, NWK:0086.1).
3. The Sequence Number field is set by default to 0 and the following frames don't need a different value (NWK:0081.1).
4. When the Sequence Number field changes sequentially, the frames are accepted, when they are not sequential, the frames are ignored (NWK:0082.1, NWK:0085.1).
5. The primary Controller Waits until Command Complete is issued and the Node issuing it can receive commands right away (NWK:0083.1).

3.25.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.26   Command Frames – Z-Wave Protocol Command Class – Transfer Presentation Command

This command is used to indicate that the controller is trying to initiate Network Management Functions (Add node, remove node, perform Controller replication).

3.26.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.26.2   Test Setup

1. Set the primary Controller in inclusion mode.
2. Include the first End Node.
3. Create one hop between the primary Controller and the second End Node.
4. Set the primary Controller in Network Wide Inclusion.
5. Set the second End Node in Learning mode.
6. Set the primary Controller in Network Wide Inclusion mode.
7. Set the secondary Controller in Learning Mode.
8. Set the primary Controller in Network Wide Inclusion mode.
9. Set the secondary Controller in Learning Mode.
10. Stop the secondary Controller from being in Learning Mode.
11. Set the primary Controller in Network Wide Exclusion mode.
12. Set the second End Node in Learning mode.
13. Set the primary Controller in Network Wide Exclusion mode.
14. Set the second End Node in Learning mode.

3.26.3   Test Result

1. Observe the Controller broadcasts Transfer Presentation Command.
2. The first End Node is included correctly.
3. The primary Controller and the second End Node can't reach each other directly.
4. The Controller broadcasts Transfer Presentation Command.
5. The second End Node is included through the repeater.
6. The Controller broadcasts Transfer Presentation Command.
7. The secondary Controller is included through repeaters.
8. The Controller broadcasts Transfer Presentation Command.
9. The secondary Controller broadcasts its Node Information Frame.
10. The Network is unaltered.
11. The controller broadcasts Transfer Presentation Command.
12. The second End Node is removed through repeaters.

13. The Controller broadcasts Transfer Presentation Command.
14. The second End Node is assigned NodeID 0 again.

3.26.4 Pass Criteria

1. The Command has the format described by Figure 4.28 (NWK:00B7.1).
2. The Option field byte shall follow Table 4.20 and its nit 0 always be set to 1 (NWK:00B8.1, NWK:00BB.1).
    a. During inclusion the option Field is set to 5.
    b. During Exclusion it's set to 3.
3. Transfer Presentation Command should only be transmitted when the Controller is in Inclusion or Exclusion mode (NWK:00B9.1).
4. It shall be sent only broadcast to destination 255 (NWK:00BA.1).
5. A node set in learning mode shall send a Node Information Frame when it receives Transfer Presentation Command (NWK:00BC.1).
6. IF a node is not in learning mode or if it's being included by another controller it shall not send its Node Information Frame (NWK:00BD.1).
7. A node already included should not send Node Information if it's set in learning mode while the Controller is in Inclusion Mode (NWK:00BE.1).
8. A Node is SmartStart Learn Mode does not return Node Information Frame (NWK:00BF.1).

3.26.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.27 Command Frames – Z-Wave Protocol Command Class – Transfer Node Information Command

This command is used for transferring the Node Information Frame from one controller to another.

3.27.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.27.2 Test Setup

1. Include all 3 End Nodes to the primary controller.
2. Include the secondary Controller to the primary Controller's Network.
3. Remove the secondary Controller.
4. Override in the primary Controller Transfer Node Info to retain the same Sequence Number.
5. Include the secondary Controller.
6. Remove the secondary Controller.
7. Override in the primary Controller Transfer Node Info to send the command as multicast.
8. Include the secondary Controller.
9. Remove the second End Node.
10. Override primary Controller to force send Transfer Node Info during inclusion.
11. Include the removed End Node.

3.27.3 Test Result

1. All 3 End Nodes are included to the Controller's Network.
2. The secondary Controller is included.
    a. Primary Controller sends 3 "Transfer Node Information" frames to the secondary Controller: one per each End Node already included.
3. Secondary Controller is removed.
4. Sequence Number is set to a constant value.
5. Secondary Controller begins being included
    a. Primary Controller sends each "Transfer Node Information" frame with the same Sequence Number value.
    b. The frames are detected as duplicate and they are ignored.
6. Secondary Controller is removed.
7. The command is set to be sent as multicast.
8. Secondary Controller begins being included
    a. Primary Controller sends each "Transfer Node Information" frame as a multicast and the secondary Controller ignores it.

9. The second End Node is removed.
10. Transfer Node Info is set to be sent forcefully.
11. The End Node inclusion begins.
    a. Primary Controller sends Transfer Node Info to the End Node.
    b. The End Node ignores the Transfer Node Info frames.

3.27.4 Pass Criteria

1. Transfer Node Information Command follows the Format from Table 4.29, which extends from the description of the fields of the regular Node Information Frame (NWK:00C0.1, NWK:00C1.1, NWK:00C4.1).
2. Each sequence number is individual and unique for each Node Information being transferred from one Controller to another (NWK:00C2.1).
3. Sequence Numbers are used to detect duplicates (NWK:00C3.1).
4. The command is sent only when including a secondary Controller (NWK:00C5.1).
5. The command is sent only singlecast and ignored when it's sent multicast (NWK:00C6.1).
6. End Nodes ignore the frame when it's sent to them during inclusion (NWK:00C7.1).
7. The secondary Controller ignores the commands when they were forcefully sent to the End Node (NWK:00C8.1).
8. When inclusion of the secondary Controller is finished, the secondary Controller has updated its Node List (NWK:00C9.1).

3.27.5 Fail Criteria

1. The command is not formatted as described, the values don't match the ones of the reported by the Node (NWK:00C0.1, NWK:00C1.1, NWK:00C4.1).
2. The sequence number on all Transfer Node Information frames is the same (NWK:00C2.1).
3. Sequence Numbers irrelevant to detect duplicates (NWK:00C3.1).
4. The command is sent outside the inclusion of a secondary Controller (NWK:00C5.1).
5. The command is accepted when delivered as multicast (NWK:00C6.1).
6. End Nodes try to adjust an internal Node List when received during inclusion (NWK:00C7.1).
7. The secondary Controller adjusts its internal Node List when the command is sent to a End Node (NWK:00C8.1).
8. The secondary Controller does not update its internal Node List after finishing inclusion (NWK:00C9.1).
9. Variation outside of the allowed parameters causes successful results when they should not be.

3.28   Command Frames – Z-Wave Protocol Command Class – Transfer Range Information Command

This command is used to transfer a node's range test result from one Controller to another.

3.28.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.28.2 Test Setup

1. Include all 3 End Nodes to the primary controller.
2. Include the secondary Controller to the primary Controller's Network.
3. Remove the secondary Controller.
4. Override in the primary Controller Transfer Range Info to retain the same Sequence Number.
5. Include the secondary Controller.
6. Remove the secondary Controller.
7. Override in the primary Controller Transfer Range Info to send the command as multicast.
8. Include the secondary Controller.
9. Remove the second End Node.
10. Override primary Controller to force send Transfer Range Info during inclusion.
11. Include the removed End Node.

3.28.3 Test Result

1. All 3 End Nodes are included to the Controller's Network.
2. The secondary Controller is included.
    a. Primary Controller sends 3 "Transfer Range Information" frames to the secondary Controller: one per each End Node already included.
3. Secondary Controller is removed.
4. Sequence Number is set to a constant value.
5. Secondary Controller begins being included
    a. Primary Controller sends each "Transfer Range Information" frame with the same Sequence Number value.
    b. The frames are detected as duplicate and they are ignored.
6. Secondary Controller is removed.
7. The command is set to be sent as multicast.
8. Secondary Controller begins being included
    a. Primary Controller sends each "Transfer Range Information" frame as a multicast and the secondary Controller ignores it.
9. The second End Node is removed.
10. Transfer Range Info is set to be sent forcefully.
11. The End Node inclusion begins.
    a. Primary Controller sends Transfer Range Info to the End Node.

      b.   The End Node ignores the Transfer Range Info frames.

3.28.4 Pass Criteria

1. Transfer Range Information is formatted as per Figure 4.30 and it extend extends from the Range Info command (NWK:00CA.1, NWK:00CB.1).
2. The Sequence Number Field increases each time it's sent, and if it remains static it's ignored (NWK:00CC.1, NWK:00CD.1).
3. It is sent as singlecast by default and it's ignored when it's sent as multicast (NWK:00CE.1, NWK:00D0.1).
4. This command is only sent while including or transferring main role between controllers and not with a End Node. When it's forcedly sent to a End Node, the End Node ignores it (NWK:00CF.1, NWK:00D1.1).
5. A Controller that is not in learning mode ignores the transmission of this command (NWK:00D2.1).
6. After this command is received, the receiving Controller updates its internal routing table (NWK:00D3.1).

3.28.5 Fail Criteria

1. Transfer Range Info does not comply with Figure 4.30 or its fields don't match the basic Range Info Command (NWK:00CA.1, NWK:00CB.1).
2. The Sequence Number Field remains static and it's accepted regardless of being seemingly duplicate (NWK:00C.1, NWK:00CD.1).
3. It is not sent as singlecast by default or it's accepted as valid when it's sent as multicast (NWK:00CE.1, NWK:00D0.1).
4. It is sent regardless of whether a Controller or a End Node is being included (NWK:00CF.1, NWK:00D.1).
5. A Controller accepts this command regardless of whether it's in learning mode or not (NWK:00D2.1).
6. A receiving Controller does not update its internal routing table after receiving this command (NWK:00D3.1).
7. Variation outside of the allowed parameters causes successful results when they should not be.

3.29   Command Frames – Z-Wave Protocol Command Class – Transfer End Command

This command is used to advertise the end of the current network operation (Static route request, Automatic controller update, Controller replication).

3.29.1   Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
1 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.29.2   Test Setup

1. Include the End Node.
2. Include secondary Controller.
3. Remove all nodes and reset the primary Controller.
4. Include the secondary Controller.
5. Include End Node to the network with Primary Controller.
6. Include the Third Controller to the Network with Primary Controller.
7. In the primary Controller, Override Transfer End Status to be 0x00 (Transfer Failed).
8. Set the Third Controller in Learning mode and activate "Shift" in primary Controller.

3.29.3   Test Result

1. End Node is included. Primary Controller states that it IS the Primary and SIS of the Network.
2. Secondary Controller is included.
    a. Transfer End is sent by the primary Controller after transferring Node information and Node Range information.
    b. The status reported is "Transfer OK= 0x01".
3. All nodes are removed. Primary Controller is reset.
4. The secondary Controller is included as SIS of the Network. Primary Controller is set as "Real Primary".
    a. Secondary Controller sends Transfer End with Status "0x02" = transfer Update Done.
5. End Node is included to the network.
    a. After secure inclusion is finished, Secondary Controller (SIS) sends Transfer End with Status "0x02" = Transfer Update Done.
6. Third Controller is included to the network.
    a. Primary Controller sends "Transfer End OK = 0x01" after transferring Node and Neighbors information to it.
    b. Secondary (SIS) Controller sends Transfer End with Status "0x02" = Transfer Update Done to Primary Controller after Secure Inclusion.
7. Status is overridden in primary Controller's Transfer End.
8. The primary Controller transfers Node Information and Node Range information to the Third Controller. The Third Controller is set as "Real Primary" Controller now.

> a. When the first Controller sends "Transfer End" with status 0x00 (Transfer Failed), the third Controller requests nodes and ranges information immediately.

3.29.4 Pass Criteria

1. Transfer End follows the format from Figure 4.31 (NWK:00D4.1).
2. The Status field notifies Network information. It is encoded as per Table 4.21 (NWK:00D5.1).
3. Transfer End is sent only after each Network Management operation and it always advertises its status (NWK:00D6.1, NWK:00D7.1).

3.29.5 Fail Criteria

1. Transfer End doesn't follow the format from Figure 4.31 (NWK:00D4.1).
2. The Status field does not follow Table 4.21 (NWK:00D5.1).
3. Transfer End is sent outside Network Management operations or the Status field is missing (NWK:00D6.1, NWK:00D7.1).
4. Variation outside of the allowed parameters causes successful results when they should not be.

3.30   Command Frames – Z-Wave Protocol Command Class – Assign Return Route Command.

This command is used to advertise the assigned route to the receiving node. Most used for associations between End Node devices.

3.30.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC Controller.
1 x End Node with more than 1 association group.
2 x AL End Nodes.
2 x FL End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.30.2   Test Setup

1. Include the End Node with multiple association groups and both AL End Nodes to the network.
2. In PC Controller, go to the Associations perspective.
    a. Select one of the End Nodes in the Nodes groups view.
    b. Enable "Assign return routes" check box under the "Create" button.
    c. Select one of the other End Nodes in the Controller's Node List.
    d. Press "Create" to make an association from a group other than 1, to the End Node selected in the Controller's Node List.
    e. Select another End Node in the Controller's Node List.
    f. Press "Create" to make an association from the same group, to the End Node selected second.
3. Execute the association created.
4. Remove both AL End Nodes and include both FL End Nodes.
5. Repeat Step 2 for both FL End Nodes and remove the existing associations to AL End Nodes.
6. Execute the associations created.

3.30.3   Test Result

1. The End Nodes are included in direct range of the Controller.
2. In associations Perspective, for the selected End Node:
    a. Association is sent from the Controller to the End Node's Association Group.
    b. It's followed by 4 "Assign Return Routes" frames.
    c. The second association is sent from the Controller to the End Node's Association Group.
    d. It is followed by 8 "Assign Return Routes" frames this time.
3. Observe how the End Node with multiple association groups sends commands to each of the nodes associated.
4. AL End Nodes are removed, and FL End Nodes are included.
5. The associations to FL End Nodes:
    a. Are each followed by "Assign Return Routes" Frames.
    b. Each of them holds a value in their "Destination Wake Up" field.

6. The associations are executed, and the FL nodes are targeted for singlecasts followed by beaming to each of them.

3.30.4 Pass Criteria

1. Assign Return Route is formatted as per Figure 4.32 (NWK:00D8.1).
2. It is not used during inclusion unless there is no SUC in the Network. In that case "Assign SUC Return Route" is used, instead (NWK:00DF.1).
3. It shall not be sent when including Controllers (NWK:00DE.1).
4. A receiving node shall store its return routes when receiving it (NWK:00E0.1).
5. In its "Number of Hops/Repeaters" field, a value of 0 indicates a direct transmission and values from 1 … 4 indicate the number of repeaters (NWK:00D9.1, NWK:00DA.1).
6. Route Number is the index of the route being assigned, the first one shall have route number 0 (NWK:00DB.1).
7. The "Destination Wake Up" field, indicates the Wake Up time capability of the destination Node. It's encoded as per Table 4.22 (NWK:00DC.1).
8. The "Destination Speed" Field specifies the data rate capability of the destination node, it shall be encoded as per Table 4.23 (NWK:00DD.1).

3.30.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.31   Command Frames – Z-Wave Protocol Command Class – New Node Registered Command

This command is used to notify the SIS Controller that an inclusion controller has included a new node in the network.

3.31.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
1 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.31.2 Test Setup

1. Set the primary controller to be SIS.
2. Include the secondary Controller.
3. Set the first End Node in Learning mode and the secondary Controller (Inclusion Controller) in inclusion mode.
4. Remove the End Node with Inclusion Controller.
5. Override "New Node Registered" Command by setting it to be sent Multicast.
6. Include the End Node with the Inclusion Controller.

3.31.3 Test Result

1. The primary Controller is set as SIS.
2. The secondary Controller is set as Inclusion Controller.
3. The End Node broadcasts its NodeID and secondary Controller notifies the primary Controller with a "New Node Registerd" frame about the inclusion.
4. The inclusion controller notifies the primary Controller of the removal with a New Node Registered.
5. "New Node Registered" is set to be sent multicast.
6. The inclusion process begins, and the secondary Controller sends "New Node Registered" as Multicast.
    a. The SIS ignores this frame.
    b. Inclusion of the End Node is not concluded successfully.

3.31.4 Pass Criteria

1. The frame is formatted as per Figure 4.33, it extends from the basic Node Information Frame and it should contain the same values as the NodeID of the node being included (NWK:00E1.1, NWK:00E2.1, NWK:00E3.1).
2. When the node is being excluded from the Network, the Generic Device Class field is set to 0 (NWK:00E4.1).
3. It is sent by default as a singlecast, it's ignored when it's sent as a multicast and it is ignored by any End Node listening during the inclusion (NWK:00E5.1, NWK:00E6.1, NWK:00E7.1).

3.31.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.32   Command Frames – Z-Wave Protocol Command Class – New Range Registered Command

This command is used to advertise the range test results that an inclusion controller has performed when including a new node.

3.32.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion.

3.32.2   Test Setup

1. Include the first End Node to the primary Controller's network.
2. Include the secondary Controller to the primary Controller's network.
3. Create one Hop of distance between the first End Node and the second End Node (so that they don't see each other during inclusion of the second End Node).
4. Use the Inclusion Controller to include the second End Node into the network.
5. Remove the second End Node with Inclusion Controller.
6. Override the New Range Registered command to be sent as multicast.
7. Set the first End Node in learning Mode.
8. Include the second End Node with the Inclusion Controller.
9. Remove the second End Node with the Inclusion Controller.
10. Override the New Range Registered command to set the Neighbor Nodes Bitmask to values that are not present in the network. Make sure to match it in the Neighbor Nodes Bitmask Length field.
11. Include the second End Node with the Inclusion Controller.

3.32.3   Test Result

1. The first End Node is included into the Controller's network.
2. The second Controller is included, it becomes an Inclusion Controller.
3. Neither End Node is within range of the other, but in range of both Controllers.
4. The second End Node is included.
    a. After probing the neighbor's range, the Inclusion Controller sends the New Range Registered Command to the primary Controller.
5. The second End Node is removed.
6. The command is overridden to be sent multicast.
7. The first End Node is in learning mode.
8. The second End Node is attempted to be included.
    a. After probing the neighbor's range, the Inclusion Controller sends as multicast the New Range Registered Command.
    b. Both the primary Controller and the first End Node ignore this multicast command.
    c. Inclusion is unsuccessful.
9. The second End Node is removed.

10. The values of the fields are overridden.
11. The second End Node is attempted to be included.
    a. The Inclusion Controller sends to the primary Controller the New Range Registered Command as a singlecast with the Neighbor Nodes Bitmask values mismatching the existing nodes in the network.
    b. The primary Controller ignores this command.

3.32.4 Pass Criteria

1. The New Range Registered Command follows the format from Figure 4.34, it is sent by default as singlecast and only during an inclusion from an Inclusion Controller or Controller Update (NWK:00E8.1, NWK:00F0.1, NWK:00F1.1).
2. The "NodeID" field corresponds to the node which the neighbors range test was performed (NWK:00E9.1).
3. The "Neighbor Nodes Bitmask Length" field corresponds to the number of nodes within range of the node being included. It should be set to the minimum of 1 (which is the Inclusion Controller) (NWK:00EA.1).
4. The "Neighbors Nodes Bitmask" field holds the list of NodeIDs that the node being included/just performed the neighbors Range Test can reach, its length should match the one described by the "Neighbor Nodes Bitmask Length" field (NWK:00EB.1).
5. The "Neighbor Nodes Bitmask" field is an actual Bitmask, where the LSB represents NodeID 1, the value 0 represents the absence of said node as a neighbor to the node being included and the value 1 represents that the node is a neighbor within range to the node being included (NWK:00ED.1, NWK:00EF.1).
6. This command shall be ignored when received by an End Node also when it's issued as a multicast (NWK:00F2.1, NWK:00F3.1).

3.32.5 Fail Criteria

1. The New Range Registered Command does not follow the specified format, it's sent to any Controller or it's sent outside inclusion or Controller update (NWK:00E8.1, NWK:00F0.1, NWK:00F1.1).
2. The "NodeID" field is not that of the node that performed the neighbors range test (NWK:00E9.1).
3. The "Neighbor Nodes Bitmask Length" does not show the actual number of neighboring nodes, not even the minimum set to 1 (NWK:00EA.1).
4. The "Neighbors Nodes Bitmask" field doesn't hold the list of Nodes that the node being included/performed the Neighbors Range Test can reach. Its length is not matching that of the "Neighbor Nodes Bitmask Length" field (NWK:00EB.1).
5. The "Neighbor Nodes Bitmask" field is not used as a bitmask matching bit positions to Node IDs or the values set to 0 and 1 are inverted (NWK:00ED.1, NWK:00EF.1).
6. This command is not ignored by End Nodes or when it's issued as multicast (NWK:00F2.1, NWK:00F3.1).
7. Variation outside of the allowed parameters causes successful results when they should not be.

3.33 Command Frames – Z-Wave Protocol Command Class – Transfer New Primary Controller Complete Command

This command is used to complete the Primary Controller role transfer procedure to another Controller node.

3.33.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.33.2 Test Setup

1. Include the second Controller to the network of the first one.
2. Include the third Controller to the first Controller's network.
3. Set the third Controller in learning Mode.
4. In the RealPrimary Controller activate the "Shift" function.
5. In the third Controller (now RealPrimary) override the field "Controller Type" to a different value than the actual Controller Type of the third Controller.
6. Don't set the first Controller in learning Mode. Activate "Shift" in the third Controller.
7. Set the first Controller in learning Mode. Activate "Shift" in the third Controller.

3.33.3 Test Result

1. The first Controller is set as RealPrimary, Inclusion Controller. The second one as SUC, SIS Controller.
2. The third Controller is included and set as Inclusion Controller.
3. The Third Controller is set in learning Mode.
4. The RealPrimary begins Primary Controller Shift.
    a. At the end it sends the Transfer New Primary Controller Complete Command.
5. The value of the "Controller Type" field is overridden.
6. Primary Controller Transfer tries to start.
    a. It does not start since no other Controller Node is in learning Mode.
7. Primary Controller Transfer starts and at the end it's not validated since the value of the Controller Type does not match the Generic Device Class field in its Node Information Frame.

3.33.4 Pass Criteria

1. The command Transfer New Primary Controller Complete is formatted as per Figure 4.35 (NWK:00F4.1).
2. The "Controller Type" field matches the Generic Device Class field in the sender's Node Information Frame Command (NWK:00F5.1)
3. The receiving node assumes the role of Primary Controller role and can start using Primary Controller functionalities (NWK:00EE.1).
4. No transfer happens when there is no node in learning Mode (NWK:00F6.1).

3.33.5 Fail Criteria

1. The command Transfer New Primary Controller Complete does not follow the specified format (NWK:00F4.1).
2. The "Controller Type" field differs from the Generic Device Class field in the sender's Node Information Frame Command (NWK:00F5.1).
3. The receiving node remains as a regular Inclusion/secondary Controller after the Transfer New Primary Controller function is completed by receiving the Transfer New Controller Complete Command (NWK:00EE.1).
4. A controller node not set in Learning Mode accepts the command (NWK:00F6.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.34   Command Frames – Z-Wave Protocol Command Class – Automatic Controller Update Command

This command is used to request transfer of the network topology information from the SUC/SIS controller to another controller in the network.

3.34.1   Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
1 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.34.2   Test Setup

1. Include the second Controller to the network of the first one.
2. Include the third Controller to the first Controler's network.
3. Include the End Node to the network using the third Controller.
4. Observe the node List of the RealPrimary Controller.
5. On the RealPrimary Controller press the "Update" button (right next to the "shift" button).
6. Remove the End Node using the third Controller.
7. On the RealPrimary Controller, Override Automatic Controller Update Start to be sent multicast. Press the "Update" button.
8. Remove the previous Override. Change the destination node to be the NodeID of the third Controller.
9. On the RealPrimary Controller sent Automatic Controller Update Start. It should be addressed to the third Controller.

3.34.3   Test Result

1. The first Controller is set as RealPrimary, Inclusion Controller. The second one as SUC, SIS Controller.
2. The third Controller is included and set as Inclusion Controller.
3. The Third Controller includes the End Node to the network.
    a. Before the inclusion begins, Automatic Controller Update Start is sent from the third Controller to the SUC/SIS.
4. Observe that the list does not have the End Node included to the network, but the SUC/SIS Controller does.
5. The first Controller (RealPrimary) sends Automatic Controller Update Start to the SUC/SIS.
    a. Its node list holds now the NodeID of the End Node included by the third Controller.
6. The End Node is removed from the network.
    a. The RealPrimary Controller does not reflect this on its Node list.
7. The RealPrimary Controller sends Automatic Controller Update Start to the SUC/SIS as a multicast.
    a. It is ignored by the SIS.
    b. The RealPrimary Controller does not remove the End Node from its node list.

8. The third Controller answers to this with a SUC Node ID command with the NodeID of the SUC/SIS.

3.34.4 Pass Criteria

1. The Automatic Controller Update Start command follows the format from Figure 4.36. It is sent in an automatic way by default as a singlecast to the SUC/SIS from an Inclusion Controller before performing an inclusion (NWK:00F7.1, NWK:00F8.1, NWK:00F9.1).
2. When a SUC/SIS receives this command, it responds with topology updates to the sending node using New Node Registered Commands (NWK:00FB.1).
3. If the receiving controller is not SUC/SIS, it responds with a SUC Node ID command to inform the sending node of the correct NodeID of the SUC/SIS (NWK:00FC.1).
4. This command shall be ignored when it's sent multicast (NWK:00FD.1).

3.34.5 Fail Criteria

1. The Automatic Controller Update Start command doesn't follow the specified format. It is not sent automatically by default as a singlecast to the SUC/SIS from an Inclusion Controller before performing an inclusion (NWK:00F7.1, NWK:00F8.1, NWK:00F9.1).
2. The SUC/SIS ignores this command or does not respond with topology updates to the sending node (NWK:00FB.1).
3. The non-SUC/SIS controllers fail at reporting back the actual NodeID of the SUC/SIS Controller if they get the command addressed to them (NWK:00FC.1).
4. SUC/SIS Controller answers to this command even when it's sent as a multicast (NWK:00FD.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.35   Command Frames – Z-Wave Protocol Command Class – SUC NodeID Command

This command is used to advertise the NodeID of the SUC and its capabilities.

3.35.1   Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.35.2   Test Setup

1. Include the second Controller to the primary one.
2. Include the third Controller using the RealPrimary Controller.
3. Reset the SUC/SIS Controller.
4. Select the second Controller in the RealPRimary Controller's Node list and click the "it's failed" button.
5. Activate "Remove Failed" button on RealPrimary Controller.
6. Repeat steps 4 & 5 on the third Controller.
7. Include the reset second Controller to the network with RealPrimary Controller.

3.35.3   Test Result

1. The first Controller is set to RealPrimary, Inclusion Controller. The second Controller is set to SUC/SIS Controller.
2. The third Controller is included as an Inclusion Controller.
   a. During its inclusion, RealPrimary Controller sends SUC NodeID to it with the NodeID of the second Controller – SUC/SIS.
3. SUC/SIS Controller resets its NodeID to 1 and Home ID to random.
4. RealPrimary Controller probes the second Controller by sending NOP frames to it.
   a. Upon failing to find it, it sets its Node ID in red in its Node list.
5. The reset SUC/SIS is removed from RealPRimary Controller's Node List.
6. Verifications 4 & 5 apply for the third Controller.
7. The second Controller is included as SUC/SIS Controller.
   a. During Inclusion RealPrimary Controller sends to the third Controller being re-included SUC Node ID command with NodeID set to 0 (since there is currently no SUC/SIS Controller in the network).
   b. At the end of the re-inclusion, the second Controller is set to be SUC/SIS.

3.35.4   Pass Criteria

1. The SUC NodeID command follows the format of Figure 4.31 (NWK:00FE.1).
2. During regular operation the "NodeID" field of SUC NodeID command is set to the NodeID value of the SUC/SIS Controller. When there is no SUC/SIS in the network it's set to 0 (NWK:00FF.1).
3. The "Capabilities" field follows Table 4.24 or it's missing. When it's missing it's assumed to have value 0x00 (NWK:0100.1, NWK:0101.1).

4. This command shall not be sent to the same NodeID that is contained in the "NodeID" field of the command (NWK:0102.1).

3.35.5 Fail Criteria

1. The SUC NodeID command is not formatted as specified (NWK:00FE.1).
2. The "NodeID" field is set to a value different from the SUC/SIS NodeID value, or it's changing without having changed the SUC/SIS, or it's set to 0 as if there was no SUC/SIS when there is. Or it retains the same value even after having verified the SUC/SIS Controller has failed and is removed from the network (NWK:00FF.1).
3. The "Capabilities" field holds values outside the defined by Table 4.24 or in case of missing altogether it's not considered as 0x00 (NWK:0100.1, NWK:0101.1).
4. This command is sent to the same NodeID in its "NodeID" field, instead of using Set SUC Command (NWK:0102.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.36   Command Frames – Z-Wave Protocol Command Class – Set SUC Command

This command is used by a primary Controller to grant the SUC Role to another controller in the network.

3.36.1   Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
1 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.36.2   Test Setup

1. Include the second Controller to the primary one.
2. Include the third Controller using the RealPrimary Controller.
3. Reset the SUC/SIS Controller.
4. Select the second Controller in the RealPrimary Controller's Node list and click the "it's failed" button.
5. Activate "Remove Failed" button on RealPrimary Controller.
6. Repeat steps 4 & 5 on the third Controller.
7. Override Set SUC command to be sent during next inclusion.
8. Include the End Node with RealPrimary Controller.
9. Include the reset second Controller to the network with RealPrimary Controller.

3.36.3   Test Result

1. The first Controller is set to RealPrimary, Inclusion Controller. The second Controller is set to SUC/SIS Controller.
   a. The first Controller sends Set SUC Command after the Node Information interview.
2. The third Controller is included as an Inclusion Controller.
3. SUC/SIS Controller resets its NodeID to 1 and Home ID to random.
4. RealPrimary Controller probes the second Controller by sending NOP frames to it.
   a. Upon failing to find it, it sets its Node ID in red in its Node list.
5. The reset SUC/SIS is removed from RealPRimary Controller's Node List.
6. Verifications 4 & 5 apply for the third Controller.
7. The Set SUC command is overridden to be sent in the next inclusion.
8. RealPrimary Controller includes the End Node to the Network.
   a. It tries sending Set SUC to the End Node.
   b. End Node ignores the command.
9. The second Controller is included as SUC/SIS Controller.
   a. During Inclusion RealPrimary Controller sends to the third Controller being re-included Set SUC Command.

3.36.4 Pass Criteria

1. The Set SUC command follows the format from Figure 4.38 (NWK:0103.1).
2. The "State" field advertises functionality and shall be set to 0x01. All other values are reserved and must be ignored (NWK:0104.1, NWK:0105.1).
3. The "SUC Capabilities" field specifies the services the SUC should run. It follows Table 4.24 it shall be set to 0x01 (NWK:0106.1, NWK:0107.1).
4. Set SUC command can only be issued by a Primary Controller, End Nodes shall ignore it (NWK:0108.1).
5. A Controller being included that receives this command shall assume the SUC role and answer with a Set SUC ACK command (NWK:0109.1, NWK:010A.1).

3.36.5 Fail Criteria

1. The Set SUC command is not formatted as specified (NWK:0103.1).
2. The "State" field is not set to 0x01 (NWK:0104.1, NWK:0105.1).
3. The "SUC Capabilities" field doesn't follow Table 4.24 and it's not set to 0x01 (NWK:0106.1, NWK:0107.1).
4. Set SUC command is issued by a non-Primary Controller and it's ignored by End Nodes (NWK:0108.1).
5. A Controller being included that received this command doesn't assume the SUC role and fails at answering with a Set SUC ACK command (NWK:0109.1, NWK:010A.1).
6. Variation outside of the allowed parameters causes successful results when they should not be.

3.37 Command Frames – Z-Wave Protocol Command Class – Set SUC ACK Command

This command is used to respond to a Set SUC Command.

3.37.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.37.2 Test Setup

1. Include the second Controller to the primary one.
2. Include the third Controller using the RealPrimary Controller.
3. Reset the SUC/SIS Controller.
4. Select the second Controller in the RealPrimary Controller's Node list and click the "it's failed" button.
5. Activate "Remove Failed" button on RealPrimary Controller.
6. Repeat steps 4 & 5 on the third Controller.
7. In the second Controller override Set SUC ACK command to be set its "Result" field to 0x00.
8. Include the reset second Controller to the network with RealPrimary Controller.

3.37.3 Test Result

1. The first Controller is set to RealPrimary, Inclusion Controller. The second Controller is set to SUC/SIS Controller.
   a. The second Controller responds to Set SUC Command with Set SUC ACK command.
2. The third Controller is included as an Inclusion Controller.
3. SUC/SIS Controller resets its NodeID to 1 and Home ID to random.
4. RealPrimary Controller probes the second Controller by sending NOP frames to it.
   a. Upon failing to find it, it sets its Node ID in red in its Node list.
5. The reset SUC/SIS is removed from RealPrimary Controller's Node List.
6. Verifications 4 & 5 apply for the third Controller.
7. The Set SUC ACK command is overridden to be responded in the next inclusion.
8. The second Controller is included but doesn't accept the SUC/SIS Controller role.

3.37.4 Pass Criteria

1. The Set SUC ACK follows the format on Figure 4.39 (NWK:010B.1).
2. When a Controller accepts the SUC role it sets its "Result" field is set to 0x01, and when rejects the SUC role, it sets it to 0x00 (NWK:010C.1).
3. The "Capabilities" field is encoded as per Table 4.24 (NWK:010D.1).

3.37.5 Fail Criteria

1. The Set SUC ACK doesn't follow the specified format (NWK:010B.1).

2. When a Controller accepts the SUC role, it doesn't set its "Result" is to 0x01, or when it rejects the SUC role, it fails at setting it to 0x00, or uses entirely any other values (NWK:010C.1).

3. The "Capabilities" field doesn't follow Table 4.24 (NWK:010D.1).

4. Variation outside of the allowed parameters causes successful results when they should not be.

3.38 Command Frames – Z-Wave Protocol Command Class – Assign SUC Return Route Command

This command is used to notify the receiving node about the route on how to reach the SUC.

3.38.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.38.2 Test Setup

1. Include the second Controller to the first one.
2. Include the first End Node to the network using the Inclusion Controller in direct range.
3. Place the second End Node one hop away from the Inclusion Controller using the first End Node as a repeater. Proceed to start a Network Wide Inclusion.
4. Reset the SUC/SIS Controller.
5. Select the second Controller in the RealPrimary Controller's Node list and click the "it's failed" button.
6. Activate "Remove Failed" button on RealPrimary Controller.
7. Place the third End Node one Hop away from the RealPrimary Controller. Begin its inclusion using the first End Node as a repeater.

3.38.3 Test Result

1. The second Controller is included to the first one's network.
   a. The first Controller is set as RealPrimary, Inclusion Controller. The second is set as SUC/SIS Controller.
2. The first End Node is included in direct range to the RealPrimary Controller.
   a. Upon inclusion, the RealPrimary Controller sends Assign SUC Return Route to the End Node.
3. The second End Node is included through the first End Node as a repeater.
   a. The RealPrimary Controller sends Assign SUC Return Route to the second End Node.
4. SUC/SIS Controller resets its NodeID to 1 and Home ID to random.
5. RealPrimary Controller probes the second Controller by sending NOP frames to it.
   a. Upon failing to find it, it sets its Node ID in red in its Node list.
6. The reset SUC/SIS is removed from RealPRimary Controller's Node List.
7. The third End Node is one hop away from the RealPrimary Controller. It's included in Network Wide Inclusion with the first End Node as a repeater.
   a. Real Primary doesn't send Assign SUC Return Routes since there is no SUC/SIS in the network.

3.38.4 Pass Criteria

1. Assign SUC Return Route Command is formatted as per Figure 4.40, it extends from the Assign Return Route Command (NWK:010E.1).
2. The "NodeID" field shall be set to the NodeID of the SUC Node (NWK:010F.1).
3. When there is no SUC/SIS in the network, the command is not sent (NWK:0110.1).
4. Nodes receiving this command should update their routing table with the route for reaching SUC NodeID (NWK:0111.1).

3.38.5 Fail Criteria

1. Assign SUC Return Route doesn't follow the specified format nor extends from the description for Assign Return Route Command (NWK:010E.1).
2. The "NodeID" field does not correspond to the NodeID of the SUC Node (NWK:010F.1).
3. The command is sent regardless of not having a SUC Node in the network (NWK:0110.1).
4. Nodes receiving this command do not update their routing table and don't learn which NodeID is the SUC (NWK:0111.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.39 Command Frames – Z-Wave Protocol Command Class – Static Route Request Command

This command is used to request static routes for one or more NodeID destinations.

3.39.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
1 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.39.2 Test Setup

1. Include the second controller to the first one.
2. Include the third Controller to the network with the RealPrimary Controller.
3. The third Controller sends Static Route Request to the first Controller.
4. Include the End Node with the third Controller.
5. The third Controller sends Static Route Request to the End Node.

3.39.3 Test Result

1. The second Controller is included successfully.
    a. The first Controller is set as RealPrimary, Inclusion Controller, the second one as SUC/SIS Controller.
2. The third Controller is included as Inclusion Controller.
3. The first Controller routes to the first SUC/SIS Controller.
    a. SUC/SIS Controller answers with Assign Return Route.
4. The End Node is included successfully.
5. The End Node ignores the command.

3.39.4 Pass Criteria

1. The Static Route Request shall follow format from Figure 4.41. It should not be sent under normal circumstances, except by legacy devices, and then it should be responded with Assign Return Route (NWK:0112.1, NWK:0115.1, NWK:0117.1).
2. Each valid value (between 1 … 232) in the "Destination NodeID X", is a NodeID for which a route is requested, a value of 0x00 indicates the byte is not used (NWK:0113.1, NWK:0114.1).
3. It should be directed/routed to the SUC/SIS Controller (NWK:0116.1).
4. End Nodes ignore receiving this command (NWK:0118.1).

3.39.5 Fail Criteria

1. The command doesn't follow the specified format, it's sent by regular End Nodes or is ignored by a receiving SUC/SIS (NWK:0112.1, NWK:0115.1, NWK:0117.1).

2. The "Destination NodeID X" fields contain values for nodes which routes are not relevant to the sending Node, or are repeated values, or higher than 232 or 0x00 is used instead of a proper value (NWK:0113.1, NWK:0114.1).
3. The command is not directed to the SUC/SIS Controller (NWK:0116.1).
4. An end node receiving this command tries to answer to it (NWK:0118.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.40   Command Frames – Z-Wave Protocol Command Class – Lost Command

This command is used to request help from another node in the network to locate the SUC/SIS in the network.

3.40.1 Prerequisites

1 x Z-Wave Zniffer.
4 x Z-Wave PC Controller.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.40.2 Test Setup

1. Include the second Controller to the first one.
2. Include the third Controller with the RealPrimary Controller.
3. Include the fourth Controller with the RealPrimary Controller.
4. Press "Update" in the third and fourth Controllers so that they update their respective Node Lists and are aware of each-other's presence.
5. Send "Request Node Info" from all Controllers to each other, to make sure they can communicate correctly.
6. Set the third Controller in learning mode and press "Shift" on the first one.
7. Reset the SUC/SIS Controller, removing itself from the network.
8. Select the second Controller (just removed SIS) in the RealPrimary Controller's Node list and click the "it's failed" button.
9. Activate "Remove Failed" button on RealPrimary Controller.
10. Repeat steps 8 & 9 in all Inclusion Controllers.
11. In the Node List of RealPrimary Controller, select the fourth Controller. Press the button "Set as SIS".
12. Make the first Controller send to the RealPrimary Controller the Lost Command.

3.40.3 Test Result

1. The first controller sets itself to RealPrimary, Inclusion Controller and the second one into SUC/SIS Controller.
2. The third Controller is included as an Inclusion Controller.
3. The fourth Controller is included as an Inclusion Controller.
4. Both third and fourth Controllers update their Node Lists and hold a complete list of nodes.
5. All Controllers can communicate correctly with each other.
6. The role of RealPrimary Controller shifts from the first Controller to the third one. The first Controller is now only an Inclusion Controller.
7. SUC/SIS Controller is rest and is removed from the Network.
8. RealPrimary Controller probes the second Controller by sending NOP frames to it.
   a. Upon failing to find it, it sets its Node ID in red in its Node list.
9. The reset SUC/SIS is removed from RealPrimary Controller's Node List.
10. All Inclusion Controllers remove the reset SUC/SIS from their respective Node Lists.
11. The fourth Controller changes from Inclusion Controller to SUC/SIS Controller.

12. Lost command is redirected to the new SIS and RealPrimary responds to the first Controller with Accept Lost.
    a. SIS starts a Neighbor test on the first Controller.
    b. The first Controller has now updated which node is SUC/SIS and its neighbors in direct range.

3.40.4 Pass Criteria

1. The Lost Command is formatted as per Figure 4.42, it is obsoleted and shall not be transmitted (NWK:0119.1, NWK:011A.1).
2. The node receiving this command forwards it to SUC/SIS and it's ignored in a network without one (NWK:011B.1).
3. When the SUC/SIS receives it, it should send Accept Lost Command, perform a Neighbor test and issue an Assign SUC Return Route command and end with Transfer End to the lost node, as per Figure 4.43 (NWK:011C.1).

3.40.5 Fail Criteria

1. The Lost command fails to comply with the specified format, or it's sent by a regular End Node on its own (NWK:0119.1, NWK:011A.1).
2. The node receiving this command does not forward it to SUC/SIS or it's aimed to be forwarded in a network without SUC/SIS (NWK:011B.1).
3. When the SUS/SIS receives the command, it doesn't respond with Accept Lost Command or perform a Neighbor test or sends Assign SUC Return Route command nor ends with Transfer End (NWK:011C.1).
4. Variation outside of the allowed parameters causes successful results when they should not be.

3.41   Command Frames – Z-Wave Protocol Command Class – Accept Lost Command

This command is used to indicate that the SUC has accepted to help a lost node.

3.41.1   Prerequisites

1 x Z-Wave Zniffer.
4 x Z-Wave PC Controller.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.41.2   Test Setup

1.   Include the second Controller to the first one.
2.   Include the third Controller with the RealPrimary Controller.
3.   Include the fourth Controller with the RealPrimary Controller.
4.   Press "Update" in the third and fourth Controllers so that they update their respective Node Lists and are aware of each-other's presence.
5.   Send "Request Node Info" from all Controllers to each other, to make sure they can communicate correctly.
6.   Set the third Controller in learning mode and press "Shift" on the first one.
7.   Reset the SUC/SIS Controller, removing itself from the network.
8.   Select the second Controller (just removed SIS) in the RealPrimary Controller's Node list and click the "it's failed" button.
9.   Activate "Remove Failed" button on RealPrimary Controller.
10. Repeat steps 8 & 9 in all Inclusion Controllers.
11. In the Node List of RealPrimary Controller, select the fourth Controller. Press the button "Set as SIS".
12. Override Accept Lost in the SUC/SIS Controller to set it's "Accepted" field to be 0x04.
13. Make the first Controller send to the RealPrimary Controller the Lost Command.
14. Cancel overrides in the SUC/SIS, Force RealPrimary Controller to answer to the Lost command with status: 0x05 = Accepted. Repeat sending from the first Controller Lost Command to the RealPrimary Controller.
15. Cancel overrides. Repeat sending from the first Controller Lost Command to the RealPrimary Controller.

3.41.3   Test Result

1.   The first controller sets itself to RealPrimary, Inclusion Controller and the second one into SUC/SIS Controller.
2.   The third Controller is included as an Inclusion Controller.
3.   The fourth Controller is included as an Inclusion Controller.
4.   Both third and fourth Controllers update their Node Lists and hold a complete list of nodes.
5.   All Controllers can communicate correctly with each other.
6.   The role of RealPrimary Controller shifts from the first Controller to the third one. The first Controller is now only an Inclusion Controller.
7.   SUC/SIS Controller is rest and is removed from the Network.

8. RealPrimary Controller probes the second Controller by sending NOP frames to it.
   a. Upon failing to find it, it sets its Node ID in red in its Node list.
9. The reset SUC/SIS is removed from RealPrimary Controller's Node List.
10. All Inclusion Controllers remove the reset SUC/SIS from their respective Node Lists.
11. The fourth Controller changes from Inclusion Controller to SUC/SIS Controller.
12. Accept Lost Command is overridden to hold Accepted with Value 0x04.
13. Lost command is redirected to the new SIS and it responds to the first Controller with overridden Accept Lost.
    a. SIS doesn't start Neighbor test on the first Controller.
    b. The first Controller has not updated yet which node is SUC/SIS.
14. Lost command is responded by the RealPrimary Controller.
    a. SUC/SIS does not initiate Neighbor testing.
    b. The first Controller doesn't update its neighbor range.
15. Lost command is redirected to the new SIS and it responds to the first Controller with Accept Lost.
    a. SIS starts a Neighbor test on the first Controller.
    b. The first Controller has now updated which node is SUC/SIS and its neighbors in direct range.

3.41.4 Pass Criteria

1. The Accept Lost Command follows the format defined in Figure 3.44 (NWK:011D.1).
2. The "Accepted" field in the Accept Lost Command uses either values 0x04 for refusing or 0x05 for accepting to help the lost End Node. All other values are reserved (NWK:011E.1, NWK:011F.1).
3. When generated and accepted ("Accepted" field = 0x05), the SUC Controller shall start a Neighbor Range test and issue an Assign SUC Return Route command and end with Transfer End to the lost node, as per Figure 4.43 (NWK:0120.1).
4. This command shall not be sent by a command that is not the SUC in the network (NWK:0121.1).

3.41.5 Fail Criteria

1. The command does not follow the expected format (NWK:011D.1).
2. The "Accepted" field holds values different from 0x04 or 0x05 or behaves in a way that doesn't correspond to the description (NWK:011E.1, NWK:011F.1).
3. The SUC doesn't start a Neighbor range test doesn't issues any of the follow up commands (NWK:0120.1).
4. If issued by a Controller that is not set as SUC, the Lost node accepts it and performs Neighbor range test on its own (NWK:0121.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.42   Command Frames – Z-Wave Protocol Command Class – NOP Power Command

This command is used to verify if a node is in direct range and used for neighbor Discovery.

3.42.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.42.2   Test Setup

1. Include the first End Node in direct range to the first Controller.
2. Include the second End Node one hop away from the RealPrimary Controller.
3. Place the second Controller in direct range to the first Controller and the first End Node but one hop away from the second End Node.

3.42.3   Test Result

1. The first End Node is included in direct range.
    a. When included, the Controller initiates a Neighbors range test on it.
    b. The first End Node can reach the RealPrimary Controller directly with NOP Power.
2. The second End Node is included through the first End Node as a Repeater.
    a. When included, the Controller initiates a Neighbors range test on it.
    b. The second End Node can only reach the first End Node directly with NOP Power.
3. The second Controller is included and can't reach directly the second End Node.
    a. When included, the Controller initiates a Neighbor's range test on it.
    b. The second Controller can reach the RealPrimary Controller and first End Node directly but can't reach the second End Node with NOP Power.

3.42.4   Pass Criteria

1. The NOP Power command follows the format from Figure 4.45 (NWK:0122.1).
2. The "Tx Power Register" is not used and shall be set to 0x00. In case the "Tx Power Dampening" field is missing, it should follow the value Table 4.25 (NWK: 0123.1, NWK:0126.1, NWK:0124.1).
3. The "Tx Power Dampening" field is used to indicate the transmit power to use in a responding MPDU Acknowledgement frame. The "Tx Power Dampening" field follows Table 4.26 (NWK:0125.1).
4. The NOP Power command is not routed through Hops and only reaches the nodes in direct range (NWK:0127.1).
5. The sending node shall apply the same dampening stated in the "Tx Power Dampening" field (NWK:0128.1).

6. Nodes receiving this command respond with an MPDU Acknowledgement frame transmitted with a Tx Power corresponding to the parameters of this command (NWK:0129.1).

3.42.5 Fail Criteria

1. The NOP Power command doesn't follow the specified format (NWK:0122.1).
2. The "Tx Power Register" is used in conjunction with the "Tx Power Dampening" field, or if the "Tx Power Dampening" field is missing, it doesn't follow Table 4.25 or it's just not set to 0x00 (NWK: 0123.1, NWK:0126.1, NWK:0124.1).
3. The "Tx Power Dampening" field doesn't follow Table 4.26 (NWK:0125.1).
4. The NOP Power command is routed and reaches nodes in indirect range (NWK:0127.1).
5. The sending node doesn't apply the same dampening stated in the "TX Power Dampening" field (NWK:0128.1).
6. Nodes receiving this command in direct range don't respond with an Acknowledgement MPDU or without dampening it to the corresponding Tx Power (NWK:0129.1).
7. Variation outside of the allowed parameters causes successful results when they should not be.

3.43   Command Frames – Z-Wave Protocol Command Class – Reserve Node IDs Command

This command is used by an Inclusion Controller to request NodeID(s) to the SUC/SIS that can be used to add new nodes in the network.

3.43.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.43.2   Test Setup

1.   Include the second Controller to the first one.
2.   Set both End Nodes in direct range to both controllers and set them both in earning mode simultaneously.
3.   Start NWI in the RealPrimary Inclusion Controller.

3.43.3   Test Result

1.   The second Controller is included to the first one's network.
     a.   The first Controller is set to RealPrimary, Inclusion.
     b.   The second Controller is set to SUC/SIS Controller.
2.   Both End Nodes broadcast their NodeId and start emitting Explorer Frames.
3.   The RealPrimary controller signalizes the SUC/SIS that it will begin starting new nodes.
     a.   It will request an Automatic Controller Update.
     b.   It will send New Node Registered to SUC/SIS.
     c.   It will end by sending Reserve Node ID to the SUC/SIS.
     d.   SUC/SIS responds with Reserved ID Command.
     e.   Real Primary Controller will proceed to include both End Nodes and having the same exchange for each of them.

3.43.4   Pass Criteria

1.   Reserved Node ID follows the format from Figure 4.46, it is sent only by Inclusion Controllers to the SUC/SIS as a singlecast (NWK:012A.1, NWK:012C.1, NWK:012D.1, NWK:012E.1).
2.   The "Number of Node IDs" field shall hold only values from 0…10. It should only be set to 1 to avoid exhausting the NodeID pool from the SIS (NWL:012B.1).
3.   The SIS responds with Reserved IDs command. It should not respond when it's received via multicast (NWK:012F.1).
4.   It is ignored by non-SIS Controller nodes in the network (NWK:0130.1).

3.43.5 Fail Criteria

1. Reserved Node ID doesn't follow the specified format, it's sent by any other type of controller to other Controller that is not SUC/SIS or it's sent as multicast by default (NWK:012A.1, NWK:012C.1, NWK:012D.1, NWK:012E.1).
2. The "Number of Node IDs" field can hold values above 10 or it's set to more than 1 by default (NWK:012B.1).
3. The SIS doesn't respond with Reserved IDs command or it responds with it's sent as multicast (NWK:012F.1).
4. Non-SIS Controller nodes in the network respond to this command (NWK:0130.1).
5. Variation outside of the allowed parameters causes successful results when they should not be.

3.44 Command Frames – Z-Wave Protocol Command Class – Reserved IDs Command

This command is used by an Inclusion Controller to request NodeID(s) to the SUC/SIS that can be used to add new nodes in the network.

3.44.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.44.2 Test Setup

1. Include the second Controller to the first one.
2. Set both End Nodes in direct range to both controllers and set them both in earning mode simultaneously.
3. Start NWI in the RealPrimary Inclusion Controller.

3.44.3 Test Result

1. The second Controller is included to the first one's network.
    a. The first Controller is set to RealPrimary, Inclusion.
    b. The second Controller is set to SUC/SIS Controller.
2. Both End Nodes broadcast their NodeId and start emitting Explorer Frames.
3. The RealPrimary controller signalizes the SUC/SIS that it will begin starting new nodes.
    a. It will request an Automatic Controller Update.
    b. It will send New Node Registered to SUC/SIS.
    c. It will end by sending Reserve Node ID to the SUC/SIS.
    d. SUC/SIS responds with Reserved ID Command.
    e. Real Primary Controller will proceed to include both End Nodes and having the same exchange for each of them.

3.44.4 Pass Criteria

1. Reserved IDs follows the format from Figure 4.47, it is sent only by Controllers with SIS function and a SIS Controller may reuse to provide Reserved NodeIDs (NWK:0131.1, NWK:0135.1, NWK:0136.1, NWK:0137.1).
2. The "Number of IDs" field shall be in the range 0 … 10 (NWK:0132.1).
3. The "Reserved NodeID" field represents a NodeID granted that the Inclusion Controllar can use. The length of this field shall match the value in the field "Number of IDs" (NWK:0133.1, NWK:0134.1).

3.44.5 Fail Criteria

1. Reserved IDs doesn't follow the specified format, it's sent by any other type of controller to (NWK:0131.1, NWK:0135.1, NWK:0136.1, NWK:0137.1).
2. The "Number of IDs" field is higher than 10 (NWK:0132.1).
3. The "Reserved NodeID" field is holding NodeID values for the Inclusion Controller to grant. Its value is not matching the value in the field "Number of IDs" (NWK:0133.1).
4. Variation outside of the allowed parameters causes successful results when they should not be.

3.45   Command Frames – Z-Wave Protocol Command Class – Node Exists Command

This command is used to advertise a list of nodes currently present in the network. This is supported only by the Static Controller in the 500s.

3.45.1   Prerequisites

1 x Z-Wave Zniffer.
4 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.45.2   Test Setup

1. Include the second Controller to the first one.
2. Disable security in the SUC/SIS Controller.}
3. Use the SUC/SIS Controller, include and exclude the other 2 controllers and End Nodes 8 times.
   a. Node Exists command is only triggered after a "Full Update" of the network, which consists in more than 64 changes (inclusions, exclusions).
4. Enable security once more in the SUC/SIS.
5. Include the Controllers and End Nodes securely.
6. On RealPrimary Controller press the "Update" button.

3.45.3   Test Result

1. The first Controller turns into RealPrimary, Inclusion Controller and the second one into SUC/SIS Controller.
2. Security is Disabled in the SUC/SIS Controller.
3. The other 2 controllers and the End Nodes are included in sequence 8 times and removed 8 times as well.
4. Security is enabled in the SUC/SIS Controller.
5. Controllers and End Nodes are included securely.
6. RealPrimary sends Automatic Controller Update Start.
   a. SUC/SIS sends a series of New Node Registered and New Range Registered for the existing Nodes and finishes with Command Nodes Exist.
   b. RealPrimary Controller replies with Cmd Nodes Exist Reply.

3.45.4   Pass Criteria

1. The Node Exist Command is formatted as per Figure 4.48 (NWK:0138.1).
2. The "Node Mask Type" field is set to 0x00 (NWK:0139.1).
3. The length of the Number of mask bytes is defined by the "Node Mask Length" Field (NWK:013A.1).
4. It contains only the nodes in the network, and it is not sent by any other Controller than SIS (NWK:013B.1).

5. The Controller receiving this command responds with Nodes Exist Reply command (NWK:013C.1).
6. An inclusion Controller that holds non-valid nodes in its network topology removes them (NWK:013D.1).
7. It is ignored if there was no Automatic Controller Update Started (NWK:013E.1).

3.45.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.46 Command Frames – Z-Wave Protocol Command Class – Node Exists Reply Command

This command is used to advertise if a Node Exist Command has been understood.

3.46.1 Prerequisites

1 x Z-Wave Zniffer.
4 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.46.2 Test Setup

1. Include the second Controller to the first one.
2. Disable security in the SUC/SIS Controller.
3. Use the SUC/SIS Controller, include and exclude the other 2 controllers and End Nodes 8 times.
    a. Node Exists command is only triggered after a "Full Update" of the network, which consists in more than 64 changes (inclusions, exclusions).
4. Enable security once more in the SUC/SIS.
5. Include the Controllers and End Nodes securely.
6. On RealPrimary Controller press the "Update" button.

3.46.3 Test Result

1. The first Controller turns into RealPrimary, Inclusion Controller and the second one into SUC/SIS Controller.
2. Security is Disabled in the SUC/SIS Controller.
3. The other 2 controllers and the End Nodes are included in sequence 8 times and removed 8 times as well.
4. Security is enabled in the SUC/SIS Controller.
5. Controllers and End Nodes are included securely.
6. RealPrimary sends Automatic Controller Update Start.
    a. SUC/SIS sends a series of New Node Registered and New Range Registered for the existing Nodes and finishes with Command Nodes Exist.
    b. RealPrimary Controller replies with Cmd Nodes Exist Reply.

3.46.4 Pass Criteria

1. The Node Exist Command is formatted as per Figure 4.49 (NWK:0162.1).
2. The "Node Mask Type" field is set to the same value as the "Node Mask Type" field in the Node Exist command that triggered this response (NWK:013F.1).
3. The "Status" field indicates that the "Node Mask Type" field is known or not by taking value 0 or 1 (NWK:0140.1, NWK:0141.1).
4. This command is generated in response to the Node Exist Command. The sending node shall advertise if its network node list was updated with the "Status" field (NWK:0142.1).

3.46.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.47   Command Frames – Z-Wave Protocol Command Class – Set NWI Mode Command

This command is used to instruct AL nodes in the network to repeat Inclusion Request Explore Frames and Routed frames sent on foreign HomeIDs.

3.47.1 Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.47.2 Test Setup

1. Include the first End Node to the Controller.
2. Place the second End Node one hop away from the Controller with the first End Node placed as a repeater.
3. Start Network Wide Inclusion (NWI) in the Controller.
4. Set the second End Node in Learning Mode.
5. Send a singlecast to each node to verify correct communication.
6. Start Network Wide Exclusion (NWE) in the Controller.
7. Set the second End Node in learning mode.

3.47.3 Test Result

1. The End Node is included in direct range to the Controller.
2. The second End Node is not in direct range to the Controller and the first End Node can be used as a repeater.
3. NWI is started.
   a. The Controller emits an explorer frame with command Set NWI Mode.
   b. In this frame, the first byte after the Command identifier is set to 0x01.
   c. Timeout is either set to 0x00 or a specific value.
4. The second End Node is included through the first End Node as a repeater.
5. Each End Node answers with an Acknowledgement frame directly or routed, respectively.
6. NWE is started.

      a.   The Controller emits an explorer frame with command Set NWI Mode.

      b.   In this frame, the first byte after the Command identifier is set to 0x00.

7. The second End Node is excluded through the first End Node as a repeater.

3.47.4 Pass Criteria

1. The command follows the format from Figure 4.50 (NWK:0143.1).
2. The "Mode" field set to 0x00 or 0x01 respectively enables or disables the nodes receiving the command to stop or start repeating inclusion requests (NWK:0144.1, NWK:0145.1).
3. The Timeout value 0x00 shall indicate the node to use a default timeout of *nwkNWIModeDefaultTimeout*.
4. Values outside this range indicate the number of minutes to remain repeating inclusion requests (NWK:0146.1, NWK:0147.1, NWK:0148.1).
5. This command is transmitted using a normal explorer frame (NWK:0149.1).
6. When this command is received by an AL node, it shall activate or deactivate NWI mode depending on the "Mode" field (NWK:014A.1).

3.47.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.48   Command Frames – Z-Wave Protocol Command Class – Exclude Request Command

This command is used by a node looking to be excluded from its current network.

3.48.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC Controller.
2 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.48.2   Test Setup

1. Include the first End Node to the Controller.
2. Place the second End Node one hop away from the Controller with the first End Node placed as a repeater.
3. Start Network Wide Inclusion (NWI) in the Controller.
4. Set the second End Node in Learning Mode.
5. Send a singlecast to each node to verify correct communication.
6. Start Network Wide Exclusion (NWE) in the Controller.
7. Set the second End Node in learning mode.

Test Result

1. The End Node is included in direct range to the Controller.
2. The second End Node is not in direct range to the Controller and the first End Node can be used as a repeater.
3. NWI is started.
4. The second End Node is included through the first End Node as a repeater.
5. Each End Node answers with an Acknowledgement frame directly or routed, respectively.
6. NWE is started.
7. The second End Node broadcasts its Node Information Frame and goes into learning mode.

       a. After broadcasting its Node Information Frame, it starts emitting Exclude Request Command as Explorer Frames.

       b. The Explorer Frame containing the Exclude Request command is repeated to the Controller and it proceeds to exclusion.

3.48.3 Pass Criteria

1. The format of the command follows the Figure 4.51 (NWK:014B.1).
2. This command extends its fields from the Node Information Frame (NWK:014E.1).
3. This command is transmitted in a Normal Explore Frame and is broadcasted to direction 255 (NWK:014C.1, NWK:014D.1).
4. This command proceeds to exclude a node only if currently in exclusion mode, it ignores the command, otherwise (NWK:014F.1, NWK:0150.1).

3.48.4 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.49   Command Frames – Z-Wave Protocol Command Class – Assign Return Route Priority Command

This command is used to assign the priority route to a NodeID destination.

3.49.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes (one of which can trigger associations with buttons).
We assume it's possible to override the fields of the command in advance to performing inclusion

3.49.2   Test Setup

1. Include two End Nodes in direct range to the RealPrimary Controller.
2. Include the third End Node (with associations enabled by buttons) one hop away from the RealPrimary Controller.
3. Include the second Controller to the network. Place it one hop away from the third End Node.
4. From RealPrimary Controller send Find Nodes in Range to the third End Node with the fields set so that the "Mask Bytes" field holds all nodes except for the RealPrimary Controller and itself.
   a. It's delivered over one repeater.
5. Send Get Nodes in Range to the third End Node from RealPrimary Controller.
6. Sent Association Set to the third End Node so that the End Node reaches out to the second Controller when triggering the associations by pressing a button.
7. Send Assign Return Route to the third End Node.
   a. Set the values of the fields so that the End Node reaches the second Controller though the first repeater.
8. Send Assign Return Route to the third End Node.
   a. Set the values of the fields so that the End Node reaches the second Controller though the other repeater.
9. Send Assign Return Route Priority to the third End Node so that it used the second Route set.
10. Activate the association by pressing the corresponding button.

11. Disable the second End Node. Activate the association again.
12. From the RealPrimary Controller send Assign Return Route to the second Controller.
    a. Set the values of the fields so that it reaches the third End Node through the RealPrimary Controller.
13. Sent Assign Return Route Priority to the second Controller to reach the Third End Node as the just set route.
14. Send a command from the second Controller to the Third End Node.

3.49.3 Test Result

1. The two End Nodes are in direct range to the RealPrimary Controller.
    a. RealPrimary Controller is also set to SUC/SIS Controller.
2. The third End Node is included using one of the other two End Nodes as repeaters.
3. The second Controller is included as an Inclusion Controller. It can reach the third End Node through one repeater.
4. The third End Node performs a Neighbors Range Test in the nodes specified in the command.
5. The Third End Node responds with Node Range Info.
6. The association is set between the third End Node and the second Controller.
7. Assign Return Route is sent with the first End Node set to be used as repeater between the third End Node and the second Controller.
8. Assign Return Route is sent with the second End Node set to be used as repeater between the third End Node and the second Controller instead of the first End Node.
9. Assign Return Route Priority is sent setting the second route instead of the first one.
10. The association is activated, and the End Node reaches the second Controller through the route established by Assign Return Route Priority Command.
11. The association is activated, and the End Node tries reaching the second Controller through the route established by Assign Return Route Priority Command. When it fails, it tries the other route.
12. The second Controller has return route set to the third End Node go through the RealPrimary Controller.
13. The second Controller has the previous Route set to be priority.
14. The second Controller tries reaching the third End Node through either the RealPrimary Controller or the first End Node regardless of the priority route.

3.49.4 Pass Criteria

1. The Assign Return Route Priority Command follows the format from Figure 4.52 (NWK:0151.1).
2. The "Route Number" field is used to define the number of the route to set as the priority one (NWK:0152.1).
3. The Route Number should exist and must have been issued by the same Controller sending this command. An End Node does not send this command (NWK:0153.1, NWK:0154.1).
4. When the command is received, the End Node updates it's priority route table, it must ignore it if the route specified does not exist. A Controller receiving this command shall ignore it. The route defined as priority should be the first routing option when transmitting (NWK:0155.1, NWK:0156.1, NWK:0157.1, NWK:0158.1, NWK:017D.1, NWK:017E.1).

5. The Priority Route that was set is attempted to be used before trying the other routes (NWK:017F.1).

6. Controller nodes may ignore priority routes and use the route of their choice on the first transmission attempt (NWK:017E.1).

3.49.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.50 Command Frames – Z-Wave Protocol Command Class – Assign SUC Return Route Priority Command

This command is used to assign the priority Route to the SUC.

3.50.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes (one of which can trigger associations with buttons).
We assume it's possible to override the fields of the command in advance to performing inclusion

3.50.2 Test Setup

1. Include two End Nodes in direct range to the RealPrimary Controller.
2. Include the third End Node (with associations enabled by buttons) one hop away from the RealPrimary Controller.
3. Include the second Controller to the network. Place it one hop away from the third End Node.
4. From RealPrimary Controller send Find Nodes In Range to the third End Node with the fields set so that the "Mask Bytes" field holds all nodes except for the RealPrimary Controller and itself.
   a. It's delivered over one repeater.
5. Send Get Nodes in Range to the third End Node from RealPrimary Controller.
6. Sent Association Set to the third End Node so that the End Node reaches out to the SUC/SIS Controller when triggering the associations by pressing a button.
7. Send Assign SUC Return Route to the third End Node.
   a. Set the values of the fields so that the End Node reaches the SUC/SIS Controller though one of the existing routes.
8. Activate the association by pressing the corresponding button.

3.50.3 Test Result

1. The two End Nodes are in direct range to the RealPrimary Controller.
   a. RealPrimary Controller is also set to SUC/SIS Controller.
2. The third End Node is included using one of the other two End Nodes as repeaters.
   a. Look at the inclusion trace and observe that there are a number of Assign SUC Return Route frames sent at the end of the inclusion.
3. The second Controller is included as an Inclusion Controller. It can reach the third End Node through one repeater.
4. The third End Node performs a Neighbors Range Test in the nodes specified in the command.
5. The Third End Node responds with Node Range Info.
6. The association is set between the third End Node and the SUC/SIS Controller.
7. Assign SUC Return Route is sent with the selected route set to be used as priority between the third End Node and the SUC/SIS Controller.
8. The association is activated, and the End Node reaches the SUC/SIS Controller through the route established by Assign SUC Return Route Priority Command.

3.50.4 Pass Criteria

1. The Assign SUC Return Route Priority Command follows the format from Figure 4.53 It extends from the Assign Return Route Priority Command (NWK:0161.1).
2. The Return SUC Route Number should exist and must have been issued by the same Controller sending this command. The NodeID field is the NodeID of the SUC/SIS. An End Node does not send this command (NWK:0159.1, NWK:015A.1, NWK:015B.1).
3. When the command is received, the End Node updates its priority route to the SUC, it must ignore it if the route specified does not exist. A Controller receiving this command shall ignore it. The route defined as priority should be the first routing option to the SUC/SIS (NWK:015C.1, NWK:015D.1, NWK:015E.1, NWK:015F.1).

3.50.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.51   Command Frames – Z-Wave Protocol Command Class – SmartStart Included Node Information Command

This command is used by nodes to notify a controller that it was just powered up and is already part of a network.

3.51.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
1 x End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.51.2   Test Setup

1. Add the DSK number of the End Node to the first Controller. Let SmartStart inclusion of the End Node to finish.
2. Remove power from the End Node.
3. Add the DSK number of the End Node to the second Controller.
4. Return power to the End Node.

3.51.3   Test Result

1. The End Node is included to the first Controller's network.
2. The End Node is powered down.
3. The second Controller holds the DSK of the End Node in its Provisioning List.
4. The End Node is powered up and emits an explorer frame with the Included Node Info Command.

      a.   The second Controller does not attempt including the End Node.

3.51.4 Pass Criteria

1. The SmartStart Included Node Information command follows the format from Figure 4.54 (NWK:0160.1).
2. The "NWI HomeID" field identifies that the Node has been included to the network with that HomeID (NWK:0163.1).
3. The format of the bytes forming the "NWI HomeID" field is structured to match bytes 9 … 12 of the S2 DSK. Bits 7 & 6 of the "NWI HomeID 1" field are set to 1. Bit 0 of the "NWI HomeID 4" field is set to 0 – Illustrated by Figure 4.55 (NWK:0164.1, NWK:0165.1, NWK:0166.1).
4. This frame is transmitted in an Inclusion Explorer Frame and it's broadcasted to NodeID 0xFF (NWK:0167.1, NWK:0168.1).

3.51.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.52   Command Frames – Z-Wave Protocol Command Class – SmartStart Prime Command

This command is used to notify SmartStart including controllers that a node is about to make an inclusion request.

3.52.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC Controller.
1 x AL End Node.
1 x FL End Node.
1 x NL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.52.2   Test Setup

1. Introduce the DSK value of the End Nodes into the Controller's Provisioning List.
2. Power up the End Nodes.

3.52.3   Test Result

1. The DSK of the End Nodes is in the Controller's Provisioning List.
2. The End Nodes each issue a SmartStart Prime Command.
   a. AL & FL nodes wait until their wakeup period is completed and then they send SmartStart Prime Command after nwkSmartStartInclusionRequestDuration has passed.

3.52.4   Pass Criteria

1. The format of the SmartStart Prime Command follows the format from Figure 4.56 and it extends from the Node Information Frame (NWK:0169.1, NWK:016A.1).
2. This command is sent in an inclusion explorer frame, it must be addressed as a multicast to node 0xFF. Must hold the NWIHomeID as HomeID. It is sent after nwkSmartStartInclusionRequestDuration has passed. Non-AL nodes may return to sleep between sending SmartStart Prime Command and SmartStart Inclusion Request Command (NWK:016B.1, NWK:016C.1, NWK:016D.1, NWK:016E.1).
3. When it's received, the Controller compares the NWIHomeID to the one obtained in the DSK keys in its Provisioning List. When finding a match, the Controller enters SmartStart Inclusion when the node issues a SmartStart Inclusion Request. IF there are more DSK matches for the

received NWIHomeID, the Controller shall enter SmartStart Inclusion alternating between the DSK candidates (NWK:016F.1, NWK:0170.1).

3.52.5   Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.53   Command Frames – Z-Wave Protocol Command Class – SmartStart Inclusion Request Command

This command is used to request to initiate a SmartStart inclusion.

3.53.1   Prerequisites

1 x Z-Wave Zniffer.
1 x Z-Wave PC Controller.
1 x AL End Node.
1 x FL End Node.
1 x NL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.53.2   Test Setup

1. Introduce the DSK value of the End Nodes into the Controller's Provisioning List.
2. Power up the End Nodes.

3.53.3   Test Result

1. The DSK of the End Nodes is in the Controller's Provisioning List.
2. The End Nodes each issue a SmartStart Prime Command.
    a. AL & FL nodes wait until their wakeup period is completed and then they send SmartStart Prime Command after nwkSmartStartInclusionRequestDuration has passed.
3. After the End Nodes have issued SmartStart Prime, they issue SmartStart Inclusion Request.
    a. When the Controller receives SmartStart Inclusion Request, it start SmartStart inclusion by issuing Assign Id.

3.53.4   Pass Criteria

1. The format of the SmartStart Inclusion Request Command follows the format from Figure 4.57 and it extends from the Node Information Frame (NWK:0171.1, NWK:0172.1).
2. This command is sent in an inclusion explorer frame, it must be addressed as a multicast to node 0xFF. Must hold the NWIHomeID as HomeID. The Sending node shall listen and accept Assign IDs Command after the HomeID has been authenticated (NWK:0173.1, NWK:0174.1, NWK:0175.1).

3. When it's received, the Controller compares the NWIHomeID to the one obtained in the DSK keys in its Provisioning List. When finding a match the Controller begins SmartStart Inclusion by issuing AssignID and it should authenticate the HomeID by constructing the 4 bytes of NWIHomeID matching bytes 13 … 16 of the DSK, in its bits 7 & 6 of the Auth HomeID byte 1 are set to 1 and bit 0 of Auth HomeID byte 4 is set to 0 as per Figure 4.58 (NWK:0176.1).

3.53.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.54   Compliance with NWK Layer Constants and Attributes

Tables 3.27 and 3.28 define the Constants and Attributes the Network Layer can use for different procedures.

3.54.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
3 x End Nodes.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.54.2 Test Setup

1. Set the first End Node in learning mode.
2. Set the first Controller in inclusion mode.
3. Set the second End Node one hop away from the Controller.
4. Set the Controller in NWI inclusion mode.
5. Wait until the *nwkMinNWIModeDefaultTimeout* runs out.
6. Power off and power on the second End Node so that it starts sending Smart Start Inclusion requests.
7. Include the DSK value of the second End Node to the Controller. Remove power from the second End Node.
8. Set the Controller in SmartStart Inclusion.
9. Power the second End Node up in order to let SmartStart inclusion conclude.
10. Include a second Controller.
11. Remove power from the second End Node. Include the third Controller.
12. Try to reach the second End Node with the third Controller with a singlecast.
13. Remove Power From the SIS.
14. On a secondary Controller press the Update Button.
15. Remove all End Nodes and Controllers.

3.54.3 Test Result

1. The End Node starts sending Explorer Frames.

      a. The explorer frames are sent with *nwkRecommendedSessionTxRandomInterval*.

      b. It remains in learning mode at least *nwkLearnModeMinDuration*.

2. The End Node is included to the Network.

3. The second End Node doesn't have direct range to the first Controller.

4. The Controller is in NWI Inclusion mode and the first End Node is also in NWI inclusion mode.

      a. The Controller sends Transfer Presentation Command after *nwkTransferPresentationRepeatTime*.

      b. The first End Node stays I Learn mode for at least *nwkLearnModeNetworkWideMinDuration*.

5. The first End Node is no longer in NWI mode.

6. The second End Node starts sending Smart Start Inclusion Requests.

      a. The requests are sent with an interval of *nwkSmartStartInclusionBackoffduration*.

      b. The End Node Emits SmartStart Prime Command and SmartStart Inclusion Request command with an interval of *nwkSmartStartInclusionRequestDuration*.

      c. The inclusion requests are never longer than *aNwkSmartStartMaxInclusionRequestInterval* between eachother.

7. The DSK is included in the Controller's Provisioning List. The second End Node is powered off.

8. The Controller starts SmartStart Inclusion. It enables the first End Node to perform NWI for SmartStart.

      a. The first End Node remains in MWI mode at minimum of *nwkMinNWIModeSmartStartDuration*.

9. The second End Node is included through a repeater in SmartStart.

      a. When it's included, it receives *nwkRecommendedNumberOfReturnRoutes* assigned.

10. The second Controller is included.

11. The second End Node is disabled. The third Controller is included.

12. The third Controller tries reaching out to the second End Node.

      a. It attempts it *nwkMinTransmitAttemptsBeforeExploreFrame* before sending an explorer frame.

      b. The Controller tries routing to the End Node, up to *nNwkRoutedAckTimeout* to determine the routed frame won't return an Acknowledgement frame.

13. The SIS is disabled.

14. The secondary Controller tries reaching for an Automatic Network Update but fails.

      a. It tries again after *nwkMinNetworkOperationBackOffTime*.

15. After each exclusion, the excluded node gets *aNwkRandomHomeID*.

3.54.4 Pass Criteria

1. All values correspond to Table 4.27 and 3.28 (NWK:0177.1, NWK:0178.1).

3.54.5 Fail Criteria

1. Neither value corresponds to Table 4.27 nor 3.28 (NWK:0177.1, NWK:0178.1).

2. Variation outside of the allowed parameters causes successful results when they should not be.

3.55   Functional Description – Routing – Assigning return routes.

Return routes provide options for one node to reach another one. They are assigned on application level.

3.55.1   Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes (one of which can trigger associations with buttons).
We assume it's possible to override the fields of the command in advance to performing inclusion

3.55.2   Test Setup

1. Include the second Controller to the first one.
2. Place the first End Node one hop away from the RealPrimary Controller but in direct range to the SUC/SIS Controller. Include the first End Node with the SUC/SIS Controller.
3. Place the second End Node outside reach of the SUC/SIS but direct range to the RealPrimary Controller. Include the second End Node using the RealPrimary.
4. Include the third End Node with associations (triggered by buttons) in direct range to the SUC/SIS and one hop away from the RealPrimary Controller.
5. On the SUC/SIS Controller, enable "assign return routes" create an association from the third End Node to the first End Node.
6. On the SUC/SIS Controller, disable "assign return routes" create an association from the third End Node to the second End Node.
7. Disable power in the second End Node.
8. Activate the association in the third End Node by pressing the corresponding button.

3.55.3   Test Result

1. The first Controller is set as RealPrimary and the second one as SUC/SIS Controller.
2. The first End Node is included by the SUC/SIS Controller and it's not in direct range to the first Controller.

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3. The second End Node is included in direct range to the RealPrimary Controller and one hop away from the SUC/SIS.
4. The third End Node is included in direct range to the SUC/SIS and one hop away from the RealPrimary.
5. The association is set between the third End Node and the first End Node including return routes.
6. The association is set between the third End Node and the second End Node without return routes.
7. The second End Node is disabled.
8. The third End Node enables its associations.
   a. The third End Node reaches the first End Node through the Route established.
   b. The third End Node tries reaching the second End Node directly.
   c. When it can't reach the second End Node, it will issue Explorer frames trying to reach out to it.

3.55.4 Pass Criteria

1. The Controller assigns the return routes between different End Nodes and Assign SUC Return Route during Inclusion (NWK:0179.1).
2. The return routes are assigned by the Application Layer (NWK:017A.1).
3. There are 4 return routes assigned if possible (NWK:017B.1).
4. When there is no return route assigned, the End Node tries reaching directly. Then try by using Explorer Frame if Direct transmission fails or request a static route from the SUC (NWK:017C.1, NWK:0184.1).
5. AL nodes repeat Routed NPDUs on their HomeID, if their NodeID is in the repeater list (NWK:0186.1).
6. AL Nodes repeat Normal Explore Frames in their HomeID (NWK:0187.1).
7. AL Nodes repeat Search Result Explore Frames sent on their HomeID, if their NodeID is in the repeater list (NWK:0188.1).

3.55.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.56 Functional Description – Network Inclusion & Formation, NWI, Learn Mode.

Functional description of Network Wide inclusion, routing and Learn Mode.

3.56.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes (one of which can trigger associations with buttons).
1 x FL End Node.
1 x NL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.56.2 Test Setup

1. Include the second Controller to the first one.
2. Set the first End Node in learning mode.
3. Include the first End Node to the network with the SUC/SIS Controller.
4. From SUC/SIC controller send Request Node Info to the first End Node.
5. Place the NL End Node in direct range to the SUC/SIS Controller. Set the NL End Node in learning mode.
6. Start NWI in SUC/SIS Controller.
    a. The SUC/SIS Controller sets the first End Node in NWI mode
7. Remove power from the first End Node. Set the SUC/SIS Controller in NWI.
8. Set the FL End Node one hop away from the SUC/SIS Controller. Set the FL End Node in learning mode while the SUC/SIS Controller is in NWI mode.
9. Get the FL End Node in direct range to the SUC/SIS Controller and set it in learning mode while the SUC/SIS Controller is in NWI mode.
10. Place the second AL End Node one hop away from the SUC/SIS Controller. Set it in learning mode while the SUC/SIS Controller is in NWI mode.
11. Enable power in the first End Node in direct range to the SUC/SIS Controller.
12. Place the third AL End Node (the one with associations triggered by buttons) in direct range to the second AL End Node (one hop away from the SUC/SIS). Set it in learning mode.

3.56.3 Test Result

1. The first Controller is set as RealPrimary. The second one is set as SUC/SIS Controller.
2. The first End Node is set in learning mode. No inclusion begins. The End Node waits for Transfer Presentation for join a network.
3. The first End Node is included. The RealPrimary Controller doesn't hold information of the first End Node on its Node List.
4. The first AL End Node answers with a Node Information frame as singlecast.
5. The NL End Node is set in learning mode.
    a. It sends explorer frames requesting inclusion that are not repeated.
6. The SUC/SIS Controller includes directly the NL End Node.
    a. The controller is transmitting Transfer Presentation frames.

b.   The first End Node doesn't repeat the inclusion frames.

7. The SUC/SIS Controller doesn't set the NL End Node into NWI mode.

8. The FL End Node is not included, as the first End Node is not working, and the NL End Node doesn't repeat the frames.

9. The FL End Node is included in direct range by the SUC/SIS Controller.

10. The second AL End Node is not included since the first End Node is not active and neither NL nor FL End Nodes repeat frames.

11. The SUC/SIS sets the first End Node in NWI mode and includes the second AL End Node.

12. It is included by NWI by the repeaters.

3.56.4 Pass Criteria

1. AL nodes repeat frames on a foreign HomeID when their NodeID has been included in the "Repeater List" in the Set NWI Mode command (NWK:0189.1).

2. AL nodes set in NWI repeat Inclusion Request Explorer Frames (NWK:018A.1).

3. AL nodes do not repeat Inclusion Request Nodes when NWI is disabled or the HomeID is different from 0x00000000 (NWK:018B.1).

4. FL & NL nodes do not repeat Routed and Explore NDPUs (NWK:018C.1).

5. Z-Wave Nodes can go into Learning Mode (NWK:0195.1).

6. Learn Mode only lasts during the time it's needed (NWK:0196.1).

7. Nodes may enter Learn Mode to join or leave a network (NWK:0197.1).

8. Node scan accept Assign ID Commands when they are trying to join a network (NWK:0198.1).

9. A secondary Controller may also enter Learn Mode Inclusion to receive the Network Topology (NWK:0199.1).

10. A node that enters Learn mode for Classic Inclusion/Exclusion shall remain in learn mode for at least *nwkLearnModeMinDuration* (NWK:019A.1).

11. A node that enters Learn mode for Network Wide Incluson/Exclusion shall remain in Learn mode for at least *nwkLearnModeNetworkWideMinDuration* (NWK:019B.1).

12. End Node shall not start a new network and wait until they are included by a controller. When not in a network they assign themselves an HomeID (*aNwkRandomHomeID*) (NWK:019C.1).

13. Nodes included in direct range follow classic inclusion as in Figure 4.67 (NWK:019E.1).

14. Nodes in learn mode, wait for a Transfer Presentation and validate the value in the "Option" field and issue a Node Information Frame Command to the Controller's NodeID (NWK:019F.1).

15. IT may be ignored sending a Node Information Frame Command addressed to the broadcast destination NodeID (NWK:01A0.1).

16. The Including Controller issue Assign ID command using the NodeId and HomeID used by the joining node, even if they are outside of the valid NodeID range (NWK:01A1.1).

17. The Neighbor Discovery step (passing Criteria 13) follows the description in Figure 4.91 (NWK:01A2.1).

18. Joining nodes may use NodeID 0xEF (NWK:01A3.1).

19. Learning mode is disabled at the end of inclusion in a Joining Node when it issues Range Info Command (NWK:01A4.1).

20. Node Information Frame issued by joining nodes doesn't request Acknowledgement frames (NWK:01A5.1).

21. Classic inclusion is considered complete by a Controller when it issues SUC NodeID or SUC Return Route (NWK:01A6.1).

22. NWI should be used as the default earn mode (NWK:01A7.1).
23. When the Controller enters NWI it issues Set NWI Mode in a normal explorer frame (NWK:01A8.1).
24. Network Wide Inclusion follows Figure 4.68 (NWK:01A9.1).
25. When a Node receives NWI learn mode, it issues Node Information Frame Command in an Inclusion Request Explore Frame, it has the Acknowledgement Request set to 1 (NWK:01AA.1).
26. Controllers in NWI add mode set the "Option" field to 0x05 in the Transfer Presentation Command (NWK:01AB.1).
27. Acknowledgement frames must be routed using the same route during inclusion as the commands they follow (NWK:01AC.1).
28. Neighbor discovery for NWI follows Figure 4.91 (NWK:01AD.1).

3.56.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.57 Functional Description – Unsuccessful Routed frame without Routed Error.

Functional description of failed routing.

3.57.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes (one of which can trigger associations with buttons).
1 x FL End Node.
1 x NL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.57.2 Test Setup

1. Include the second Controller to the first one.
2. Include the first End Node to the network with the SUC/SIS Controller.
3. Include the NL End Node in direct range to the SUC/SIS Controller
4. Set the FL End Node in direct range to the SUC/SIS Controller and set it in learning mode while the SUC/SIS Controller is in NWI mode.
5. Place the second AL End Node one hop away from the SUC/SIS Controller. Set it in learning mode while the SUC/SIS Controller is in NWI mode.
6. Place the third AL End Node (the one with associations triggered by buttons) in direct range to the second AL End Node (one hop away from the SUC/SIS). Set it in learning mode.
7. On the RealPrimary Controller press the "Update" Button.
8. Remove power from the third AL End Node. Send a singlecast to it from the RealPrimary Controller.
9. Power Back the third AL End Node.
10. From SUC/SIS set an association to it so that it reaches RealPrimary Controller when the association is activated with one of its buttons.
11. From SUC/SIS send return routes to the third End Node so that it reaches the RealPrimary Controller over different routes, excluding the NL & FL End Nodes.
12. Activate the Association in the third AL End Node.
13. Remove power from the RealPrimary Controller. Activate the association once more.
14. Remove power from the last Repeater when it starts sending explorer frames.

3.57.3 Test Result

1. The first Controller is set as RealPrimary. The second one is set as SUC/SIS Controller.
2. The first End Node is included. The RealPrimary Controller doesn't hold information of the first End Node on its Node List.
3. The SUC/SIS Controller directly includes the NL End Node.
4. The FL End Node is included in direct range by the SUC/SIS Controller.
5. The SUC/SIS sets the first End Node in NWI mode and includes the second AL End Node.
6. It is included by NWI by the repeaters.
7. The RealPrimary Controller requests an automatic update from the SUC/SIS.

      a. The SUC/SIS performs a network update to RealPrimary Controller.

      b. The RealPrimary Controller performs a neighbor test trying to reach to all nodes in direct range to it.

8. RealPrimary tries routing to the third End Node but since it's powered down, it can't be reached.

      a. RealPrimary receives a Routing Error frame.

9. The third AL End Node is powered up.

10. The association is set from the third AL End Node to the RealPrimary Controller.

11. Return routes are set for the third AL End Node.

12. The third AL End Node sends a singlecast routing to the RealPrimary Controller.

13. The third End Node tries routing, but it can't reach the RealPrimary Controller.

      a. The last repeater tries sending explorer frames reaching for the RealPrimary Controller.

14. The last repeater has its power removed.

      a. The Third End Node doesn't receive a routed Acknowledgement frame.

      b. The Third End Node times out and doesn't try routing its singlecast to the RealPrimary Controller.

3.57.4 Pass Criteria

1. Sending nodes timeout after *zNwkRoutedAckTimeout* when Routed Acknowledgement or Routed Error frames are not received (NWK:0191.1).
2. AL nodes in the same network repeat the first Normal Explorer Frames (NWK:0192.1.1).
3. Explore Frames are repeated like in Figures 3.65 & 3.66. Nodes in direct range are the first to repeat them (NWK:0193.1).
4. Search result Explore Frames are returned using the same route that reached them (NWK:0194.1).

3.57.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.58 Functional Description – Network Exclusion, NWE, Removing Failing Nodes.

Functional description of Exclusion, Network Wide Exclusion and Failing Nodes.

3.58.1 Prerequisites

1 x Z-Wave Zniffer.
2 x Z-Wave PC Controller.
3 x End Nodes (one of which can trigger associations with buttons).
1 x FL End Node.
1 x NL End Node.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.58.2 Test Setup

1. Include the second Controller to the first one.
2. Include the first End Node to the network with the SUC/SIS Controller.
3. Include the NL End Node in direct range to the SUC/SIS Controller.
4. Configure the NL End Node to wake up every 20 – 30 seconds, so that SUC/SIS Controller can track soon when it goes off-line.
5. Set the FL End Node in direct range to the SUC/SIS Controller and set it in learning mode while the SUC/SIS Controller is in NWI mode.
6. Place the second AL End Node one hop away from the SUC/SIS Controller. Set it in learning mode while the SUC/SIS Controller is in NWI mode.
7. Place the third AL End Node (the one with associations triggered by buttons) in direct range to the second AL End Node (one hop away from the SUC/SIS). Set it in learning mode.
8. Start Network Wide Exclusion in the SUC/SIS Controller.
9. Set the third AL End Node in learning mode.
10. Exclude the FL End Node from the network with SUC/SIS.
11. Set the RealPRimary Controller in Learning Mode.
12. Stop NWE in the SUC/SIS.
13. Place the recently removed Controller in direct range to the first and second End Nodes.
14. Start Exclusion mode in the recently removed Controller.
15. Set the second End Node in Learning Mode.
16. Set the NL End Node in Learning Mode. Exclude it with the Independent Controller.
17. On the SUC/SIS Probe the second End Node removed to verify if it is failing.
18. Wait a while the SUC/SIS may consider the NL End Node to be removed when it doesn't send any frame.

3.58.3 Test Result

1. The first Controller is set as RealPrimary. The second one is set as SUC/SIS Controller.
2. The first End Node is included. The RealPrimary Controller doesn't hold information of the first End Node on its Node List.
3. The SUC/SIS Controller directly includes the NL End Node.
4. The NL End Node is set to wake up every 20-30 seconds.

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a.   It sends Wake Up notifications periodically.
5.   The FL End Node is included in direct range by the SUC/SIS Controller.
6.   The SUC/SIS sets the first End Node in NWI mode and includes the second AL End Node.
7.   It is included by NWI by the repeaters.
8.   The Controller sets the network in Network Wide Exclusion.
     a.   It starts broadcasting Transfer Presentation commands.
9.   The SUC/SIS removes the third End Node from the network through repeaters.
10. The FL End Node is removed from the network in direct range.
11. The RealPrimary Controller is removed from the network by the SUC/SIS.
     a.   Exclusion ends with Transfer End.
12. NWE is stopped.
13. The first Controller has the first and second End Nodes in direct Range.
14. The Controller begins broadcasting Transfer Presentation.
15. The Controller removes the second End Node from the Network.
     a.   The Controller sends to the End Node assign NodeID with value 0x00 and HomeID = 0x00000000.
16. The NL End Node is removed from the network by the removed Controller.
17. The SUC/SIS verifies that the node doesn't respond and can be considered failing.
18. The SUC/SIS can consider the NL End Node to be failing.

3.58.4 Pass Criteria

1.   When a Controller is not in a network it starts its own assigning themselves HomeID and NodeId (*aNwkRandomHomeID*), set itself as Primary Controller and/or SUC/SIS (NWK:019D.1).
2.   Classic exclusion is performed in direct range only (NWK:01BF1.1).
3.   Classic exclusion follows Figure 4.75 (NWK:01C0.1).
4.   A Node being excluded in learn Mode waits for Transfer Presentation with the "*Option*" field indicating exclusion, to which the Node responds with a Node information Frame to the Controller (NWK:01C1.1).
5.   The Node may ignore Transfer Presentation and issue Node Information Command to the broadcast destination (NWK:01C2.1).
6.   Node Information command issued by leaving nodes Doesn't request Acknowledgement frame (NWK:01C3.1).
7.   End Nodes excluded assume NodeID 0x00 and random HomeID (*aNwkRandomHomeID*). Controller nodes excluded start a new network (NWK:01C6.1).
8.   A Controller in exclusion mode also removes nodes in a different network (NWK:01C7.1).
9.   Controller in exclusion mode shall send Assign ID command in its own HomeID if it detects a Node Information Frame (NWK:01C8.1).
10. A node in Learn Mode looking for exclusion accepts Assign ID Commands issued in a different HomeID (NWK:01C9.1).
11. Network Wide Exclusion follows Figure 4.77 (NWK:01CA.1).
12. When a node doesn't respond it may be identified as failing (NWK:01CB.1).
13. It's possible to remove non-responsive nodes by Remove Failed Node (NWK:01CD.1).
14. Before removing a non-responsive Node, the Controller issues NOP frames to it (NWK:01CE.1).
15. A responding node can only be removed by Classic exclusion or Network Wide Exclusion (NWK:01CF.1).

16. A failing Node will be removed following Figure 4.78 (NK:01D0.1).
17. NL Nodes should be considered failing after missing more than 2 consecutives wake Up Periods (NWK:01D1.1).
18. Controller May remove NL node after any arbitrary duration without receiving any frame from the node (NWK:01D2.1).

3.58.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.59 Functional Description – Smart Start

Smart Start allows for an automatic inclusion if the user holds the DSK number of the device.

3.59.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
3 x End Nodes
We assume it's possible to override the fields of the command in advance to performing inclusion

3.59.2 Test Setup

1. Take the DSK from one of the controllers and add it to the Provisioning List of a second Controller.
2. Set the controller to be included in Smart Start Learning Mode.
3. Place the first End Node in direct range to both Controllers.
4. Introduce the DSK of the first End Node in the Secondary Inclusion Controller's Provisioning List. Reset/power up the End Node so that it starts requesting Smart Start inclusion.
5. Remove the DSK of the first End Node from the Inclusion Controller and add it to the RealPrimary Controller. Press the Learning Mode button on the first End Node as soon as it's powered up.
   a. Wait until it stops emitting Classic Inclusion requests.
6. Take the second End Node and place it one hop away from the RealPrimary Controller. Introduce its DSK in the Real Primary Controller.
7. Create a separate network including the DSK of the third End Node in the third Controller.
8. Power down the third End Node. Include its DSK in the RealPrimary Controller of the first network.
9. Power Up the third End Node. It emits a single SmartStart Included Node Information frame.
10. Remove the DSK of the third End Node from the third Controller. Exclude it from its network. Remove power from the Third End Node.
11. On the RealPrimary Controller set S2 Nonce Get to be sent withZensys 15 seconds delay.
12. Power up the third End Node it starts emitting Smart Start Prime and Smart Start Include.

3.59.3 Test Result

1. The DSK of the Controller is included in the other Controller's Provisioning List.
2. The Controller is included and set as Secondary Inclusion Controller.
3. The first End Node is in direct reach for both Controllers.
4. The Secondary Inclusion Controller doesn't include the End Node.
5. During the period the first End Node is in Classic Learning Mode it doesn't emit SmartStart inclusion requests. Once it finishes it begins requesting SmartStart inclusion again.
6. RealPrimary Controller includes the first End Node via SmartStart.
7. The RealPrimary Controller broadcasts Set NWI Mode as soon as the DSK is included in its Provisioning List.
   a. The second End Node starts emitting Smart Start Prime and Smart Start Include.

> b. The RealPrimary Controller includes the second Controller through the first End Node as Repeater.

8. The third Controller includes the third End Node via SmartStart.
9. The RealPrimary Controller holds the DSK of the third End Node as well. It broadcasts a Set NWI Mode command.
10. The Controller doesn't try to include the third End Node until its reset.
11. The DSK of the third End Node is removed and it's removed from the third Controller's network. The third End Node is powered down.
12. The RealPrimary Controller sets S2 Nonce Get to be delayed 15s during inclusion.
13. The RealPrimary Controller begins trying to include the third End Node.
    a. S2 Inclusion fails.
    b. The third End Node self-resets.
    c. SmartStart inclusion is attempted once again.

3.59.4 Pass Criteria

1. SmartStart supporting nodes go into SmartStart Learn Mode right as they are powered up (NWK:01AE.1).
2. After powering up, node shall initiate SmartStart inclusion depending on their state (NWK:01AF.1).
3. When a node is not part of a network, it shall issue SmartStart Inclusion Request in intervals (NWK:01B0.1).
4. SmartStart Inclusion request follows Figure 4.69 (NWK:01B1.1).
5. Nodes in Classic Inclusion or NWI Learn Mode stop issuing SmartStart inclusion requests until they return to SmartStart Learn Mode (NWK:01B2.1).
6. Nodes requesting SmartStat Inclusion do so as per Table 4.29 (NWK:01B3.1).
7. A node already included in a network sends a single SmartStart Included node Information upon power up as per Figure 4.70 (NWK:01B4.1).
8. A Controller shall be Primary Controller in order to include nodes via SmartStart. Secondary and Inclusion Controllers can't (NWK:01B5.1).
9. A Controller needs the DSK of a node to include it via SmartStart (NWK:01B6.1).
10. A Controller remains in SmartStart Inclusion mode for no less than *nwkMinNWIModeSmartStartDuration* minutes as per Figure 4.71 (NWK:01B7.1).
11. A Controller including via SmartStart shall perform S2 bootstrapping (NWK:01B8.1).
12. Direct Smart Start inclusion follows Figure 4.72. SmartStart inclusion through repeaters follows Figure 4.73 (NWK:01B9.1).
13. Routing during SmartStart does the same as NWI when Assigning IDs Commands and routing Acknowledgement frames back: Same new HomeID but the previous NodeID (NWK:01BA.1).
14. Neighbor Discovery follows Figure 4.91 (NWK:01BB.1).
15. When S2 bootstrapping fails, SmartStart Inclusion is considered failed (NWK:01BC.1).
16. A node that fails being included eaves the network and considers itself not included to any network (NWK:01BD.1).
17. A Controller that fails including a node, should consider the joining node removed from the network. It may verify by issuing NOP commands (NWK:01BE.1).

3.59.5 Fail Criteria

1. Any of the passing Criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.60 Functional Description – Controller Roles and Network Operations

Controllers can change roles in a network following different procedures.

3.60.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
2 x AL End Nodes.
1 x FL End Node.
1 x Controller with variable SUC capabilities.
We assume it's possible to override the fields of the command in advance to performing inclusion

3.60.2 Test Setup

1. Set to "No SUC" the controller with variable SUC capabilities, include it to one of the regular Controllers. Try assigning it the SUC/SIS Role.
2. Reset both Controllers.
3. Set only to "SUC" the controller with variable SUC capabilities, include it to one of the regular Controllers. Try assigning it the SUC/SIS Role.
4. Reset both Controllers.
5. Take two regular controllers. On the first one disable "Automatically Set as SIS", include the second Controller to the first one.
6. Reset both Controllers.
7. Set the first controller to be SUC/SIS. Include the second regular Controller.
8. Reset both Controllers.
9. Override on the first Controller to send the SUC Node ID Command overridden with bit 0 of "SUC Capabilities" field set to 1. Include the second Controller again.
10. From the Primary Controller send Set as SIS to the secondary Controller.
11. Include FL End Node to the Network with the RealPrimary Controller.
12. Include the first AL End Node to the Network using SUC/SIS Controller directly.
13. On the Third Controller, include the second AL End Node (as a separate network).
14. On the Primary Controller of the first network, start exclusion. Set the second AL End Node (included to the third Controller) in Learning Mode.
15. Set the SUC/SIS in inclusion Mode. Set the third Controller in Learning Mode.
16. On the Third Controller select the RealPrimary Controller and find the button "Set as SIS".

3.60.3 Test Result

1. The Controller is included. It rejects the SUC/SIS role in the network as per Figure 4.82.
2. Both Controllers are reset and set the NodeID to 1 and HomeID to random.
3. The Controller is included. It rejects the SIS role in the network as per Figure 4.83.
4. Both Controllers are reset and set the NodeID to 1 and HomeID to random.
5. The Including Controller is set as RealPrimary Controller, the included Controller is set as Secondary Controller.
6. Both Controllers are reset and set the NodeID to 1 and HomeID to random.

7. During inclusion SUC/SIS issues a SUC NodeID command to the new Controller.
8. Both Controllers are reset and set the NodeID to 1 and HomeID to random.
9. The Controller is included as Secondary Controller, it answers with Set SUC ACK (SUC Capability = 0x00) and assumes the Inclusion Controller role.
    a. The including Controller assumes the role of RealPrimary Inclusion Controller.
10. The Secondary Controller answers with Set SUC ACK (SUC Capability = 0x01) and assumes the SIS Role.
11. Real Primary requests a Reserve Node ID to the SIS before starting Inclusion Mode.
    a. Secure bootstrapping is handled by the SIS.
12. The SIS Controller includes the AL End Node and it performs a Neighbor and Range test on it.
    a. The AL End Node probes both Controllers and the FL End Node.
13. The second AL End Node is included to the third Controller.
14. The RealPrimary Controller removes the second AL End Node.
    a. The RealPrimary Inclusion Controller does not notify the SUC/SIS about removing it.
15. The third Controller is included to the SUC/SIS Controller.
    a. The third Controller updates its network information with the new one and drops the previous one while in learning mode.
    b. The RealPrimary Controller does not update its Network information.
    c. The third Controller probes all existing nodes in the network.
    d. The third Controller is included as a Secondary Inclusion Controller.
16. The button is disabled. Secondary Controllers can't give that role to another controller.

3.60.4 Pass Criteria

1. A Controller included in a network shall assume the Secondary Controller role (NWK:01D3.1).
2. A secondary Contrller receiving SUC NodeID with SUC Capabilities bit 0 set to 1 becomes an Inclussion Controller (NWK:01D5.1).
3. A Controller receiving Set SUC Command from the Primary Controller shall assume the SUC/SIS role (NWK:01D6.1, NWK:01D9.1).
4. Secondary Controllers don't give the SUC role to other Controllers (NWK:01DA.1).
5. A SUC/SIS Controller that is the only controller in its network issues SUC NodeID to the other Controllers in the network (NWK:01DE.1).
6. A Controller with no SUC Capabilities declines the role as per Figure 4.82 (NWK:01DF.1).
7. A Controller with only no SIS capabilities should decline the role as per Figure 4.83 (NWK:01E0.1).
8. The SUC/SIS stores the network topology and updates it when the nodes are added/removed. It updates nodes that request the network topology (NWK:01EA.1, NWK:01CC.1).
9. Inclusion Controllers update the topology with an Automatic Controller Update from the SUC either by a full transfer of network information or a list of changes. The requesting Controller does not erase the existing information of the same network and only updates it (NWK:01EB.1, NWK:01EC.1, NWK:01ED.1).
10. Inclusion Controller sends Automatic Controller Update Start to the SUC to start an Automatic Update. The SUC sends the topology information using New Node Registered and New Range Registered. A Node Exists Command is issued when updating over 64 changes (supported only by Static Controller in 500s) (NWK:01EE.1).

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11. Automatic Controller update follows Figures 3.86 or 3.87. This is triggered on application Layer (NWK:01EF.1, NWK:01F0.1).
12. Controller Replication is initiated by the Primary Controller. The Controller that will be included/transfer Topology is in learning mode and the process follows Figure 4.90 (NWK:01F6.1, NWK:01F7.1).
13. Any Controller starts a Neighbor Discovery as part of inclusion. Neighbor Discovery may be done periodically by a Primary Controller to update its network topology. It shall follow Figure 4.91 or Figure 4.92 (NWK:01F8.1, NWK:01F9.1, NWK:01FA.1).
14. FL nodes of 250ms and 1000ms may be in the same Find Nodes In Range command setting the "Wake Up Time" field to 0x01 as per Figure 4.92 (NWK:01FB.1).

3.60.5 Fail Criteria

1. Any of the passing Criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

3.61 Functional Description – Controller Functionalities and Network Maintenance

Controllers can perform different functionalities depending on their role and maintain the status of the network.

3.61.1 Prerequisites

1 x Z-Wave Zniffer.
3 x Z-Wave PC Controller.
2 x AL End Nodes (one of which can trigger Static Route Request Command).
1 x FL End Node
We assume it's possible to override the fields of the command in advance to performing inclusion

3.61.2 Test Setup

1. Include the second Controller setting it as SIS to the secondary Controller.
2. Include FL End Node to the Network with the RealPrimary Controller.
3. Include the first AL End Node to the Network using SUC/SIS Controller directly.
4. Set the SUC/SIS in inclusion Mode. Set the third Controller in Learning Mode.
5. Include the second AL End Node to the third Controller.
6. Set the Secondary Inclusion Controller in Learning Mode. On Real Primary Controller press the Shift button to transfer the role of Primary Controller.
7. On the new RealPrimary Controller select the first (now Secondary/Inclusion) Controller. Press Set as SIS button.
8. Set the new RealPrimary in exclusion mode. Exclude the AL Node which can trigger Static Route Request Command.
9. In the new Secondary Controller press the Update button.
10. Remove the new Secondary Controller from the network with the new RealPrimary Controller.
11. Place the excluded Secondary Controller one hop away from the SUC/SIS and the Real/Primary Controller. Include it with NWI to the network using the AL End Node as a repeater.
12. Include the AL End Node which can trigger Static Route Request Command using the Secondary Controller so that it has 1 or 2 hops distance to the SUC/SIS.
13. On the Primary Controller Request a Network Update to the SUC/SIS and at the same time trigger the Static Route Request Command on the remote AL End Node.
14. Trigger the Static Route Request Command on the AL End Node (this command is not supposed to be used other than for testing purposes). Make sure it's configured to request return routes for up to 5 nodes.

3.61.3 Test Result

1. The Secondary Controller is included answers with Set SUC ACK (SUC Capability = 0x01) and assumes the SIS Role.
    a. The including Controller assumes the RealPrimary role.
2. Real Primary requests a Reserve Node ID to the SIS before starting Inclusion Mode.
    a. Secure bootstrapping is handled by the SIS.
3. The SIS Controller includes the AL End Node and it performs a Neighbor and Range test on it.

　　　　a. The AL End Node probes both Controllers and the FL End Node.
4. The third Controller is included to the SUC/SIS Controller.
　　　　a. The third Controller updates its network information.
　　　　b. The RealPrimary Controller does not update its Network information.
　　　　c. The third Controller probes all existing nodes in the network.
　　　　d. The third Controller is included as a Secondary Inclusion Controller.
5. The third Controller (Secondary Inclusion Controller) includes the second AL End Node to the Network.
　　　　a. The Inclusion Controller requests an Automatic Controller Update before the Inclusion.
　　　　b. The Inclusion Controller requests a Reserved Node ID to the SIS.
　　　　c. The SUC/SIS Controller handles the secure Bootstrapping.
　　　　d. The second AL End Node probes all nodes in the network.
　　　　e. Only the SUC/SIS and Secondary Inclusion Controllers update their Network information.
6. The RealPrimary Controller starts the process to shift Roles
　　　　a. RealPrimary Controller requests an Automatic Network Update to the SIS.
　　　　b. It transfers all Node Info and Range info it holds to the Secondary controller.
　　　　c. The transference ends with a Transfer New Primary Completed command and Transfer End.
7. There can only be one SUC/SIS in the network. The attempt is rejected.
8. The new RealPrimary Controller excludes the AL End Node which can trigger Static Route Request Command.
　　　　a. It issues a New Node Registered Command to the SUC/SIS Controller.
　　　　b. The SUC Updates its Network Topology status.
9. The new Secondary Controller requests a Network Update by going in Learning Mode.
10. The new Secondary Controller is removed from the Network.
　　　　a. The SUC/SIS is notified of this change.
　　　　b. The new RealPrimary Controller ends the exclusion issuing a Transfer End to NodeID 0.
11. The Secondary Controller is reincluded to the network through a repeater.
12. The AL End Node is included to the network managing Secure bootstrapping by the SUC/SIS through repeaters.
13. The SUC/SIS starts updating the RealPrimary Controller on direct range.
　　　　a. The command of Static Route Return Request may be answered with a Transfer End by the SUC before being available again.
14. The SUC/SIS assigns return routes to the End Node for the different nodes in the command.

3.61.4 Pass Criteria

1. A secondary Controller in Learning Mode must accept Transfer Primary Controller when received (NWK:01D4.1).
2. When shifting the Primary Controller role, it follows Figure 4.80. This role shall be accepted (NWK:01D7.1, NWK:01D8.1).
3. Giving the SUC/SIS role follows Figure 4.81. Primary Controller doesn't assign the SUC/SIS role if there is one already present in the network (NWK:01DB.1, NWK:01DC.1).

4. A Primary Controller takes the Inclusion Controller role if the other controller accepts the SUC/SIS role returning Set SUC Ack with "State" and "Capabilities" fields set to 0x01 (NWK:01DD.1).

5. Inclusion Controllers can add nodes on behalf of the SIS (NWK:01E1.1).

6. An Inclusion Controller requests an Automatic Controller Update to the SIS prior including a node (NWK:01E2.1).

7. Secondary Controller goes into Learn Mode to receive the network topology (NWK:0195.1, NWK:0199.1).

8. Controllers excluding a Controller should issue a Tranfer End command to HomeID 0x00000000 and NodeID 0x00 for backwards compatibility; The excluded Controller acknowledges the Transfer End (NWK:01C4.1, NWK:01C5.1).

9. Inclusion Controllers request NodeID to the SIS before inclusion (NWK:01E3.1).

10. Inclusion Controller issues New Node Registered and New Range Registered to the SIS after successful inclusion (NWK:01E4.1).

11. Inclusion by an Inclusion Controller follows Figure 4.84 (NWK:01E5.1).

12. Inclusion Controller may remove nodes from the network on behalf of the SIS. Issuing a New Node Registered to the SIS when it's a node from the same network but not when it's a foreign Network. Exclusion by an Inclusion Controller follows Figure 4.85 (NWK:01E6.1, NWK:01E7.1, NWK:01E8.1, NWK:01E9.1).

13. When the SUC is not the Primary Controller, the Primary Controllers update the SUC with updated topology after including or excluding a node, by Issuing New Node Registered and New Range Registered after a successful inclusion after Figure 4.88 (NWK:01F1.1, NWK:01F2.1).

14. A Primary Controller Issues New Node Registered to the SUC after successfully removing a node in the same network, not when it's in a different network and the exclusion update follows Figure 4.89 (NWK:01F3.1, NWK:01F2.1, NWK:01F3.1).

15. End Nodes shouldn't calculate routes on their own, since they don't have a full topology of the network. They may request information to the SUC using Static Route Request command following Figure 4.93. The SUC should assign *nwkRecommendedNumberOfReturnRoutes* return routes for each NodeID in the command (NWK:01FC.1, NWK:01FD.1, NWK:01FE.1).

16. If the SUC is busy carrying other other operation, it may return a Transfer End Command with "Status" field set to 0x04 as per Figure 4.94 (NWK:01FF.1).

3.61.5 Fail Criteria

1. Any of the passing criteria is not met.
2. Variation outside of the allowed parameters causes successful results when they should not be.

REFERENCES

[G.9959]   ITU-T G.9959, Short range narrowband digital radiocommunication transceivers – PHY & MAC layer specifications

[PHY_TEST] ZWA_Z-Wave PHY layer Test specification

[MAC_TEST] ZWA_Z-Wave MAC Layer Test Specification

[NWK]   ZWA_Z-Wave and Z-Wave Long Range Network Layer Specification