ENGINEERING
TOMORROW

User Manual

PLUS+1® GUIDE
Extended Dynamic RedCAN

www.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
December 2019	Converted to Engineering Tomorrow standards	0201
January 2013	Check Appendix modes added	AD
February 2012	Wording, parameter changes	AC
March 2010	First revision	AB
January 2010	Original revision	AA

Contents

Risk Reduction

Downloading and testing your applications

Once you have created an application, you have the responsibility to download and test the application.

You should only download your application to hardware or change software parameters while the vehicle is not in operation. After downloading, test application operation under normal and abnormal operating conditions. You should make sure that:

- Individual inputs produce expected outputs .
- Combinations of inputs do not produce unexpected or dangerous outputs
- Fault handling and error checking work as designed

Important information to reduce risk

The applications that you create with the PLUS+1® GUIDE Service Tool program typically control heavy, powerful, and mobile off-road equipment such as tractors, cranes, and harvesters.

Fault checking and error handling

The PLUS+1® GUIDE Service Tool program has no automatic protections against these risks. The Service Tool has no protection against the risks that result from bugs in the Service Tool software, errors in the Service Tool manual, or incompatibilities between software versions of the Service Tool.

You must design and test your application to reduce these risks.

You have the responsibility when designing a Service Tool application to include the checking and the error handling needed to reduce risks in normal and abnormal operating conditions.

The following are some items to consider when developing fault checking and error handling for your application:

- How the machine is normally used.
- Possible operator errors and their consequences.
- Industry safety standards and legal requirements.
- Input and output failures and their consequences. These failures can include:
- — Joystick, sensor, and other inputs suddenly going to 100 % or to O %.
  — Outputs that control machinery direction, speed, and force suddenly changing direction or going to 100 % or to O %.

Decide how likely each failure is. The more likely a failure, the more you need protect against the consequences of the failure .

- The sequence of events and consequences of a fault or error.
- The sequence of events and consequences of an emergency stop.

Warning

Under normal operating conditions, using this type of machinery always involves risk of personal injury and equipment damage. Abnormal operating conditions increase the risk of personal injury and equipment damage.

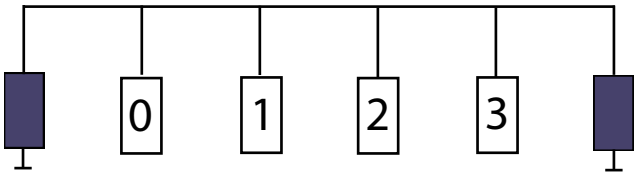
Introduction

Overview

Normal CAN structure

A normal CAN structure is illustrated below. There is one single CAN connection per module. Bus termination is handled with external resistors.

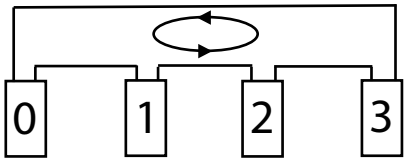
Normal CAN Structure



Danfoss RedCAN is based on a redundant CAN communication principal. RedCAN uses two CAN connections per module. The modules are connected in a ring structure to provide a second path for communication in the event of a segment error.

RedCAN structure

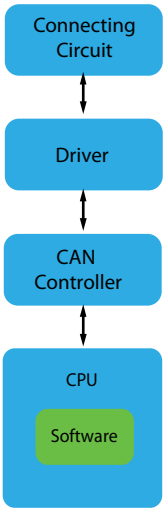
RedCAN Structure



Termination of the bus is handled automatically inside the ECU by the RedCAN connection. No external resistors are required.

System behavior depends on parameter settings. Incorrect parameters may lead to system malfunction. It is recommended to disconnect the controller from the system and set parameters before reconnecting it to the system.

RedCAN uses one standard CAN driver with controller but has the additional connecting circuit logics to terminate the bus and provide the second communication path in the event of a bus failure.



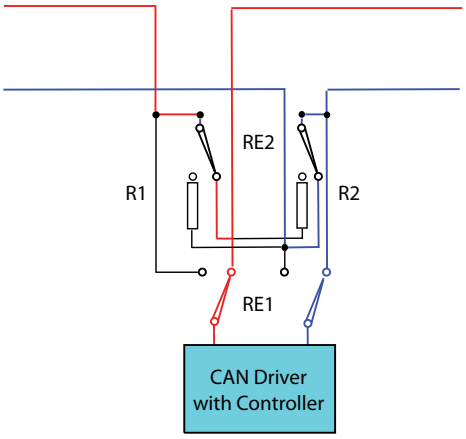
Introduction

Transparent connection mode

The Connecting Circuit consists of relays that provide three different connection options:

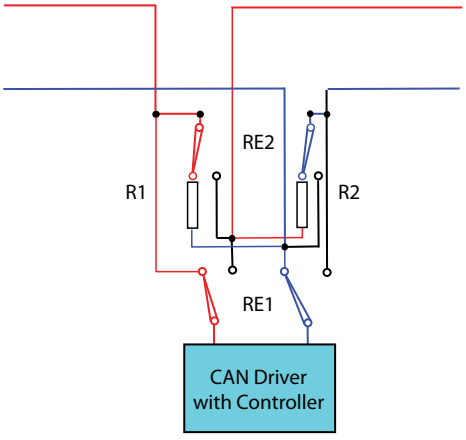
Transparent Mode Normal and Redundant connections are both connected to the CAN controller. Terminators are not connected.

Transparent connection mode



Normal connection mode

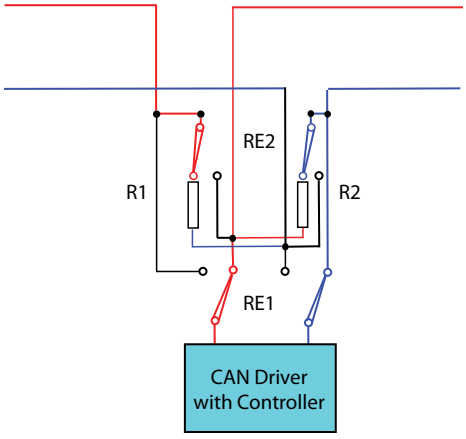
Normal Connection Mode Both Normal and Redundant connections are terminated. Only Normal connection is connected to the CAN controller.



Introduction

Redundant connection mode

Redundant Connection Mode	Both Normal and Redundant connections are terminated. Only Redundant connection is connected to the CAN controller.



RedCAN Overview

Overview

Description

When using Dynamic RedCAN each node has knowledge about its closest neighbors and with that information determines if it should act as a master holding the termination and initiating the fault detection heartbeat or go transparent while waiting for the heartbeat to initiate.

RedCAN inputs

RedCAN function block inuputs

Input	Type	Range	Description
Freeze	BOOL	—	Used to turn off RedCAN
Check Appendix	BOOL	—	Used to turn master relays to look opposite direction.
Def System	ARRAY (128) U8	—	Array containing predefined system. (Lowest ID in position 0, Normal neighbor in position 1, etc).
Scan	BOOL	—	Initialize a system scan
Max Exectime	U8	5–255	Maximum execution time during system scan. This is the execution time of the slowest unit on the RedCAN loop and, is used for all units connected to the RedCAN loop. Constant recommended (default 30 ms).
Max Timeout	U16	75–50000	Sets how long to wait for heartbeat message before regarded as error. Minimum default setting is 5 times greater than Time Base (450 ms).
TimeBase	U16	15–10000	Sets detection timeout and heartbeat rate. (how often the heartbeat should be sent). Minimum default setting is 3 times greater than Max_ExecTime (90 ms).
CAN	Bus	—	—
Extended_ID	BOOL	—	Use extended CAN message IDs
CAN_ID_Offset	U32	0x0-0x1FFFFF00	Offset for CAN ID to put messages in a desirable range. Messages used are in this range (0x00–0xFF) + Offset.
Node	U8	0–127	Number to distinguish nodes from each other
Port	Port	—	CAN port to use
BusOff	BOOL	—	Error on CAN wire
Reset	BOOL	—	Output activated -> Reset BusOff (delete connection in Unit_Config).

RedCAN Outputs

Ouput	Type	Range	Description
OS_Out			
RedCAN_RelayMode	U8	0–2	0: Transparent 1: Normal 2: Redundant This signal is either the signal from the RedCAN_ Link block or the signal decided from the diagnostic tool.
Status	Bus		

RedCAN Overview

Ouput	Type	Range	Description
Mode	S16	-1–4	-1: Undefined (no mode has been detected after Startup or Check Appendix) 0: System Ready 1: System Scan 2: Freeze 3: Download 4: Check Appendix
NbrOfNodes	U8	0–128	Total number of connected RedCAN nodes in the system.
MisplacedArray	ARRAY (128) U8	—	Holds information about nodes that are not placed as defined system describes.
NodeMisplaced	BOOL	—	Flag that informs that there are nodes in the designed system that are not connected.
NodeNvrFnd	BOOL	—	Flag that informs that there are nodes in the designed system that are not connected.
NodeNvrFndArray	ARRAY (128) U8	—	Holds information about nodes that are not connected.
Fault	Bus		
BusError	BOOL	—	A wire error has been detected.
Node1	U8	0 – 127	The error is on Normal side of this node (only certain if all N-R connections).
Node2	U8	0 – 127	The error is on the Redundant side of this node (only certain if all N-R connections).
NodeGone	BOOL	—	Flag that informs that a node has disappeared from the system after startup.
NodeGoneArray	ARRAY (128) U8	—	Holds information about nodes that have been lost since startup.

Block Functions

Block types

The Extended implementation consists of five separate block parts:

- Link Block
- Beat Block
- Diagnostic Block
- Freeze Block
- Relays Block

The blocks could all be used in every controller but it could also be that one controller acts as the diagnostic interface and is the only one using the Diagnostic block. Other controllers in the system only need Link and/or Beat blocks.

Link block

The Link Block detects the nodes in the System and their relative positions. It also takes care of bus termination and disconnects faulty segments to keep the bus intact.

Link block inputs

Input	Type	Range	Description
Freeze	BOOL	—	Use to turn off RedCAN
Check Appendix	BOOL	—	Use to turn master relays to look opposite direction. Enables detection of some faults that may otherwise be missed.
System	ARRAY (128) U8	—	Array containing actual system (Lowest ID in position 0, Normal neighbor in Position 1, etc).
Scan	BOOL	—	Initialize a system scan
Init	BOOL	—	Controls whether a scan should be initiated on power up. T: Scan is initiated on power up. F: No scan, system is regarded as correct.
Delay	U16	0–65535	Sets the delay time before heartbeat is enabled. This is to handle differences in startup time for the nodes in the system. Only valid when init=false.
Max Exectime	U8	5–255	Maximum execution time during system scan. Constant recommended (default 30 ms).
CAN	Bus	—	—
Extended_ID	BOOL	—	Use extended CAN message IDs.
CAN_ID_Offset	U32	0x0- 0x1FFFFF00	Offset for CAN ID to put messages in a desirable range. Messages used in the range (0x00–0xFF) + offset.
Node	U8	0–127	Number to distinguish nodes from each other.
Port	—	—	CAN port to use
BusOff	BOOL	—	Error on CAN wire
Reset	BOOL	—	Output activated-> Reset BusOff (delete connection in Unit_Config.

Block Functions

Link block outputs

Output	Type	Range	Description
OS_out	Bus	—	—
RedCAN_RelayMode	U8	0–2	0: Transparent 1: Normal 2:Redundant
Status	Bus	—	—
Mode	S16	-1–4	-1: Undefined (no mode has been detected after Startup or Check Appendix) 0: System Ready 1:System Scan 2: Freeze 3: Download 4: Check Appendix
NodeError	BOOL	—	Error found during system scan
Ready	BOOL	—	System scan completed
Neighbors	Bus	—	—
ClosestNeighb	U8	0–127	Node ID of the neighbor the side that relays are turned towards.
IStartSprint	BOOL	—	The lowest node in the system that initiates the heart beat. First position in system array.
ImMaster	BOOL	—	The lowest terminating node. Master.
ImMstrOpsitNeigh	BOOL	—	The node on the opposite side of the master.
LowestRandID	U32	0–4294967295	Needed to handle multiples with same node number.
Max_ExecTime	U8	0–255	Maximum Max_ExecTime value in the system. Used to set the limits for beat block timings.
MyRandomID	U32	0–4294967295	Needed to handle multiples with same node number.
NormNeighbNodeID	U8	0–127	Node ID of the normal side neighbor.
NormNeighbRandID	U32	0–4294967295	Needed to handle multiples with same node number.
OpRandID	U32	0–4294967295	Needed to handle multiples with same node number.
OppstNeighb	U8	0–127	Node ID of the opposite side neighbor.
RedNeighbNodeID	U8	0–127	Node ID of the Redundant side neighbor.
RedNeighbRandID	U32	0–4294967295	Needed to handle multiples with same node number.

Beat block

The Beat Block detects the absolute position of the nodes (actual system) and detects errors in runtime

Beat block inputs

Input	Type	Range	Description
Enable	BOOL	—	Enable heartbeat function. Connected to Link block output ready by default.
Neighbors	Bus	—	Information about the system to determine how the heartbeat should be sent through the system.

Block Functions

Input	Type	Range	Description
IStartSprint	BOOL	—	The lowest node in the system that initiates the heartbeat. First position in system array.
ImMaster	BOOL	—	The lowest terminating node. Master.
ImMstrOpsitNeigh	BOOL	—	The node on the opposite side of the master.
LowestRandID	U32	0–4294967295	Needed to handle multiples with the same node number.
Max_ExecTime	U8	0–255	Maximum Max_ExecTime
MyRandomID	U32	0–4294967295	Needed to handle multiples with the same node number.
NormNeighbNodeID	U8	0–127	Node ID of the Normal side neighbor.
NormNeighbRandID	U32	0–4294967295	Needed to handle multiples with the same node number.
OpRandID	U32	0–4294967295	Needed to handle multiples with the same node number.
OppstNeighb	U8	0–127	Node ID of the opposite side neighbor.
RedNeighbNodeID	U8	0–127	Node ID of the redundant side neighbor.
RedNeighbRandID	U32	0–4294967295	Needed to handle multiples with same node number.
Max Timeout	U16	75–50000	Sets how long to wait for heartbeat message before regarded aserror. Minimum default setting is 5 times greater than Time Base (450 ms).
TimeBase	U16	15–10000	Sets detection timeout and heartbeat rate. (how often the heartbeat should be sent). Minimum default setting is 3 times greater than Max_ExecTime (90 ms).
CAN	Bus	—	—
Extended_ID	BOOL	—	Use extended CAN message IDs.
CAN_ID_Offset	U32	0x0-0x1FFFFF00	Offset for CAN ID to put messages in a desirable range (0x00–0xFF) + Offset.
Node	U8	0–127	Numbers to distinguish nodes from each other.
Port	—	—	CAN port to use

Beat block outputs

Output	Type	Range	Description
Status	Bus	—	—
FirstDone	BOOL	—	First heartbeat loop done.
MasterMsg	ARRAY (128) U8	—	Holds information about terminating nodes. Used to report wire errors.
NbrOfNodes	U8	0–128	Total number of connected RedCAN nodes in system
System_OK	BOOL	—	No errors detected.
System	ARRAY (128) U8	—	Array containing actual system (Lowest ID in position 0, Normal neighbor in Position 1, etc).
Scan	BOOL	—	Initiate a system scan.

Block Functions

Diagnostic block

The Diagnostic block recieves information from the other two blocks to report different types of error situations.

Diagnostic block inputs

Input	Type	Range	Description
Link Status	Bus	—	
Mode	S16	-1 –4	-1: Undefined (no mode has been detected after Startup or Check Appendix) 0: System Ready 1: System Scan 2: Freeze 3: Download 4: Check Appendix
NodeError	BOOL	—	An error has been detected during system scan.
BeatStatus	Bus	—	—
FirstDone	BOOL	—	First heartbeat loop done
MasterMsg	ARRAY (8) U8	—	Holds information about terminating nodes.
NbrOfNodes	U8	0–128	Total number of connected RedCAN nodes in system.
NodeFault	BOOL	—	A node has failed to pass on the heart beat.
Def System	ARRAY (128) U8	—	Predefined system, what the desired system looks like.
Act System	ARRAY (128) U8	—	Actual system, how the system looks (Lowest ID in position 0, Normal neighbor in position 1, etc).
CAN	Bus	—	—
Extended_ID	BOOL	—	Use Extended CAN message IDs
CAN_ID_Offset	U32	0x0- 0x1FFFFF00	Offset for CAN ID to put messages in a desirable range. (0x00–0xFF) + Offset
Port	—	—	CAN port to use

Diagnistic block outputs

Output	Type	Range	Description
Status	Bus	—	—
Mode	S16	-1–4	-1: Undefined (no mode has been detected after Startup or Check Appendix) 0: System Ready 1: System Scan 2: Freeze 3: Download 4: Check Appendix
NbrOfNodes	U8	0–128	Total number of connected RedCAN nodes in system.
MisplacedArray	ARRAY (128) U8	—	Holds information about nodes that are not placed as defined system implies.
NodeMissplaced	BOOL	—	Flag that informs that there are nodes with wrong position in system.
NodeNvrFnd	BOOL	—	Flag that informs that there are nodes in the designed system that are not connected.

Block Functions

Output	Type	Range	Description
NodeNvrFndArray	ARRAY (128) U8	—	Holds information about nodes that are not connected.
Fault	Bus	—	—
BusError	BOOL	—	A wire error has been detected.
Node1	U8	0–127	There is an error between Node 1 and Node 2. The error is on the Normal side of this node. (Only certain if all N–R connections).
Node2	U8	0–127	There is an error between Node 1 and Node 2. The error is on the Redundant side of this node. (only certain if all N–R connections)
NodeGone	BOOL	—	Flag that informs that a node has disappeared from the system after startup.
NodeGoneAway	ARRAY (128) U8	—	Holds information about nodes that have been lost since startup.

Freeze block

The Freeze block listens to CAN message KP0 from the Service Tool to set RedCAN to freeze. Therefore it will keep its current status and will not react to any faults.

Freeze block inputs

Input	Type	Range	Description
CAN	Bus	—	—
Node	U8	0–127	Number to distinguish nodes from each other
Port	—	—	CAN port to use

Freeze block outputs

Output	Type	Range	Description
Freeze	BOOL	—	Freeze set from diagnostic tool
Checkpoint	—	—	—
CP_RedCANFreeze			Shows current freeze status

Relays block

The Relays block controls the steering of the RedCAN relays. When the RedCAN block is in freeze, it is possible to set the relays to either Transparent, Normal or Redundant. The Relays block listens to CAN message KP136.

Relays block inputs

Input	Type	Range	Description
Freeze	BOOL	—	Freeze set from diagnostic tool
CAN	Bus	—	—
Node	U8	0–127	Number to distinguish nodes from one another
Port	—	—	CAN port to use

Block Functions

Input	Type	Range	Description
OS_In	Bus	—	—
RedCAN_RelayMode	U8	0–2	0: Transparent 1: Normal 2: Redundant The signal coming from the RedCAN_Link block. This is the signal determined from the last linking of the units.

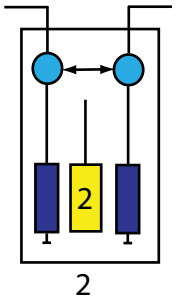
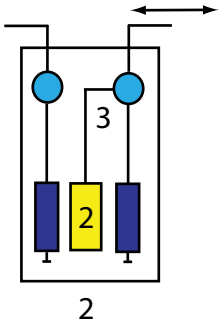
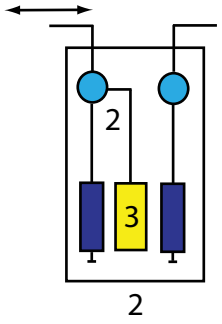
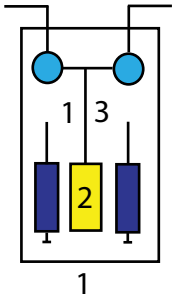
Relays block outputs

Output	Type	Range	Description
OS_Out	—	—	—
RedCAN_RelayMode	U8	0–2	0: Transparent 1: Normal 2: Redundant This signal is either the signal from the RedCANLink block or the signal decided from the service tool.
Checkpoint	—	—	—
CP_RedCANRelayMod	U8	0–2	Shows the current status of the RedCAN relay mode.

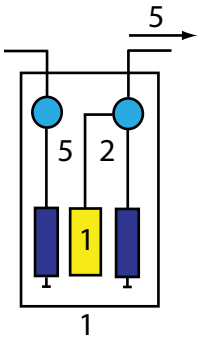
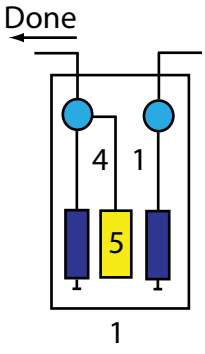
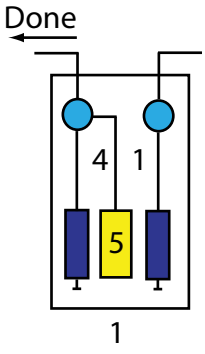
Theory of Operations

Theory of operation

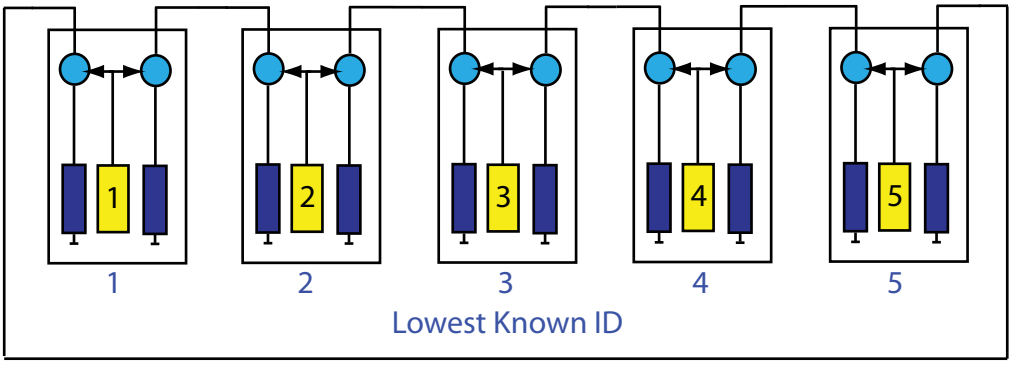
When the system is complete and there are no faults, each node could be in any of the following states:

Scanning. No Neighbor found		Own node ID: 2, Lowest node ID: 2. None found: Lowest = Own
Normal neighbor found. Perform handshake.		Own node ID: 2, Lowest node ID: 2, Normal neighbor: 3
Redundant neighbor found. Perform handshake		Own node ID: 3, Lowest node ID: 2, Redundant neighbor: 2
Lower node ID detected. Set Transparent		Own node ID: 2, Lowest node ID: 1, Own ID (2) >Lowest ID (1), Normal neighbor : 3, Redundant neighbor : 1

Theory of Operations

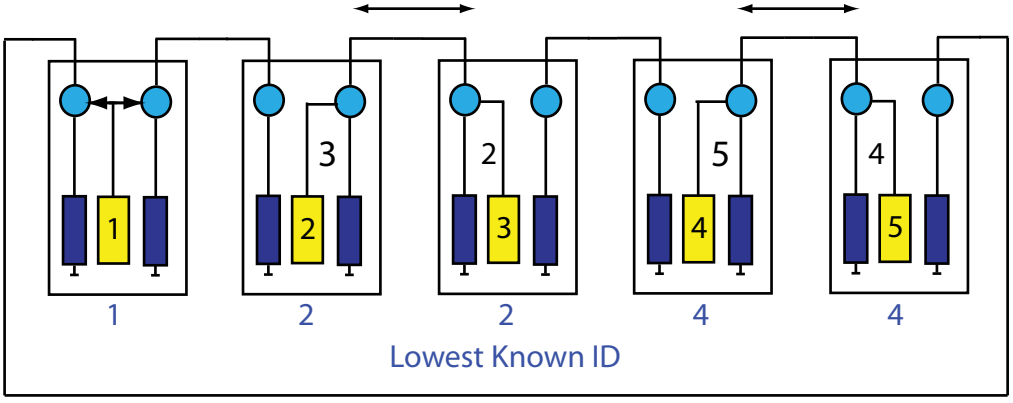
Node is detected as lowest Node ID, terminate and ask for opposite neighbor		Own Node ID : 1, Lowest Node ID : 1, Own ID (1) = Lowest ID, Normal neighbor : 2, Redundant neighbor : 5, Opposite neighbor : 5
Node is asked for as opposite neighbor. Reply		Own Node ID :5, Lowest Node ID : 1, Normal neighbor : 1, Redundant neighbor : 4, Opposite neighbor : 5, Own ID (5) : Opposite neighbor
Lowest Node ID has recieved reply from opposite neighbor. Ring is complete and • heart beat is initiated		

At start up, or if an error is detected, a scan system is initialized:

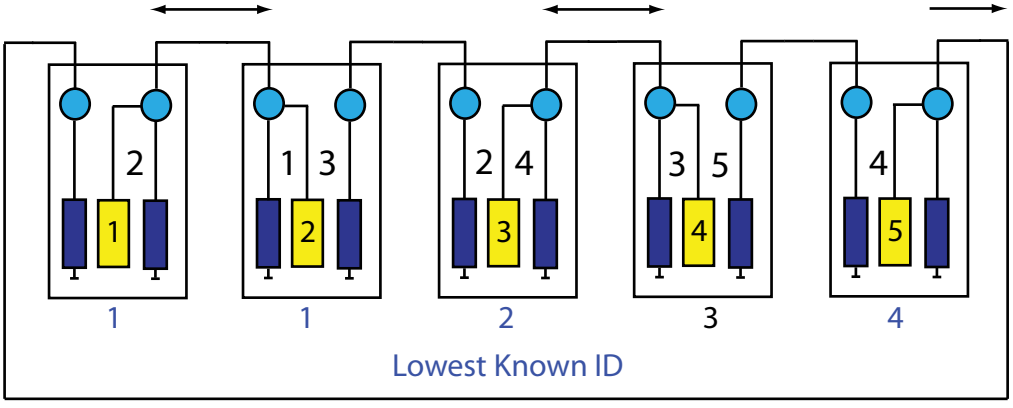


Theory of Operations

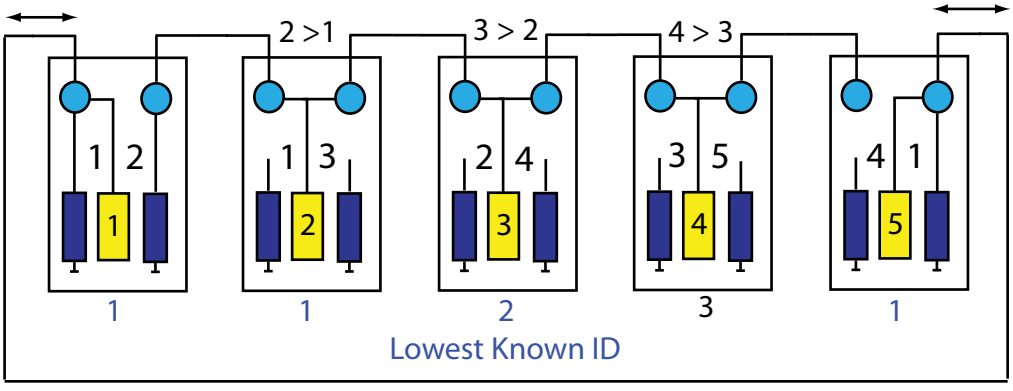
The position in the system determines if the node should turn to the normal or the redundant side:



When the neighbor has been detected or if the random time out passes, the node turns toward the opposite side.

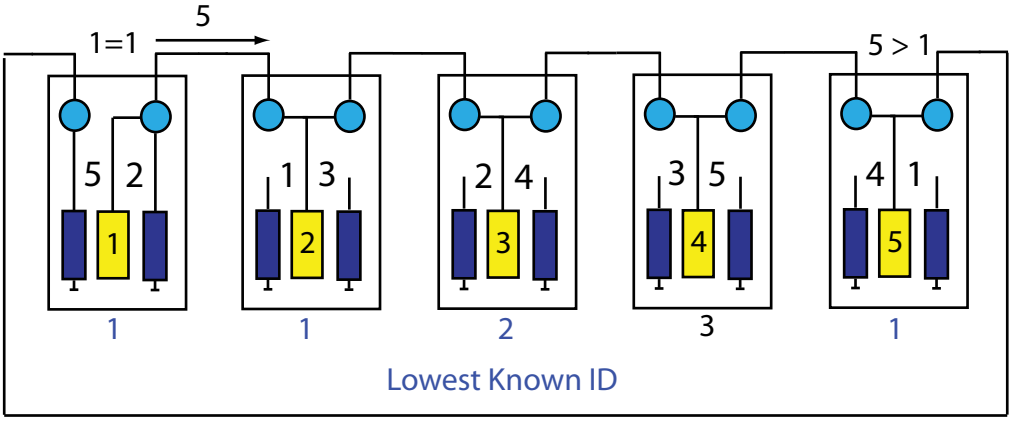


When the Node ID is not the lowest known ID in the system and both neighbors are found, the node turns transparent.

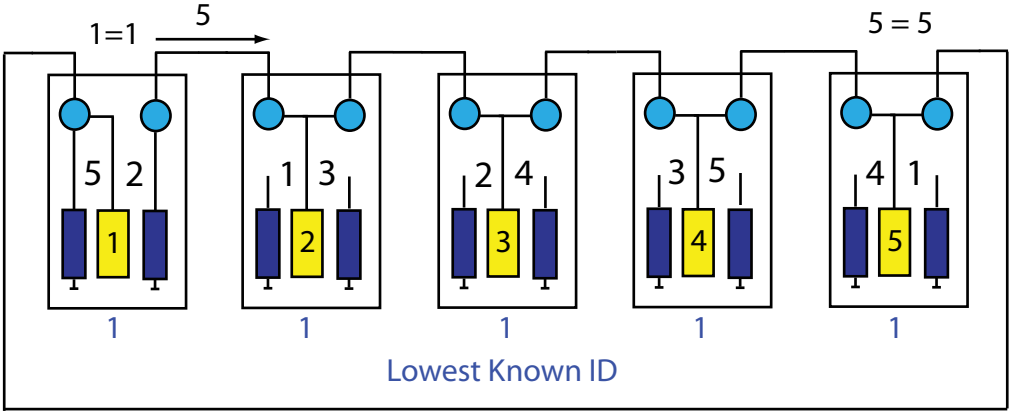


Theory of Operations

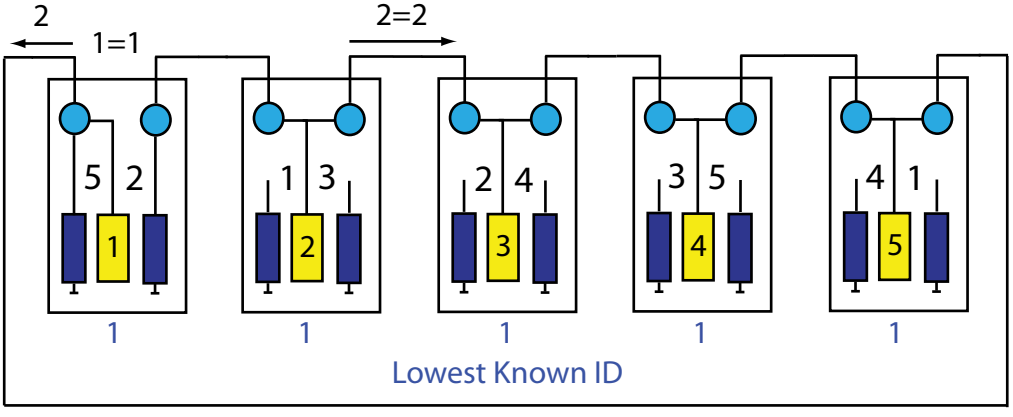
The lowest known ID in the system takes the role of master and holds termination for the system.



The lowest known ID in the system takes the role of master and holds termination for the system.

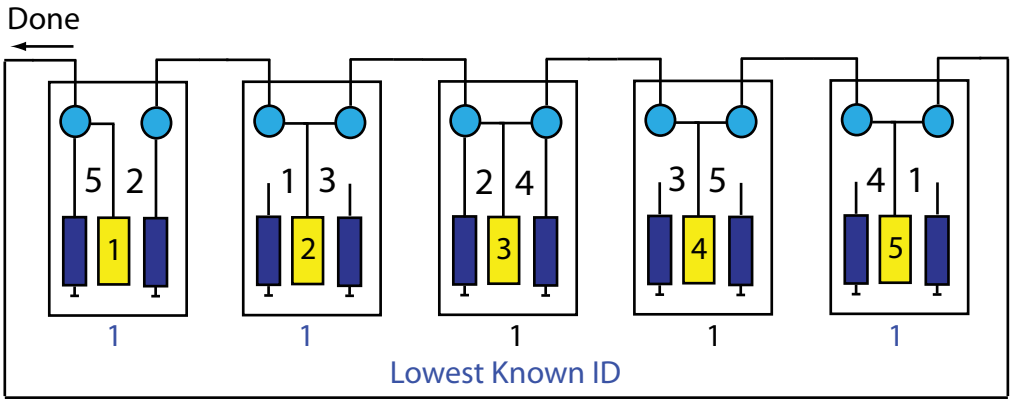


Then turns and ask for other opposite neighbor to ensure a complete system and the opposite neighbor applies.



Theory of Operations

The master then sends out a system OK and initiates the heart beat.



Theory of operation: Summary

When the system is connected (Mode = 0), a heartbeat message is transmitted to confirm a healthy communication path. Each node then listens to the heartbeat messages from its two neighbors and if one of the messages does not come through an error is declared and a new scan is initiated.

To determine the exact setup of the system, a sequence of messages is sent from the master node to it's neighbor in normal direction. The messages are then passed on to the next neighbor until the complete system is covered. In this way, all nodes will get information about the complete system setup and it can be compared with the predefined system to detect errors in node order.

It is optional to scan at power up. If init is false, a scan is not triggered and the system input is used as a predefined system to determine the master node (terminating and starting the heart beat). The entire ring is always checked at startup by the master asking for opposite neighbors in both directions.

Troubleshooting

Possible error conditions

This table identifies errors that could possibly occur:

Problem	Possible Cause
Bus/segment errors	CAN wires shortened, faulty ground connection
Node missing/ not responding or 'babbling idiot' behavior	All nodes in defined system are not present in actual system
Node misplaced	Positions in actual system differ from defined system

Fixing errors

The time to detect an error and fix it depends on the parameter settings. The parameter 'Time Base' sets the timeout for the heartbeat message. This is the error detection time. The parameter 'Max_ExecTime' is used to calculate how long a node will wait for a response before changing direction during a scan. The theoretical worst case scan time is 112*Max_ExecTime, calculated based on the total timeout. The theoretical best time is 32*Max_ExecTime, based on the time for communicating only (no waiting time).

The total fix time is the sum of error detection time and scan time:

- Worst Case fix time: TimeBase + 112*Max_ExecTime
- Best Case fix time: Time Base + 32*Max_ExecTime

Table of errors and system reactions

If several errors appear at once, they are all reported but a functional system cannot be guaranteed if more than one error occurs at the same time.

RedCAN is able to handle the first error and report where the first error occurs so it can be fixed. But, if that error is not fixed then there is no guarantee that the system will continue to work if another error is occurring.

Output	Type	Range	Description
Status	Bus	—	—
Mode	S16	-1–4	-1: Undefined (no mode has been detected) 0: System Ready 1: System Scan 2: Freeze 3: Download 4: Check Appendix
NbrOfNodes	U8	0–128	Total number of connected RedCAN nodes in system
MisplacedArray	ARRAY (128) U8	—	Holds information about nodes that are not placed as defined system implies.
NodeMissplaced	BOOL	—	Flag that informs that there are nodes with wrong position in system.
NodeNvrFnd	BOOL	—	Flag that informs that there are nodes in the designed system that are not connected.
NodeNvrFndArray	ARRAY (128) U8	—	Holds information about nodes that are not connected.
Fault	Bus	—	—
BusError	BOOL	—	A wire error has been detected.
Node1	U8	0–127	There is an error between Node 1 and Node 2. The error is on the Normal side of this node. (Only certain if all N–R connections).

Troubleshooting

Output	Type	Range	Description
Node2	U8	0–127	There is an error between Node 1 and Node 2. The error is on the Redundant side of this node (only certain if all N–R connections).
NodeGone	BOOL	—	Flag that informs that a node has disappeared from the system after startup.
NodeGoneAway	ARRAY (128) U8	—	Holds information about nodes that have been lost since startup.

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