ETHERNET POWERLINK

EPSG Draft Standard 302-E

Ethernet POWERLINK

Part E: Dynamic Node Allocation

Version 1.2.1

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Pre. 2 History

Vers.	Date	Author		short description
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Pre. 6 Definitions and Abbreviations

Pre. 6.1 Definitions

Pre. 6.2 Abbreviations

ASnd	Asynchronous Send (POWERLINK frame type)
CN	Controlled Node
CRC	Cyclic Redundancy Check
DNA	Dynamic Node Allocation
ID	Indentifier
MAC	Media Access Control
MN	Managing Node
NN	Node Number
PReq	Poll Request (POWERLINK frame type)
PRes	Poll Response (POWERLINK frame type)
PResMN	PRes frame of the Managing Node
SoA	Start of Asynchronous (POWERLINK frame type)
SoC	Start of Cyclic (POWERLINK frame type)

Pre. 7 References

[1] EPSG Draft Standard 301 (EPSG DS 301), Ethernet POWERLINK, Communication Profile Specification

[2] EPSG Draft Standard 302-A (EPSG 302-A), Ethernet POWERLINK, High Availability Extension

1 Introduction

Setting the node number of POWERLINK devices turned out to be a significant source of error during commissioning. The node switches are tiny and often hard to recognize on the devices mounted in the electrical cabinet.

If a wrong node number is assigned to a device the managing node is not able to identify it. Even worse, if the same node number is set on two ore more devices usually all of them cannot be identified and additionally collisions will occure on the network.

To overcome these troubles it would be much easier if there is no need to set any node number switch. The node number should be assigned to the devices by the managing node instead.

This specification defines how to assign node numbers by the managing node depending on the topology of the network.

2 Basics

2.1 General

The node switch of all nodes that obtain their node number by DNA shall be set to 0.

The MN sends IdentRequest frames to the NN 0 to identify such nodes. When a node replies with an IdentResponse the MN sends the NMT Command DNA to assign the node number.

To prevent all nodes with node switch 0 to reply to such an IdentRequest every node shall deactivate sending on all its Ethernet ports in case node switch is 0 or the MN has set the AN flags inside the SoC and SoA frames. Due to this the IdentRequest frame will only reach one node with no node number configured. After assigning a node number the MN enables an Ethernet port of this node and sends further IdentRequests.

The MN knows the network topology and with the NMT Command DNA it is able to switch on or off the Ethernet ports of the CNs. So the MN is able to parse through the network, search for the nodes and assign the node numbers one by one.

2.2 Topology

DNA does not limit the topology of the network. However it might not be possible that every node gets its node number from DNA service.

A line topolology can be built with DNA nodes easily. Therefore DNA capable nodes shall be equipped with an onboard hub. This hub shall be able to switch on and off each hub port individually.

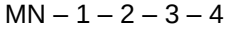

Fig. 1. Line topology

A star topology may be implemented with nodes including a multi-port onboard hub. Each port of this hub shall be controllable by the node itself resp. by NMT command from the MN.

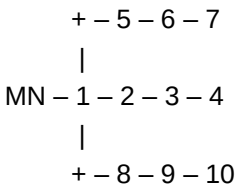

Fig. 2. Star topology with internal hub

Otherwise conventional hubs may be used. In this case DNA is not possible for the nodes connected to the hub directly. These nodes are so called head-of-line nodes (marked with a * in the figure below). For the nodes behind head-of-line nodes DNA is possible again.

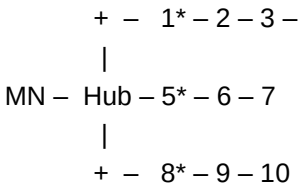

Fig. 3. Star topology with external hub

Nodes not supporting DNA shall be placed at the end of a line or in separate segments. There is no need to switch on or off ports of an hub. Anyway it is not allowed to place DNA devices behind devices not supporting DNA.

2.3 Head-of-line node

The node number of a head-of-line node is derived from the node switch only and cannot not be configured by NMT Command DNA.

A head-of-line node usually is the first node of a line of nodes. However every node with node switch not equal 0 is called a head-of-line node.

Head-of-line nodes are used when connecting more than one node to an external hub. Because the hub cannot be addressed with the NMT Command DNA for switching on and off its ports an IdentRequest to NN0 will be received by all nodes directly connected to the hub. So all of them would reply to the IdentRequest at the same time. This leads to a collision of the various IdentResponse frames.

2.4 Loss of communication, lease time

The node number set by the MN is only valid as long any POWERLINK communication takes place. After the reception of the last POWERLINK frame the node number is still valid for the lease time. When the lease time expires the node number is the number set by the node switch again.

The lease time is set by MN within the NMT Command DNA.

If no lease time is configured the new node number is valid until power down. In this case the node will not respond to IdentRequests to NN0 until a power cycle is executed.

2.5 Compatibility

Conventional POWERLINK devices may be used in DNA networks without any restriction except network topology.

Because it is not possible to switch on and off the Ethernet ports of conventional devices they shall always be placed at the end of a line or in separate network segments. Anyway it is not allowed to place DNA devices behind conventional devices.

For DNA configuration conventional devices are treated like head-of-line nodes.

2.6 Features

- No setting of the node number by node switch on the devices necessary
- Knowledge about the network topology necessary
- Increased network boot-up time (due to assigning the node number one by one)
- Use of conventional devices and DNA devices in the same network possible
- DNA Nodes require a special onboard hub.

3 Extensions of the communication profile specification

3.1 AN flags inside the SoC and SoA frames

The MN sets the ANglobal flag in all SoC and SoA frames to indicate that DNA is active.

As a result CNs with an integrated hub shall not forward frames and send response frames on the receive port only unless they receive a dedicated IdentRequest with the ANlocal flag reset or a specific hub port has been activated by the NMT Command DNA.

Note:

The ANlocal flag is necessary in case a CN not supporting DNA is replaced by a CN supporting DNA and the configuration on the MN has not been changed.

Otherwise the new CN supporting DNA would keep all its ports switched off because it interprets the ANglobal flag and does not get a NMT Command DNA to switch on its ports.

	Bit Offset							
Octet Offset [1]	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	res	MessageType						
1	Destination							
2	Source							
3	reserved							
4	MC	PS	res	res	**AN global**	res	res	res
5	res	res	res			res		
6 .. 13	NetTime / reserved							
14 .. 21	RelativeTime / reserved							
22	**SoCFeatureFlags**							
	res	res	res	res	res	res	res	**DNA**
23 .. 25	**SoCFeatureFlags (reserved)**							
26 .. 45	reserved							

Tab. 1 SoC frame structure

[1] Octet Offset refers to the start of the POWERLINK frame. Offset to the start of the Ethernet frame is 14 Octets.

	Bit Offset							
Octet Offset [2]	7	6	5	4	3	2	1	0
0	res	MessageType						
1	Destination							
2	Source							
3	NMTStatus							
4	res	res	res	**AN local**	**AN global**	EA/res	ER/res	res
5	res	res	res			res		
6	RequestedServiceID							
7	RequestedServiceTarget							
8	EPLVersion							
9 .. 45	Reserved							

Tab. 2 SoA frame structure

Field	Abbr	Description	Value
Automatic Node Numbering global flag	AN global	Flag: Shall be set if DNA is active. On detection of this flag a CN shall not forward frames and send response frames on the receive port only unless a specific hub port has been activated by a separate command.	
Automatic Node Numbering specific flag	AN local	Flag in IdentRequest only: Shall be set if DNA is active for a dedicated CN. On detection of this flag reset a CN shall forward frames and send response frames on all port, i.e. the CNs behaves like a node not supporting DNA.	
DNA feature flag in SoC	DNA	Flag: Shall be set if the MN is supporting DNA (and especially signalling of AN global flag in SoC).	

Tab. 3 Additional SoC and SoA frame data fields

See [1] for a detailed description of the SoC and SoA frame structure.

3.2 NMT Command DNA

This new NMT command shall be used to

- set the node number,
- enable and disable ports of the onboard hub of CNs and
- set the lease time of the node number.

Furthermore the MAC ID and current node number may be used additionally to make sure that the right node is addressed.

[2] Octet Offset refers to the start of the POWERLINK frame. Offset to the start of the Ethernet frame is 14 Octets.

	Bit Offset							
Octet Offset	7	6	5	4	3	2	1	0
0[3]	res	MessageType						
1	Destination							
2	Source							
3	Service ID = 4							
4	NMT Command ID = 0x2D (DNA)							
5	res	res	res	LTV	HPM	NNN	MAC	CNN
6	Current MAC ID (48 Bit)							
7								
8								
9								
10								
11								
12	Hub-Port-Enable-Mask (64 Bit)							
13								
14								
15								
16								
17								
18								
19								
20	Current Node Number (32 Bit)							
21								
22								
23								
24	New NodeNumber (32 Bit)							
25								
26								
27								
28	Lease Time [µsec] (32 Bit)							
29								
30								
31								

Tab. 4 NMT Command DNA

[3] Octet Offset refers to the start of the POWERLINK frame. Offset to the start of the Ethernet frame is 14 Octets.

Field	Abbr	Description	Value
Lease time valid	LTV	Flag: Shall be set if the field “Lease Time” is valid. The lease time shall be adopted immediately.	
Hub port enable mask valid	HPM	Flag: Shall be set if the field “Hub port enable mask” is valid. The dedicated hub ports shall be enabled immediately.	
Set new node number	NNN	Flag: Shall be set if the field “New node number” is valid. The new node number shall be adopted within the time specified in D_NMT_CNSetNodeNumberTime_U32.	
Compare current MAC ID	MAC	Flag: If set the CN shall compare the field “Current MAC ID” with its own MAC ID before processing this NMT command.	
Compare current node number	CNN	Flag: If set the CN shall compare the field “current node number” with its own node number before processing this NMT command.	
Current MAC ID		Current MAC ID of the CN addressed by this command.	
Hub port enable mask		Enable mask for the Ethernet ports of the onboard hub.	Bit value 0…disable 1…enable
Current node number		Current node number of the CN addressed by this command.	
New node number		New node number to be set.	
Lease Time		Specifies how long the new node number set by this command is valid after a Loss of communication occured. [µs]	

Tab. 5 NMT Command DNA data fields

4 Controlled Node operation

If the node switch is set to 0 the node number is assigned to the CN by the NMT Command DNA. After a Loss of communication the new node number is valid until the lease time expires. Then the node number is 0 again.

As long as no node number has been assigned the CN shall reply to an IdentRequest with RequestedServiceTarget = 0.

On CNs with more than one Ethernet port, sending on these ports shall be deactivated by default if the node switch is 0 or the CN receives an SoA with the ANglobal flag equal to 1.

The CN may only send response frames (Ident, Status, PReq) on a deactivated port if a request frame has exactly been received on this port. No other frames may be sent on deactived ports.

A port is activated only if

- the device is in Basic Ethernet Mode or
- the CN receives a dedicated IdentRequest with the ANlocal flag reset or
- the CN receives the dedicated NMT command.

If the AN flags inside the SoC and SoA frames are reset DNA is not used in the network then. Hence all ports are active and act as usual.

Whatever topology is used one port of the CN is always connected towards the MN. The cable towards the MN shall be connected to port no. 1. All other ports of the CN shall be used to connect further parts of the network.

In case of ring redundancy [2] port no. 2 shall be used as second port if the device has more than two ports.

5 Managing Node operation

5.1 General

So far and without DNA the POWERLINK protocol is independent of the network topology. The MN does not have any knowledge about the topology. The MN only knows about some timeouts due to runtimes on the wire.

Now with DNA the MN must know the topology of the network to be able to parse through and search for the CNs. This can be achieved with three parameters per node. These parameters are:

- Predecessor node number
  see Object 1FA0$_h$: NMT_PredecessorNodeNumberList_AU32
- Hub port on predecessor.
  See the chapter on Controlled Node operation for a detailed use of the different ports and Object 1FA1$_h$: NMT_PredecessorHubPortList_AU32.
- Head-of-line node yes/no
  see Object 1F81$_h$: NMT_NodeAssignment_AU32

The MN identifies the DNA nodes one by one. Therefore it has to switch on the dedicated hub port of the predecessor node and send an IdentRequest to NN0. If the node does not reply with an IdentResponse the hub port of the predecessor has to be switched off. Now the MN is ready to search for the next DNA node in another branch of the topology tree. If the node replies with an IdentResponse the MN sends the NMT Command DNA to assign the node number and set the lease time. If the DNA node replies to an IdentRequest with the new node number in the IdentResponse the MN is ready to search for the next DNA node in this line or in another branch.

Head-of-line nodes are identified with an IdentRequest to the dedicated node number.

5.2 Loss of a node

If the managing node detects the loss of a node it shall switch off the dedicated hub port of the predecessor node immediately.

This is to make sure only one device responds to the IdentRequest to NN0. After switching off the hub port the managing node may continue the search for not identified nodes.

5.3 Ring redundancy

Ring redundancy as defined in [2] may be used together with DNA. However special attention must be paid on switching on and off the hub ports.

6 Additional Object Description

6.1.1 Object 1030h .. 1039 h: NMT_InterfaceGroup_*Xh*_REC

The following objects are used to configure and retrieve parameters of the network interfaces (physical or virtual) via SDO. Each interface has one entry. See [1] for more details.

Additional subindex 0A h used:

Index	1030h .. 1039 h	Object Type	RECORD
Name	NMT_InterfaceGroup_Xh_REC		
Data Type	NMT_InterfaceGroup_Xh_TYPE	Category	1030h: M 1031h .. 1039h: O

To allow access by name "*_Xh*" is replaced with a name index. For example, the name index is "*_0h*" if the object index is 1030h. The name index is incremented up to "*_9h*" corresponding to object index 1039h.

- **Sub-Index 00h: NumberOfEntries**

Sub-Index	00h		
Name	NumberOfEntries		
Value Range	9-10	Access	const
Default Value	-	PDO Mapping	No

NumberOfEntries is implemetation specific.

- **Sub-Index 0Ah: PortEnableMask_U64**

Sub-Index	0Ah		
Name	PortEnableMask_U64		
Data Type	UNSIGNED64	Category	O
Value Range	UNSIGNED64	Access	ro
Default Value	-	PDO Mapping	No

This value is set by the field Hub-Port-Enable-Mask of the NMT Command DNA frame and may be read for diagnosis.

PortEnableMask_U64 specifies the enable mask for all ports of this interface, e.g. in case of an Ethernet interface with an onboard hub is used.

Value interpretation: Every bit corresponds to a port. Bit enumeration starts with the LSB. Bit value = 0…port disabled, = 1…port enabled.

6.1.2 Object 1F81h: NMT_NodeAssignment_AU32

This object assigns nodes to the NMT Master (MN). On the CN the object is conditional. See [1] for more details.

Each sub-index in the array corresponds to the node with the node ID equal to the sub-index.

The object should be set by the system configuration.

Additional bit used:

Index	$1F81_h$	Object Code	ARRAY
Name	NMT_NodeAssignment_AU32		
Data Type	UNSIGNED32	Category	MN: M CN: Cond

- **Sub-Index 01_h .. FE_h: NodeAssignment**

Sub-Index	01_h .. FE_h		
Name	NodeAssignment		
--	--	Category	M
Value Range	Bit field, see below	Access	rw, valid on reset
Default Value	0	PDO Mapping	No

Octet	Bit	Value	Description	Property	Evaluate
2	15	0_b	Node number not assigned by DNA (head-of-line node)	CN	MN
		1_b	Node number assigned by DNA		

Tab. 6 NMT_NodeAssignment_AU32 additional bit interpretation

6.1.3 Object $1F82_h$: NMT_FeatureFlags_U32

The Feature Flags indicate communication profile specific properties of the device given by its design. The object shall be setup by the device firmware during system initialisation.

Additional bit used:

Octet	Bit	Name	TRUE	FALSE
2	20	Dynamic Node Allocation	Device supports DNA	Device does not support DNA

Tab. 7 NMT_FeatureFlags_U32 additional bit interpretation

6.1.4 Object $1F98_h$: NMT_CycleTiming_REC

NMT_CycleTiming_REC provides node specific timing parameters, that influence the POWERLINK cycle timing.

Additional subindex $0F_h$ used on the CN only:

Index	$1F98_h$	Object Code	RECORD
Name	NMT_CycleTiming_REC		
Data Type	NMT_CycleTiming_TYPE	Category	M

- **Sub-Index 00_h: NumberOfEntries**

Sub-Index	00_h		
Name	NumberOfEntries		
Value Range	9 .. 15	Access	const
Default Value	-	PDO Mapping	No

- **Sub-Index $0F_h$: LeaseTime_U32**

Sub-Index	$0F_h$		
Name	LeaseTime_U32		
Data Type	UNSIGNED32	Category	MN: no, CN: O
Value Range	UNSIGNED32	Access	ro
Default Value	0	PDO Mapping	No

This value [µs] is set by the field Lease Time of the NMT Command DNA frame and may be read for diagnosis.

LeaseTime_U32 specifies how long the new node number set by NMT Command DNA is valid after a Loss of communication occurred.

6.1.5 Object $1FA0_h$: NMT_PredecessorNodeNumberList_AU32

NMT_PredecessorNodeNumberList_AU32 holds a list of the predecessor node number of the nodes.

Index	$1FA0_h$	Object Code	ARRAY
Name	NMT_ PredecessorNodeNumberList_AU32		
Data Type	UNSIGNED32	Category	MN: M, CN: no

- **Sub-Index 0_h: NumberOfEntries**

Sub-Index	00_h		
Name	NumberOfEntries		
Value Range	1 .. 254	Access	rw
Default Value	254	PDO Mapping	No

- **Sub-Index 01_h .. FE_h: PredecessorNodeNumber**

Sub-Index	01_h .. FE_h		
Name	PredecessorNodeNumber		
--	--	Category	M
Value Range	UNSIGNED32	Access	rw
Default Value	240	PDO Mapping	No

Each sub-index in the array corresponds to the CN with the Node ID equal to the sub-index. The sub-index value is valid only if there is a CN assigned to the Node ID by index NMT_NodeAssignment_AU32[sub-index] bits 0 and 1.

Each sub-index holds the node number of the predecessor node.

6.1.6 Object $1FA1_h$: NMT_PredecessorHubPortList_AU32

NMT_PredecessorHubPortList_AU32 holds a list of the hub port number on the predecessor node.

Index	1FA1h	Object Code	ARRAY
Name	NMT_ PredecessorHubPortList_AU32		
Data Type	UNSIGNED32	Category	MN: M, CN: no

- **Sub-Index 0h: NumberOfEntries**

Sub-Index	00h		
Name	NumberOfEntries		
Value Range	1 .. 254	Access	rw
Default Value	254	PDO Mapping	No

- **Sub-Index 01h .. FEh: PredecessorHubPort**

Sub-Index	01h .. FEh		
Name	PredecessorHubPort		
--	--	Category	M
Value Range	UNSIGNED32	Access	rw
Default Value	0	PDO Mapping	No

Each sub-index in the array corresponds to the CN with the Node ID equal to the sub-index. The sub-index value is valid only if there is a CN assigned to the Node ID by index NMT_NodeAssignment_AU32[sub-index] bits 0 and 1.

Each sub-index holds the hub port number on the predecessor node.

The value 0 indicates that it is not possible to switch the hub port of the predecessor node on or off.

7 Additional Device Description Entry (normative)

Name	Description	Type	Category		Default	
			MN	CN	MN	CN
D_NMT_CNDNA_BOOL	Ability of a Controlled Node to perform Dynmic Node Allocation	BOOL	-	M	-	N
D_NMT_CNSetNodeNumberTime_U32	Maximum time the CN needs to set the new node number in [µs]	UNSIGNED32	-	M	-	0
D_NMT_MNDNA_BOOL	Ability of a Managing Node to perform Dynmic Node Allocation	BOOL	M	-	N	-

end-of-file