Report on the Current Status of Rework on the Device Profile CiA 408 'Fluid Power, Proportional Valves'

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Device specific profiles provide important advantages when implementing intelligent network structures for machine control. In these supplementary standards (device and application profiles), the behaviour and parameters of standardized devices or applications are specified.
For proportional valves, hydrostatic pumps, and hydrostatic transmissions the common device profile CiA 408 has been specified, which is based on the bus independent device profile 'Fluid Power Technology' of the VDMA (Verband Deutscher Maschinen- und Anlagenbau). The initial version of CiA 408 was published in 2003. This profile has been implemented by many manufacturers of hydraulic components to provide a common, vendor-independent way of hydraulic device integration into a CANopen system.
Since then, the functionality of hydraulic devices has increased: new control modes and sensor interfaces have been defined and a lot of feedback from the field has been collected during the last years. In order to take account of these developments, the fieldbus independent device profile 'Fluid Power Technology', was updated in 2011 which resulted in the new version 1.6. This report will give a short overview and point out the changes and new features of the derived CAN bus specific device profile CiA 408.

Introduction

The actual CANopen device profile 'Fluid Power' CiA 408 describes the functionality of interconnectable proportional valves, hydrostatic pumps and hydrostatic transmissions, e.g., axis control with a hydraulic cylinder. The document is based on the profile 'Fluid Power Technology', version 1.5 released by VDMA Verband Deutscher Maschinen- und Anlagenbau e.V., Frankfurt/Main, Germany /VDMAPROP/. The following report will give an update of the changes made in the new version 1.6 of this VDMA device profile 'Fluid Power Technology'. There are plans to take over these changes from the fieldbus independent device profile into the new version of the CANopen specific CiA 408 device profile.

Initial Trigger for the Rework of the Device Profile CiA 408

In October 2006, the 1st VARAN (real time bus system based on Ethernet physics) Profile Meeting - Hydraulics took place in Böblingen, Germany. Companies manufacturing or using hydraulic components and representatives of the fieldbus organisations participated on this meeting.

The purpose of the meeting was to define a communication and device profile which can be used for hydraulic components like valves, pumps and hydrostatic transmissions.

The participants decided to use the CANopen protocol as upper layer protocol. Especially the protocols PDO, SDO, NMT according CiA 301 and CiA 408 should be used. The lower network and data link layer is provided by the VARAN bus itself including a hard realtime synchronization protocol. The agreements and decisions of the meeting resulted in a document describing the CANopen mapping onto this bus, entitled 'CANopen Abbildung auf VARAN-Bus, V1.4.0', /VNOCAN/. Using the protocols just mentioned, the effort to integrate hydraulic devices into the real time Ethernet networks becomes as low as possible.

To keep communication as simple as possible the following issues for the VDMA device profile 'Fluid Power Technology' have been identified and solved:

- Only one data type for cyclic transmissions should be used: signed integer, 32bit.
- A default PDO mapping for the most common applications has been defined.
- Added Combined Power Supply and Communication Connector

However, touching the VDMA device profile, is an opportunity to improve the weak points in this profile as well. So the VDMA committee 'Bus Systems for Proportional Valves' decided to rework and update the following additional topics in the device profile by:

- specifying some details in the device state machine, adding the new state FAULT_INIT
- adding new sensor/actor interfaces / transducer types
- adding new control modes for pressure compensated flow control
- updating several diagrams
- adding detailed description for the dither signal

This resulted in the new version 1.6 of the VDMA device profile 'Fluid Power Technology'.

The Changes on the VDMA Device Profile 1.6 in Detail

Data Types for Setpoint and Actual Values

To control the hydraulic devices, setpoint values and actual values are provided for things like spool position, flow, pressure or axis position. The data format of these values is defined in the profile.

In the current Version of CiA 408, the following formats have been defined:

- Drives: data type of the values is INT32 / UINT32 (axis position, angle)
- Valves and pumps: data type of the values is INT16 / UINT16 (spool position, pressure)

In the VDMA profile, these types are referred as internal resolution ir or ir32.

The new profile defines the 32-bit setpoint and actual values not only for drives but also for valves and pumps. This makes the data exchange between devices easier as the programmer does not have to care about different resolutions. Thus several parameter values now can have 32-bit representation, too. The 32-bit parameters are mandatory for devices with VARAN interface.

The ControlWord and StatusWord are also represented as a 32-bit word. The lower 16bit are compatible to the 16bit ControlWord and StatusWord which, for compatibility reasons, remain unaffected.

The actually used data type depends on the implementation, see parameter '*Device_Capability*'

Bit 16	Bit 24	Description
0	0	not valid
0	1	16-bit implementation for valves / pumps (16-bit setpoints, actual values, Control- and StatusWord)
1	0	32-bit implementation for drives and valves / pumps (32-bit setpoints, actual values, Control- and StatusWord)
1	1	32-bit implementation for drives (32-bit setpoints, actual values, Control- and StatusWord) 16-bit implementation for valves / pumps (setpoints, actual values, Control- and StatusWord)

Table: Detailed description of Bit 16 and Bit 24 of Device_Capability

Diagram: Actuator control valves

Default PDO Mapping

As in the CANopen device profiles CiA 4xx, a default PDO mapping has been defined for the most common hydraulic applications. This should reduce the configuration/commissioning effort during initial operation as much as possible. Mapping 0..8 have been taken from CiA 408. Additional mappings have been defined with 32bit setpoint values having fixed resolutions:

- Valve spool position or pump swivel angle setpoint (resolution: 0.1%)
- Drive force or pressure setpoint (resolution: 0,01mbar)
- Drive position setpoint (resolution: 0.1µm)

Valve and Pump Application State Machine

The new state FAULT_INIT has been defined. This was necessary in order to avoid making transitions from INIT 'up to' FAULT_DISABLED caused by a device fault.

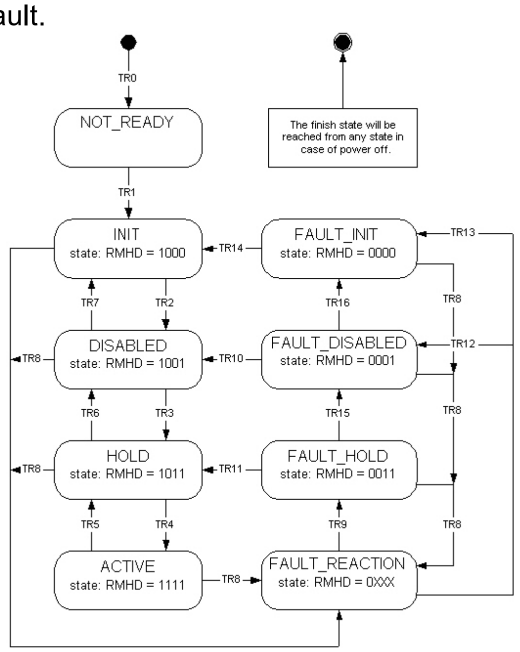


Diagram: Device State Machine

The explanations of all states and transitions have been improved. The transitions are now grouped into

- Transitions caused by ControlWord
- Transitions caused by enable signal
- Internal transitions (e.g., transitions caused by fault reaction)

New Control Modes

New control modes (13..15) for pressure compensated flow control have been introduced. For each type of device, one or several control modes are supported.

Control Mode	Meaning	Valve	Drive
0	control mode not defined (substitute value for valves)	X	
1	spool position control open loop	X	
2	spool position control closed loop	X	
3	pressure control valve open loop	X	
4	pressure control valve closed loop	X	
5	p/Q-control (p=pressure / force, Q=spool position)	X	
6	open loop movement (substitute value for hydrostatic axis)		X
7	velocity control axis		X
8	force / pressure control axis		X
9	position control axis		X
10	positional dependent deceleration		X
11	position control axis with pressure / force override		X
12	velocity control axis with pressure / force override		X
13	**flow control**	**X**	
14	**p/flow control (p=pressure / force, flow=flow control)**	**X**	
15	**p/flow control with power limitation**	**X**	
16.. 127	reserved		
-1..	vendor specific		

-127			

Table: Parameter description ‘Control Mode’

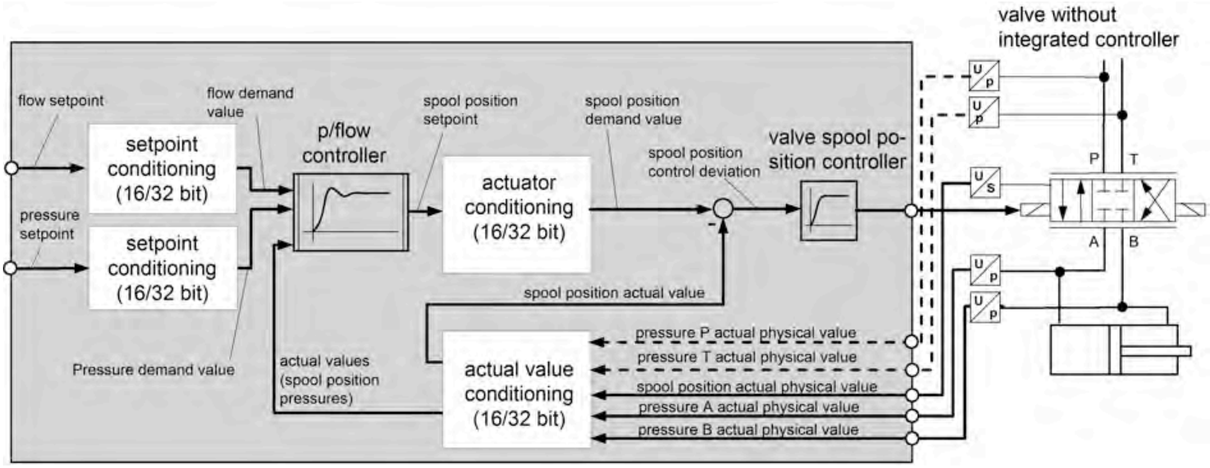


Diagram: Structure of p/flow control

In the p/flow control mode, pressure and flow are inputs as setpoints. The actual pressure(s) and spool position (in case of a valve) or pump displacement are measured. The actual flow is either measured or calculated internally. The controller structure, the parameters, and the dependencies of the setpoint derivation are defined vendor specifically.

Position Transducer Types

New position transducer types have been introduced. This parameter defines the type of the actual value conditioning of a sensor value. The transducer type 3 (differential pressure transducer) can be used to control differential pressure and thereby force of an axis. The transducer types 70..73 have been introduced to read in actual values for the drive controller (axis position) via fieldbus.

Actuator Conditioning

The CiA 408 based on the VDMA device profile 1.5 defined a ‘Demand Value Generator’ which is a signal conditioner for the spool position setpoint value. The name ‘Demand Value Generator’ suggests a functional block generating a setpoint value by itself. However this functional block does not generate a setpoint curve but it modifies/conditions a given setpoint value. In this sense, this block can be divided into two blocks: The first part does setpoint conditioning like limiting, scaling, rise limitation. The second part does actuator conditioning like deadband correction, zero correction and

characteristic compensation. In consequence, the previous block ‘Demand Value Generator’ has been split into two new blocks named setpoint conditioning and actuator conditioning.

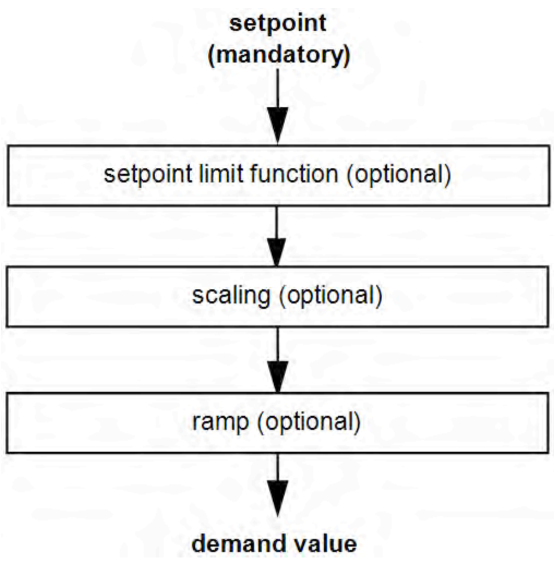


Diagram: Setpoint Conditioning

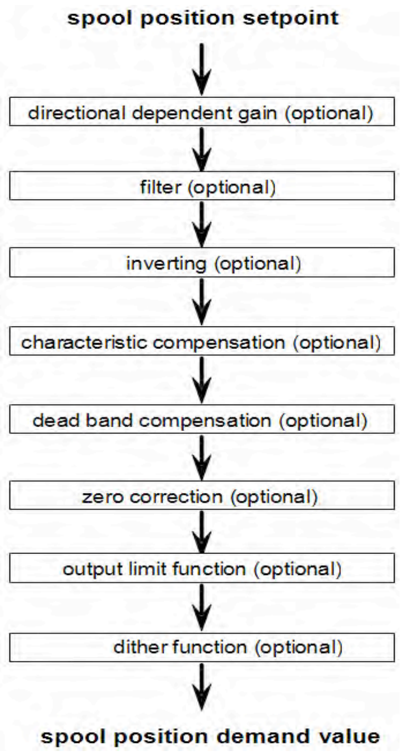
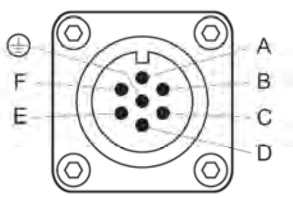


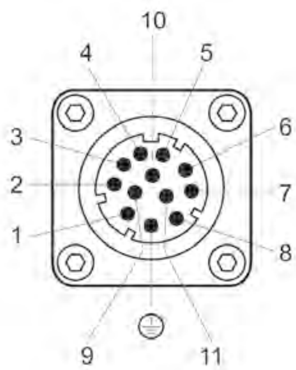
Diagram: Actuator Conditioning

Valve Connector

The following connectors are defined to supply the hydraulic devices with power, enable signals and analog setpoint values. The following connectors had been defined with the first release of the VDMA profile. They have proven their worth and fit hydraulic valves.



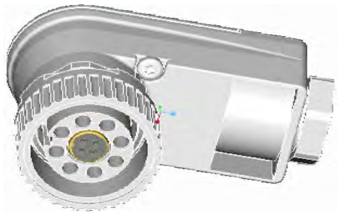
Power Supply 6+PE

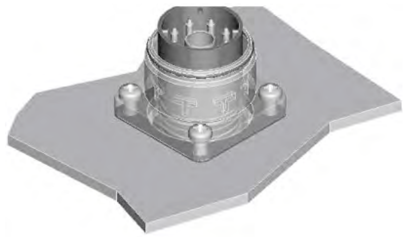


Power Supply 11+PE

When using these connectors in combination with a fieldbus, they show a certain disadvantage, as in this case at least one separate plug has to be used for the fieldbus signals. To solve this problem, a new connector with combined power and communication has been defined. It has been especially defined for Ethernet-based fieldbusses, see the following picture.

It is a connector type HC.26, which is an 8+4 pin connector, 8 pins for power and enable signals and 4 pins for the Ethernet signals.





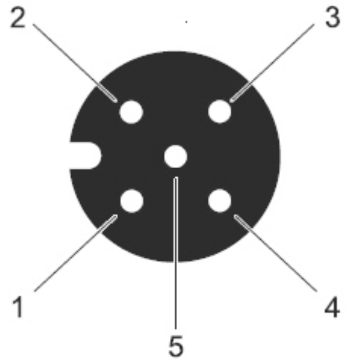
Pin	Marking	Description
1	+ UB P	power supply voltage +24 VDC
2	0 V P	power supply voltage 0V
3	ENABLE A	Enable input signal for output stage A
4	ENABLE B	Enable input signal for output stage B
5	/ERROR	error output
6	RECEIPT A	Receipt output signal for output stage A
7	RECEIPT B	Receipt output signal for output stage B
8	PE	PE (protected earth)
10	TX+	Ethernet TX+
11	TX-	Ethernet TX-
12	RX+	Ethernet RX+
13	RX-	Ethernet RX-

Table: Pinning of 8+4 Connector

Two more connectors for sensors have also been newly defined:

Sensor Interface Connector M12

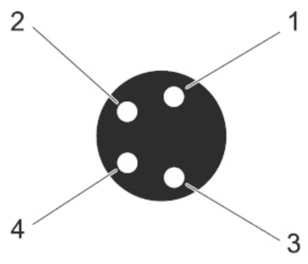
This connector has been defined as common used sensor interface for analog sensors. It corresponds to IEC 61076-2-101, coding A.



Pin	Marking	Description
1	+ UB	power supply +24 VDC
2	value 1	input/output value
3	0 V	power supply voltage 0 V
4	value 2	input/output value
5	vs	vendor specific

Sensor Interface Connector M8

This connector has been defined as common used sensor interface for analog sensors. It corresponds to IEC 61076-2-104, coding A.



Pin	Marking	Description
1	+ UB	power supply +24 VDC
2	value 1	input/output value
3	0 V	power supply voltage 0 V
4	value 2	input/output value (ground of Pin 2)

Summary

The CANopen device profile CiA 408 has proven its worth for many years and is successfully used in many devices. After this rework, it fits the future needs of faster physical transmissions and extended usage of connected sensors. More detailed and improved descriptions simplify the use of this device profile.

References

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/CiA 408/
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