Delta-Q IC-series CANopen Simplified

version 6 – Updated with SW v4.5.x objects (CAN Interface v2.4)

Conway Hui
Sales Application Manager
chui@delta-q.com

Remote Control Tutorial

Introduction

This document will describe, in basic CAN messages, how to fully control the Delta-Q IC-series Charger (COMM Version) via CAN bus.

Requirements

The following tutorial assumes the following set-up:

- IC-series charger, COMM version with CAN circuitry and configured:
  - To send all PDOs;
  - To be in Remote Control Mode; and
- CAN Physical Interface
- AC power cord and power
- DC cord and battery

Connections

Please refer to the IC-series Design Guide for proper CAN hardware connections to the charger. For testing you will also need AC power and a battery connected, preferably the one you will be charging, but any voltage source greater than 0.1V/cell will do (ie. 1.2V on a 24V charger).

Configuration

USB scripts can configure the following CAN parameters on the IC-series chargers. Settings changed for this tutorial are listed:

Parameter	**Default**	**Setting**
Charger Node	10	
Battery Node	1	
Baud Rate	125kbps	
PDO Mask	Send All CiA 418/419	
Heartbeat Timeout	2000ms	
Heartbeat Period	1000ms	
Remote Control Mode	Disable	Enable

NOTE: All data bytes are in little-endian.

Start-up

On establishing a connection the charger's heartbeat should appear on the bus:

CAN ID	Data Length (Bytes)	Data	Frequency (ms)	Note
70A	1	7F: Pre-operational	1000	Heartbeat Producer

The battery/BMS needs to send a heartbeat response to the charger telling it to go Operational:

701	1	05: Operational	1000	Heartbeat Response

The charger will respond with one event and one message. 08A is the fault register, it is confirming that the missing heartbeat error has been cleared. 601 will appear if the charger needs to poll the CAN bus looking for Nodes to configure PDOs for. This happens if the PDO Mask is set to CiA301 Standard. The charger will poll all CAN Nodes until it receives a response, ie. 601, 602, 603, and so on.

08A	8	00 00 00 00 00 00 00 00	One-time event	Fault register
601	8	N/A	500	Poll

"Start the Network" using the NMT command at 000, with an instruction 01 to start and directed at Node 10 (0A).

000	2	01 0A	One-time event	NMT Start

The charger should now start sending some PDOs if they are enabled. See Annex or the Electronic Data Sheet for the mapping of these PDOs. If they are not sent you will need to configure the PDOs manually or check your charger's PDO Mask setting. This example uses the CiA 418/419 default PDOs.

18A	1		200	TPDO0
28A	3		200	TPDO1
38A	4		200	TPDO2
48A	6		1000	TPDO3

Command

If the charger is set to Remote Control Mode, it is now ready to accept commands.

To start charging the charger needs:

- Battery Ready (6000h) set to 1
- Valid Current Request (6070h)
- Valid Voltage Request (2271h) [NOTE: Voltage Request is via SDO Only on 418/419 Standard PDO map, but has been added to the Delta-Q Standard PDO map]

First, set the battery status to ready so the charger closes the output relay. This can be done one of three ways: via the third byte of RPDO0;

20A	3	00 00 01	500	RPDO0

the third byte of RPDO1; or

30A	7	00 00 01 00 00 00 00	500	RPDO1

by writing an SDO to object 6000h with value 01.

60A	8	2F 00 60 00 01 00 00 00	One-time event	Battery Status

You should hear the output relay click closed and the lightning bolt symbol come on. The charger is now ready to output some power. At this point the charger should also be reporting Battery Voltage on 48A, third and fourth bytes. Here's an example:

48A	6	00 00 D1 32 60 10	1000	TPDO3

Here the data is 32D1h (byte reversed) which is 13009d. The voltage scaling factor is 1/1024 so this is 13009/1024 = 12.70V. The test system used for the rest of this example is a 12V battery. We'll attempt to give it a low power charge.

Let's start by setting a target voltage for this 12V test battery of 13.5V. That would be 13.5 * 1024 = 13824d = 3600h. So we want to write the data "3600h" to the CANOpen Object "2271h". With standard CiA 418/419 PDOs, we can only send this via SDO:

60A	8	23 71 22 00 00 36 00 00	One-time event	Request Voltage

We then also need to send a current command. Let's set 1.0 Amp. The scaling factor for writing current is 1/16 so 1.0 * 16 = 16d = 10h. This should be written to CANOpen Object "6070h" which can be done two ways: via RPDO2; or

40A	3	10 00 00	500	RPDO2

Or SDO.

60A	8	2B 70 60 00 10 00 00 00	One-time event	Request Current

The charger should start charging the battery. You will see the data on TPDO3 or 48A:

48A	6	A1 00 3D 36 60 10	1000	TPDO3

The current data is the first two bytes and the scaling factor for READING current is 1/256:

00A1h = 161d / 256 = 0.63A

The voltage data is the next two bytes and the scaling factor is 1/1024:

363Dh = 13885d / 1024 = 13.56V

Shut Down

To stop charging while retaining the existing connections (a soft shut down), it is recommended to first set the Current Request to 0 Amps. This can be via RPDO2 or SDO, but we'll use RPDO2 in this example:

40A	3	00 00 00	500	RPDO2

Once current is off, we'll set the Battery Status (6000h) to 0 via RPDO0, RPDO1, or SDO. If doing it by SDO remember that the RPDOs will overwrite the status immediately if they are still sending Battery Status of 1. For this example, we'll change the RPDO1 data:

20A	3	00 00 00	500	RPDO0

You will hear the output relay click off. This is the end of charging.

NOTE: CAN remains active even after AC power is removed. You will still continue to receive TPDOs from the charger and Heartbeats. The charger powers itself from DC. If you need an indication that the charger is disconnected from AC, use the interlock dry contacts on the COMM connector. You will also see a Charger Status "0" in TPDO1 (18A). On SW v3.x and later, AC Detect is in Object 2006h bit 4. See Annex for more details.

ANNEX A: CAN Objects

CiA 418/419 PDO Mappings:

	Base COB-ID	Length	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
RPDO0	200h	3	6010h *Battery Temperature LSB*	6010h *Battery Temperature MSB*	6000h *Battery Status*		
RPDO1	300h	5	6010h *Battery Temperature LSB*	6010h *Battery Temperature MSB*	6000h *Battery Status*	6060h *Battery Voltage LSB*	6060h *Battery Voltage MSB*
RPDO2	400h	3	6070h *Charger Current Request LSB*	6070h *Charger Current Request MSB*	6081h *Battery State of Charge*		

	Base COB-ID	Length	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
TPDO0	180h	1	6001h *Charger Status*					
TPDO1	280h	3	6001h *Charger Status*	6052h *Ah Returned During Last Charge LSB*	6052h *Ah Returned During Last Charge MSB*			
TPDO2	380h	4	6001h *Charger Status*	6052h *Ah Returned During Last Charge LSB*	6052h *Ah Returned During Last Charge MSB*	6080h *Charger State of Charge*		
TPDO3	480h	6	2002h *Charger Current LSB*	2002h *Charger Current MSB*	6060h *Battery Voltage LSB*	6060h *Battery Voltage MSB*	2006h *Extended Charge Status LSB*	2006h *Extended Charge Status MSB*

Delta-Q Standard PDO Mappings:

	Base COB-ID	Length	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
RPDO1	300h	5	6010h *Battery Temperature LSB*	6010h *Battery Temperature MSB*	6081h *Battery State of Charge*	6060h *Battery Voltage LSB*	6060h *Battery Voltage MSB*		
RPDO2	400h	7	*6070h Charger Current Request LSB*	*6070h Charger Current Request MSB*	*6000h Battery Status*	*2271h Voltage Limit Request LSB*	*2271h Voltage Limit Request*	*2271h Voltage Limit Request*	*2271h Voltage Limit Request MSB*

	Base COB-ID	Length	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
TPDO1	180h	4	6001h *Charger Status*	6080h *Charger State of Charge*	*6010h Battery Temperature LSB*	*6010h Battery Temperature MSB*			
TPDO2	380h	5	6001h *Charger Status*	*2005h-1 Elapsed Time LSB*	*2005h-1 Elapsed Time MSB*	*2009h-1 Ah Returned in Present Cycle LSB*	2009h-1 Ah Returned in Present Cycle MSB		
TPDO3	480h	6	2002h *Charger Current LSB*	2002h *Charger Current MSB*	2101h *Battery Voltage LSB*	2101h *Battery Voltage MSB*	2006h *Extended Charge Status LSB*	2006h *Extended Charge Status MSB*	

ANNEX B

Delta-Q SW v4.x, and CANopen 301, 419 objects:

Object	Sub-index	Length	Read Write	Description	Scaling Factor, range (units)	Default Value
1000h		UNSIGNED32	R	Device Type		000001A3
1001h		UNSIGNED16	R	Error Register	See CiA301	
1002h		UNSIGNED32	R	Manufacturer Status	Not Used	
1003h				Pre-Defined Error Field	See Delta-Q Interface Specification	
100Ah		ASCII		Manufacturer Software Version	See CiA301	
1014h		UNSIGNED32	R	COB-ID EMCY	See CiA301	
1016h	0	UNSIGNED8	R	Consumer Heartbeat Time, Number of Entries		2
	1	UNSIGNED32	RW	Consumer Heartbeat Time 1		000107D0
	2	UNSIGNED32	RW	Consumer Heartbeat Time 2		002107D0
1017h		UNSIGNED16	RW	Producer Heartbeat Time		03E8
1018h	0	UNSIGNED8	R	Identity Object, Number of Entries		5
	1	UNSIGNED32	R	Vendor Id		00000110
	2	UNSIGNED32	R	Product Code		
	3	UNSIGNED32	R	Revision Number		
	4	UNSIGNED32	R	Serial Number		
1F50h				Program Download	See Delta-Q Interface Specification “Program Download” section	
1F51h				Program Control		
1F56h				Program Software Identification		
1F57h				Flash Status Identification		
2002h		UNSIGNED16	RW	Charger Current	1/256, (A)	FFFF
2005h	1	UNSIGNED16	R	Elapsed Time since current charge cycle	*10, (seconds)	FFFF
	2	UNSIGNED16	R	Elapsed Time since current battery cycle	*10, (seconds)	FFFF
2006h		UNSIGNED16	R	Extended Charge Status	See below for details	FFFF
2009h	1	UNSIGNED32	R	Ah Returned in Present Cycle	1/8, (Ah) Resets on complete.	FFFFFFFF
200Bh		UNSIGNED8	R	Type of Current Charge Cycle	0: no charge started 1: charge 2: maintenance charge	00

					3-15: Reserved	
200Ch		UNSIGNED16	R	Start Battery Voltage of Current Charge Cycle	1/256, (V)	00
200Dh		UNSIGNED16	R	End Battery Voltage of Current Charge Cycle	1/256, (V)	00
200Eh		UNSIGNED16	R	Max Battery Voltage of Current Charge Cycle	1/256, (V)	00
200Fh		INTEGER16	R	Max Charger Temperature of Current Charge Cycle	1/4, (°C)	00
2010h		INTEGER16	R	Min Charger Temperature of Current Charge Cycle	1/4, (°C)	00
2011h		UNSIGNED8	R	Termination Reason of Current Charge Cycle	0: not terminated 1: algorithm disabled 2: external disable 3: AC removed 4: battery disconnected 5: algo changed 6: hardware suspend 7: charger reprogramming 8: termination by platform 9-15: reserved	00
2060h	2	UNSIGNED32	R	Ah Returned in Present Battery Connection	1/8 (Ah) Resets on loss of battery or AC.	FFFFFFFF
2100h		UNSIGNED16	RW	Battery Voltage	1/1024, (V)	FFFF
2101h		UNSIGNED16	RW	Battery Voltage (v3.x)	1/256, (V)	FFFF
2200h		UNSIGNED16	R	AC Voltage	1/16, (VAC)	FFFF
2241h		UNSIGNED16	RW	Active Algorithm Request	*See Delta-Q CANopen Interface Spec*	FFFFFFFF
2242h			R	Installed Algo Count Request	*See Delta-Q CANopen Interface Spec*	
2243h			RW	Set Algo Index Request	*See Delta-Q CANopen Interface Spec*	
2244h		UNSIGNED32	R	Get Algo Information Request	Bit 31-24: Major Version Bit 23-16: Minor Version Bit 15-00: Algo ID	
2250h			R	Charger Mode	0 = Power Supply	

					1 = Charging 2 = Diagnostic 3 = Safe	
2251h			R	Configuration Number	Returns configuration number of the charger as a string	
2271h		UNSIGNED32	RW	Voltage Limit Request	1/1024, (V)	FFFFFFFF
2275h		UNSIGNED8	RW	Cable Resistance	milliohms	
2302h		UNSIGNED16	RW	Ah Return Target	1/8, (Ah)	FFFF
2400h				Authentication	*See Delta-Q CANopen Interface Spec*	
2500h				Cumulative Counters	*See Delta-Q CANopen Interface Spec*	
2E00h				Retrieve Charge Data History – Write Record Number	*See Delta-Q CANopen Interface Spec*	
2E01h				Retrieve Charge Data History – Read Record Data	*See Delta-Q CANopen Interface Spec*	
2FFBh				Receive PDO CRC	*See Delta-Q CANopen Interface Spec*	
2FFCh				Transmit PDO CRC	*See Delta-Q CANopen Interface Spec*	
2FFDh				Receive PDO Sequence Count	*See Delta-Q CANopen Interface Spec*	
2FFEh				Transmit PDO Sequence Count	*See Delta-Q CANopen Interface Spec*	
4000h			W	Reset Request	Write 55AAh to reset	0
6000h		UNSIGNED8	RW	Battery Status	Bit 0: 1 = Ready 0 = Not ready	0
6001h		UNSIGNED8	R	Charger Status	Bit 0: 1 = Ready 0 = Not ready	0
6010h		INTEGER16	RW	Battery Temperature	1/8, -40 to + 85 (°C) -32768 if no sensor or shorted	0
6052h		UNSIGNED16	R	Ah Returned During Last Charge	1/8, (Ah)	FFFF
6060h		UNSIGNED32	RW	Battery Voltage	1/1024, (V)	0
6070h		UNSIGNED16	RW	Charge Current Request	1/16, (A)	0
6080h		UNSIGNED8	R	Charger State of Charge	1, 0 to 100 (%)	FF
6081h		UNSIGNED 8	RW	Battery State of Charge	1, 0 to 100 (%)	0

Object 2006h

Bits	Variable	Value	Description	Notes
15-12	Charge Cycle Type	0	No Active Cycle	
		1	Charge	
		2	Maintenance	
		3-15	(Reserved)	
11-8	Charge Indication	0	Inactive	
		1	< 80%	
		2	> 80%	
		3	Finishing	
		4	Complete	
		5	Resting	
		6	Equalize	
		7	Power Supply Mode	
		8-15	(Reserved)	
7-6	Override Status	0	Disabled	
		1	Enabled	
		2-3	(Reserved)	
5	Charger Status	0	Disabled	Same as bit 0 in 6001h
		1	Enabled	
4	AC Connection Status	0	No AC Detected	
		1	AC Detected	Actual Voltage at 2200h
3	Charger Derating Status	0	Charger is not derating	
		1	Charger is derating output	
2	Charger Hardware Shutdown Status	0	Charger is running normally	
		1	Charger hardware has shut down	
1-0	(Reserved)			

Annex C: Remote Mode Application Note

The application note below was provided by Delta-Q's software team:

The IC Series charger may be configured for remote operation. In this mode, the charger accepts voltage and current requests that together with an appropriate algorithm (e.g., 45) allow another node (e.g., battery monitor) to control the charger's output. There are several requirements that must be met in order for remote operation to work properly.

1) The charger must be configured for remote operation with an appropriate algorithm. Your Delta-Q applications engineer can assist you with this.
2) Before the charger will accept voltage and current requests, two conditions must be satisfied:
    a. The charger must periodically receive a heartbeat from the battery monitor node. The charger detects the heartbeat by node id. By default, the charger is configured to recognize node id 1 (0x1) as the battery monitor. The charger's default heartbeat timeout is 2 seconds. That means that the battery monitor must transmit its heartbeat with a period of less than two seconds (e.g., 1 second).
    b. Once the heartbeat is established, the charger must receive a battery status object (0x6000) indicating the battery is ready to charge (1). The battery status will only be accepted if the heartbeat has been established.
3) After establishing the heartbeat and battery status ready, the charger will accept voltage (0x2271) and current (0x6070) request objects. Both requests must be received by the charger at least once before it will produce any output.

If the charger receives a battery status object (0x6000) of zero it will perform the following actions:

1) Reset the voltage request object (0x2271) to zero.
2) Reset the current request object (0x6070) to zero.
3) Reduce the output to zero.

If the charger detects a loss of heartbeat it will perform the following actions:

1) Reset the voltage request object (0x2271) to zero.
2) Reset the current request object (0x6070) to zero.
3) Reset the battery status object (0x6000) to zero.
4) Reduce the output to zero.
5) Transmit an emergency (EMCY) message indicating loss of heartbeat (CANopen error code 0x8130).
6) Go back to preoperational mode (heartbeat 0x7f)

If the charger receives an NMT application reset command (129) it will perform the following actions:

1) Reset the current request object (0x6070) to zero.

2) Reset the battery status object (0x6000) to zero.
3) Reduce the output to zero.

If the charger loses power (AC and DC) then the following objects will be reset on restart:

1) Voltage request object (0x2271)
2) Current request object (0x6070)
3) Battery status object (0x6000)

In order to maintain reliable operation, Delta-Q recommends periodically transmitting the battery status (0x6000), voltage request (0x2271) and current request (0x6070) objects.

In addition, the charger status object (0x6001) or equivalently bit 5 in the extended charger status object (0x2006) may be used by the battery monitor to determine whether the charger is ready and able to charge. The charger will be ready to charge if all of the following conditions are met:

1) The charger is NOT in algorithm selection mode
2) The user is NOT attempting to enter algorithm selection mode
3) The charger is NOT performing a self-test (during start-up)
4) An algorithm is configured
5) AC (mains) power is qualified
6) The charger's power conversion circuitry is functioning properly
7) The battery is not reverse polarity
8) There are NO alarms or faults that could prevent charging

PDO's can help automate the periodically resending of the battery status (0x6000), voltage request (0x2271) and current request (0x6070) objects. Note: The voltage request (0x2271) object is only available for inclusion in PDO's in version 4.2 SW and later.

Transmission and reception of PDO's can be enabled by putting the charger into the CANOpen bus state "operational mode" and disabled by putting it back into a "preoperational mode". Note: The charger's application can only receive PDO's while in an operational state and not in a pre-operational state.

The operation/preoperational state of the charger does not have any direct effect on remote mode, it is only the receiving of the battery status (0x6000), voltage request (0x2271) and current request (0x6070) objects within the PDO's that effect the current and voltage behavior. Note: As above, even with PDO's the charger still requires to see the Heartbeat from the battery Module before passing any of the battery status (0x6000), voltage request (0x2271) and current request (0x6070) commands to the application.

If the charger loses power (AC and DC) then the charger's CANOpen mode will be reset on restart to Boot followed by preoperational. It is up to the battery module to command the charger back into operational mode if PDO's are required.

For further information regarding particular CANopen objects, please refer to the following documents:

1) CAN in Automation, "CiA 301: CANopen Application Layer and Communication Profile", Version 4.2.0 or later, 2011/02/21

2) Delta-Q, “IC Series CANopen Interface Specification”, CANopen Version 2.0 or later