White Paper
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XDPL8221 controller UART interface

XDP™ digital power

Abstract

This white paper describes the electrical UART (universal asynchronous receiver/transmitter) interface characteristics and the communication protocols of the XDPL8221 UART command interface. The intended audience are engineers who design LED lighting power supplies using the XDPL8221 digital controller.

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1 General description

The digital controller XDPL8221 uses a common half-duplex UART interface with a fixed transmission speed of 57600 baud.

In half-duplex mode, the communication partners share one line to exchange data with a wired-AND structure. Therefore, the data outputs (driver type: open-drain) are connected together with a common pull-up resistor to maximum 3.3 V. The value of the resistor defines the rise time of the data signal at a 0-1 transition.

The data receivers (slave) are connected to the same line as sender (master). To detect data collision, each device also reads the data it is transmitting and checks the read data against the data that was intended to be sent. In case of a mismatch, a data collision occurs.

2 XDPL8221 UART data format

The XDPL8221 UART communication is based on data bytes with 8 bit width, LSB first as shown in the Figure 1. Each data transfer starts with a “START” bit at low level and stops with two “STOP” bits at high level. The idle level is high.

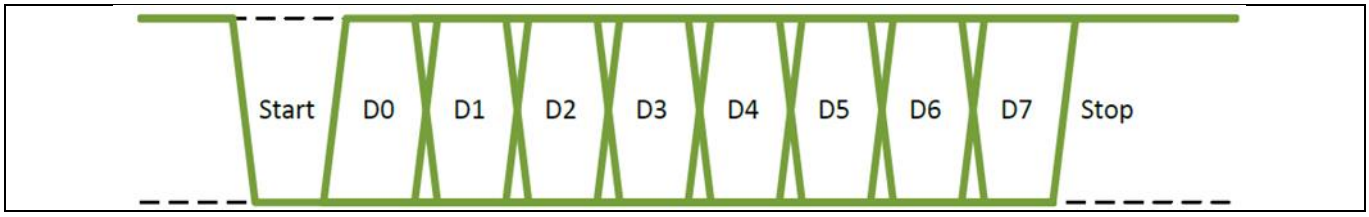

Figure 1 UART byte frame

In order to establish a UART communication with the XDPL8221 as slave, the external master must send one or multiple SYNC commands (0x7F) first. Only after the reception of one or more ACK (0x00) from the XDPL8221, the UART communication is successfully established and GET or SET commands can be subsequently sent.

In case UART communication is requested while the XDPL8221 is in the power saving mode (e.g. dim-to-off), a SYNC command will trigger a wakeup of the controller. Before the XDPL8221 can respond to the SYNC command with an ACK, it will first charge up the V_{CC}. This ensures a wakeup with full V_{CC} for the UART communication to avoid V_{CC} undervoltage. The XDPL8221 will be available for the UART communication for a timeout of t_UART (10 ms default), which can be configured in the CSV file. The UART communication must finish within this timeout t_UART, otherwise a V_{CC} undervoltage may occur. After the timeout, the XDPL8221 will go into the power saving mode which was interrupted by the UART communication.

Note: The UART pin is pulled low for typically 500us when the XDPL8221 is in an auto restart condition. This must not be misinterpreted as an UART frame error by other UART devices.

3 UART commands

After the XDPL8221 successfully responds the SYNC command (0x7F) with ACK (0x00), a GET or SET command can be sent.

A GET or SET command contains 9 bytes data. The time between each byte must not exceed 500us. The checksum at the end of the command is the XOR combination of the previous bytes of the command.

All the GET and SET UART commands are summarized in the following Table 1:

Table 1 UART Commands

Command	Class	Command	ARG0	ARG1	ARG2	ARG3	ARG4	ARG5	Checksum
SYNC	0x7F	-	-	-	-	-	-	-	-
GET status	0x7C	0x04	0x41	ID	0x00	0x00	0x00	0x00	0xXX
GET internal temperature	0x7C	0x04	0x44	ID	0x00	0x00	0x00	0x00	0xXX
GET external NTC resistance	0x7C	0x04	0x45	ID	0x00	0x00	0x00	0x00	0xXX
GET output voltage	0x7C	0x04	0x64	ID	0x00	0x00	0x00	0x00	0xXX
GET RMS input Voltage	0x7C	0x04	0x65	ID	0x00	0x00	0x00	0x00	0xXX
GET Bus Voltage	0x7C	0x04	0x66	ID	0x00	0x00	0x00	0x00	0xXX
GET Output Current	0x7C	0x04	0x6A	ID	0x00	0x00	0x00	0x00	0xXX
SET non-dimmed current	0x7C	0x84	0x68	ID	current value		0x00	0x00	0xXX
GET non-dimmed current	0x7C	0x04	0x68	ID	0x00	0x00	0x00	0x00	0xXX
SET dimming level	0x7C	0x84	0x84	ID	dimming level value		0x00	0x00	0xXX
GET dimming level	0x7C	0x04	0x84	ID	0x00	0x00	0x00	0x00	0xXX
START application	0x7C	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x7C
STOP application	0x7C	0x01	0x00	0x00	0x00	0x00	0x00	0x00	0x7D
SET sleep	0x7C	0x84	0x4F	0x00	0x00	0x00	0x00	0x00	0xB7

Restrictions apply to the non-dimmed current which can be set via UART SET command:

- $I_{out,min}$ < current set via UART < $I_{out,full}$: this is the normal operation range. The current will be regulated according to the current value set by the UART command.
- Current set via UART > $I_{out,full}$: this case would overload the design. The controller will limit the output current to $I_{out,full}$.

› Current set via UART < $I_{out,min}$: this configuration is not allowed as it causes an undefined function. The UART master must not program a current level in this range.

Note: The application related parameter values which can be set through the UART communication are the output non-dimmed current and the dimming level.

Note: The application related parameter values which can be fetched through the UART communication are the actual real time output current, voltage as well as dimming level, internal temperature external NTC resistor value and operating status.

Note: *The commands "Start/Stop Application and set sleep" require an external supplied V_{CC}. Without it, V_{CC} will drop below off-threshold and IC will reset.*

The ID field allows addressing one out of multiple XDPL8221 on a shared UART bus. Only devices with a matching ID will react to the UART commands. Commands can use the broadcast ID 0x00 to address any XDPL8221 controller on the shared bus. A broadcast GET command does not make sense in a multi-controller set up and will cause a collision on the shared bus in case multiple devices are connected. Thus, it is advised to use only GET commands with a certain device ID to ensure a response from a single, unique XDPL8221 controller. For single controller architecture, it is recommended to use the broadcast address.

Note: The ID of XDPL8221 controller can be burned during parametrization by using .dp Vision. All IDs of any XDPL8221 controller on a shared UART bus must be unique.

4 UART responses to GET commands

A UART response frame from the XDPL8221 controller can contain either 1 byte or 9 bytes as shown in the Table 2:

Table 2 UART Responses to GET commands

Response	ACK/NACK	ARG 0	ARG 1	ARG 2	ARG 3	ARG 4	ARG 5	ARG 6	Checksum
Successful response to a SET or SYNC command	0x00 (ACK)	-	-	-	-	-	-	-	-
Successful response to a GET command	0x00 (ACK)	Value		0x00	0x00	0x00	0x00	0x00	0xXX
Generic error code for general protocol purposes or used as a non-contextualized generic NACK	0x01	-	-	-	-	-	-	-	-
One of the arguments in the given command is not valid	0x02	-	-	-	-	-	-	-	-
The command is not known	0x03	-	-	-	-	-	-	-	-

The main power stage controlled by the XDPL8221 is a noisy environment, so the UART communication may be disturbed occasionally. The checksum ensures that the XDPL8221 does not react to any disturbed wrong communication.

In case of a mismatching checksum or an incomplete frame, the XDPL8221 will not send any response. If a response to a GET command is missing, the UART master is not allowed to send any new request for $t_{\_UART,error}$ = 15 ms.

5 Coding of SET or sensed values

The application related parameter values which can be set through the UART communication are the output non-dimmed current and the dimming level.

The application related parameter values can be read out through UART communication are the actual real time output current, voltage, as well as dimming level, internal temperature, external NTC resistor value and operating status.

The conversion of the electrical values to the corresponding digital representations in the XDPL8221 controller is given in the following Table 3:

Table 3 UART Responses to GET commands

SET or sensed value	Meaning of 1 LSB	Offset	Min. decimal value	Max. decimal value
Output current	4096 LSB / A	0	1 (= 244 uA)	40960 (= 10 A)
Output/bus/input RMS voltage	16 LSB / V	0	1 (= 62.5 mV)	8000 (= 500 V)
Dimming level	81.92 LSB / %	0	0 (= 0%)	8192 (= 100 %)
Internal temperature	1 LSB / °C	40	0 (= - 40°C)	190 (= 150 °C)
External NTC resistance	1 LSB / Ω	0	0 (= 0 Ω)	32768 (= 32.768 KΩ)

6 Coding of the XDPL8221 operating status

The actual operating status of the XDPL8221 controller can be fetched through the UART command “Get Status”. The coding of the status is given in the following Table 4:

Table 4 Coding of the operating status

Bit	Description
15 to 14	Output current is determined by: › 00: Dimming › 01: Advanced temperature protection › 10: Limited power
13	FB regulates in: › 0: CC mode › 1: CV mode
12	Dimming is determined by: › 0: PWM › 1: UART
11	AC or DC input voltage: › 0: AC input voltage › 1: DC input voltage
10 to 9	Current protection reaction is › 00: Auto-restart › 01: Fast auto-restart › 10: Latch › 11: Stop mode
8	The on-going protection requires a V_{CC} charging for the restart (1) or not (0)
7	A protection reaction is on-going (1) or not (0)
6	A DLM[1] protection was triggered ($Protection_{DLM} > 0$)
5	A FB protection was triggered ($Protection_{FB} > 0$)
4	A PFC protection was triggered ($Protection_{PFC} > 0$)
3 to 0	Bit number of any bit set in either $Protection_{PFC}$, $Protection_{FB}$ or $Protection_{DLM}$ [2]

The coding of system protections indicated by the value of the lowest 7 bits (bit 0-6) in the Table 4 is given in the following Table 5 :

[1] DLM = device level management

[2] This assumes only one bit will be set in all three signals at a time. If multiple bits would be present, only the first error found will be chosen.

Table 5 Coding of system protections

Value (Bit 6 – 0)	System protections
000 0000	No protection
001 0001	Bus overvoltage protection level 2
001 0010	Input undervoltage protection
001 0011	Input overvoltage protection
001 0100	PFC CCM protection
001 0101	PFC soft-start failure protection
001 0110	Bus undervoltage protection
001 0111	PFC overcurrent protection level 2
010 0000	Flyback CS pin short to GND protection
010 0001	Flyback output undervoltage protection at startup
010 0010	Flyback output undervoltage protection during operation
010 0011	Flyback output overvoltage protection
010 0100	Flyback output overcurrent protection
010 0101	Flyback overcurrent protection level 2
010 0110	Flyback CCM protection
010 0111	Flyback maximum T_{osc} exceeding protection
010 1000	Dim-to-off at startup
010 1001	Dim-to-off during operation
010 1010	Flyback output overpower protection
010 1011	Flyback V_{bus} plausibility check failure protection
010 1100	Flyback data missing protection
010 1101	Sleep mode set by UART
100 0000	External overtemperature protection
100 0001	Internal overtemperature protection
100 0010	Task scheduler protection
100 0011	V_{CC} undervoltage lock out protection
100 0100	V_{CC} overvoltage protection
100 0101	RAM parity error protection
100 0110	Watch dog error protection
100 0111	Clock check error protection

7 UART communication during the power saving mode

The XDPL8221 will be in the power saving mode under following conditions:

- Dim-to-off
- Protection mode
- UART command “set sleep”

There are two different behaviors in the protection mode:

- Fast auto-restart or auto-restart
- Latch

The UART communication is always available during the (fast) auto-restart and optional in the latch mode (can be configured through parametrization).

There are three operations which require the communication with XDPL8221 during the power saving mode:

- Set a new dimming level during dim-to-off to exit the dim-to-off state
- Read the error code in the protection mode
- UART wake up from sleep with 100% dimming

To communicate with XDPL8221 during the power saving mode, following procedure is required:

1. Sending a “SYNC (0x7F)” command
2. The falling edge of the “SYNC (0x7F)” command at the UART pin will wake up XDPL8221 from the power saving mode. After wake up, XDPL8221 will first pull the UART pin low for 400 µs and then charge the V_{CC} to on-threshold.

Note: The 400 µs low level at UART pin is due to the IC internal hardware reset. This is a violation of a valid UART command (max. 174 µs) and should be ignored.

3. XDPL8221 will respond with an “ACK (0x00)” to signalize that it is ready for the UART communication.
4. After an successful response from XDPL8221 is received, an UART command to set the new dimming level or read the error code (get status) must be sent immediately before the default UART time out t_{UART} = 10 ms happens. This time is configurable through parametrization related to the V_{CC} capacitance. It will prevent V_{CC} from undervoltage protection. After t_{UART} is expired, XDPL8221 goes back into power saving mode and there will be no correct response to the corresponding set or get commands. A delayed ACK response from XDPL8221 will be returned as the answer. For the case that V_{CC} is power supplied externally, the UART time out t_{UART} can be configured to a higher value which eases the communication.

Note: If there is no response from XDPL8221 within the restart time (t_{AR} or t_{AR_fast} dependent on different protection modes) due to any possible communication error, a new “SYNC” command must be sent renewed until an “ACK (0x00)” is received.

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