YKUSH3 v1.2.1 data sheet

YEPKIT LDA

January 2019

Contents

1 Board layout

The board layout main components, which are highlighted in figure 1, are the following.

USB upstream port is for the connection to the USB host (e.g., a PC). In this port a USB 3.0 Micro USB Type B terminal is used.

USB downstream ports are USB 3.0 Standard A terminals to which the USB devices are to be connected.

5V switchable power output is a two pin breakout of 3.24mm pitch of a 5V power switch.

GPIO pins that can be used as a general purpose I/O or as a downstream port switching control interface. See section 7 on page 18.

I^{2}C, UART and SPI interfaces breakout pins. These interfaces can be used to access, configure and control several functionalities.

External power input through a 3.54mm pitch screw terminal.

Power input selection jumper to select the active board powering mode. See section 2 on page 5.

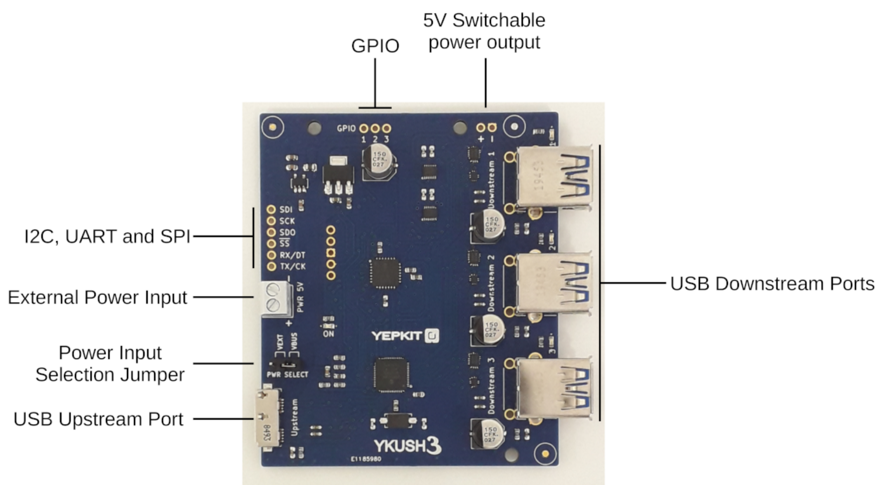

Figure 1: YKUSH3 Board

Details on the board technical dimension are detailed on the *board dimensions document*[1] available at the YKUSH3 product page in the documents and

[1] https://www.yepkit.com/uploads/documents/13290_YKUSH3_Dimensions_v1.1.pdf

resources section.

Pin group	**Pin**	**Description**
I^2C	SDI	SDA line.
	SCK	SCL line.
UART	RX/DT	RX/DT line.
	TX/CK	TX/CK line.
SPI	$\overline{SS}$	Slave select.
	SDO	Serial Data Out.
	SDI	Serial Data In.
	SCK	Serial Clock.
GPIO	1	General purpose I/O 1
	2	General purpose I/O 2
	3	General purpose I/O 3

Table 1: Breakout pins

2 Power supply and start-up considerations

The board has two power supply modes, namely:

- Bus powered.
- Self powered.

Bus powered is when the board sources the power from the upstream USB bus through the Vbus line.

Self powered is when an external power supply is used to power the board. This power supply must be of 5.00V to 5.25V.

The power supply mode selection is done through a on-board jumper, shown in figure 1 on page 3. If the jumper is in position *VBUS* the board is Bus powered. If the jumper is in position *VEXT* the board is Self powered.

For applications that require high power, for example when connecting multiple USB hard drives, the Self powered mode should be used together with an adequate 5V power supply.

Higher load current on a downstream port causes a voltage drop in the Vbus line that should be taken in consideration when selecting a power supply. This voltage drop effect is shown in figure 2.

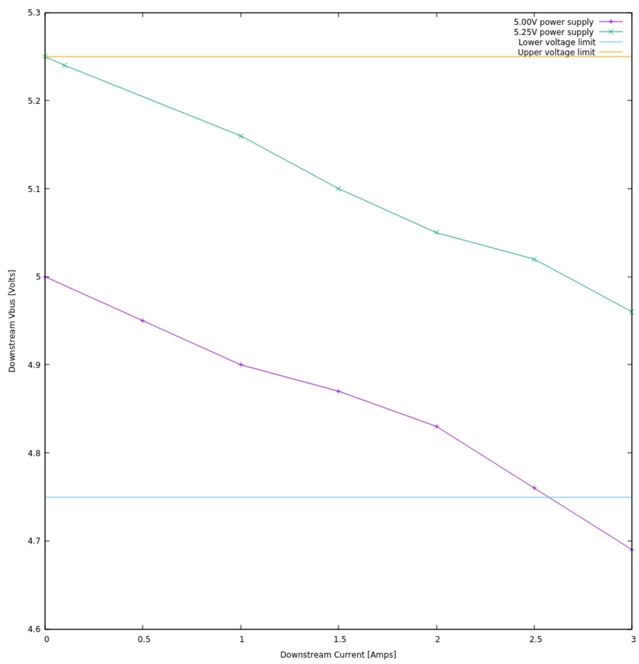

Figure 2: Power input to downstream voltage drop

3 USB hub core

The hub supports USB 3.2 Gen1 and USB 2.0 implementing 5 Gbps SuperSpeed (SS), 480 Mbps High-Speed (HS), 12 Mbps Full-Speed (FS) and 1.5 Mbps (LS) USB downstream devices on all downstream ports.

Battery charging is supported in all downstream ports. The integrated battery charger detection circuitry supports the USB-IF Battery Charging (BC1.2) detection method and most Apple devices. The hub provides the battery charging handshake and supports the following USB-IF BC1.2 charging profiles:

- DCP - Dedicated Charging Port (Power brick with no data).
- CDP - Charging Downstream Port (1.5A with data).
- SDP - Standard Downstream Port (0.5A with data).
- Custom profiles loaded through firmware customization.

The hub supports full downstream port switching (enable/disable). By full switching we mean that all components of the downstream ports can be switched by the user, namely the VBUS lines (power), SuperSpeed data lines and USB 2.0 data lines.

4 Downstream ports switching

All downstream ports can be individually switched on/off (enable/disable) using the following interfaces.

- USB
- GPIO
- I^2C

USB is the default control control interface and always active. In the factory firmware the USB control interface cannot be disabled but alternative firmware versions which allow for disabling the USB control interface are available upon request. All other interfaces are disabled from factory and must be enabled, initially, using the USB control interface. These configuration are persistent between power-cycles and resets.

5 5V switchable power output

A switchable 5V DC power output is available through two breakout pins, as shown in figure 1 on page 3. The on/off switching of this power output is controllable through the interfaces indicated in the previous section. Also, the power switch used for the switchable power output is the same than the switches used for the downstream ports, so the voltage drop per load current level is the one presented in figure 2 on page 5. The (-) pin is GND and the (+) pin is the +5V[2] (relative to ground) output.

The main 5V switched power output parameters are the following.

Parameter	**Symbol**	**Value**	**Units**
On resistance	R_{ON}	10	mΩ
Max continuous current	I_{C_MAX}	6	A

[2]The output voltage varies with the current according with the power switch R_{ON} resistance

6 USB control interface

The USB control interface is the primary control interface, always active, in the factory firmware. This interface becomes available as soon as the board is attached to the USB host, for example a computer.

When a YKUSH3 board is connected, the following components get attached to the host operating system: a) USB 3.2 hub; b) USB 2.0 hub; and c) YKUSH3 control device configured as a HID. In practice connecting a YKUSKH3 board to a computer is "seen" by the operating system as attaching three devices, two USB hubs and a USB HID device. This HID device is the board USB control interface. It's by communicating with this device that the user controls the YKUSH3 board programmable functionalities. For additional information in how to use the control interface, from a user point of view, check the YKUSH3 user manual[3] available at the product page[4].

The board USB control device can be accessed by the USB host using the Vendor ID (VID) and Product ID (PID), which is 0x04D8 and 0xF11B respectively.

Additionally, all YKUSH3 boards have a unique USB serial number which can be used to address a specific board. This is useful when multiple YKUSH3 boards are attached to a same host. By having a unique serial number the command can be univocally sent to a specific board.

Issuing commands to the board from the host is done by sending 64 byte messages (HID USB reports). The communication is always driven by the USB host, which acts as a master, by sending a message to which the board control device will reply with a 64 byte message.

The following functionalities are available through the USB control interface.

- Downstream port switching.
- Get downstream port state/status.
- 5V power output port switching.
- Configuration of board power-on defaults.
- Trigger board reset/reboot.
- Load firmware updates.
- Enable/disable GPIO control interface.
- Enable/disable I^2C slave mode (control interface).
- Enable/disable I^2C master mode (bridge mode).

The commands are detailed bellow.

[3] https://www.yepkit.com/uploads/documents/03e4b_YKUSH3_User_Manual_v1.0.0.pdf
[4] https://www.yepkit.com/product/300110/YKUSH3

6.1 Downstream port switching

The command message, from the USB host, to switch on/off the downstream ports has the following structure.

byte 0	byte 1	...	byte 63
action	control	don't care	don't care

The response message, from the board has the following structure.

byte 0	byte 1	...	byte 63
status	response	don't care	don't care

The byte values for all port switching commands are detailed on table 2. The byte values for the board reply messages are listed on table 3.

action byte	control byte	Command
0x01	0x01	Switch OFF port 1
0x02	0x02	Switch OFF port 2
0x03	0x03	Switch OFF port 2
0x0A	0x0A	Switch OFF all ports
0x11	0x11	Switch ON port 1
0x12	0x12	Switch ON port 2
0x13	0x13	Switch ON port 3
0x1A	0x1A	Switch ON all ports

Table 2: USB control interface port switching commands

status byte	response byte	Response
0x01	0x01	Port 1 switched OFF
0x01	0x02	Port 2 switched OFF
0x01	0x03	Port 3 switched OFF
0x01	0x0A	All ports switched OFF
0x01	0x11	Port 1 switched ON
0x01	0x12	Port 2 switched ON
0x01	0x13	Port 3 switched ON
0x01	0x1A	All ports switched ON

Table 3: USB control interface port switching replies from the board

6.2 Downstream port status

The command message to get port switching state/status has the following structure.

byte 0	byte 1	...	byte 63
action	control	don't care	don't care

The response message has the following structure.

byte 0	byte 1	...	byte 63
status	port state	don't care	don't care

The byte values for each status command and reply messages are listed in table 4 and table 3, respectively.

action byte	control byte	Command
0x21	0x21	Get state of port 1
0x22	0x22	Get state of port 2
0x23	0x23	Get state of port 3

Table 4: USB control interface port status commands

action byte	port state	Response
0x01	0x01	Port 1 OFF
0x01	0x02	Port 2 OFF
0x01	0x03	Port 3 OFF
0x01	0x11	Port 1 ON
0x01	0x12	Port 2 ON
0x01	0x13	Port 3 ON

Table 5: USB control interface port status command replies

6.3 5V switchable power output

The command structure to control the 5V output is the following.

byte 0	byte 1	...	byte 63
action	control	don't care	don't care

The response message, from the board to host has the following structure.

byte 0	byte 1	...	byte 63
status	action	don't care	don't care

action byte	control byte	Command
0x04	0x04	Switch OFF 5V power output
0x14	0x14	Switch ON 5V power output
0x24	0x24	Get 5V power output state

Table 6: USB control interface 5V power output commands

status byte	response byte	Response
0x01	0x04	5V power output switched OFF
0x01	0x14	5V power output switched OFF
0x01	0x04	5V power output state is OFF
0x01	0x14	5V power output state is ON

Table 7: USB control interface 5V power output replies from the board

6.4 GPIO Read/Write

GPIO pins value is written or read using the commands detailed bellow.

The commands have the following structure.

byte 0	byte 1	byte 2	...	byte 63
action	GPIO pin	value	don't care	don't care

Response messages have the following structure.

byte 0	byte 1	byte 2	byte 2	...	byte 63
status	action	GPIO pin	value	don't care	don't care

action	GPIO pin	value	Command description
0x30	0x01	-	Read value of GPIO pin 1
0x30	0x02	-	Read value of GPIO pin 2
0x30	0x03	-	Read value of GPIO pin 3
0x31	0x01	0x01	Write value 1 to GPIO pin 1
0x31	0x01	0x00	Write value 0 to GPIO pin 1
0x31	0x02	0x01	Write value 1 to GPIO pin 2
0x31	0x02	0x00	Write value 0 to GPIO pin 2
0x31	0x03	0x01	Write value 1 to GPIO pin 3
0x31	0x03	0x00	Write value 0 to GPIO pin 3

Table 8: GPIO read and write commands

6.5 GPIO control interface enable or disable

An external device can command the board port switching using the GPIO control interface. This interface is enabled or disabled using the commands detailed bellow.

The commands have the following structure.

byte 0	byte 1	...	byte 63
0x32	action	don't care	don't care

Response messages have the following structure.

byte 0	byte 1	byte 2	...	byte 63
status	0x32	action	don't care	don't care

status	action	GPIO pin	value	Command description
0x01	0x30	0x01	0x01	GPIO pin 1 is at value 1
0x01	0x30	0x01	0x00	GPIO pin 1 is at value 0
0x01	0x30	0x02	0x01	GPIO pin 2 is at value 1
0x01	0x30	0x02	0x00	GPIO pin 2 is at value 0
0x01	0x30	0x03	0x01	GPIO pin 3 is at value 1
0x01	0x30	0x03	0x00	GPIO pin 3 is at value 0
0x01	0x31	0x01	0x01	GPIO pin 1 was set to value 1
0x01	0x31	0x01	0x00	GPIO pin 1 was set to value 0
0x01	0x31	0x02	0x01	GPIO pin 2 was set to value 1
0x01	0x31	0x02	0x00	GPIO pin 2 was set to value 0
0x01	0x31	0x03	0x01	GPIO pin 3 was set to value 1
0x01	0x31	0x03	0x00	GPIO pin 3 was set to value 0

Table 9: GPIO read and write command replies

action	Command description
0x01	Enable GPIO control interface
0x00	Disable GPIO control interface

Table 10: GPIO enable and disable commands

status	action	Command description
0x01	0x01	GPIO control interface enabled
0x01	0x00	GPIO control interface disabled
0x00	-	Error

Table 11: GPIO enable and disable commands response messages

6.6 Downstream port default state configuration

Downstream port default state defines how a port will be set on power-on or after a reset. The default state is configurable using the commands detailed here.

The commands have the following structure.

byte 0	byte 1	byte 2	...	byte 63
0x41	port	default state	don't care	don't care

Response messages have the following structure.

byte 0	byte 1	byte 2	byte 3	...	byte 63
status	0x41	port	default state	don't care	don't care

port	default state	Command description
0x01	0x00	Set port 1 default state to Off
0x01	0x01	Set port 1 default state to On
0x02	0x00	Set port 2 default state to Off
0x02	0x01	Set port 2 default state to On
0x03	0x00	Set port 3 default state to Off
0x03	0x01	Set port 3 default state to On

Table 12: Downstream port power-on default state configuration commands

status	port	default state	Command description
0x01	0x01	0x00	Port 1 default state set to Off
0x01	0x01	0x01	Port 1 default state set to On
0x01	0x02	0x00	Port 2 default state set to Off
0x01	0x02	0x01	Port 2 default state set to On
0x01	0x03	0x00	Port 3 default state set to Off
0x01	0x03	0x01	Port 3 default state set to On
0x00	-	-	Error

Table 13: Downstream port power-on default state configuration commands replies

6.7 Enter firmware update mode

A new firmware can be loaded into the board, through the USB connection, when in bootloader mode. The board is driven to bootloader mode using the command bellow.

The command that set's the board into bootloader mode is the following.

byte 0	...	byte 63
0x42	don't care	don't care

6.8 I^2C interface configuration

I^2C interface can be used in slave or master mode. The factory configuration has this interface disabled by default. To use the interface the desired operation mode, slave or master, has to be enabled. For slave mode the device I^2C address should also to be configured by the user, overriding the factory defined address (*0b10100110*).

All these configurations are persistent on power cycles or resets.

The commands have the following format.

byte 0	**byte 1**	**byte 2**	**...**	**byte 63**
0x51	action	value	don't care	don't care

action	**value**	**Command description**
0x01	0x00	Disable I^2C slave mode
0x01	0x01	Enable I^2C slave mode
0x02	0x00	Disable I^2C master mode
0x02	0x01	Enable I^2C master mode
0x03	*i2c_addr*	Configures the board I^2C slave address with value *i2c_addr*

Table 14: Downstream port power-on default state configuration commands

Slave mode activates the control interface through I^2C enabling master I^2C devices to control the port switching.

Master mode activates the I^2C bridge mode which makes possible for a USB host to communicate with I^2C slave devices.

The if the command is executed with success the board replies the following.

byte 0	**...**	**byte 63**
0x01	don't care	don't care

6.9 I^2C master mode

Master mode enables the board to provide an I^2C bridge functionality between the upstream USB host and the slave devices connected to the same I^2C bus as the YKUSH3. I^2C master mode must be enabled before using bridge related commands.

With I^2C master mode enabled, *read* and *write* commands are made available to the USB host. They allow to write and read an arbitrary number of bytes to or from the I^2C slave devices.

I^2C bridge commands have the following structure.

byte 0	**byte 1**	**byte 2**	**byte 3**	**byte 4**	**...**	**byte 63**
0x52	action	i2c_address	n_bytes	buff_0	don't care	don't care

Where:

- **action** is a write or read action code. *0x01* is a write; *0x02* is a read.
- **i2c_address** is the 7 bit slave address aligned to the most significant bit and with the byte least significant bit at zero. For example, *0b10100110* byte represents the I^2C address *0b1010011*.
- **n_bytes** is the number of bytes to read from or written to the slave device.
- **buff_0** is the first byte of the buffer containing the data to be written or where the read data should be stored.

A write example where the USB host transmits two bytes, 0x11 and 0x22, to I^2C slave device with 7 bit address 0x1111111 using the YKUSH3 as a bridge. The command for this example is the following.

byte 0	**byte 1**	**byte 2**	**byte 3**	**byte 4**	**byte 5**	**...**
0x52	0x01	0x11111110	0x02	0x11	0x22	-

In the case of a successful write the following response is received by the USB host from the YKUSH3.

byte 0	**byte 1**	**...**
0x01	0x52	-

The response message structure, for both write and read commands, is the following.

byte 0	**byte 1**	**byte 2**	**byte 3**	**...**
status	0x52	n_bytes	data-byte-1	...

Where:

- **status** is 0x01 on success, 0x02 error due to board not being set to I^2C master mode or 0x03 I^2C transmission error.
- **n_bytes** is the number of data bytes to be transmitted , on a write command, or the number of data bytes received on a read command.
- **data-byte-x** is the data byte received from the I^2C slave device in the case on a read command. For write command responses this bytes are not used.

6.10 Reset board

YKUSH3 boards are reset using a USB command. The command has the following structure.

byte 0	**...**	**byte 63**
0x55	-	-

6.11 Get bootloader and firmware version

Version information of the bootloader and firmware is obtained using the commands presented here.

The command structure is the following.

byte 0	**byte 1**	**...**	**byte 63**
0x61	subject	-	-

subject defines if the command is for the bootloader or firmware version. **0x01** is for bootloader and **0x02** for firmware.

The board will reply to a command with a message that provides information on the status of command execution. Response messages have the following structure.

byte 0	**byte 1**	**byte 2**	**byte 3**	**byte 4**	**...**	**byte 63**
status	0x61	major	minor	patch	-	-

Where:

1. **status** 0x01 for success and 0x00 for error.
2. **major** version number.
3. **minor** version number.
4. **patch** version number.

7 GPIO

Three GPIO pins are available for use as a control interface or as a GPIO/USB bridge.

GPIO control interface enables port switching using a device with GPIO pins.

GPIO/USB bridge enables the use of YKUSH3 GPIO pins as digital I/O ports from the USB host.

Not all GPIO pin use the same type of buffer. GPIO 1 and 2 use TTL digital buffers while GPIO 3 uses Schmitt trigger buffer. This leads to slightly different input/output thresholds on digital levels. These input/output characteristics are detailed in the tables bellow.

Input/Output characteristics for GPIO with TTL buffer

Characteristics	**Min.**	**Max.**	**Units**
Input low voltage	-	0.50	V
Input high voltage	1.63	-	V

Input/Output characteristics for GPIO with Schmitt trigger buffer

Characteristics	**Min.**	**Max.**	**Units**
Input low voltage	-	0.6	V
Input high voltage	2.64	-	V

8 I^2C

I^2C SDA and SCL lines have in board pull-up resistors and can be directly connected to an I^2C bus or device.

The interface can be configured in one of two operation modes: 1) Slave mode; 2) Master mode.

When in slave mode it can be used as a control interface to switch hub ports.

If in master mode it's used as a USB I^2C bridge allowing a user to communicate with I^2C slave devices from a USB host console.

8.1 I^2C slave mode

Byte Code	**Command**
0x03	Switch port 1 On
0x04	Switch port 2 On
0x05	Switch port 3 On
0x07	Switch port 1 Off
0x08	Switch port 2 Off
0x09	Switch port 3 Off
0x0B	Switch all ports On
0x0C	Switch all ports Off

Table 15: I^2C control interface command bytes

8.2 I^2C master mode

When in master mode the device works as a USB/I^2C bridge allowing the USB host, to which YKUSH3 is connected, to communicate with I^2C slave devices. For details on the USB command relating to this mode refer to section 6.9 on page 15.

9 Firmware

YKUSH3 has a bootload which allows firmware updates through the USB connection. No specific hardware programmers are required, just a PC with a USB port and the Yepkit firmware loader application is required.

9.1 Update firmware

Current versions of the bootloader use a soft trigger to enter into firmware update mode. Older versions used a hardware trigger.

Soft trigger to enter firmware update mode is a USB command that instructs the board to enter bootloader and wait for a firmware update. For details on this command see section 6.7 on page 14.

Hardware trigger to enter firmware update mode is a mechanism where the user sets GPIO 1 and 2 to digital high[5] and then resets the board.

When the board is in firmware update mode the power LED will slowly blink.

Note that only the firmware can be updated through USB. To update the bootloader a specific hardware programmer is required. See section 10 on page 20.

To update the firmware follow these steps:

1. Connect the board to your PC through USB;
2. Set the board into bootloader mode;
3. Open the firmware update tool (run the *HIDBootloader* for Linux and *ykush3_firmware_update.bat* for Windows);
4. Load the firmware binary file by clicking *Import Firmware Image*;
5. Program the new firmware image by clicking *Erase/Program/Verify Device*;
6. Reset the device, by clicking on *Reset Device*, once the programming process has finished.

10 ICSP in-circuit programming

Both firmware and bootloader can be programmed using ICSP interface. Programming this way requires specific external programmer hardware.

Firmware updates should always be done using the USB interface, as described in the previous section.

[5] See voltage levels at section 7 at page 18

While reprogramming the bootloader is not expected to be required there's the possibility of doing it through ICSP interface. If you find necessary to program a new bootloader contact Yepkit technical support for details on the procedures and requirements for your board hardware version.

11 Operational characteristics

11.1 Absolute Maximum Ratings [†]

Ambient temperature under bias .... $-40°C to +125°C$
Storage temperature .... $-65°C to +150°C$
Voltage on pins with respect to GND
on +PWR 5V pin .... -0.3V to +6V
on all other pins .... -0.3 to 3.6V
GPIO maximum output current
sunk by any I/O pin .... 25 mA
sourced by any I/O pin .... 25 mA

[†] **NOTICE:** Stresses exceeding those listed in this section could cause permanent damage to the device. This is a stress rating only. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

11.2 Operating Conditions [‡]

The standard operating conditions are defined as:
Operating Voltage: $V_{EXTMIN} \leq V_{EXT} \leq V_{EXTMAX}$
Operating Temperature: $T_{A\_MIN} \leq T_A \leq T_{A\_MAX}$
V_{EXT} - Operating Supply Voltage
V_{EXTMIN} .... +5.00V
V_{EXTMAX} .... +5.25V
T_A - Operating Ambient Temperature Range
T_{A_MIN} .... $-40°C$
T_{A_MAX} .... +85°C

[‡] Proper operation of the device is guaranteed only within the ranges specified in this section.

11.3 Power consumption

Scenario	**Typical**
Attached / all ports switched Off	60 mA (300 mW)
Attached / all ports switched On / no devices	78 mA (390 mW)
Attached / all ports switched On / all ports at FS	112 mA (560 mW)
Attached / all ports switched On / all ports at HS	122 mA (612 mW)
Attached / all ports switched On / all ports at SS	278 mA (1.4 W)
Attached / all ports switched On / all ports at SS/HS	304 mA (1.5 W)
Detached / all ports switched Off	14 mA (70 mW)
Detached / all ports switched On / no devices	36 mA (180 mW)

Table 16: In-circuit power consumption with 5V power input in VEXT