SC20&SC60

USB to Ethernet Application Note

Smart LTE Module Series

Rev. SC20&SC60_USB_to_Ethernet_Application_Note_V1.0

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About the Document

History

Revision	Date	Author	Description
1.0	2017-10-27	Oscar LIU/ Klein ZHOU	Initial

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1 Introduction

Ethernet interface is often used when customers design their products by using Smart modules based on baseband chipset from Qualcomm, and typically there is no Ethernet interface on Smart modules. So a conversion chip is needed externally to convert USB interface to Ethernet interface. This document describes the design of converting USB to Ethernet in detail to guide customers to design their products quickly.

This document is applicable for Quectel Smart modules SC20 and SC60.

2 Design Theory

Smart modules do not support Ethernet devices. And converting USB to Ethernet can support Ethernet devices when Smart modules work in Host mode.

The Smart modules work in Device mode after power-on, and USB_ID is at high level; USB_ID can be pulled to low level to make modules work in Host mode to support Ethernet devices.

3 Software/Hardware Designs of Converting USB to Ethernet

This chapter describes the software and hardware designs of converting USB 2.0 to 10/100M Ethernet and USB 3.0 to 10/100/1000M Ethernet.

The general Smart terminals usually work in Device mode. If Ethernet devices are needed to be supported, Smart modules need to work in Host mode by controlling USB_ID pin, so as to achieve the function of converting USB to Ethernet. Smart modules work in Device mode when USB_ID is at high level while works in Host mode when the pin is at low level.

3.1. Hardware Design of Converting USB to Ethernet

3.1.1. Hardware Design of Converting USB 2.0 to 10/100M Ethernet

The following figure is the hardware design diagram of converting USB 2.0 to 10/100M Ethernet.

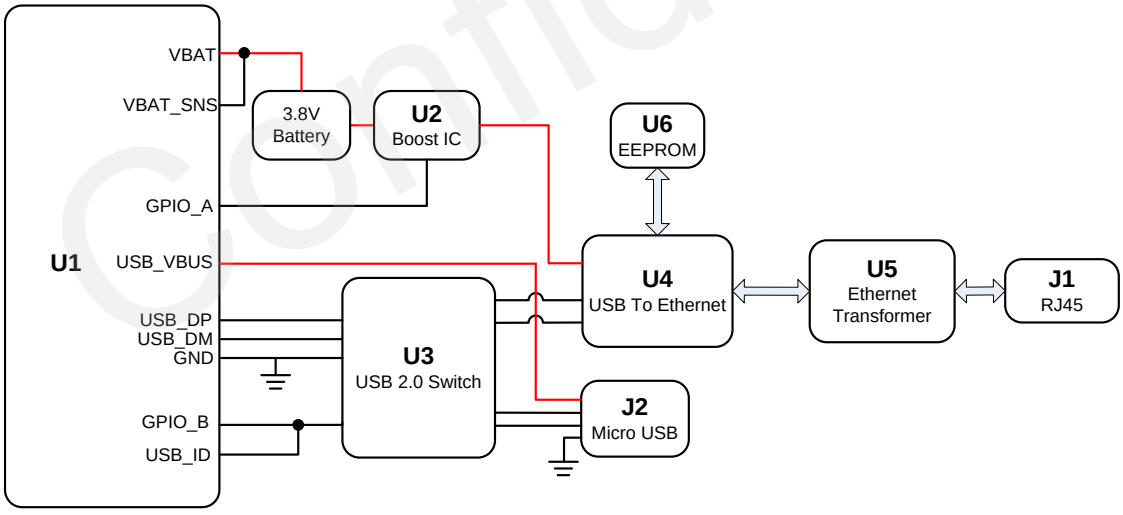

Figure 1: Hardware Design Diagram of Converting USB 2.0 to 10/100M Ethernet

The following tables describe the working mechanisms, pin definition and key devices of converting USB 2.0 to 10/100M Ethernet.

Table 1: Working Mechanisms of Converting USB 2.0 to 10/100M Ethernet

Mechanism	Mode	Description
Communication with PC	Device mode	After the module is powered on, GPIO_B is at high level by default, USB_DP/USB_DM are connected to J2, and module works in Device mode. After PC connects to J2 via USB cable, module detects there is USB insertion and communicates with PC.
USB To Ethernet	Host mode	API opens Ethernet and GPIO_B will be at low level. Pull USB_ID pin to low level and module enters into Host mode; meanwhile, API opens Ethernet and GPIO_A will be at high level, and U2 outputs power for OTG devices. GPIO_B controls USB 2.0 high-speed switch U3 to switch USB_DP/USB_DM to connect to U4 from J2, so as to achieve the function of converting USB to Ethernet.

Table 2: Pin Definition of Converting USB 2.0 to 10/100M Ethernet

Pin Name	Description
VBAT	Power supply for the module; 3.5V~4.2V
VBAT_SNS	Battery voltage detection; 3.5V~4.2V
GPIO_A	Boost IC enabling pin; low level by default
GPIO_B	USB 2.0 switch enabling/USB_ID control pin; high level by default
USB_VBUS	USB 5V power input and USB/charger insertion detection.
USB_DP/DM	USB 2.0 differential data bus (plus/minus)
USB_ID	USB ID detection; high level by default

Table 3: Key Devices of Converting USB 2.0 to 10/100M Ethernet

Item Number	Model	Description
U1	Quectel SC20/SC60	Smart modules based on baseband chipset from Qualcomm
U2	AW3605DNR	OTG device power supply IC
U3	SGM7227	USB 2.0 high-speed switch
U4	AX88772C	USB 2.0 to Ethernet IC
U5	NS0013LF	Ethernet transformer
U6	AT93C66B	EEPROM
J1	C10001-108A4	RJ45 connector
J2	UAF95-05254-S113	Micro USB connector

For the reference circuit design of AX88772C, please refer to ASIX official website: http://www.asix.com.tw/cs/download.php?sub=applicationdetail&PItemID=136.

3.1.2. Hardware Design of Converting USB 3.0 to 10/100/1000M Ethernet

The following figure is the hardware design diagram of converting USB 3.0 to 10/100/1000M Ethernet.

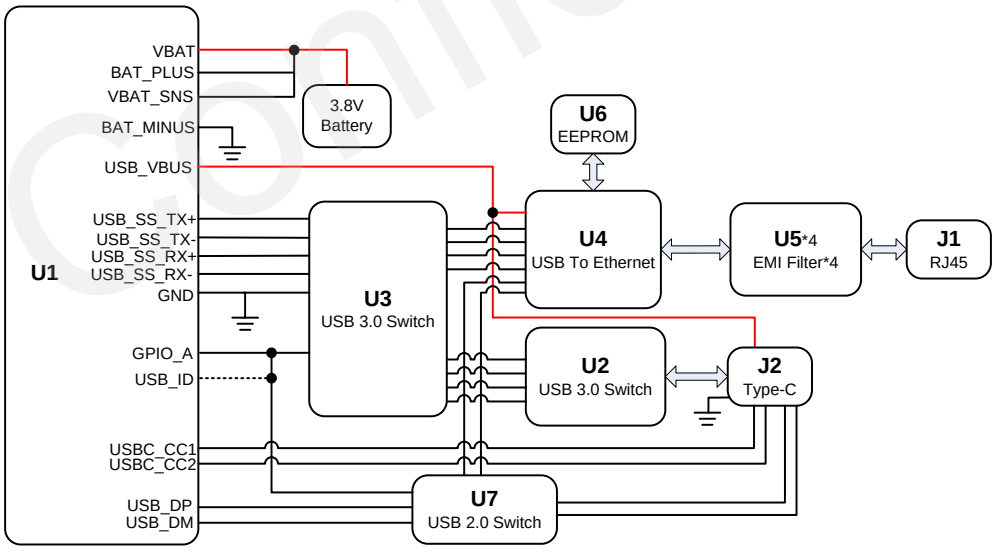

Figure 2: Hardware Design Diagram of Converting USB 3.0 to 10/100/1000M Ethernet

The following tables describe the working mechanisms, pin definition and key devices of converting USB 3.0 to 10/100/1000M Ethernet.

Table 4: Working Mechanisms of Converting USB 3.0 to 10/100/1000M Ethernet

Mechanism	Mode	Description
Communication with PC	Device mode	After the module is powered on, GPIO_A is at high level by default, and USB_DP/USB_DM are connected to J2; USB_SS_TX/USB_SS_RX are connected to U2, U2 is connected to J2, and module works in Device mode. After PC connects to J2 via USB cable, module detects there is USB insertion and communicates with PC.
USB To Ethernet	Host mode	API opens Ethernet and GPIO_A will be at low level. Pull USB_ID pin to low level and module enters into Host mode; moreover, GPIO_A controls USB 2.0 high-speed switch U7 and USB 3.0 ultra-speed switch U3 to switch USB_DP/USB_DM, USB_SS_TX/USB_SS_RX to connect to U4 from J2, so as to achieve the function of converting USB to Ethernet.

Table 5: Pin Definition of Converting USB 3.0 to 10/100/1000M Ethernet

Pin Name	Description
VBAT	Power supply for the module; 3.5V~4.2V
BAT_PLUS	Differential input signal of battery voltage detection (plus)
BAT_MINUS	Differential input signal of battery voltage detection (minus)
VBAT_SNS	Battery voltage detection; 3.5V~4.2V
GPIO_A	USB 3.0 switch enabling/USB_ID control; high level by default
USB_VBUS	USB 5V power input; Power supply output for OTG device; USB/charger insertion detection
USB_DP/DM	USB 2.0 USB differential data bus
USB_SS_TX+/TX-	USB 3.0 transmit differential data (plus/minus)
USB_SS_RX+/RX-	USB 3.0 receive differential data (plus/minus)
USBC_CC1	USB Type-C control configuration channel 1

USBC_CC2	USB Type-C control configuration channel 2
USB_ID	USB ID detection; high level by default

Table 6: Key Devices of Converting USB 3.0 to 10/100/1000M Ethernet

Item Number	Model	Description
U1	Quectel SC60	Smart modules based on baseband chipset from Qualcomm
U2/U3	PI3DBS12212AXUAEX	USB 3.0 ultra-speed switch
U7	SGM7227	USB 2.0 high-speed switch
U4	AX88179	USB 3.0 to Ethernet IC
U5	LECM2012H-900QT	EMI filter
U6	AT93C66B	EEPROM
J1	LA1S109-43	RJ45 connector (with transformer)
J2	USB-U1CF24S-3.1	Type-C USB connector

For the reference circuit design of AX88179, please refer to ASIX official website: http://www.asix.com.tw/cs/download.php?sub=applicationdetail&PItemID=131.

NOTES

1. The voltage of SC60's USB_ID pin is 3.2V, but the voltage of GPIO_A is 1.8V, so there is a need to convert the voltage of GPIO_A to 3.2V.
2. J2 (Type-C) connector does not support OTG device.

3.2. Software Design of Converting USB to Ethernet

The process of converting USB to Ethernet is shown as following figure.

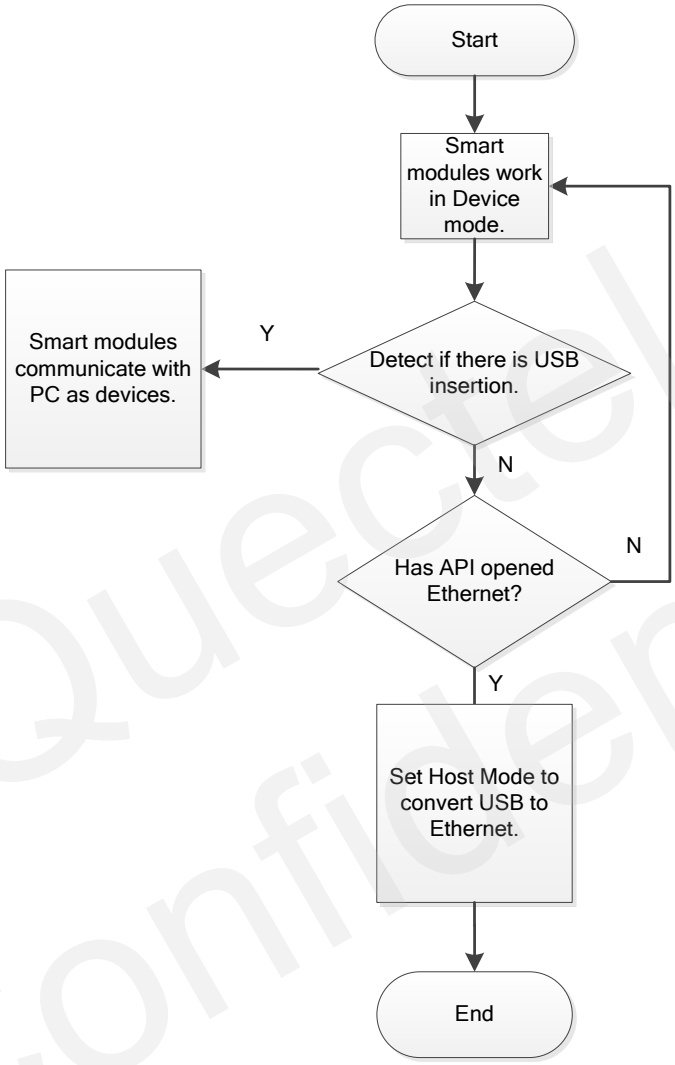

Figure 3: Software Design Diagram of Converting USB to Ethernet

NOTE

The related document for software modification is *phy-msm-usb.c*, and the file can be obtained from path */kernel/drivers/usb/phy/*. For details, please consult relevant software engineers.

4 Appendix A Reference

Table 7: Terms and Abbreviations

Abbreviation	Description
EEPROM	Electrically Erasable Programmable Read Only Memory
EMI	Electromagnetic Interference
OTG	On-The-Go
USB	Universal Serial Bus