

1 USB

&

渡辺 明植

USB

5

USB

1

(1 2) ()

가 5m

30m

. USB

가 USB

가 7

가

가

USB

127

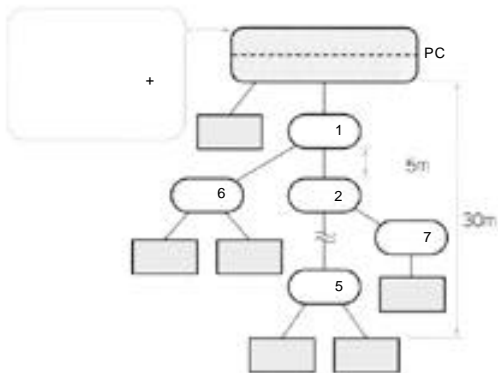
USB

USB

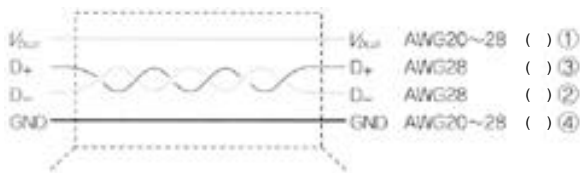
2

1

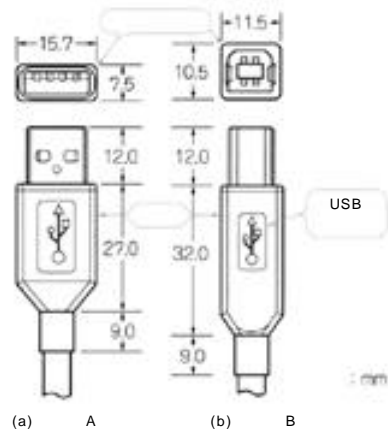
(D₊ D₋) (V_{bus}), (GND) 4



1. USB



2. USB



(a)

A

(b)

B

3. USB

D₊ D₋

USB

가

가 3m

+5V

500mA

3 USB

A

가

B

(

)

USB

가

CPU

USB

가

6

4 USB

5

6

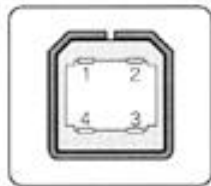
FIFO

USB

가



(a) A

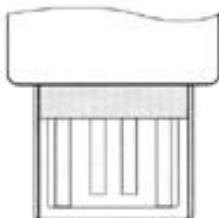


(b) B

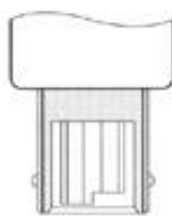
1	Vbus
2	D-
3	D+
4	GND

(c)

4. USB

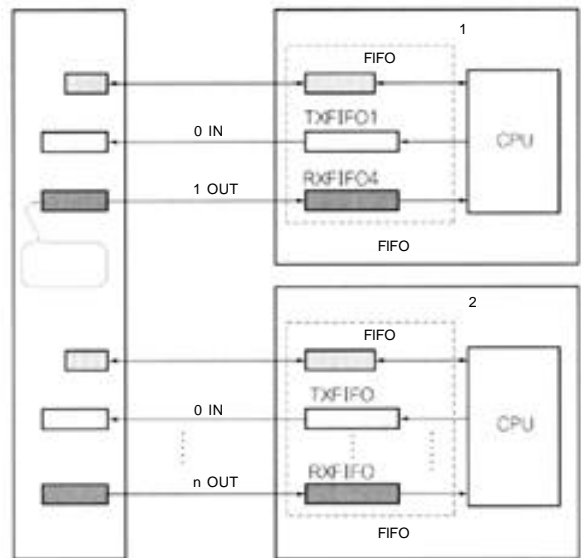


(a) A



(b) B

5. USB



6.

USB

가

(USBN 9602)

가

0

가

8

가

FIFO

OUT (

), IN

IN

FIFO

OUT

(

USB

가

USB

가

7 USB

(OUT)

가

6

OUT

USB

FIFO가

가

가

FIFO

가

, ACK()

1 1

(FIFO가

가

)

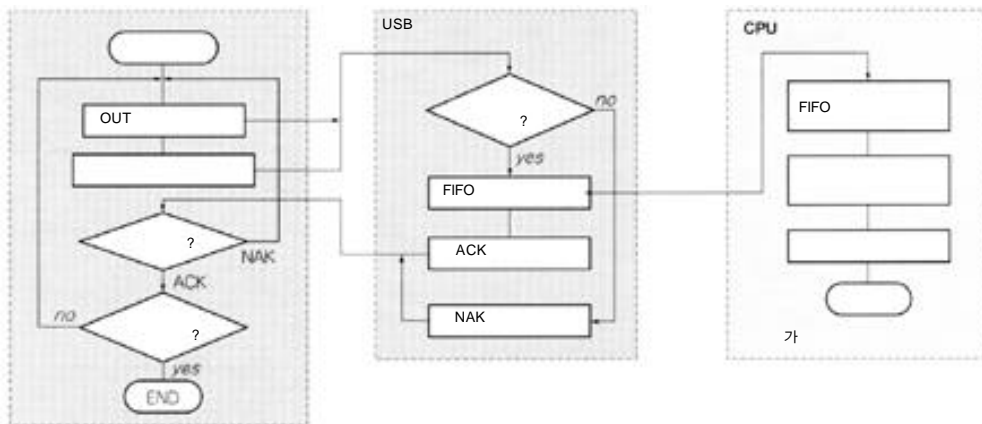
가

가

NAK

0

()



7.

ACK 가

가 가

가 2 USB

NAK

1.

USB 가

CPU가

1ms

USB 가

FIFO

CPU

(1 x1,000)

CPU FIFO

[/s]

가 가

USB 가 ,가 가

가

SOF(Start Of Frame)

, CRC(Cyclic Redundancy Check)

USB

(10^{-10})

FIFO

-USB

가



USB 4

2.

USB

1.

	△	○	○
	○	○	△
	○	○	○

2.

	12 Mbps	12 Mbps	1.5 Mbps/12 Mbps	1.5 Mbps/12 Mbps
	1 ms (1)		Nms(N = 1 ~ 255)	
1	1 ~ 1023	8/16/32/64	1 64 () 1 8 ()	1 64 () 1 8 ()

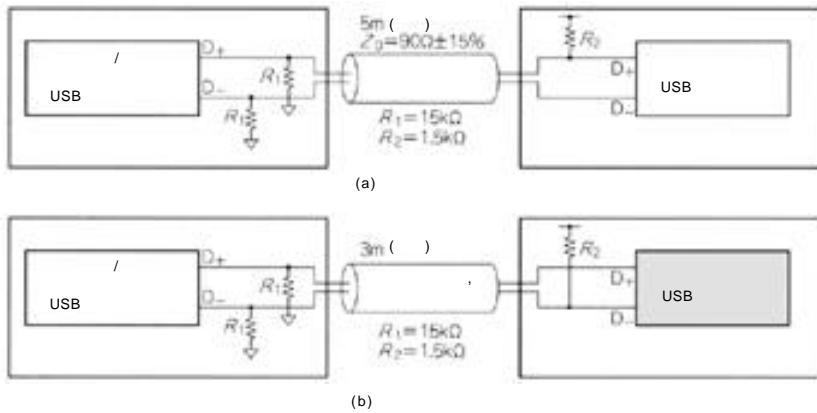
3.

		(USB2.0)	(USB1.1)	(USB1.1)
[Mbps]		480	12	1.5
[]		1 ~ 64	1 ~ 64	1 ~ 8
		1 ~ 3072	1 ~ 64	1 ~ 8
		1 ~ 512	1 ~ 64	—
		1 ~ 3070	1 ~ 1023	—

4.

"1"	$D_+ - D_- > 200 \text{ mV}$
"0"	$D_- - D_+ > 200 \text{ mV}$
J	: "0" : "1"
K	: "1" : "0"
(Idle)	: $D_- > V_{DR(\text{idle})}$, $D_+ < V_{DR(\text{idle})}$: $D_+ > V_{DR(\text{idle})}$, $D_- < V_{DR(\text{idle})}$
SOP ()	K Idle → K

8.



가

가

가

USB1.1

가

4.

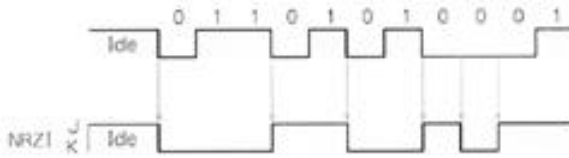
3.

(

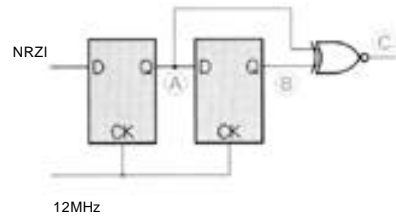
)

USB

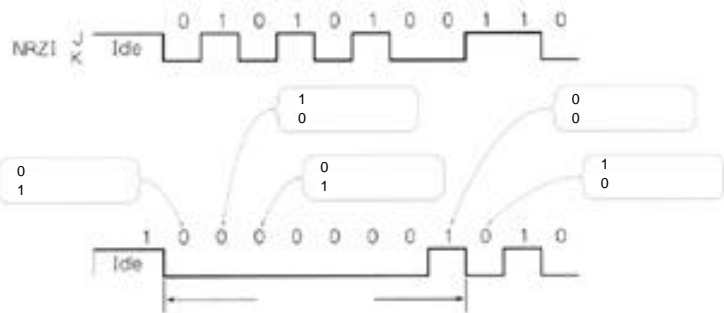
9. NRZI



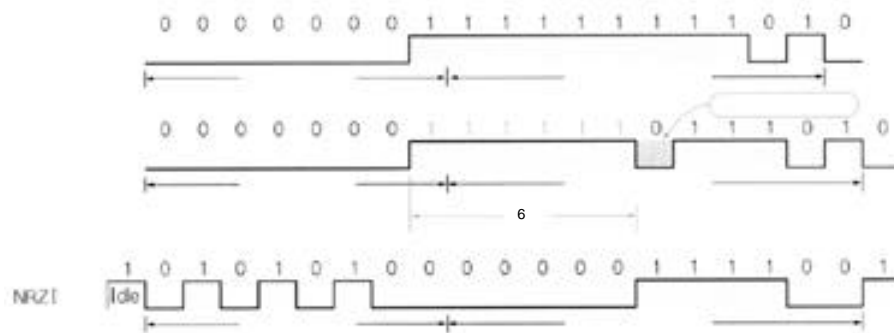
11. NRZI



10.



13.



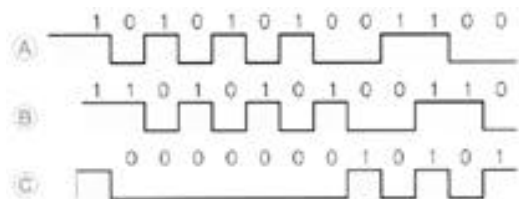
가

USB1.1

2가 가

가

3



12.

1.5Mbps

USB

가

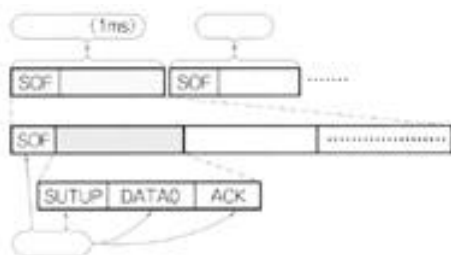
8 USB

D₊, D₋ 15k

D₊ 1.5k 3.0 3.6V

D₊, D₋

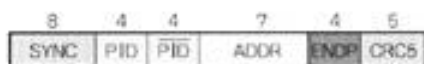
3V 가



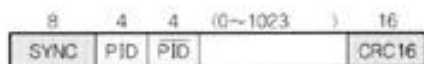
14. / /



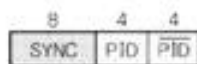
(a) SOF



(b)



(c)



(d)

15.



USB , 4

D₊, D₋

D₊-

D₋가 0.2V

"1"

J

K

J

"0"

"1"

가

9

NRZI

(Non Return to Zero Invert)

NRZI

가 "1"

가 "0"

NRZI

10

()

NRZI가 "0"

"1"

"0"

"1"

"0"

"0"

"0"

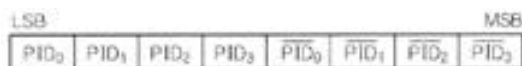
"1"

"0"

80h가

5. PID

PID	PID	PID[3:0]	
	OUT	0001	
	IN	1001	
	SOF	0101	
	SETUP	1101	
	DATA0	0011	PID
	DATA1	1011	PID
	ACK	0010	
	NAK	1010	가
	STALL	1110	
	PRE	1100	



16. PID

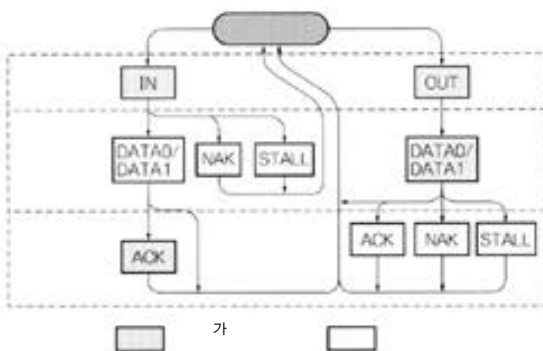
11
12
가
"1"
(slit)
13
"1" 6
"0"
NRZI
"1" 6
"0"
"1" 7
가



USB
14
USB

1ms

SOF
가
SOF



17. /

1.
USB
15
SYNC ((種別)
PID(ID:Packet Identifier) (定型)
80h가
PID 3가

PID 4 5 10 가
16 PID 8 4
4 "1" "0"
가

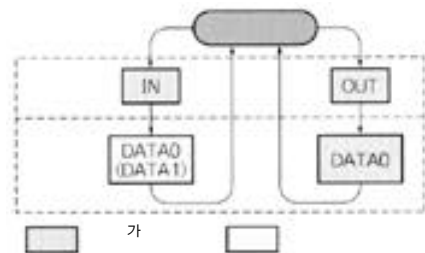
CRC가
가

(1) SOF(Start Of Frame)

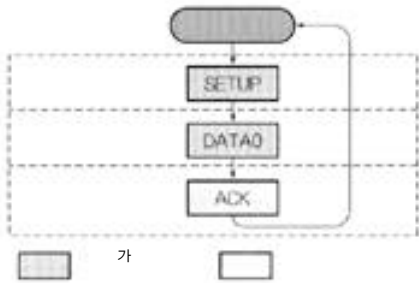
SOF 1ms 가

15(a) SOF . PID(A5h)
11 (0 7FFh) 가 . CRC

5
(2)



18.



19. SETUP

OUT, IN, SETUP 15(b)
SYNC, PID, ADDR, ENDP, CRC5 5가

IN ADDR, ENDP

, OUT

. SETUP

SETUP

(3)

15(c) SYNC, PID, DATA, CRC16

4가

0 1023

PID DATA0, DATA1 2 가

가

(4)

15(d) SYNC PID

. PID ACK,

NAK, STALL 3 가

ACK

IN 가, OUT

가

NAK

가

가

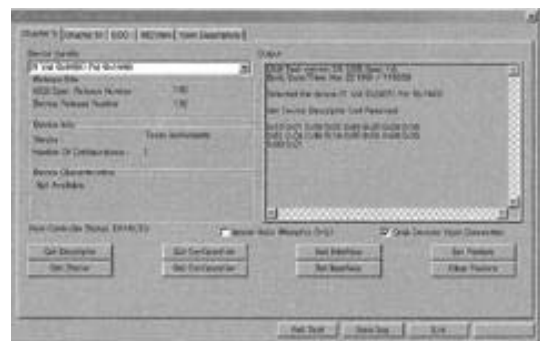
OUT

IN

NAK

6.

Audio Interface	0x00	0x01
	0x02	---
HID	0x00	0x03
	0x09	0x09
	0x00	0x08
HID		HID
	---	0x07



20. USBCheck. exe

NAK

STALL

IN OUT

가

가

가

2.

(1) /

17

4 가

Windows

USB2.0

USB2.0 1999 10
480Mbps() . USB1.1
/
, , , ,
, USB1.1 .

1. USB2.0
USB1.1

USB1.1 가 ,
480Mbps USB1.1
12Mbps 1.5Mbps
가 .

2. $125\mu s$

가 512

3072

3. “Ping Flow Control,” “Split Transaction” 가 . 2000 PDK (Peripheral Development Kit)

USB2.0 가 .

