EZBee series Manual

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AHHA-Tech

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1. Products Overview

EZBee™ formats include OEM modules (M100), industrial serial adapters (S100), USB type serial adapters (U100), and internet access points (L100) for supporting various customers who need to get wireless solutions in industrial automation, medical automation, building automation, information technology, retail/POS and so on.

The EZBee™ series is a 2.4GHz ISM band transceiver, based on the Chipcon CC2420 chip for IEEE 802.15.4. The EZBee™ series supports various AT- style command line interfaces for allowing customers to quickly build mesh networks requiring lower power consumption without skillful wireless RF engineering and complex software engineering. It also provides 2 ADC ports and 8 I/O ports for enabling customers to conveniently design own embedding systems.

The EZBee™ series implements three different data transmission modes including ASCII, Bypass and EBI (EZBee Binary Interface) mode.

In ASCII mode, all data are transmitted as format of ASCII HEX by utilizing the AT command sets for data transmission.

In Bypass mode, all raw data are transmitted to the pre- assigned EZBee module without utilizing any specific commands or building any communication packet, as if EZBee modules are wired together.

In EBI mode, the transmitting data packets can be configured by

customers for more flexible and effective communication.

A specified own ID and an extended/short address are assigned for each modem of EZBee formats. The specified own ID is used for pointing a data receiving modem in every data transmission modes.

The specifications of EZBee™ is summarized as follows:

EZBee Specifications	
Communication range	2500m (LOS)
TX power	0 dBm ~ 18 dBm (selectable by software)
RF Data Rate	250,000 bps
Serial Interface Data Rate	1,200 – 115,200 bps (selectable by software)
Receive sensitivity	-100dBm (packet error ratio 1%)
Supported Network Topologies	Point-to-point, point-to-multipoint, peer-to-peer
Number of Channels	16 direct sequence channels (selectable by software)
Addressing Options	PAN ID, Channel, Addresses

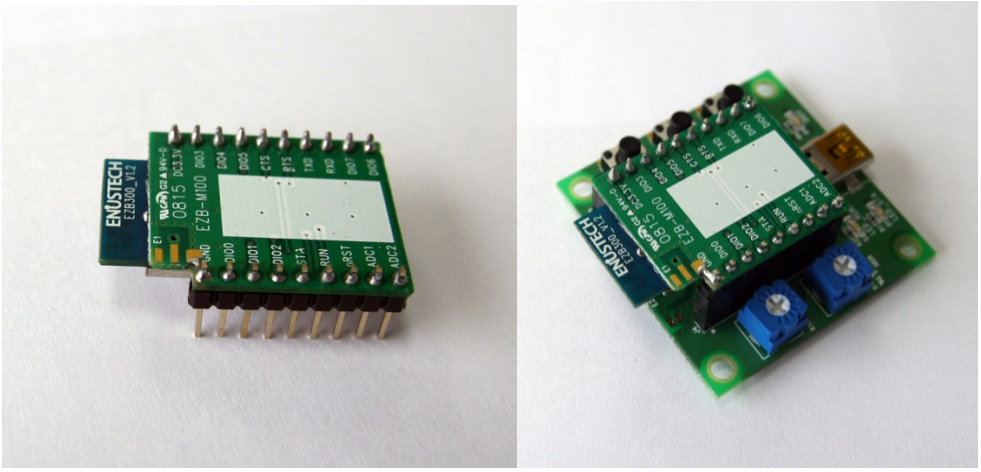
EZB-S100, EZB-U100 and EZB-L100 comply with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

2. EZBee M100

EZBee M100 based on IEEE 802.5.4 specification, is designed for an embedded solution to provide stable wireless communication with low power consumption.



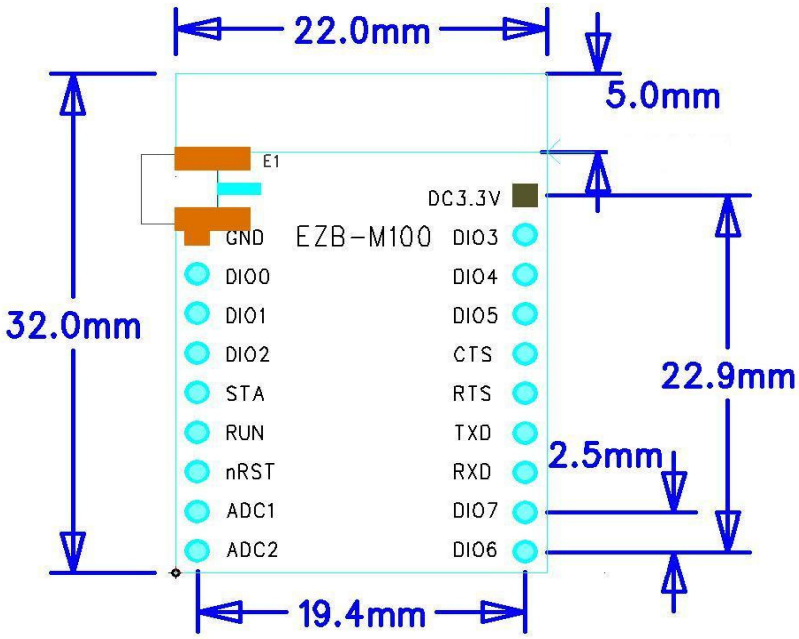
2.1 Specification of EZBee M100

General Specifications	
Operating Frequency	ISM 2.4 GHz ISM 2.4 GHz
Dimension*	32.0mm(L) x 22.0mm(W) x 10.5mm(H)
Operating Temperature	-25 ~ 85° C
Electrical Specifications	
Supply Voltage	2.7~3.6V
Transmit Current(typical)	190mA
Idle/Receive Current(typical)	27mA

2.2 EZBee M100 PIN Assignments

PIN	Name	Direction	Description
1	GND	-	Power Ground
2	DIO0	Input / Output	Digital Input or Output
3	DIO1	Input / Output	Digital Input or Output
4	DIO2	Input / Output	Digital Input or Output
5	STA	Output	Status LED
6	RUN	Output	Active LED
7	nRST	Input	RESET, Low Active
8	ADC1	Input	Analog to Digital Converter
9	ADC2	Input	Analog to Digital Converter
10	DIO6	Input / Output	Digital Input or Output
11	DIO7	Input / Output	Digital Input or Output
12	RXD	Input	UART Data
13	TXD	Output	UART Data
14	RTS	Output	UART Request to Send
15	CTS	Input	UART Clear to Send
16	DIO5	Input / Output	Digital Input or Output
17	DIO4	Input / Output	Digital Input or Output
18	DIO3	Input / Output	Digital Input or Output
19	DC 3.3V	-	Power supply 3.3V

2.3 EZBee M100 Dimension

Dimension*


2.4 EZBee M100 LED Display

LED display	
ACT LED (blue colour)	Flash when data are transmitted (Tx/Rx mode)
STA LED (orange colour)	When the device is not joined in PAN - Repeat Turning ON during 1 second and OFF during 1 second
	When the device is joined in PAN - In ASCII MODE : ON continuously - In EBI MODE : Repeat flashing twice every 0.5 second and turning OFF during 0.5 second - In BYPASS MODE : Repeat Turning ON during 0.5 second and OFF during 0.5 second

※ Please refer Appendix for how to use EZBee M100.

※ EZBee M100- S (MMCX Type) has a connection point for an external antenna.

3 EZBee S100

EZBee S100 is designed to communicate with other devices based on IEEE 802.5.4 specification without installing any serial cable. Two EZBee S100 serial adaptors are connected to each other immediately when power is supplied. If 38,400 baud rate is set for stable transmission, a pair of S100 is able to connect without any extra setting.

3.1 Specification of EZBee S100

General Specifications	
Voltage	DC 4.5V~DC 5.5V (mini usb type jack or DSUB 9 pin)
Hardware interface	RS-232, RS-422, RS-485
LED display	On/Off, current status
Operating environment	Operating temperature: -25~70 ° C
	Storage temperature: -25~70 ° C
	Humidity: 0 ~ 90% non-condensing
Physical properties	Dimension: 31mm(w) x 15mm(H) x 60mm(L)
	Weight: 16g

3.2 Configuration of EZBee S100

Configuration method for a serial adaptor can be divided for RS-232 and RS-422/485 communication mode.

The baud rate of each communication mode is set by only DIP switches on the EZBee S100.

3.2.1 RS-232 communication mode

1 Selection switch for 232 or 422/485 is pushed to the 232 side.

2 Flow control method and baud rate for serial communication are set by DIP switches.

3 EZBee S100 is connected to the serial port of a PC or DTE.

4 A mini USB cable protruded from a PC USB port or DC adaptor should be connected to the mini USB port on EZBee S100 for power supply.

3.2.2 RS-422/485 communication mode

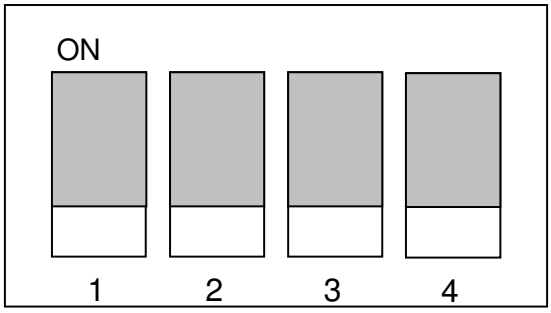
1 Selection switch for 232 or 422/485 is pushed to the 422/485 side.

2 The 422 or 485 mode is selected by DIP switches.

3 The baud rate for serial communication is set by DIP switches.

4 A mini USB cable protruded from a PC USB port or DC adaptor should be connected to the mini USB port on EZBee S100 for power supply.

3.3 Dip switch setting



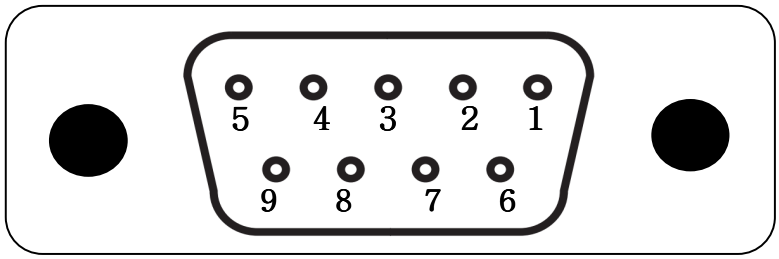
► **DIP1 mode setting**

	RS-232 mode	RS-422/485 mode
DIP1 ON	Hardware Flow Control ON	RS-422
DIP1 OFF	Hardware Flow Control OFF	RS-485

► **Baud rate setting**

Baud rate	DIP2	DIP3	DIP4
38400 bps	OFF	OFF	OFF
2400 bps	OFF	OFF	ON
9600 bps	OFF	ON	OFF
19200 bps	OFF	ON	ON
38400 bps	ON	OFF	OFF
57600 bps	ON	OFF	ON
115K bps	ON	ON	OFF
38400 bps	ON	ON	ON

► **DSUB 9 Pin Definition**



Pin Number	RS-232	RS-422	RS-485
1	DCD		
2	TXD	RXD-	TXD-/RXD-
3	RXD	TXD-	
4	DTS		
5	GND		
6	DTR		
7	CTS	RXD+	
8	RTS	TXD+	TXD+/RXD+
9	DC Input	DC Input	DC Input

3.4 EZBee S100 LED display

LED display	
ACT LED (blue colour)	Flash when data are transmitted (Tx/Rx mode)
STA LED (orange colour)	When the device is not joined in PAN - Repeat Turning ON during 1 second and OFF during 1 second
	When the device is joined in PAN - In ASCII MODE : ON continuously - In EBI MODE : Repeat flashing twice every 0.5 second and turning OFF during 0.5 second - In BYPASS MODE : Repeat Turning ON during 0.5 second and OFF during 0.5 second

4 EZBee U100

EZBee U100, a dongle type EZBee format, makes it easy monitor and control the devices on a PC or hand- held device. In addition, it can be utilized as a router for IEEE 802.15.4 network for extending communication range or overcoming weak signal strength in certain area.

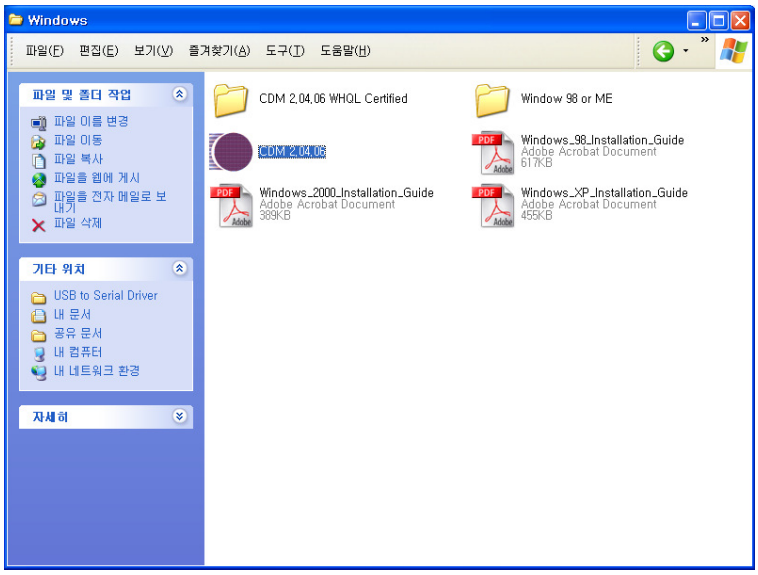
4.1 Specification of EZBee U100

General Specifications	
Voltage	DC 4.5V~DC 5.5V (mini usb type jack)
Hardware interface	USB 2.0
LED display	On/Off, current status
Identification on PC	USB to Serial device
Operating environment	Operating temperature: -25~70 ° C
	Storage temperature: -25~70 ° C
	Humidity: 0 ~ 90% non-condensing
Physical properties	Dimension: 19.5mm(w) x 8.5mm(H) x 54mm(L)
	Weight: 9g

4.2 Configuration of EZBee U100

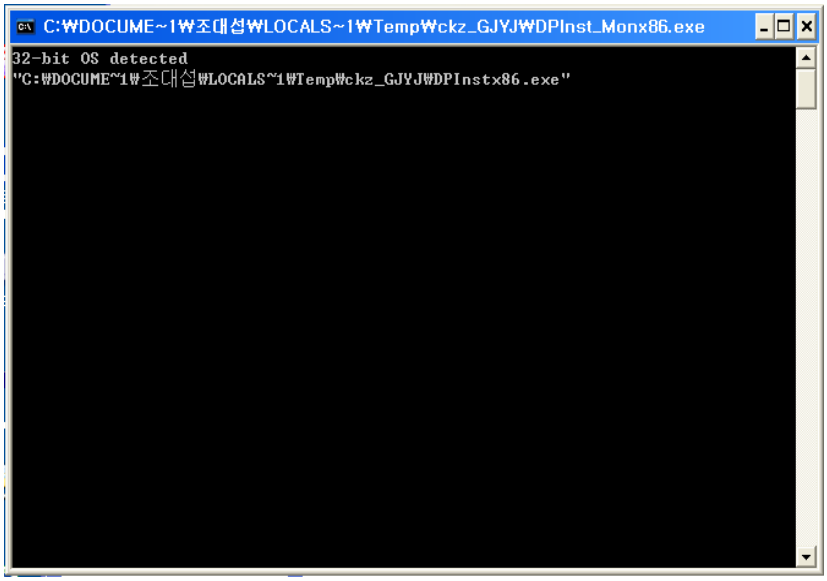
1 To use the EZBee U100 on a PC, a USB port connecting U100 should be set as a virtual conventional COM port in the PC.

2 For virtual COM port setting, the FTDI driver should be installed on PC by running the CDM 2.04.06 on the enclosed CD.

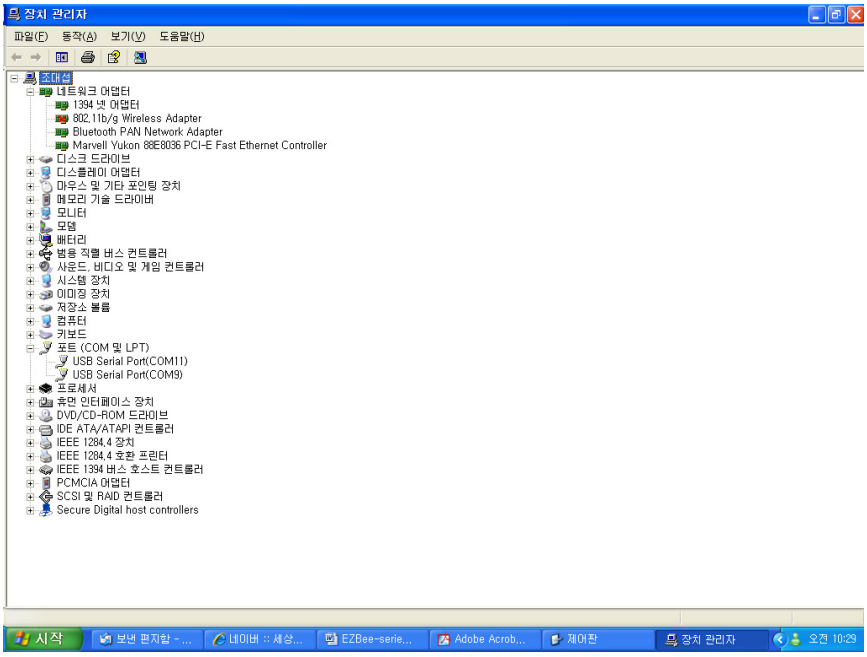


- Suporting OS : Window, MAC, Linux

3 The FTDI driver is installed automatically as shown.



4 After virtual COM port setting, please find the COM port number at port (COM or LPT) of device manager.



4.3 EZBee U100 LED display

LED display	
ACT LED (blue colour)	Flash when data are transmitted (Tx/Rx mode)
STA LED (orange colour)	When the device is not joined in PAN - Repeat Turning ON during 1 second and OFF during 1 second
	When the device is joined in PAN - In ASCII MODE : ON continuously - In EBI MODE : Repeat flashing twice every 0.5 second and turning OFF during 0.5 second - In BYPASS MODE : Repeat Turning ON during 0.5 second and OFF during 0.5 second

5 EZBee L100

EZBee L100 acts as a bridge between the devices based on IEEE 802.5.4 network and conventional TCP/IP network. When sensor data are collected through wireless network, EZBee L100 provides the sensor data into the TCP/IP network enables user to monitor the process.

5.1 Specification of EZBee L100

General Specifications	
Voltage	DC 4.5V~DC 5.5V (mini usb type jack)
Ethernet Interface	10/100 Base-T Ethernet with RJ45 jack
LED display	On/Off, current status
Network protocol	HTTP, DHCP Client
Communication setting	Web, Manager Program
Operating environment	Operating temperature: 0~70 ° C
	Storage temperature: -25~70 ° C
	Humidity: 0 ~ 90% non-condensing
Physical properties	Dimension: 35mm(W) x 20.5mm(H) x 64.5mm(L)
	Weight: 30g

5.2 Configuration of EZBee L100

Firstly a LAN connector for TCP/IP network should be connected to a LAN port prepared on EZBee L100. For the power supply, please connect a mini USB cable protruded from a PC USB port or DC adaptor into the mini USB port on EZBee L100.

5.3 Network Setting

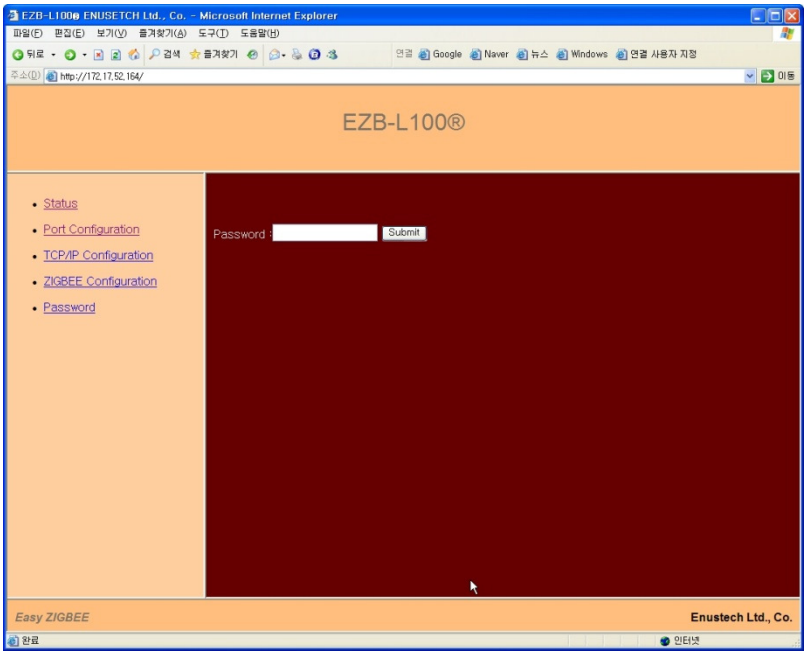
Initial setting	
IP	172.17.52.164
Netmask	0.0.0.0
Gateway	0.0.0.0
default password	enus

5.3.1 Using web browser

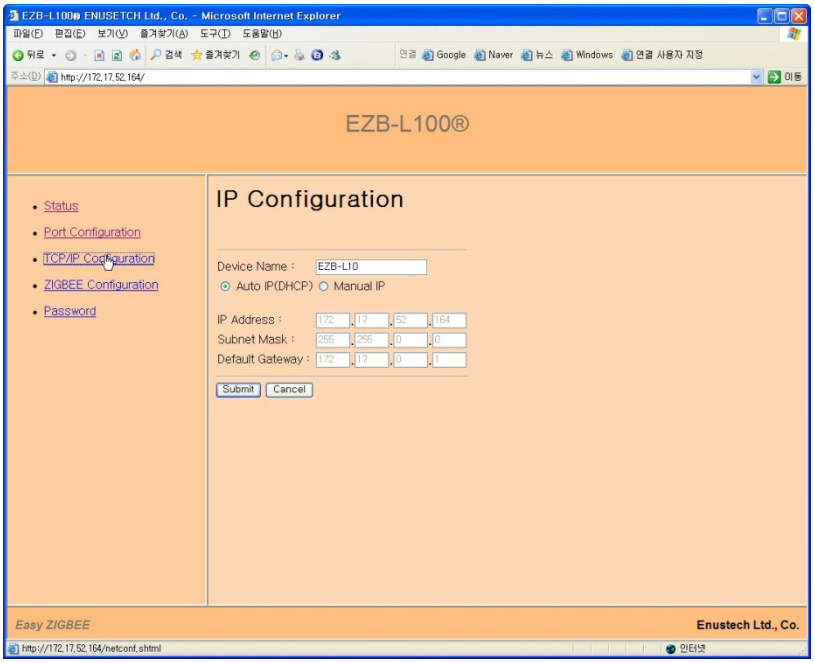
1 Connect to http://172.17.52.164 on web browser. In this moment, please check the IP and Netmask of the PC whether it can access

to default IP.

2 Type enus as the default password



3 After set your network IP at [TCP/IP configuration], reboot the EZBee L100.



5.3.2 Using EZBee manager program

The EZBee manager program is an utility program developed for easy setting and management of a EZBee L100.

Useful function for setting : <scanning broadcasting device>

The useful function of the EZBee manager program is a scanning broadcasting device. It searches and shows all list of EZBee L100 connecting to the same network of a user computer.

1 Click the button denoting [start search].

2 A list of all EZBee L100 connecting to the network is displayed when the automatic scanning is over.

3 When you want to change the setting of one U100 among the list, move the mouse point onto that EZBee L100 and just click the right button of a mouse, then you can change the parameter from the displaying menu.

5.4 Menu related to communication of EZBee L100

Status Monitoring	Shows current status of the EZBee L100
Port configuration	Set operation of the EZBee L100 - **Active connection** : EZBEE L100 acts as a client of TCP/IP network, and tries to connect to a designated server. - **client connecting time (period) :** When a port is assigned as TCP/IP client, the assigned port tries to connect to the specified host IP by the period of client connecting time. **- KeepAlive Enable:** Check whether the TCP/IP connection is alive or not. **- KeepAlive Interval:** In case of setting 'KeepAlive Enable' function, it checks whether the connection is alive or not when data is not transmitted to the specified port during a period of time. **- Port Setting:** port number: TCP port number Active: Active TCP connection request. Client mode Server IP: IP address for active connection P-P: peer-to-peer mode setting for EZBee **- Communication:** P-P: peer-to-peer mode set for wirelss communication MODULE ID: Module ID
TCP/IP Configuration	- Device Name: assign the name of EZBee L100. - Set the specified IP address.
EZBee	Set channel ID, PAN ID, group ID and module ID

Configuration	

5.5 Communication modes of EZBee L100

EZBee- L100 supports the TCP/IP socket programming. It can be assigned as a client or server according to each ports and handles data as unit of packet.

The packet format is selectable among the EBI mode, P- P(Peer to Peer, Bypass mode), according to the port. The default setting is the EBI mode, enables to communicate any modules connecting to same socket. When the P- P mode is selected, it switched to the Bypass mode, and enable to communicate without the specified module or header data.

5.6 EZBee L100 LED display

LED display		
ACT LED (blue color)	Flash when data are transmitted (Tx/Rx mode)	
STA LED (orange color)	In case of turning ON	denotes EZBee L100 is joined in the network, and ready to communicate with other EZBees.
	In case of flashing	denotes EZBee L100 is not joined in the network.

6. AT Command

The EZBee formats support various AT commands for controlling the modem. Customers can configure the desired characteristics of a specific network using the rich AT commands

6.1 Reference table for AT Commands

AT command	Category	Description	Parameter	Default
D	System	Change modem mode to 'BYPASS' mode	<Modem ID>	
B	System	Change modem mode to 'EBI' mode	None	
Z	System	Modem reset	None	
NZ	System	Modem reset with erase network states	None	
V	System	Show modem version	None	
S	System	Show modem status	None	
+SPI	Set	Set/Get RS-232C interface configuration	? =<baud>,<flow>	38400/ HW flow
+CH	Set	Get /Set frequency channel	? =<11~26>	11
+DST	Set	Get/ Set default destination ID for binary mode	? =<Modem ID>	0
+E	Set	Serial echo on/off	0 / 1	1
+EA	Set	Get 64-bit extended address	?	
+ID	Set	Set/Get modem ID	?	23

			=<Modem ID>	
+PID	Set	Get/Set PAN ID	0~16383	4911
+GID	Set	Get/Set Group ID	1~255	1
+AS	Set	Get/Set Network auto start/Join	0/1	0
+PMJ	System	Permit join	?/=<0/1>	1
+SA?	System	Show 16-bit short address	None	
+IO	System	Access GPIO	?/=<Value>	
+IOD	System	Access GPIO direction	?/=<Value>	
+ADC?	System	Query ADC value	<ch1>,<ch2>	
+RA	System	Permit remote access	?/=<0/1>	1
&MSG	Network	Send Message		
&PS	Network	Start/Join PAN manually	None	

6.2 Notification message

Notification message is a message sent from a modem asynchronously. It is generated when the status of a modem or data is transmitted.

message	Parameter	Description
$MSG	<ID>,<SADDR>,<LinkQuality> ,<Message>	Generated upon receiving data from a modem having <ID> number.
$SND	<transID>,<Result>	Shows the sending result
$RESET	None	Generated at modem reset
$NWK	COORD	Shows a modem is configured as a EZBee Coordinator in the PAN.
	ROUTER,<SADDR>	Shows a modem is joined at PAN as a EZBee Router, and the short address of the modem is <SADDR>

6.3 Result message

Every modem of EZBee formats returns a resulting message after executing the AT command as following:

Message	Description
OK	Denotes execution of AT command is success
ERROR	Means an undefined AT command or un-allowed parameter is inputted
FAIL	Display an internal error is generated during execution of AT command
NO_MEM	Shows shortage of memory space for execution of AT command

7 Description of AT commands

7.1 Serial communication interface

7.1.1 Serial port setting

EZBee formats support a standard serial communication port (RS-232C). The basic setting parameters for a serial communication of the EZBee are shown as followings.

parameters	
Baud rate	38400
Data	8-bit
Parity	None
Stop bit	1-bit
Flow control	H/W flow control ON

The setting parameters of the EZBee can be changed using the following AT commands.

Command	Parameter	Result	Description
AT+SPI?	none	<baud >,<flow >	Check current values of setting parameters
AT+SPI=	<baud>,<flow>	**OK** or **ERROR**	Change values of Baudrate and Flow control

The possible values for each parameter are summarized as:

Parameter	value	description
baud	**2400, 9600, 19200, 38400, 57600, 115200**	Baudrate possible to use
flow	**0**	No Hardware follow control
	1	Use hardware follow control

When a very high baudrate is set, the data transmitted can be lost because the I/O buffer size of EZBee is 128 byte each. According, it is recommended to use a hardware follow control. If it is difficult to use a hardware follow control, the low baudrate such as under 9600 is recommended strongly.

7.1.2 Echo mode setting

The option for an echo according to the AT commands inputted are selectable as shown as:

Command	Parameter	Result	Description
AT+E0	None	**OK**	Cancel echo mode
AT+E1	None	**OK**	Activate Echo mode
AT+E?	None	**0** or **1**	Check current echo option

7.2 EZBee Modem setting

In order to communicate using the EZBees, each EZBees should be joined in PAN (personal area network). All EZBees in a specific PAN should have an identical channel ID and PAN ID. If the channel IDs are identical but different PAN IDs, then the EZBee belongs to other PAN. Further, if the PAN IDs are identical but different channel IDs, then the EZBee also belongs to other network. Only one coordinator is allowed in a specific PAN.

7.2.1 Channel setting

Total 16 channels are ready to use in the EZBee formats. All EZBees in a certain PAN should be set to use an identical communication channel number.

Followings are the AT commands for setting a channel number or checking the channel number assigned.

Command	Parameter	Result	Description
AT+CH	?	**11 ~ 26**	Shows a current channel assigned
	=<channel>	**OK** or **ERROR**	Set a channel.

If the EZBee is already joined in PAN using AT&PS command, it should be rebooted after setting a channel for the effectiveness of channel setting. Furthermore, if the channel of a Coordinator is changed, then all channels

of routers should be changed as that of coordinator.

When you select a channel number, check the overlapping with other wireless devices in the vicinity of the EZBee to avoid interference between channels.

The frequency of each channel is assigned as following.

Channel	Frequency	Channel	Frequency
11	2405 MHz	19	2445 MHz
12	2410 MHz	20	2450 MHz
13	2415 MHz	21	2455 MHz
14	2420 MHz	22	2460 MHz
15	2425 MHz	23	2465 MHz
16	2430 MHz	24	2470 MHz
17	2435 MHz	25	2475 MHz
18	2440 MHz	26	2480 MHz

7.2.2 PAN ID setting

All EZBees in a specific PAN should have an identical PAN ID. Accordingly, a different PAN can be built by different PAN ID.

Followings are the AT commands for setting a PAN ID or checking the PAN ID assigned.

Command	Parameter	Result	Description
AT+PID?	none	<PAN ID>	Shows a current PAN ID assigned
AT+PID=	**0~16383**	**OK**	Set PAN ID
		ERROR	

If the EZBee is already joined in PAN using AT&PS command, it should be rebooted after setting a PAN ID for the effectiveness of PAN ID setting.

7.2.3 Modem ID setting

Each modem embedded in EZBee formats has the own 64bit address, called as an extended address, and it is used to identify a specific modem among various modems in PAN. However, the extended address is difficult to use due to its big size. The short- address is mostly used in real practical communication. Because the short- address is assigned dynamically by a coordinator when a modem is joined in PAN, users can not know the short- address before joining in PAN.

Followings are the AT commands for setting a new modem ID or checking the modem ID assigned.

Command	Parameter	Result	Description
AT+ID?	None	**0~253**	Check the own modem ID assigned
AT+ID=	**0~253**	**OK** **ERROR**	Set a modem ID
AT+ID@	<SADDR>?	**OK**	Check a modem ID having a short-address <SADDR> within same PAN

All modem in the network should have a different own modem ID. Especially, a modem ID 0 represents a EZBee coordinator. After establishing a PAN by assigning a coordinator, other modems should be tried to join in the PAN.

If the characteristics of a coordinator is changed or the other modem is assigned as a coordinator in PAN already established, all modems in a PAN should be reset to erase network states using '**ATNZ**' and rebooted.

In case of the ID command for a remote modem '**$ID@**', <SADDR> means a short- address and display as ASCII- HEX format. When the ID command for a remote modem is conducted successfully, the following return message is returned.

Message	Description
$ID@<SADDR>=<ID>	Shows a short-address <SADDR> and <ID>

7.2.4 Group ID setting

The EZBee formats support a group communication in a PAN. A group includes several modems and data can be transmitted to a specified group in a PAN.

For group transmission, following AT commands are utilized.

Command	Parameter	Result	Description
AT+GID?	None	**0~255**	Check a group ID of a modem
AT+GID=	**0~255**	**OK** / **ERROR**	Set a group ID of a modem.
AT+GID@<DstID>**?**	**None**	**OK**	Check a group ID of a remote modem
AT+GID@<DstID>**=**	**0~255**	**OK**	Set a group ID of a remote modem

For setting a group ID of a remote modem, the remote modem should be set the 'value for remote access' as 1. Please refer AT+RA command.

When the group ID command for a remote modem is conducted successfully, the following return message is returned.

Message	Description
$GID@<DstID>=<GroupID>	Group ID < GroupID> setting in a remote modem <DstID>

7.2.5 Receiver ID setting for Bypass mode

The EZBee formats supports the bypass mode communication which all data are collected by a specified modem as if all modem in a network is wired to a specified modem.

The receiver modem should be assigned before starting the bypass mode communication using following AT commands.

Command	Parameter	Result	Description
AT+DST?	None	**0~253**	Check the ID of a receiver modem assigned already within the modem
AT+DST=	**0~253**	**OK** **ERROR**	Set the ID of a receiver modem onto the modem

7.2.6 Automatic start mode setting

When a modem is reset, the PAN can be started or joined automatically by using following AT commands. The commands are effective in the ASCII mode communication only.

Command	Parameter	Result	Description
AT+AS?	None	**0** or **1**	Show a current automatic start mode
AT+AS=	**0**	**OK**	Cancel a automatic start mode
	1	**OK**	Activate a automatic start mode

7.2.7 Starting EZBee network

In case of setting a modem for the first time or turning a automatic start mode off, a following command initiates a PAN. A coordinator establishes the PAN and routers try to join the PAN.

Command	Parameter	Result	Description
AT&PS	None	**OK**	Establish a PAN or join a PAN
		ERROR	PAN is already established or modem is already joined in the PAN

When establishing a PAN or joining in the PAN is succeeded, following event messages are delivered.

Message	Description
$NWK=COORD	Show a PAN is stated and modem is set as a coordinator
$NWK=ROUTER,< SADDR>	Show a modem is joined as a router, and the assigned short-address by a coordinator is <SADDR>

7.3 Network message transmission

The EZBee formats support 3 different communication mode including ASCII mode, Bypass mode and EBI mode for data transmission.

7.3.1 Data transmission in ASCII mode

In ASCII mode, all data are transmitted as ASCII HEX format to a pointed modem.

Command	Parameter	Result	Description
AT&MSG=	<Modem ID>, <Message>	<transID>/ **ERROR/ FAIL/ NO_MEM/**	<Message> is transmitted to modem ID <Modem ID>
	S<SADDR>,<Message>		<Message> is transmitted to a modem having a short-address <SADDR>
	G<GroupID>,<Message>		<Message> is transmitted to modems having a group ID <GroupID> (Multi-Cast function)
	BROAD,<Message>		<Message> is transmitted to modems joined in the PAN (Broadcast function).

After transmission, following event message is returned.

Message	Parameter	Description
$SND=	<transID>,<result>	Show Transaction ID and transmission result

In here, <transID> means the transaction ID which is generated by a modem automatically after finishing the transmission, thereby every transmission generates different transaction IDs.

<result> shows the result of data transmission. If transmission is succeeded, it shows as 1, if failed, number except 1.

Besides, if a modem is not joined in the PAN yet, or the format of transmission message is wrong, following error messages may be returned.

Error Message:

Result	Description
ERROR	Indicate a wrong message format or command
FAIL	Fail data transmission
NO_MEM	Indicate the shortage of internal modem memory
NWK_STOP	Show the PAN is not stated or modem is not joined in PAN yet

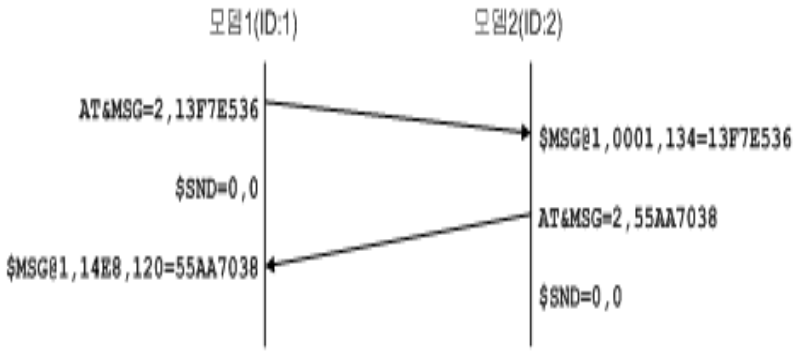
On the other hand, the pointed modem which is received a message generates a following event message.

Message	Parameter	Description
$MSG@	<Modem ID>,<SADDR>,<link quality>=<Message>	Show data receiving from a modem <Modem ID>

The transmitted message should be converted as ASCII HEX format. The length of the message should be less 127 characters including AT command.

Following diagram shows the example of data transmission in ASCII

mode.



A modem 1 sends a message (0x13F7E53) to a modem 2. The modem 2 received data from a sender having the ID=1, the short-address=0x0001. The receiving sensitivity is 134 and the received message is 0x13F7E536.

While, a modem 2 sends the message(0x55AA7038) to a modem 1. The received data by a modem 1 is shown as 0x55AA7038 with a receiving sensitivity 120.

7.3.2 Data transmission in Bypass mode

In Bypass mode, all data inputted from a serial port can be transmitted without any modification to a pointed modem. Accordingly, the Bypass mode is suitable for transmitting all data to one specified modem in a PAN.

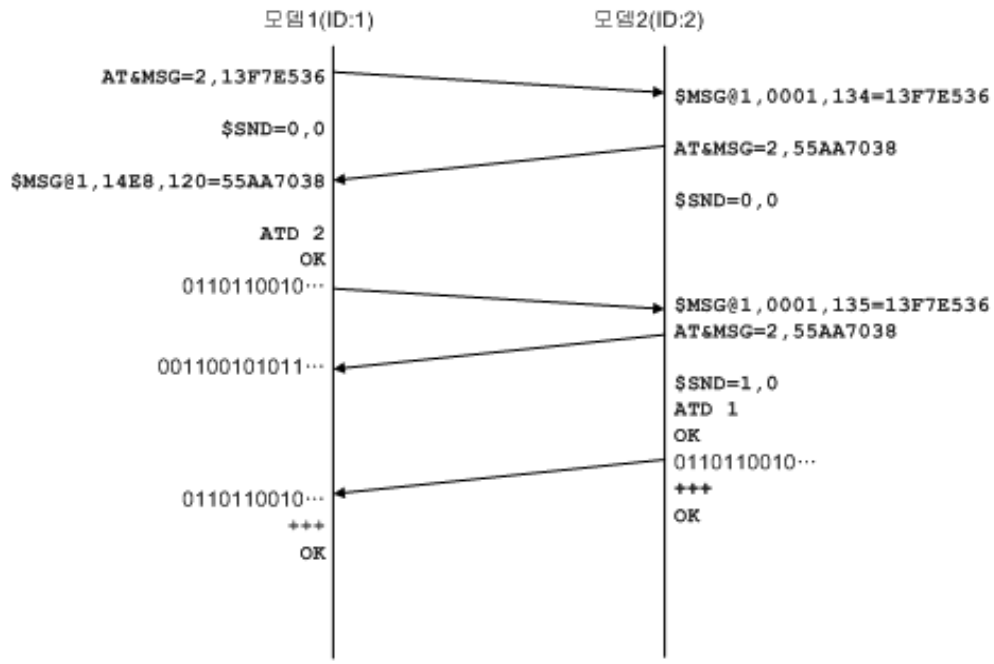
Followings are AT commands related to the Bypass mode communication.

Command	Parameter	Result	Description
ATD	<space><DstID>	**OK/ERROR/FAIL/NO_MEM /NWK_STOP**	Convert from ASCII mode to Bypass mode
AT+DST	**?**	**<DstID>**	Read a receiver ID of the Bypass mode
	=<DstID>	**OK /ERROR**	Set a receiver ID of the Bypass mode
+++	**None**	**OK**	Convert from Bypass mode to ASCII mode

In Bypass mode, all data are transmitted to the assigned receiving modem. Accordingly the ASCII or EBI mode is more suitable than the Bypass mode when a receiving modem is changed frequently or data are transmitted to group or broadcasted all modem joined in the network.

ATD command can omit the <DstID> parameter. In this case, data are transmitted to a modem ID which was set by 'AT+DST' or previous ATD command.

Following diagram shows the example of data transmission in Bypass mode.



It is not necessary the receiver and sender have been set as same communication mode. The communication mode is selected according to the operating environment.

If a sender is set as Bypass mode and a receiver as ASCII mode, and the sender sends a long message, the receiver can receive the message as divided length of messages due to the size of internal buffer or transmission delay.

For converting from the Bypass to ASCII mode, a string “+++” should be typed at least 300 [msec] later after transmitting the final data. A mode converting is succeeded if no characters are inputted during 300 [msec] after inputting the string “+++”. If any characters are inputted within 300 [msec], it is considered as the transmitting data.

7.4 Reading a Short- address

A 16 bit short- address assigned during the process of joining in the PAN can be obtained by utilizing following AT commands. A short- address is mainly used in practical communication instead of an extended address.

Command	Parameter	Result	Description
AT+SA?	None	<short address>	Read a short-address assigned
AT+SA@	<DstID>**?**	**OK/ERROR/NWK_STOP**	Check a short-address having a remote modem ID <DstID>

If the short- address returned from a modem shows 0xFFFE, then it means the short address is not assigned because the PAN is not started or a modem is not joined in the PAN yet.

In case of a remote modem, it returns a following message when a message transmission is succeeded.

Message	Parameter	Description
$SA@	<DstID>=<SADDR>	Show a short-address <SADDR> of a remote modem <DstID>

7.5 Reading an extended address

Using following commands, the IEEE 64bit extended address of a specific modem is readable.

Command	Parameter	Result	Description
AT+EA?	None	<extended address>	Read an extended address of a current modem.
AT+EA@	<DstID>**?**	**OK/ERROR/NWK_STOP**	Read an extended address of a remote modem having <DstID>

In case of a remote modem, it returns a following message when a message transmission is succeeded.

Message	Parameter	Description
$EA@	<DstID>=<EADDR>	Show an extended address <EADDR> of a remote modem <DstID>.

7.6 Resetting a Modem

The command for modem resetting is shown as following.

Command	Parameter	Result	Description
ATZ	None	**$RESET**	Software reset for a modem

7.7 Resetting a Network

In case of changing network parameters or joining again in the PAN, the network status should be reset using following AT command.

Command	Parameter	Result	Description
ATNZ	None	**$RESET**	Reset the network

7.8 Reading a modem version

It is checked the firmware version of a modem using following AT command.

Command	Parameter	Result	Description
ATV	None	**EZB300FV1.0**	EZBEE300 FFD version 1.0
		EZB300RV1.0	EZBEE300 RFD version 1.0

7.9 Reading a modem status

It is checked the current status of a modem using following AT command.

Command	Parameter	Result	Description
ATS	None	**$NWK=STOP**	Non- establishing a PAN or not join in the PAN
		$NWK=COORD	PAN is started and a modem set as a coordinator in the PAN
		$NWK=ROUTER,<SADDR>	A modem is joined in the PAN as a Router, and a short- address is assigned as <SADDR>

7.10 GPIO control and setting

The EZBee formats support the functionality to read GPIO and ADC of remote modems. It can read 8 GPIO ports and 2 ADC channels having 10 bit resolution.

7.10.1 GPIO direction setting

The GPIO direction of a local or remote modem can be set by utilizing following AT commands.

Command	Parameter	Result	Description
AT+IOD?	None	<direction value>	Read the GPIO direction of a local modem
AT+IOD=	<value>	<direction value>	Set the GPIO direction of a local modem
AT+IOD@	<DstID>?	**OK**	Read the GPIO direction of a remote modem.
	<DstID>=<value>		Set the GPIO direction of a remote modem

The format of GPIO is shown as following.

7(MSB)	6	5	4	3	2	1	0(LSB)
PORT7	PORT6	PORT5	PORT4	PORT3	PORT2	PORT1	PORT0
Effective value (**00~FF**)							

If the bit value of a port is 1, then the port acts as the output port. If the bit value of a port is 0, then the port acts as the input port.

In order to set the GPIO input/output mode of a remote modem, the value for accessing to a remote modem should be set as 1. Please refer to a command 'AT+RA'.

When the command for a remote modem is accomplished successfully, a following event message is returned.

Message	Parameter	Description
$IOD@	<DstID>=<value>	Return the GPIO input/output mode value of a remote modem <DstID>

7.10.2 GPIO control

For control or monitor GPIO of a local or remote modem, following AT commands are utilized.

Command	Parameter	Result	Description
AT+IO?	None	<value>	Read the GPIO status value of a local modem
AT+IO=	<value>	<value>	Set the GPIO status value of a local modem
AT+IO@	<DstID>?	**OK**	Read the GPIO status value of a remote modem
AT+IO@	<DstID>=<value>	**OK**	Set the GPIO status value of a remote modem

The format of GPIO is shown as following.

7(MSB)	6	5	4	3	2	1	0(LSB)
PORT7	PORT6	PORT5	PORT4	PORT3	PORT2	PORT1	PORT0
Effective value (**00~FF**)							

When the bit value of each port is 1, it means the port voltage level (status) is high. When the bit value is 0, the port voltage is low. It is possible to set the bit of each port when the port is assigned as an output port.

When the command for a remote modem is accomplished successfully, a following event message is returned.

Message	Parameter	Description
$IO@	<DstID>=<value>	Return the GPIO status value of a remote modem <DstID>

7.10.3 ADC reading

The status value of a local or remote modem can be checked by following AT commands.

Command	Parameter	Result	Description
AT+ADC?	None	< CH1>,<CH2>	Read the ADC status value of a local modem
AT+ADC@	<DstID>?	**OK**	Read the ADC status value of a remote modem

The ADCs in EZBee modem are 2 channels having 10 bit resolution, and operated based on 3.3V reference voltage.

The status value of the ADC is expressed as ASCII HEX format. For example, if 1.25V and 2.5V are inputted onto channel 1 and channel 2, respectively, the ADC status values are expressed as 060F and 0C1E.

When the command for a remote modem is accomplished successfully, a following event message is returned.

.

Message	Parameter	Description
$ADC@	<DstID>=<CH1>,<CH2>	Return ADC status value of a remote modem <DstID>

7.11 Remote control allowance setting

In the EZBee formats, the allowance is selectable whether it make a remote modem control the GPIO or change parameters of a local modem in the PAN.

Command	Parameter	Result	Description
AT+RA?	None	**1 / 0**	Check the current allowance assigned
AT+RA=	**1**	**OK**	Allow a remote control.
	0		Does not allow a remote control

7.12 PAN joining allowance setting

The allowance for joining in PAN is selectable. The EZBee formats can set a parameter which is a decision value for other modem to join in the PAN via a local modem.

Command	Parameter	Result	Description
AT+PMJ?	None	**1 / 0**	Check the current allowance assigned
AT+PMJ=	**1**	**OK**	Allow for other modem to join the PAN
	0		Does not allow for other modem to join the PAN
AT+PMJ@	<DstID>**?**	**OK**	Check the current allowance or set the allowance of a remote modem
	<DstID>=**<1/0>**		

When the command for a remote modem is accomplished successfully, a following event message is returned.

Message	Parameter	Description
$PMJ@	<DstID>=<value>	Return the allowance of a remote modem <DstID>

8 EBI Commands

8.1 EBI mode overview

To provide more flexible communication method in EZBee formats, the EBI (EZBee Binary Interface) communication mode is developed. In EBI mode, the receiving modem can be assigned. Furthermore, the data are transmitted to a specific group modems or to all modems in a PAN.

Following AT command is useful to enter EBI mode from ASCII mode.

Command	Parameter	Result	Description
ATB	None	OK	Convert a communication mode to EBI

8.2 EBI mode communication

In EBI mode, following packet is utilized for data transmission.

SOP	Type	ID	Length	DATA
1byte	1byte	1byte	1byte	Variable length

The effective values of each field are summarized as:

Field	Value	Meaning
SOP	0x55	Start Of Packet
Type	Refer EBI type	Message type
ID	0~0xFF	sender/receiver ID
Length	0~0x50	Data length
DATA	-	-

8.3 EBI packet type

The packet type and its meanings are summarized as following.

Packet type(Mnemonic)	CODE	Meaning
EBI_TYPE_UNICAST_MSG	0x10	Unicast message
EBI_TYPE_GROUP_MSG	0x11	Group message
EBI_TYPE_BROAD_MSG	0x12	Broadcast message
EBI_TYPE_ACK	0x80	Response according to message transmission
EBI_TYPE_IO_REQ	0x20	Set or check the GPIO status value of a local or remote modem
EBI_TYPE_IO_ACK	0x21	Response according to EBI_TYPE_IO_REQ
EBI_TYPE_IOD_REQ	0x22	Set or check the GPIO input/output mode value of a local or remote modem
EBI_TYPE_IOD_ACK	0x23	Response according to EBI_TYPE_IOD_REQ
EBI_TYPE_ADC_REQ	0x24	Request ADC status value of a local or remote modem
EBI_TYPE_ADC_ACK	0x25	Response according to EBI_TYPE_ADC_REQ
EBI_TYPE_ESCAPE	0x55	Escape from EBI mode (convert to ASCII mode)

8.3.1 EBI_TYPE_UNICAST_MSG

Description	Sending/receiving data to/from a specified modem in the PAN
Direction	send/receive
Data length	Variable data length
ID	sender/receiver modem ID

8.3.2 EBI_TYPE_GROUP_MSG

Description	Sending/receiving data to/from a specified modem group in the PAN

Direction	send/receive
Data length	Variable data length
ID	sender/receiver modem group ID

8.3.3 EBI_TYPE_BROAD_MSG

Description	Sending/receiving broadcast data in the PAN
Direction	send/receive
Data length	Variable data length
ID	Broadcast ID (0xFF)

8.3.4 EBI_TYPE_ACK

Description	Result of message transmission from a modem to the PAN
Direction	receive
Data length	2
ID	0

Data format:

Result	TransID
1(byte)	1(byte)

Meaning :

Field	Value	Meaning
Result	0	Success
	1	Format is not valid
	2	Fail (internal error)
	3	Fail to memory allocation
TransID	0~255	When succeeded, transaction ID of message

EBI_TYPE_ACK packet always returns ‘success’ for the broadcast or group message transmission.

In unicast message transmission, if a short- address of a receiver modem ID does not exist, the data are transmitted as a broadcast message in order to fix the short- address problem. Accordingly, even the modem having identical modem ID with a receiver does not exist in the PAN, the transmission result can be returned as ‘success’.

8.3.5 EBI_TYPE_IO_REQ

Description	Request to check or set the GPIO status value of a local or remote modem
Direction	send
Data length	0 or 1
ID	Local or remote ID

Data length and parameter:

Data length	Parameter	Description
0	0	Request the current value of GPIO ports
1	0x00~0xFF	Set the status value of GPIO ports

8.3.6 EBI_TYPE_IO_ACK

Description	Response according to EBI_TYPE_IO_REQ
Direction	receive
Data length	1
ID	A local or remote modem ID

Data length and parameter:

Value	Description
0x00~0xFF	Show the GPIO status value of a local or remote modem

8.3.7 EBI_TYPE_IOD_REQ

Description	Set a GPIO input/output mode, or request a current setting value of a local or remote modem
Direction	send
Data length	0 or 1
ID	A local or remote modem ID

Data length and parameter:

Data length	Parameter	Description
0	None	Request a setting value of the GPIO input/output mode
1	0x00~0xFF	Set the GPIO input/output mode

8.3.8 EBI_TYPE_IOD_ACK

Description	Response according to EBI_TYPE_IO_REQ
Direction	receive
Data length	1
ID	A local or remote modem ID

Data length and parameter:

Value	Description
0x00~0xFF	Show a setting value of the GPIO

8.3.9 EBI_TYPE_ADC_REQ

Description	Request the ADC status value of a local or remote
Direction	send
Data length	0
ID	A local or remote modem ID

8.3.10 EBI_TYPE_ADC_ACK

Description	Response according to EBI_TYPE_ADC_REQ
Direction	receive
Data length	4
ID	A local or remote modem ID

Data format:

Channel-1 value	Channel-2 value
2 byte	2 byte

8.3.11 EBI_TYPE_ESCAPE

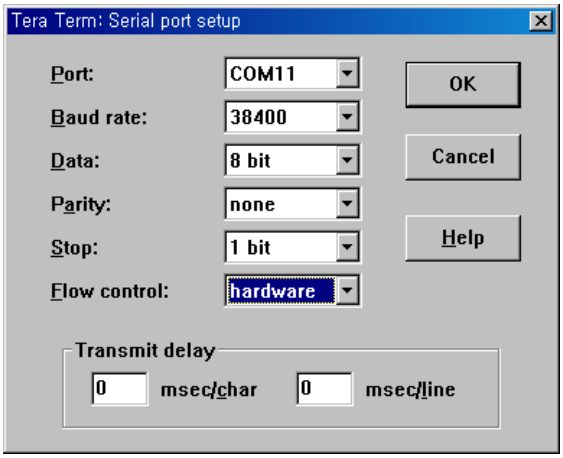
Description	Convert the communication mode from EBI to ASCII mode
Data length	0x55
ID	0x55

For successful communication mode conversion from EBI to ASCII mode, 0x55555555, namely, string "UUUU" should be inputted to a modem within 1 second.

Appendix How to use EZBee M100

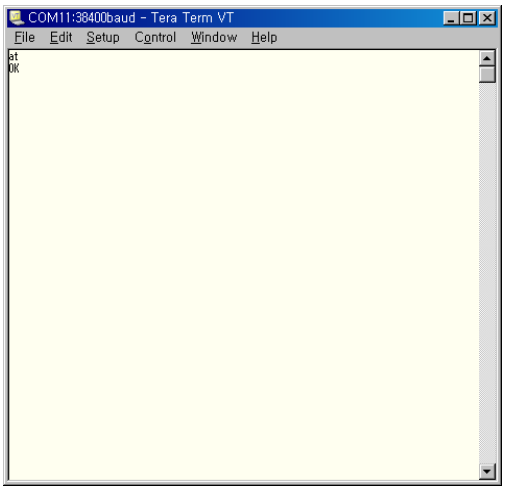
1. Setting Serial Port

1 Install the 'FTDI USB to Serial' driver on a user PC.
2 Connect a EZBee M100 to the user PC.
3 After running a terminal emulator such as Hyper Terminal or Tera Term, set the parameters as followings.



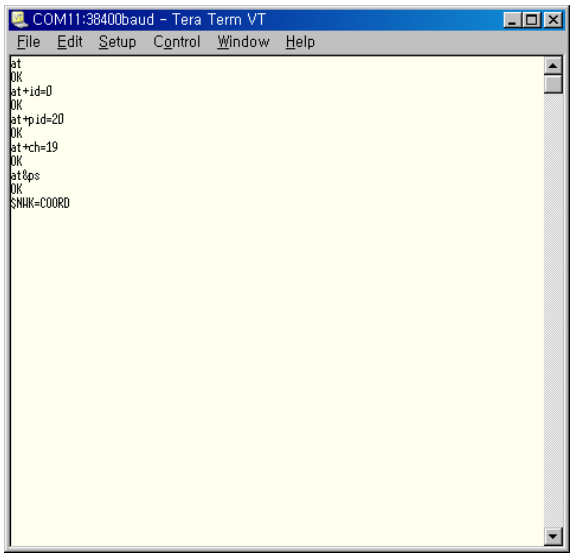
※ Displaying parameters may be different from the PC environment.

4 If **"OK"** message is displayed on the terminal when **"AT"** command is typed, the EZBee M100 is installed successfully to a serial port.



2. Start PAN Network

For starting a PAN, type the AT commands related to a module ID, PAN ID and channel number as shown in the following figure. The module ID should be 0 for a coordinator setting. Finally type **"AT&PS"** to start the PAN.



If the PAN is started successfully, **" $NWK=COORD "** message is displayed. It means the EZBee M100 connected to a serial port is assigned as a coordinator in the PAN.

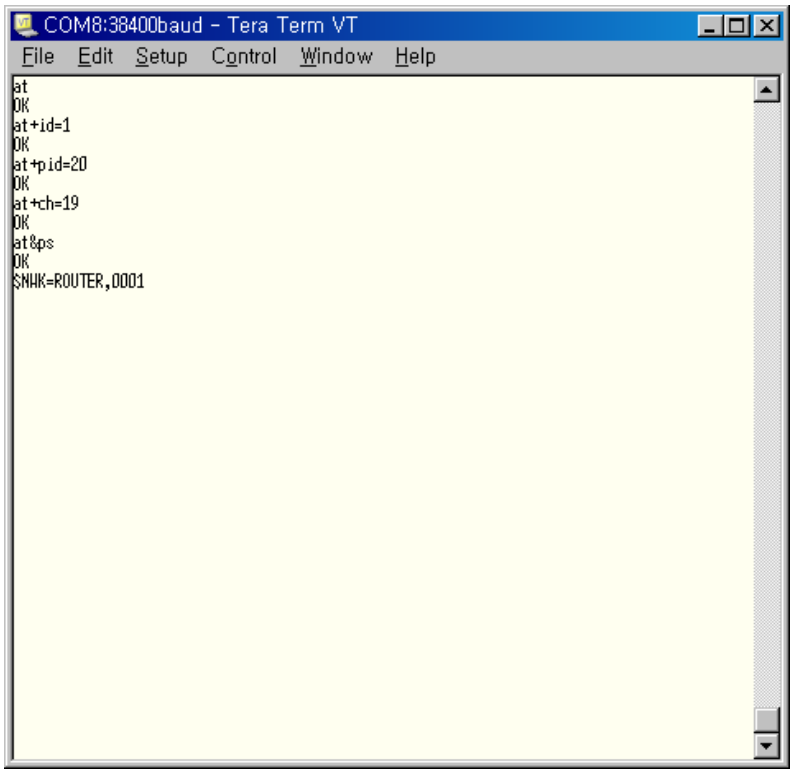
The PAN ID and channel number can be assigned differently as user's wish.

From now on, we call this terminal as a *Coordinator Terminal*, and the EZBee M100 connected to the coordinator terminal as a *Coordinator Module*.

3. Joining the PAN

After running another terminal emulator, set the serial port and EZBee M100 as shown in 1 and 2 steps above.

Then, type the AT commands related to a module ID, PAN ID and channel number. In this moment, the module ID can be any number except '0'. However, a PAN ID and channel number should be same numbers as coordinator setting for joining in the PAN established already. Finally type **"AT&PS"** for a new EZBee M100 to join in the PAN.



If the EZBee M100 is joined in the PAN successfully, **"$NWK=ROUTER**,<SADDR>**"** message is displayed.

It means the EZBee M100 is assigned as a router in the PAN, and a short- address of this EZBee router is assigned as <SADDR> by a

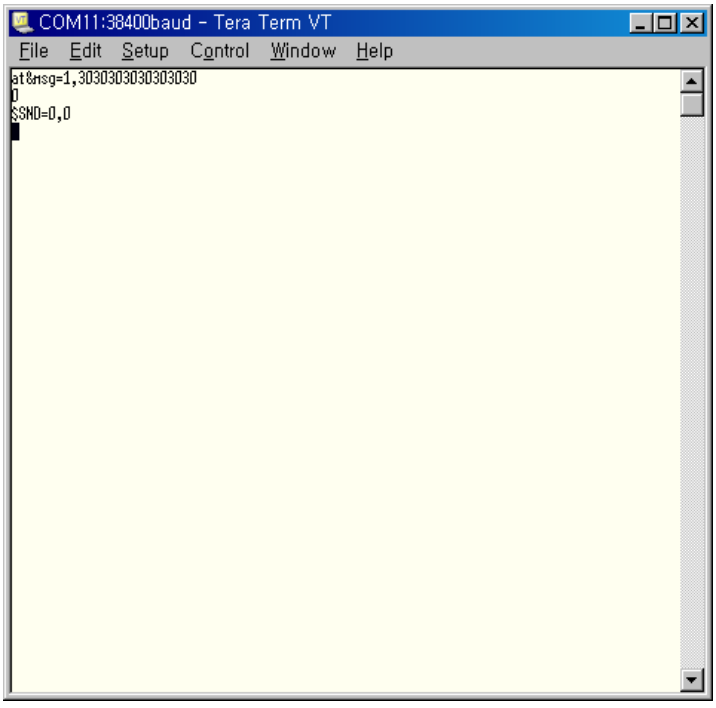
coordinator. In this example, a short-address of EZBEE module is assigned as **0001**(hexadecimal).

Now, we call this terminal as a *Router Terminal*, and the EZBee M100 connected to the coordinator terminal as a *Router Module*.

4. Testing message transmission in ASCII mode

To transmit a message in ASCII mode, type a following command on a coordinator terminal. **"AT&MSG=**<DstID>**,**<Msg>**"**

In here, DstID and Msg mean a receiver ID and a sending message, respectively. The sending message should be prepared as ASCII hexadecimal format. Following example shows that the receiver ID, 'DstID' is **1**, and the sending message, 'Msg' is **"3030303030303030"**.



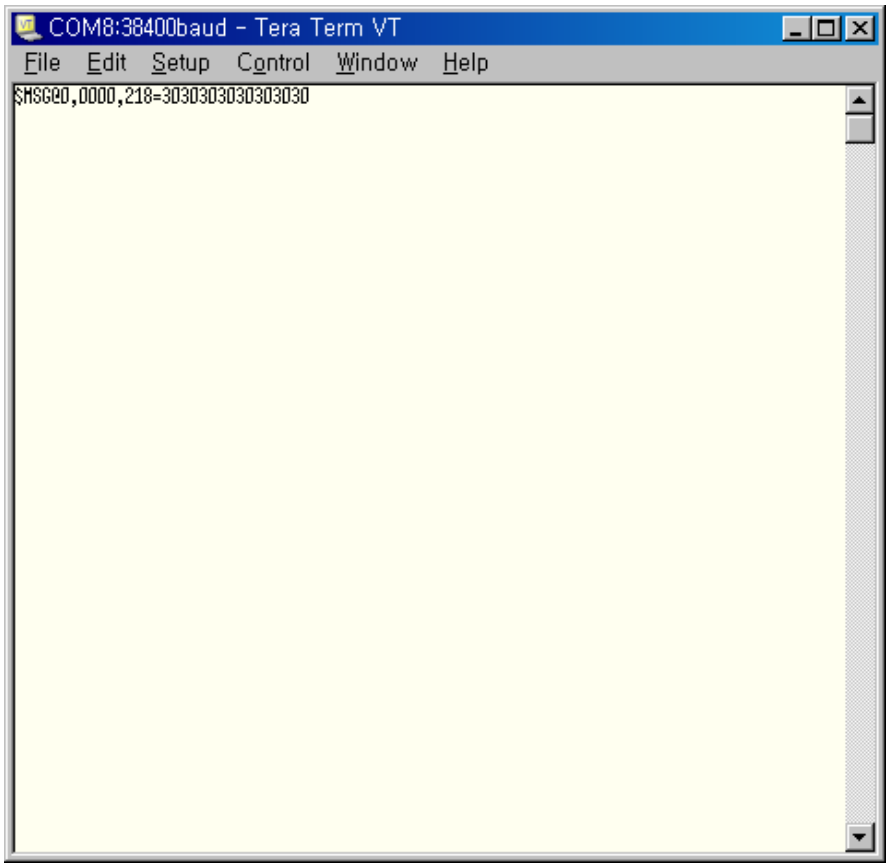
When the command is completed successfully, firstly the Transaction ID

is returned. In here, Transaction ID '0' is returned as shown in second line of above example.

Furthermore, an event message related to the transmission result is displayed as **"$SND=**<TransID>**,**<Result>**".**

<TransID> means a Transaction ID, **0** in this example, and <Result> shows the transmission result, **0** in this example means the transmission is succeeded. If failed, non- zero value is shown as <Result>.

Accordingly, the message is transmitted successfully; a following event message related to the message arrival is displayed in a router terminal.



The format of an event message related to the message arrival is,

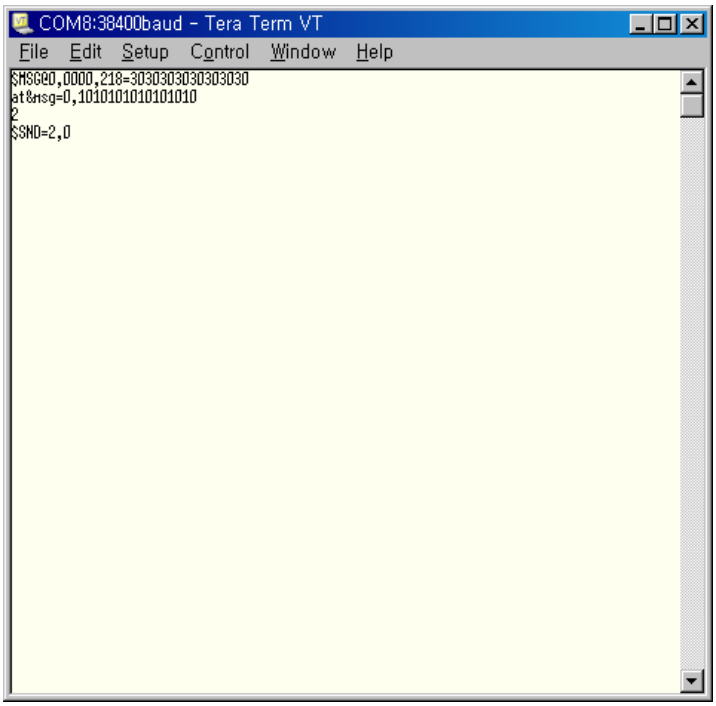
"$MSG@<SrcID>**,**<SrcSaddr>**,**<LinkQuality>**=**<Msg>**"**

where, <SrcID> is a sender ID, <SrcSaddr> is a short- address of sender, <LinkQuality> means a receiving sensitivity, and <Msg> means the received message having same ASCII Hexadecimal format as sending message

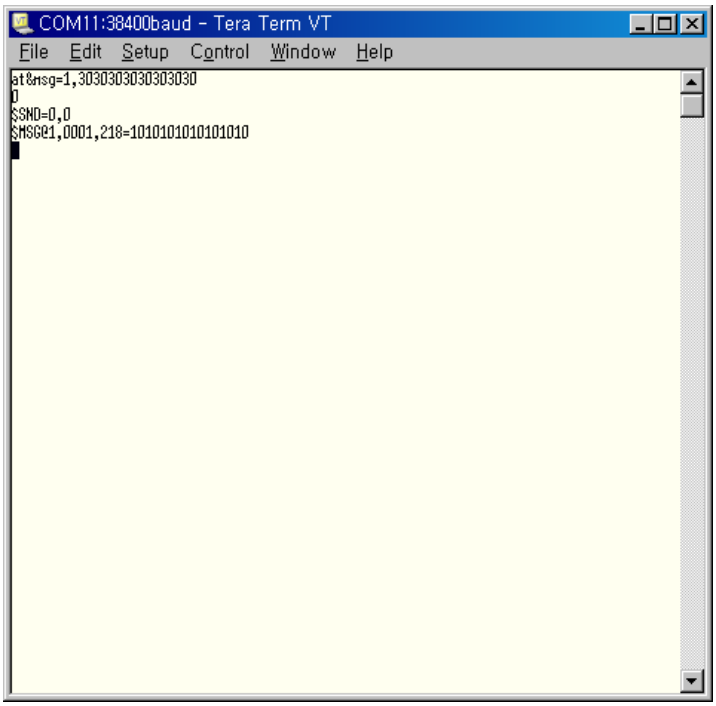
In this example, <SrcID> is **0**, and it means a sender is a coordinator. <SrcSaddr> is **0000**. It shows that the short- address of the coordinator is always 0000. <LinkQuality> is **218**. The value of receiving sensitivity is between 0 and 255. Finally, <Msg> is **3030303030303030**. It means 8 byte data string having value of 0x30.

From now on, as a reverse transmission, a router terminal sends a data to a coordinator terminal.

Using **"AT&MSG=**<DstID>**,**<Msg>**"**, a router sends a message to a coordinator. In this case, <DstID> is set as 0 for a coordinator.



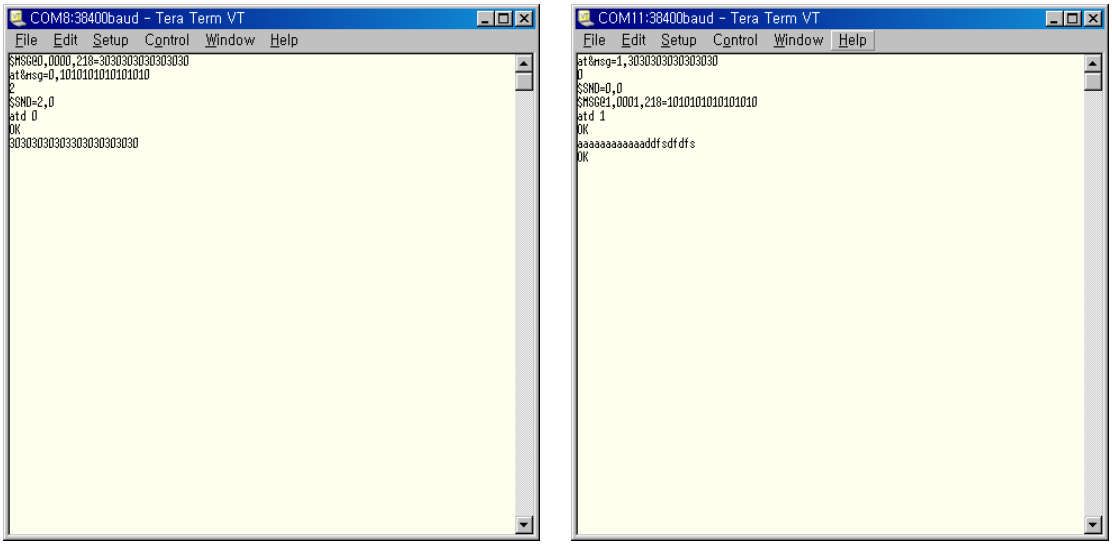
When the command is completed successfully, the event message related to the message arrival is shown on a coordinator terminal.



5. Testing message transmission in Bypass mode

1) Enter **"ATD 1"** command on a coordinator terminal, and **"ATD 0"** on a router terminal.

2) Type any keys on one terminal, and verify successful data transmission on the other terminal.

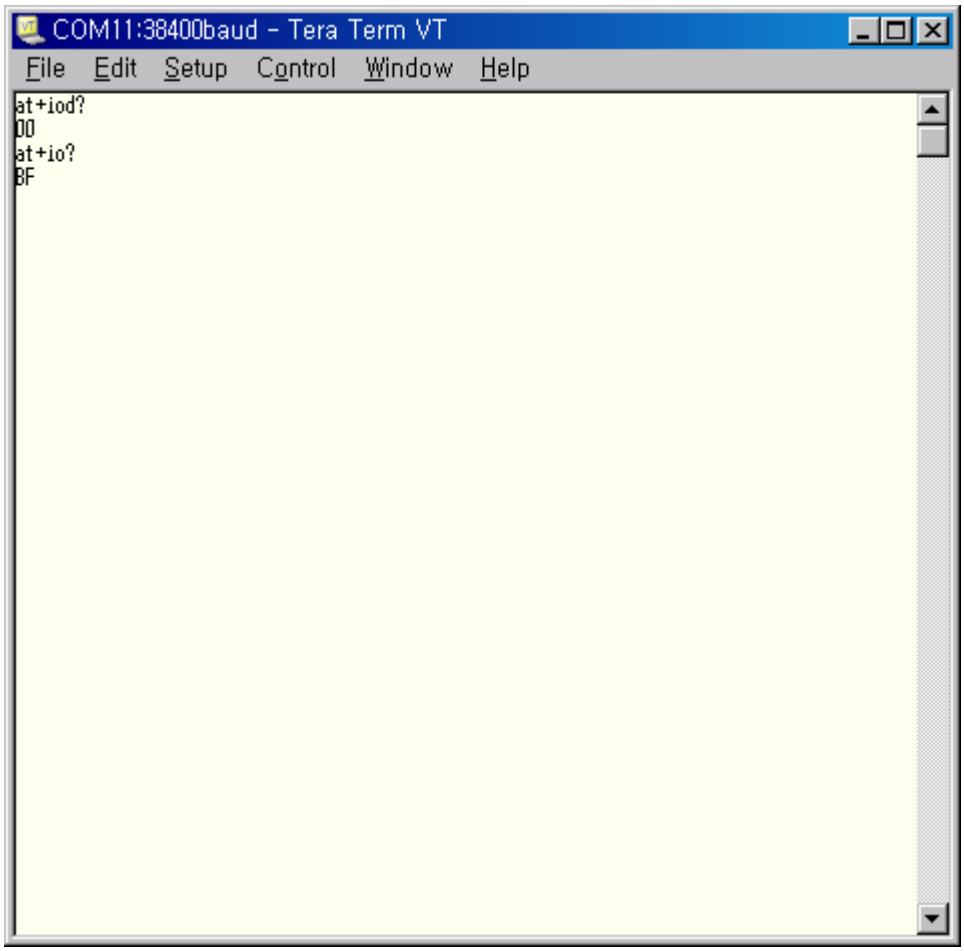


3) To end Bypass mode, enter **"+++"** on each terminals.

6. Testing Input/output function of EZBee M100

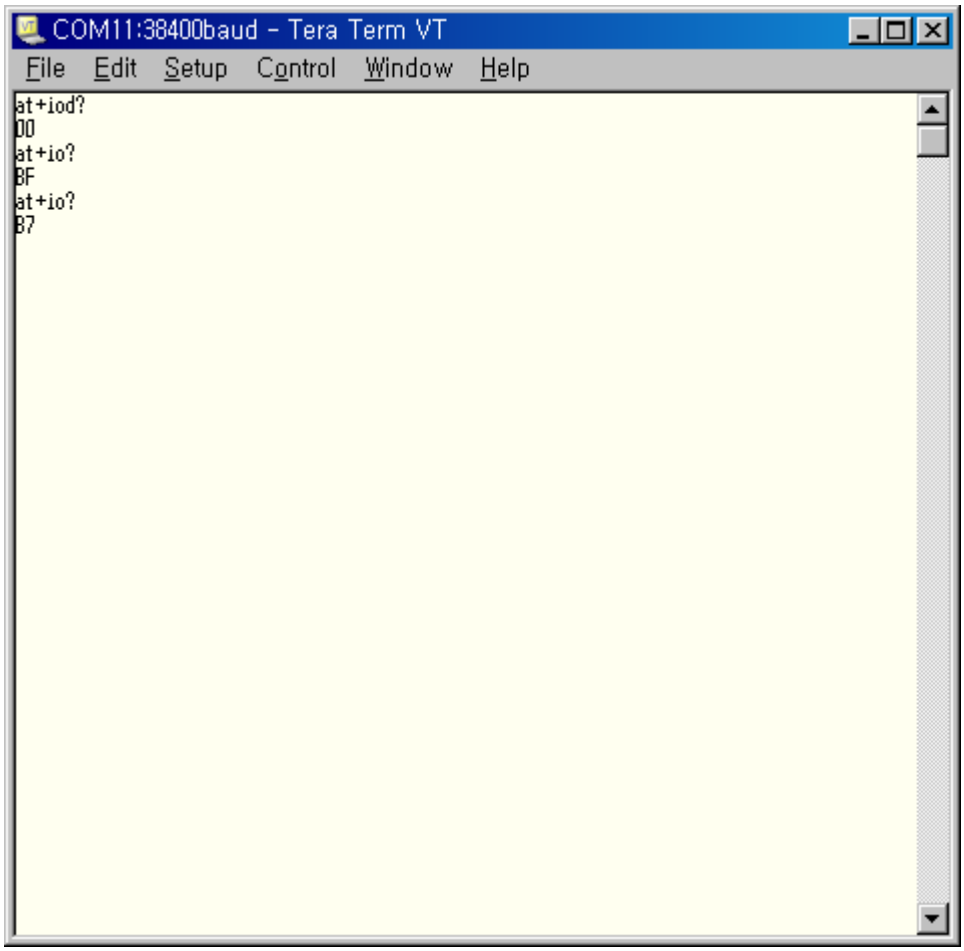
EZBee M100 supports total 8 ports of GPIO from DIO0 through DIO7 which are set or controlled by a local or remote modem of EZBee.

First, enter **"AT+IOD?"** command on a coordinator terminal to check the I/O directions of local EZBee M100. In this example, the return value shows **"00"**, it means all I/O ports are assigned as input ports.



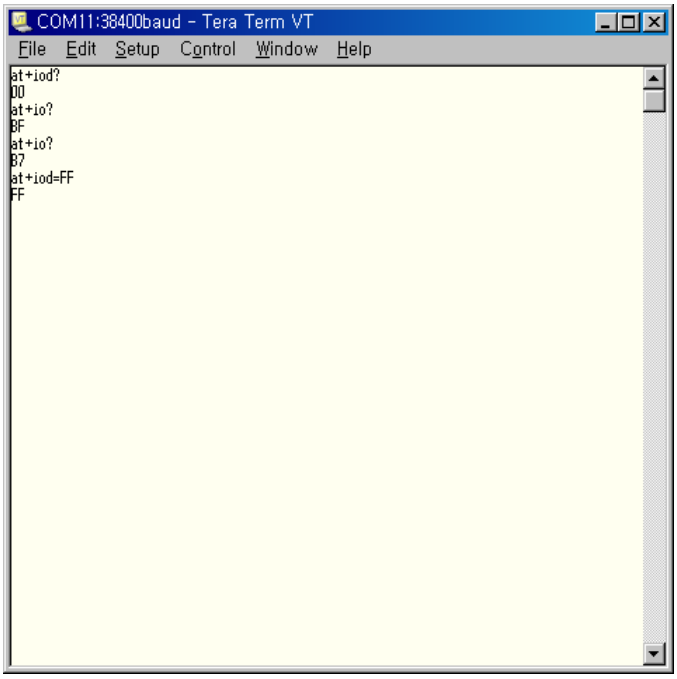
Next, enter **"AT+IO?"** command in order to read the input value of a current I/O ports. The return value is **"BF"**, it is interpreted that DIO6 is **0**, the others are all **1**.

During pushing DIO3 of a coordinator module, enter **"AT+IO?"** on coordinator terminal again.

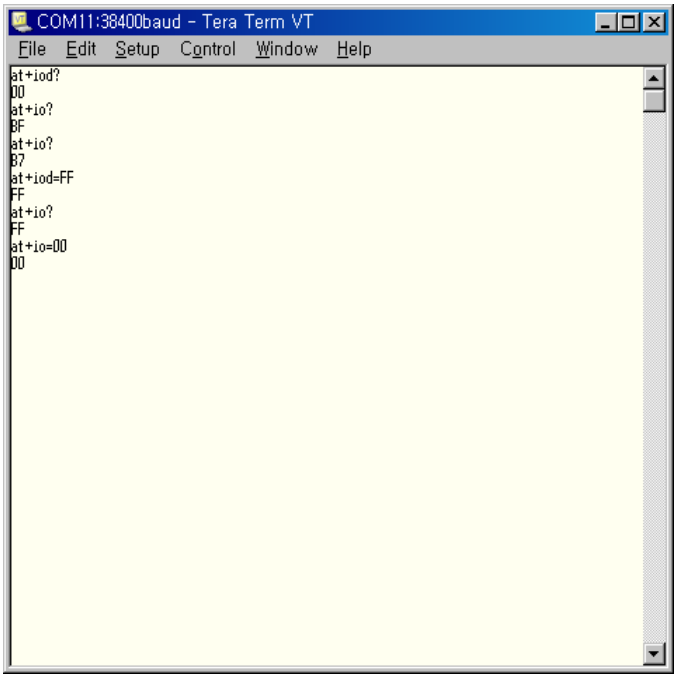


The return value is changed to **"B7"**. It means the input of DIO3 is changed from 1 to 0.

Now, enter **"AT+IOD=FF"** command on a coordinator terminal. The GPIO I/O direction is changed, thereby all ports acts as output ports. If command is completed successfully, the direction value of input/output is displayed as shown in a figure.



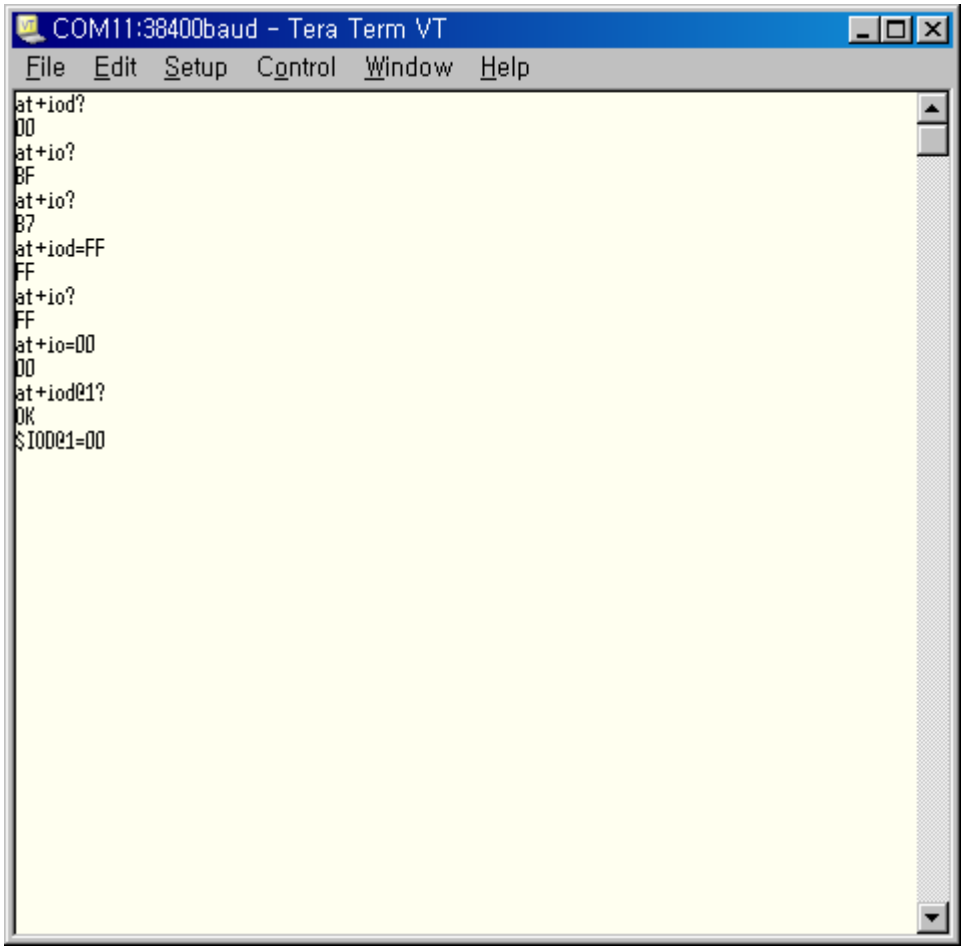
In this moment, enter **"AT+IO=00"** command again.



You can see that DIO0 and DIO1 LED in the coordinator module are turning ON.

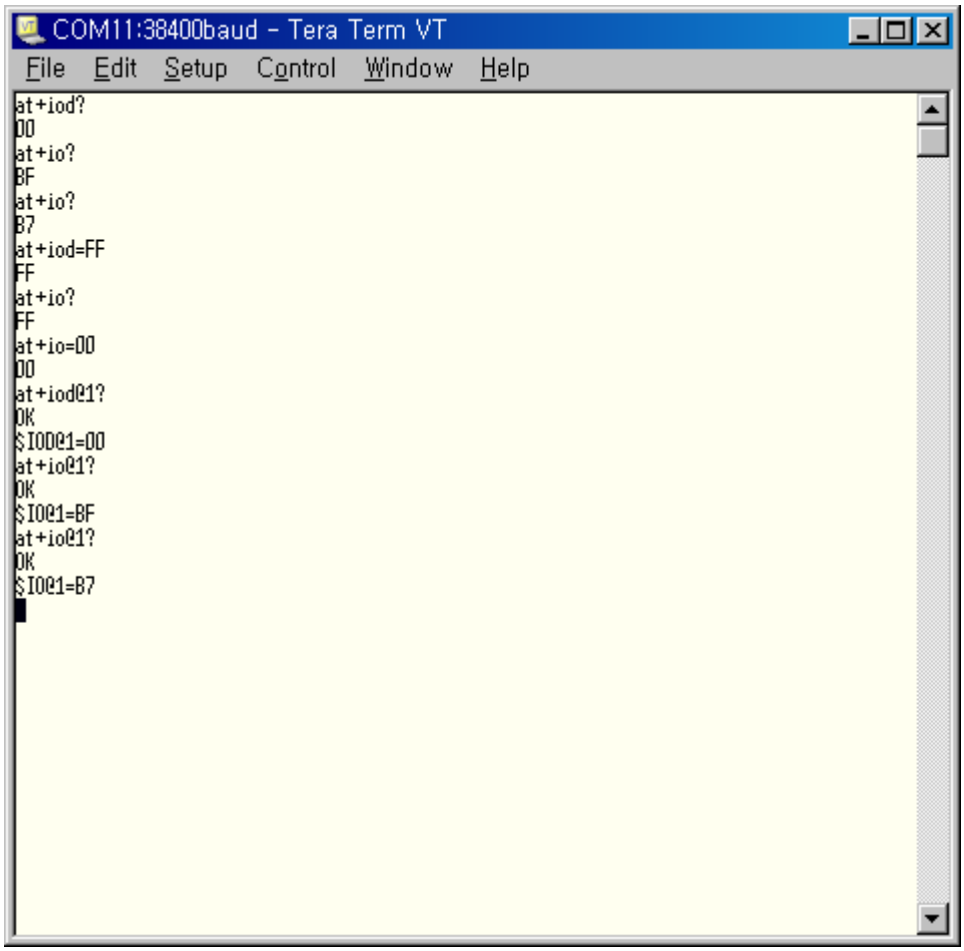
Using similar philosophy, the GPIO of a remote modem is able to set and control.

Enter **“AT+IOD@1?”** command on a coordinator and read GPIO input/output status.



When the command is completed successfully, the response message, **“$IOD@1=00”** is displayed, which means all GPIO of a router is set as inputs.

To read GPIO input status value of a router module, enter **“AT+IO@1?”** on a coordinator terminal. If the command is completed successfully, the response message such as **“$IO@1=BF”** is outputted. It means the input value of DIO6 is 0 and the others of GPIO are 1.

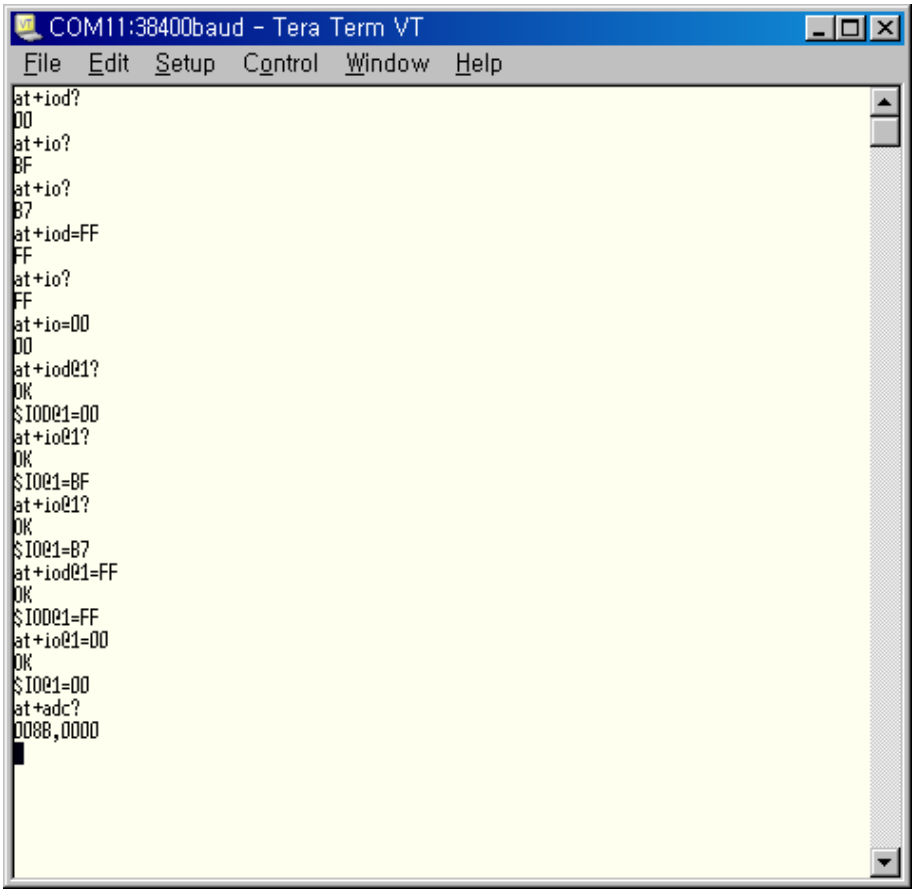


Enter **"AT+IO@1?"** on a coordinator terminal while the button of DIO3 is pushed. When the command is completed successfully, **"$IO@1=B7"** message is outputted, and it means the input value of DIO3 is changed to 0.

7. Testing ADC of EZBee M100

EZBee- M100 provides 2 channel ADC having 10- bit resolution and is possible to read the ADC value of a local or remote modem.

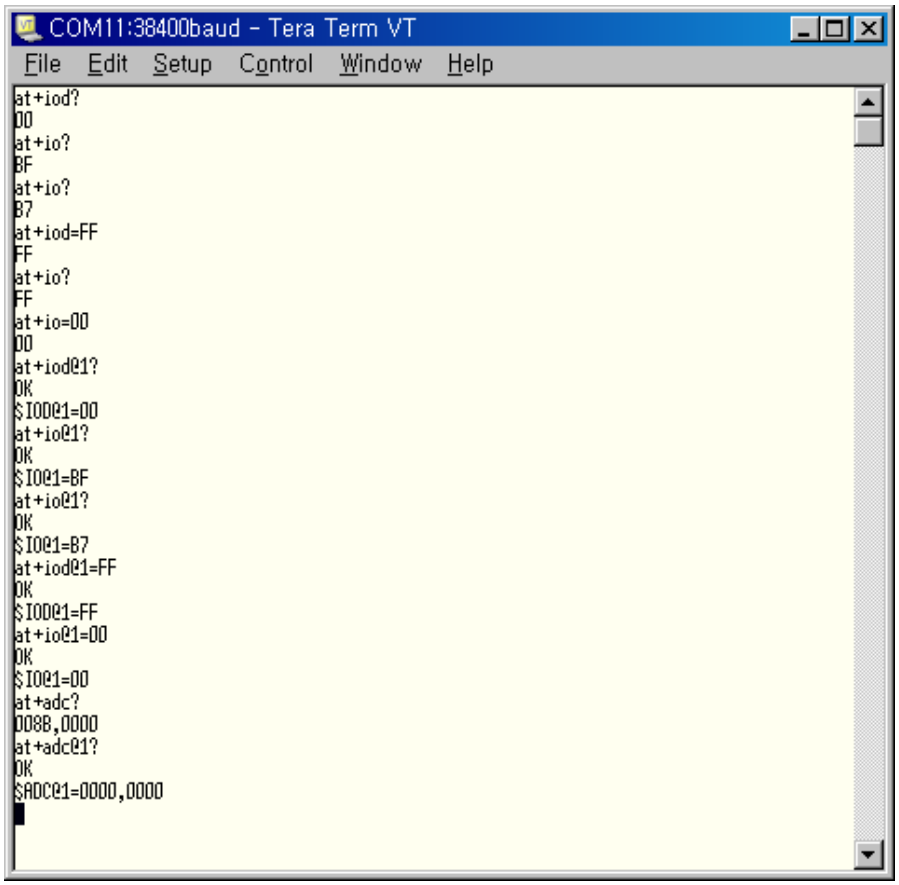
Enter **"AT+ADC?"** command for reading ADC value of a coordinator module.



When the command is completed successfully, the value of "<CH1>,<CH2>" are displayed as shown in above figure. In this example, the channel values of ADC are **008B** for <CH1> and **0000** for <CH2>.

In similar manner, the ADC value of a remote modem is able to read.

To read the ADC value of a router module, enter **" AT+ADC@1?"** command on a coordinator terminal.



When the command is completed successfully, the result message such as **"$ADC@**<SrcID>**=**<CH1>**,**<CH2>**"** is displayed. In here, <SrcID> is a remote modem ID, <CH1> and <CH2> means the ADC channel value of each modem. In this example, <SrcID> is **1**, <CH1> and <CH2> are **0000** and **0000**, respectively.

※ The usage of EZBee U100 and EZBee L100 is same as EZBee M100.

※ In data transmission process between EZBee formats, the transmitting data loss may be happened due to the characteristics of RF signal and environment of RF transmission.

FCC Information

This device complies with Part 15 of the FCC Results. Operation is subject to the following two conditions :

(1) This Device may not cause harmful interface, and

(2) This Device must accept any interference received, including interference that may cause undesired operation.

Note : This equipment has been tested and found to comply with the limits for CLASS B digital device, pursuant to Part 15 FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.
However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try correct the interference by one or more of the following measures ;

1.1. Reorient or relocate the receiving antenna.
1.2. Increase the separation between the equipment and receiver.
1.3. Connect the equipment into an outlet on a circuit different from that to which receiver is connected.
1.4. Consult the dealer or experienced radio/TV technician for help.

WARNING

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

CAUTION : Exposure to Radio Frequency Radiation.

To comply with FCC's RF exposure limits for general population / uncontrolled exposure, the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.