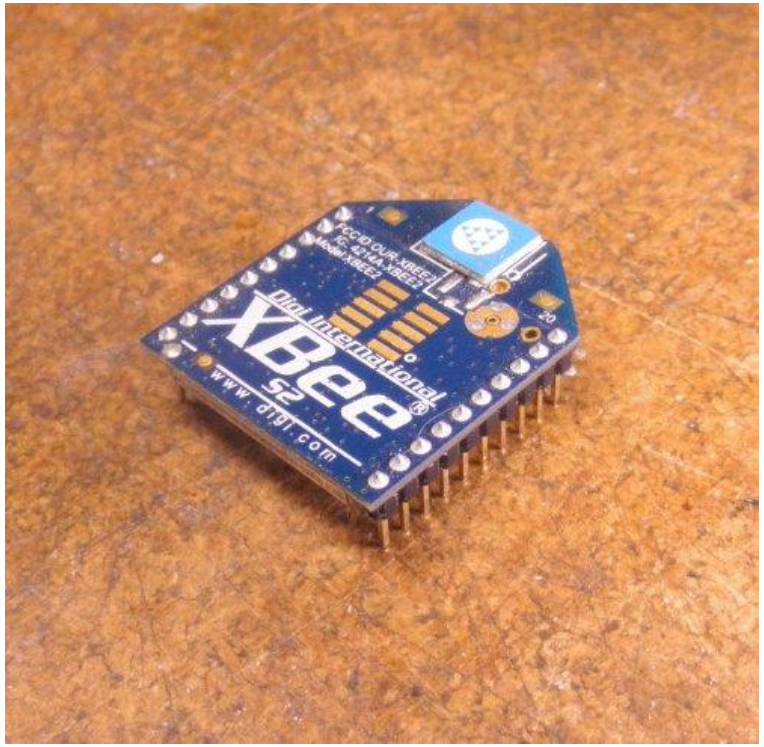
XBee Programming, Wiring and Use



By Walter Clark
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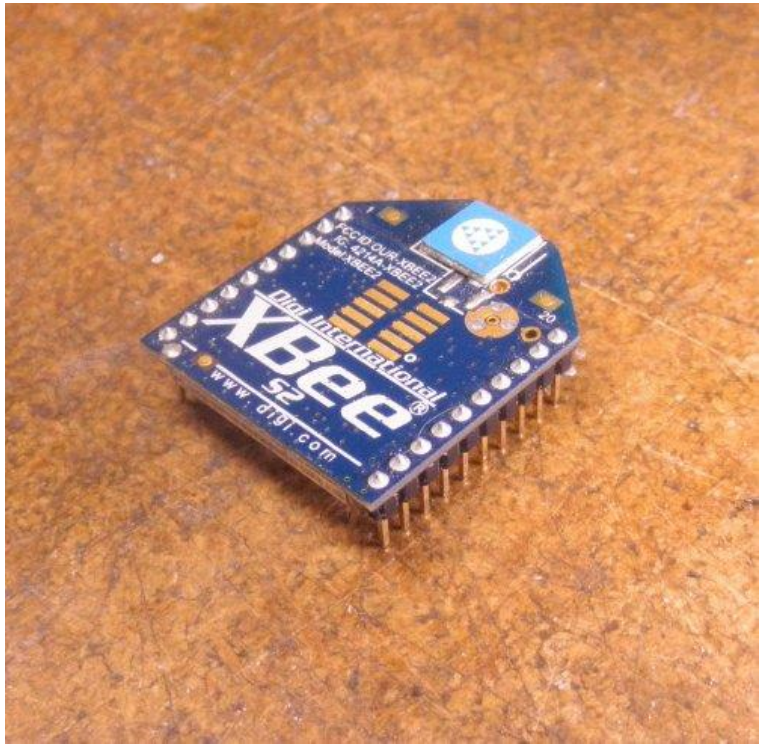
XBee: Low Bandwidth Data Communication

and Introduction to Spread Spectrum



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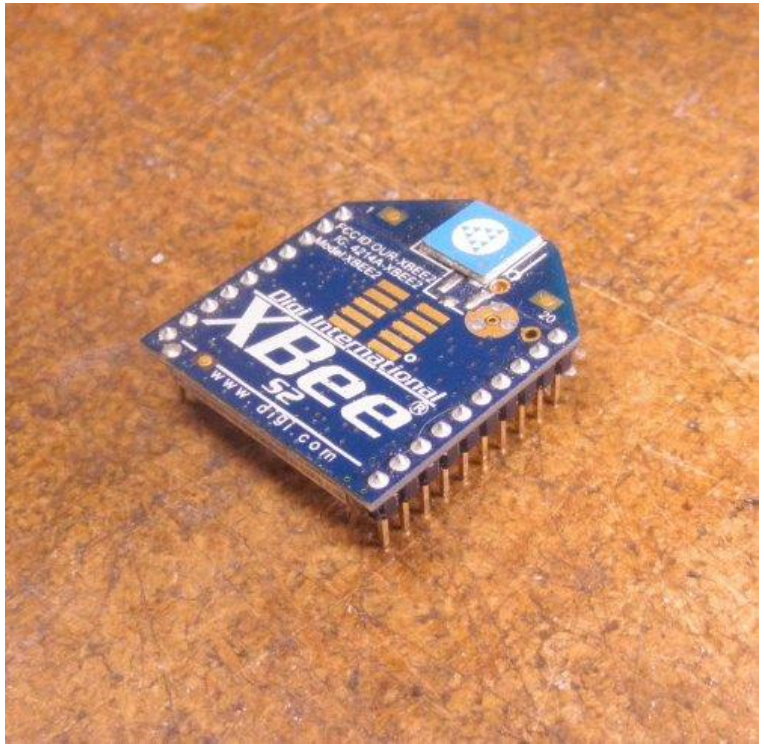

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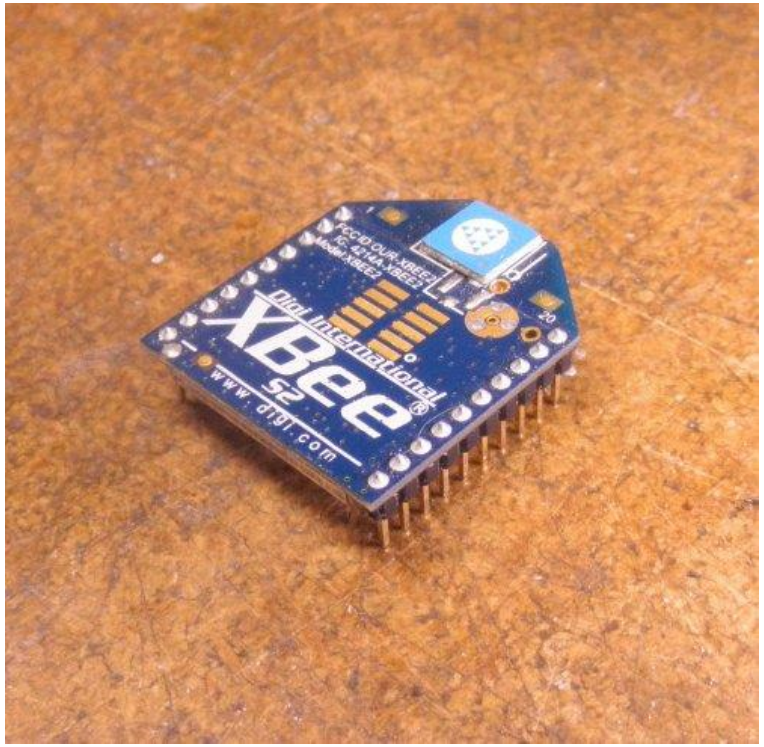

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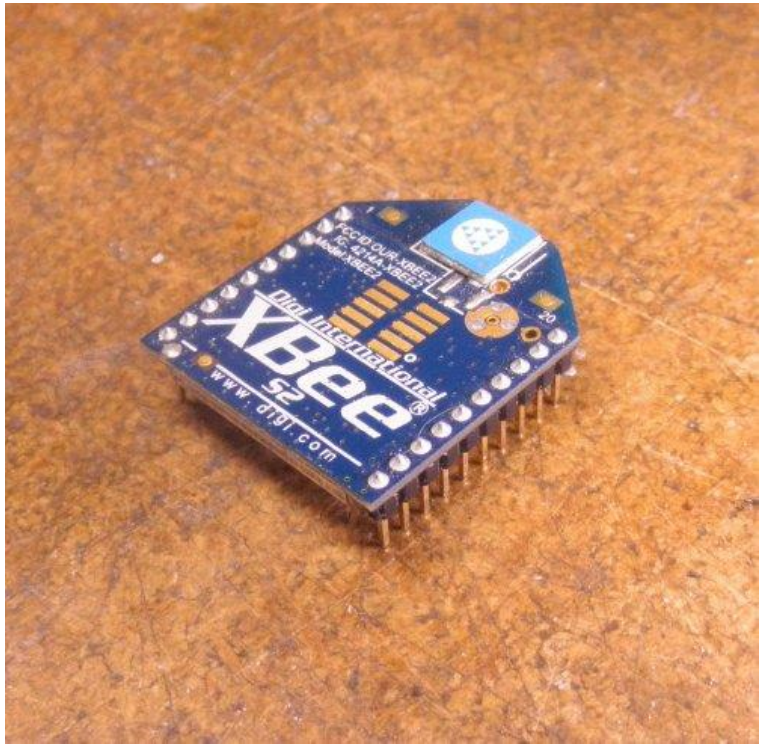

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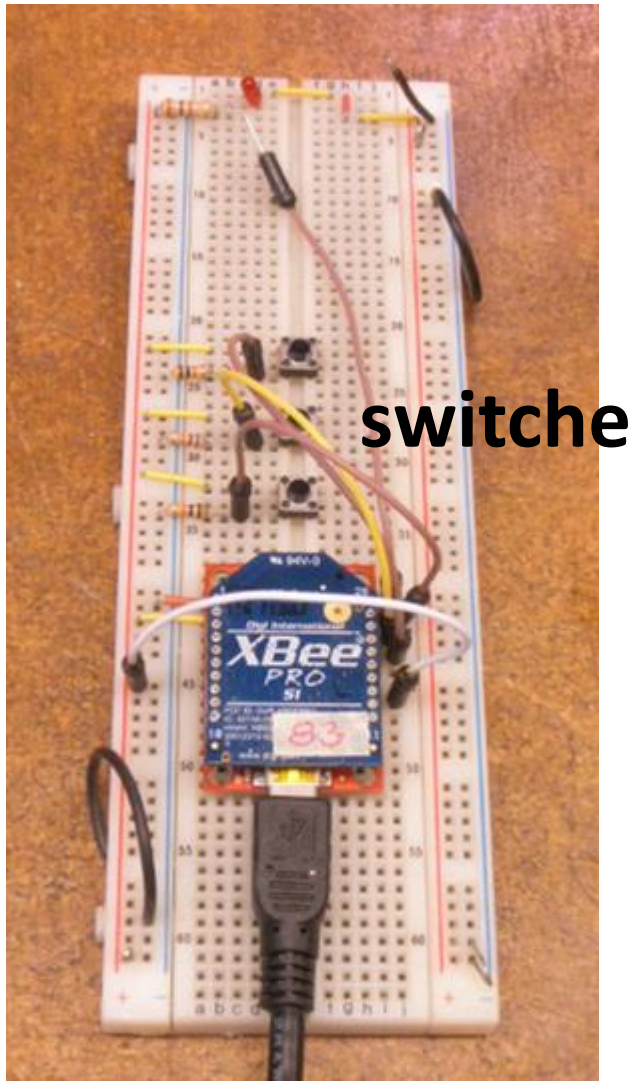

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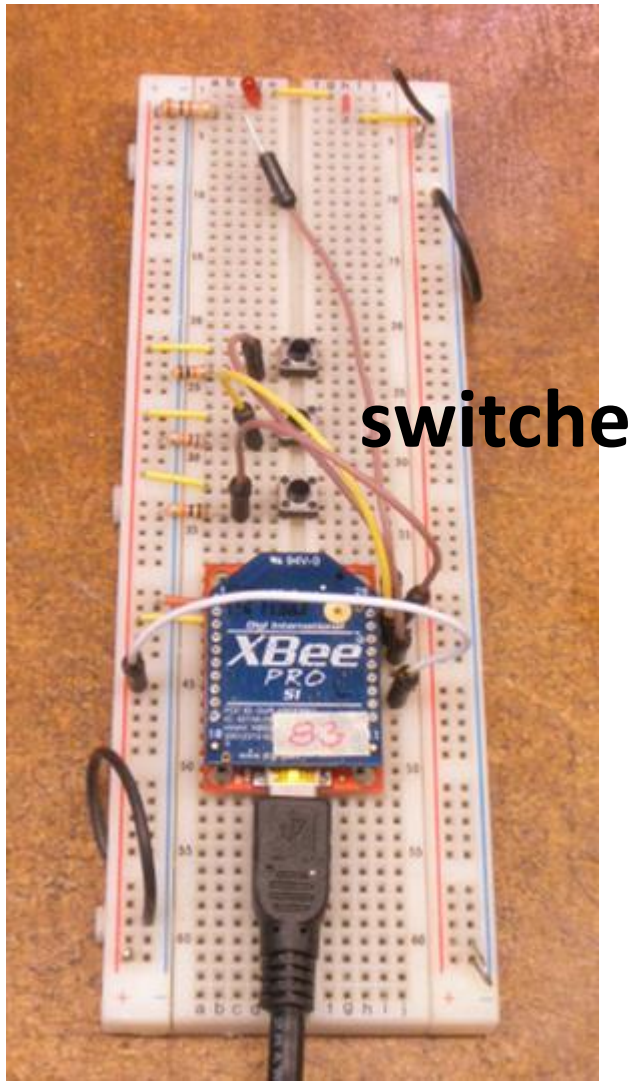

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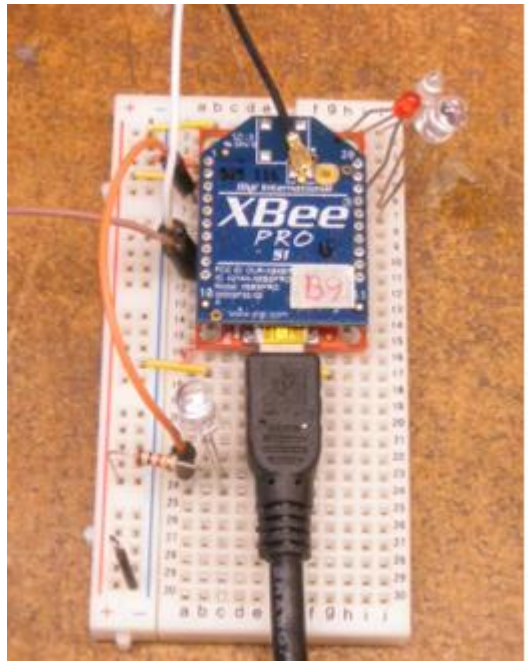
volt meter or LEDs on the base station XBee



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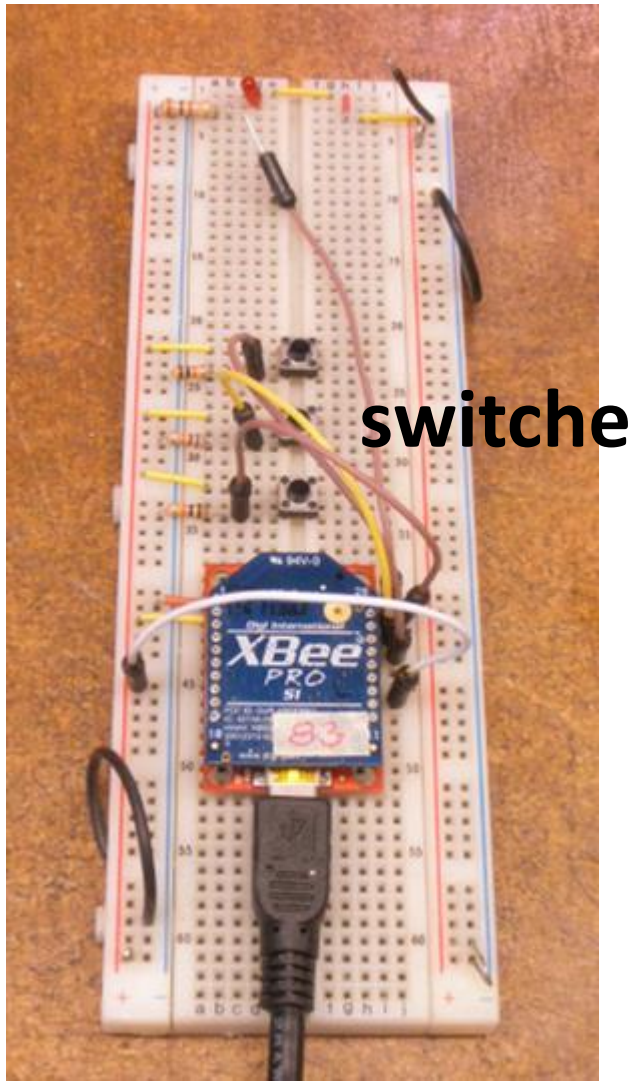

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Virtual Wires

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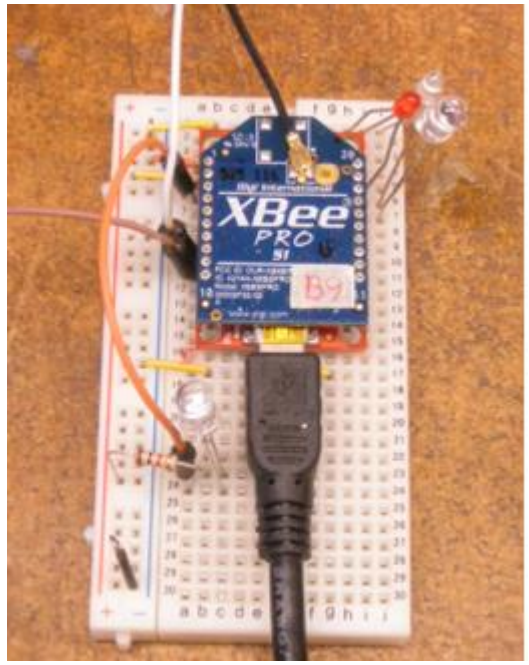

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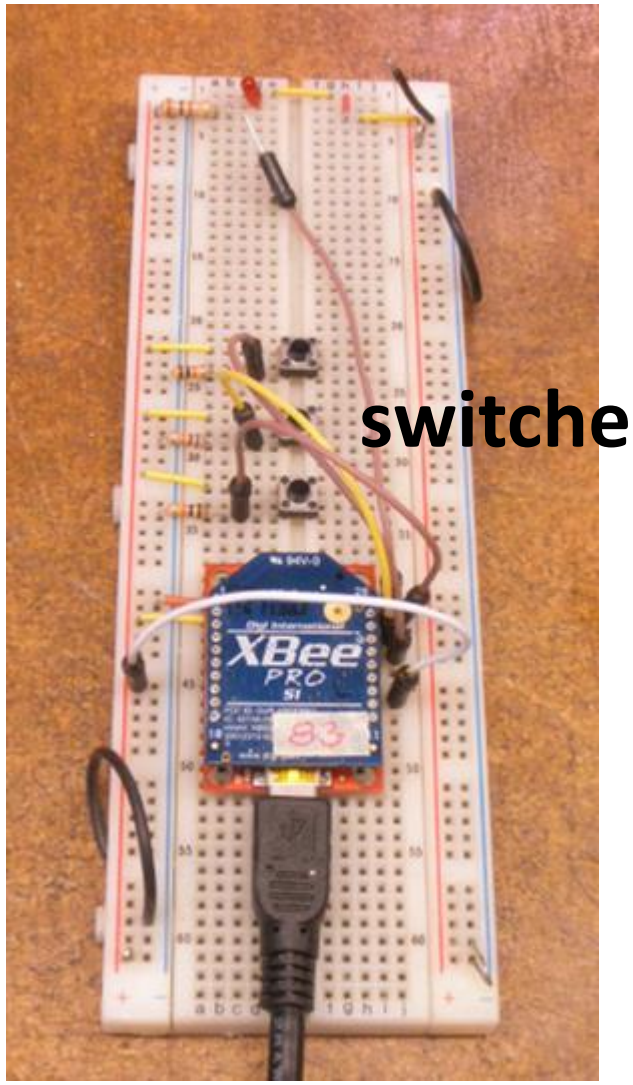

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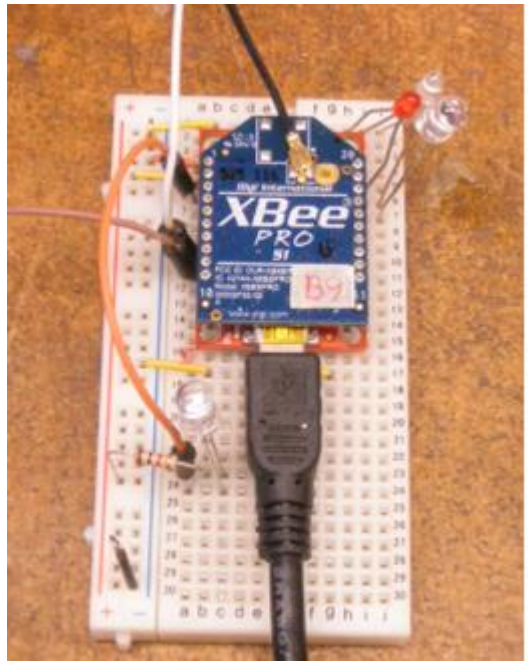

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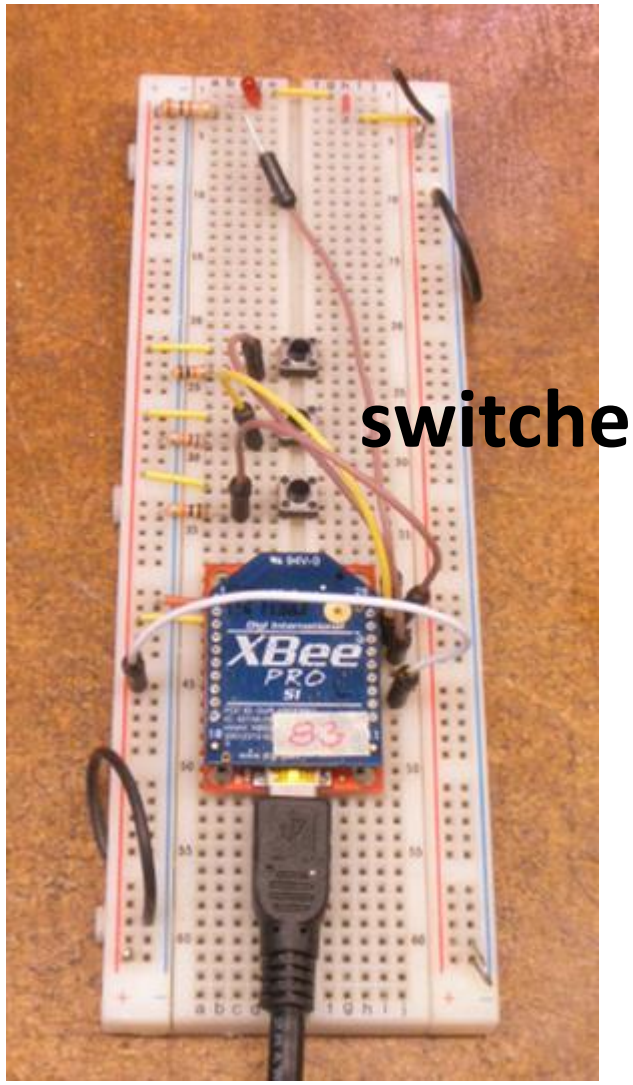

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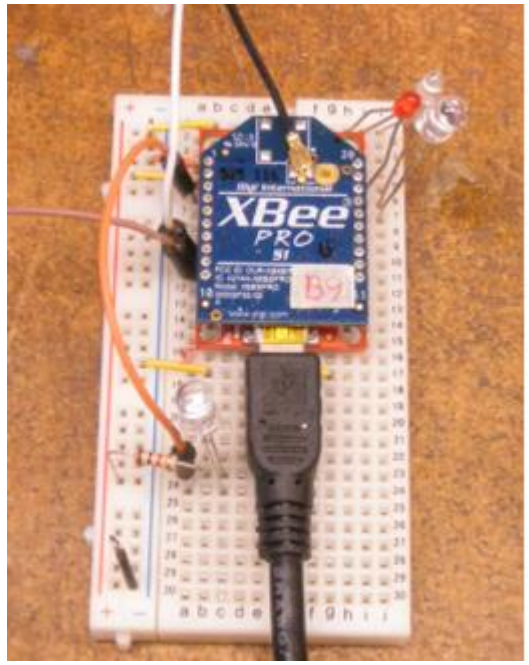

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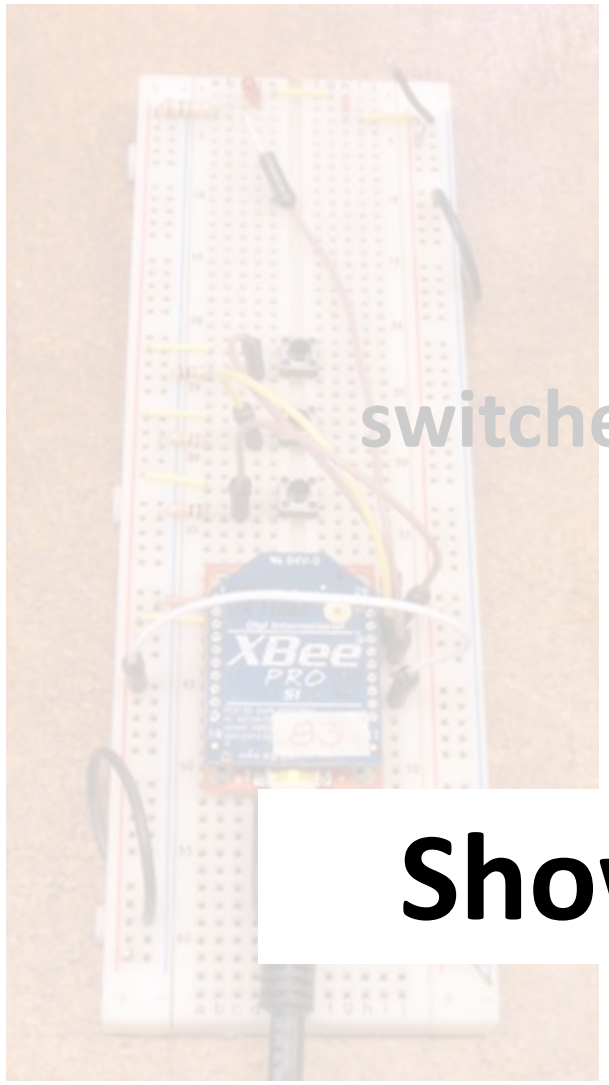

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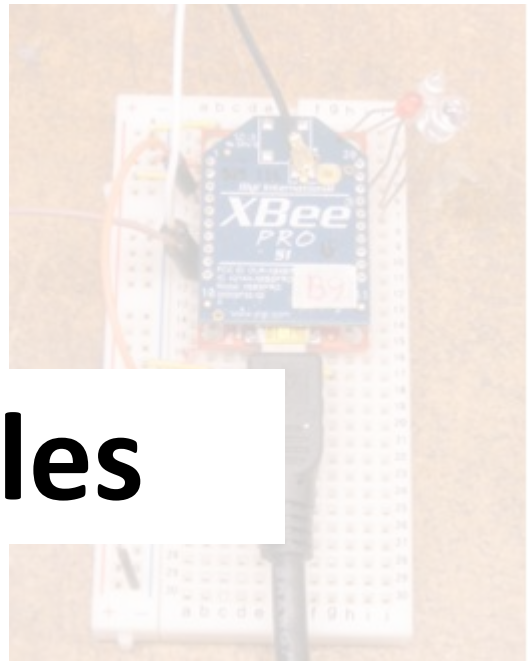

Virtual Wires (line passing)

Show Examples

XBee: Low Bandwidth Data Communication

How “data” transmission (XBee) differs from ham radio:

- multiple XBees can be networked
- digital headers allows secure transmission
- spread spectrum allows sharing the frequency
- data transfer involves confirmation; transmitting while receiving
- data is sent in bursts; the carrier is mostly off
- transmitting power; minimum necessary

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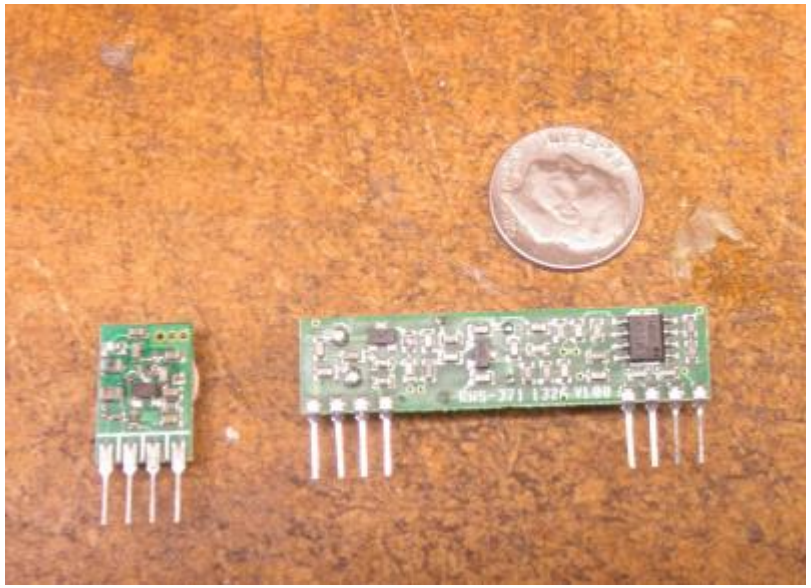

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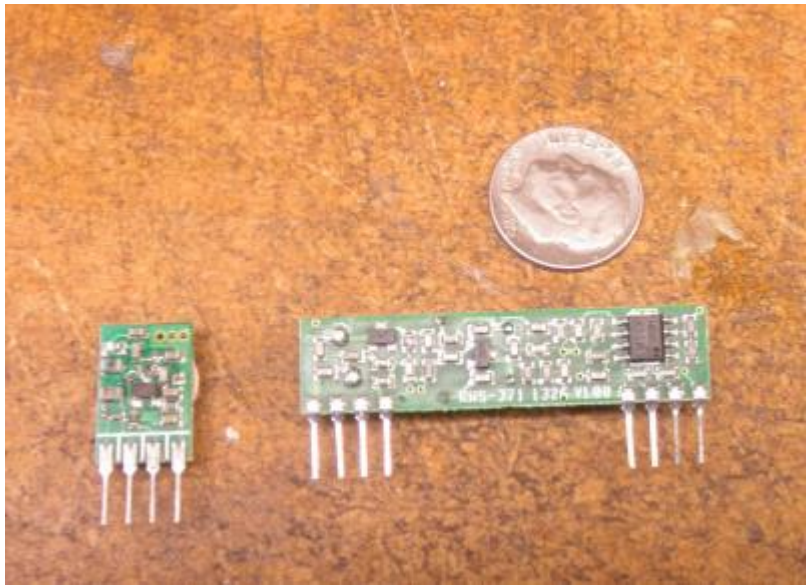

Transmitter: https://www.sparkfun.com/products/10534 $4
Receiver: https://www.sparkfun.com/products/10532 $5

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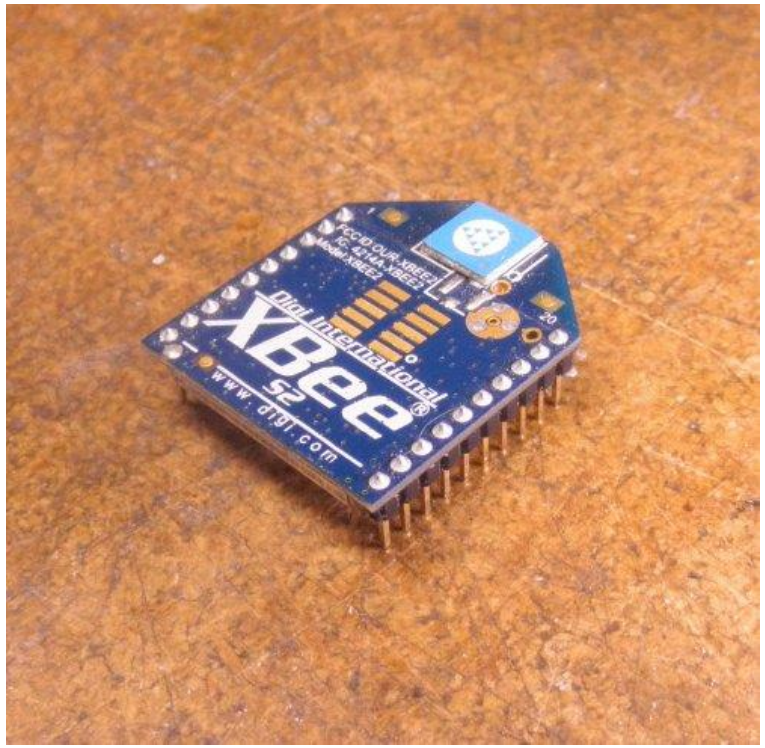

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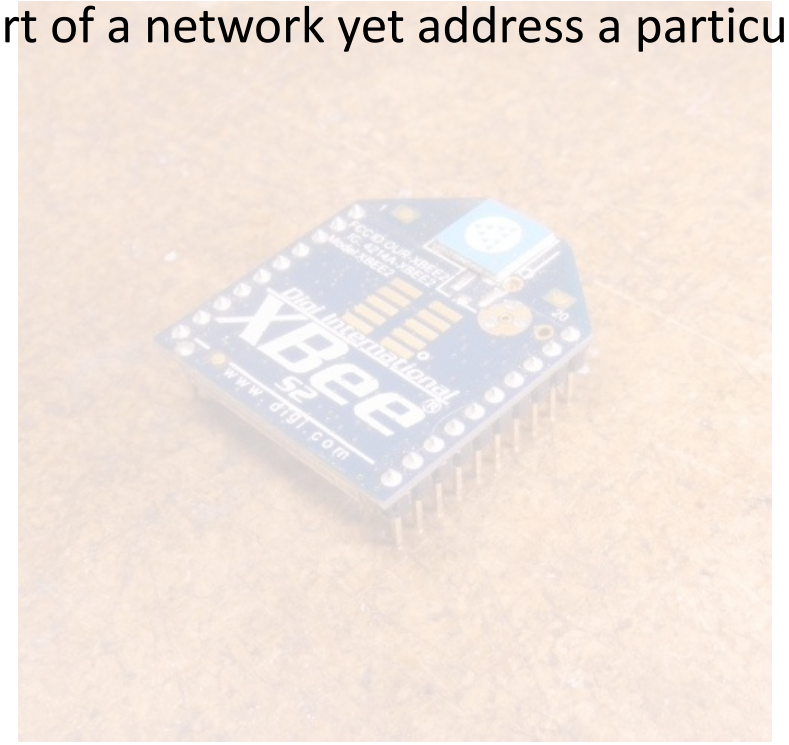

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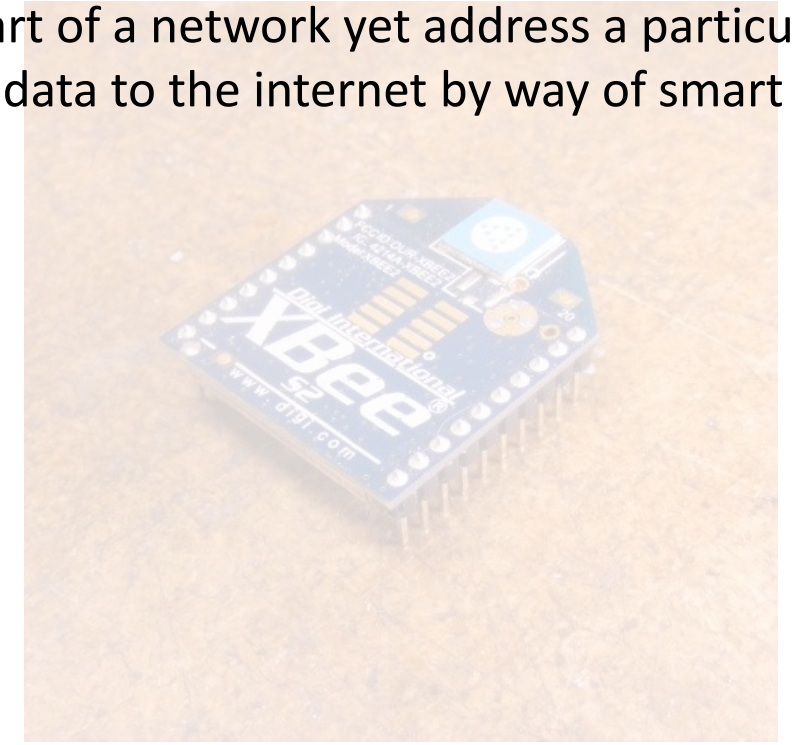

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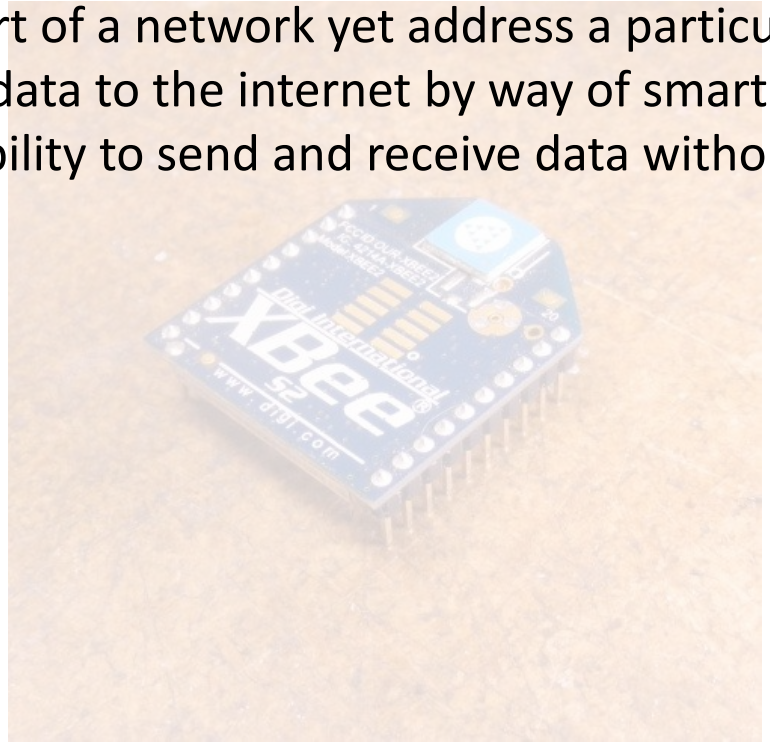

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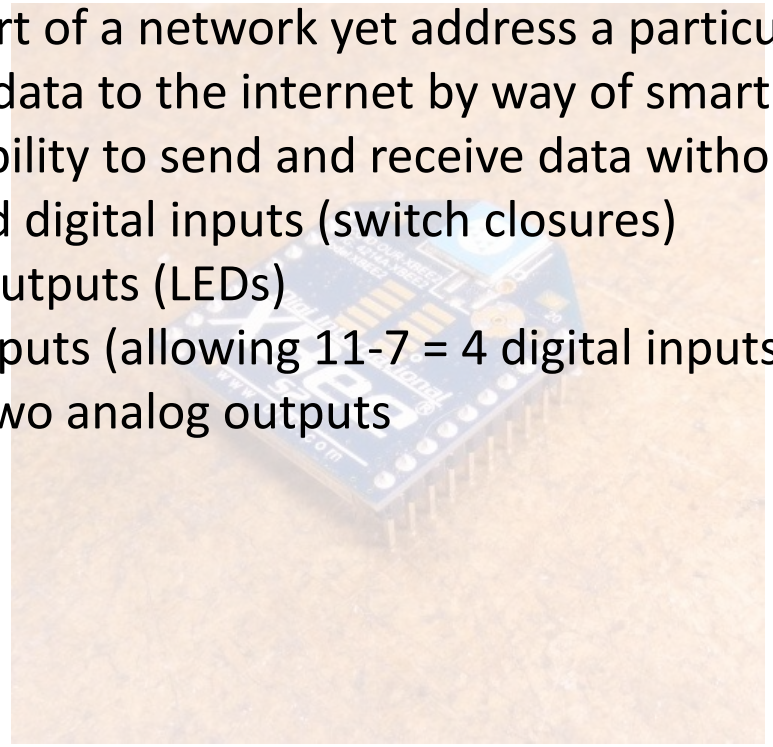

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XBee Competition → (MC1322)

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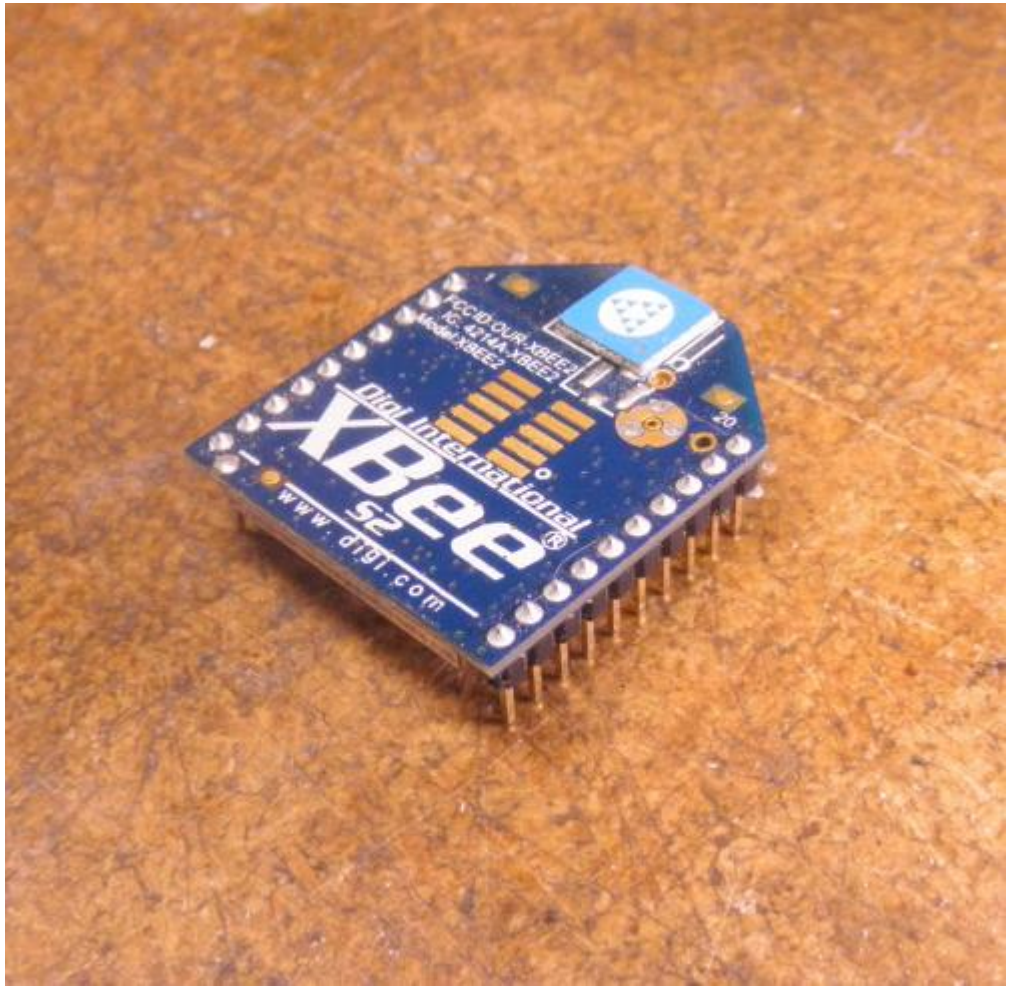

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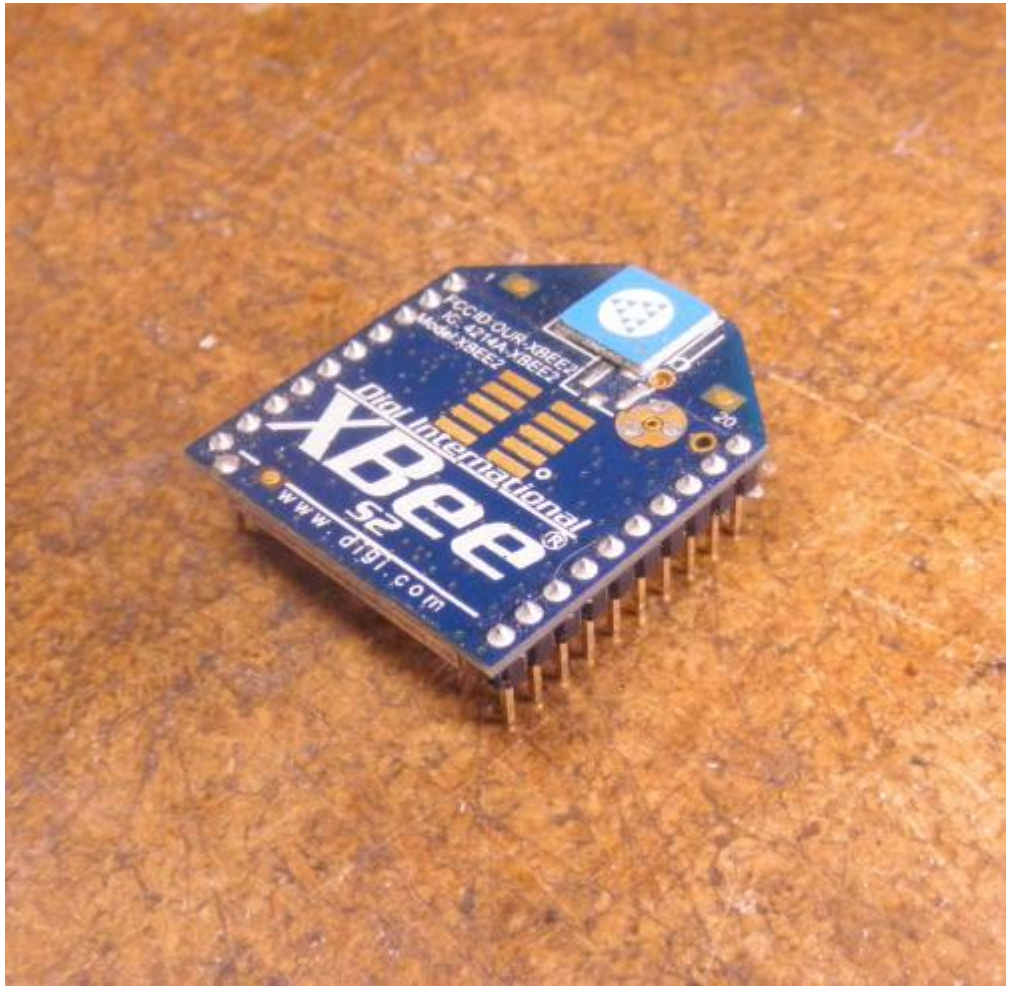

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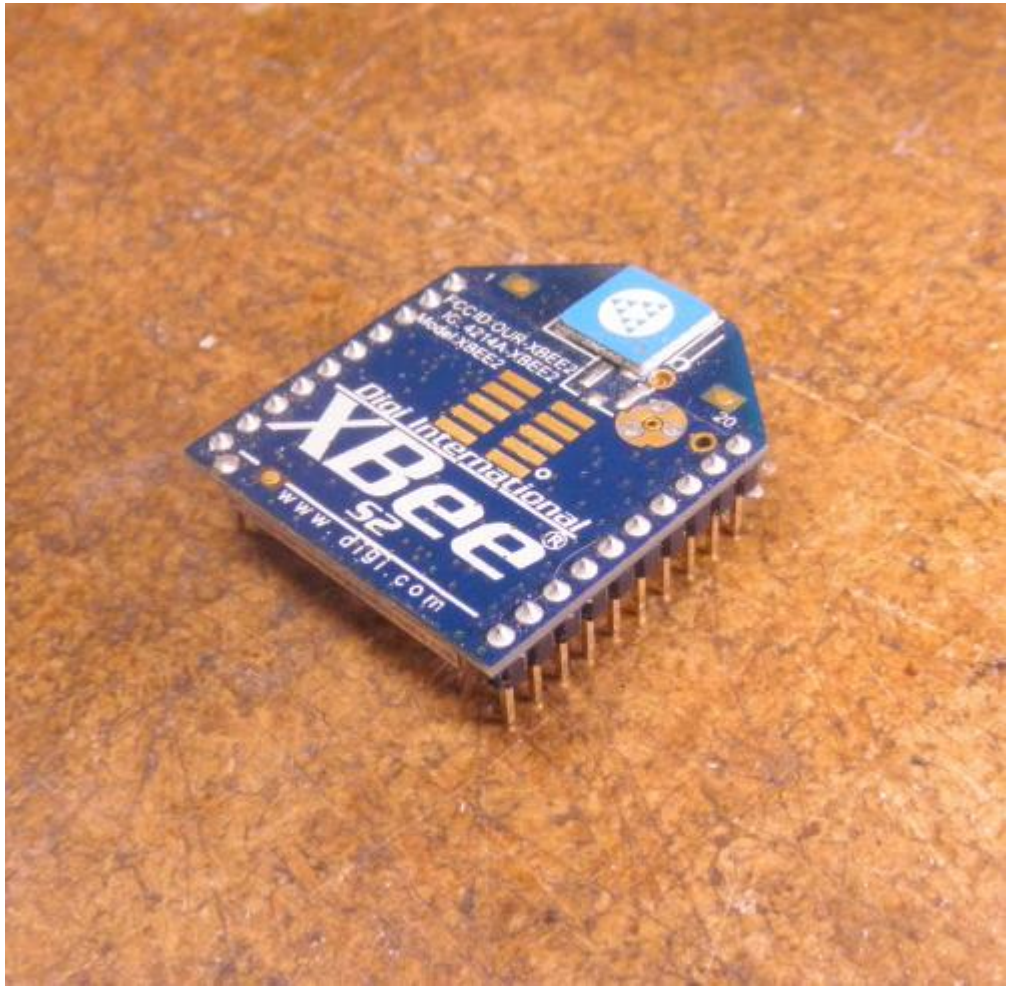

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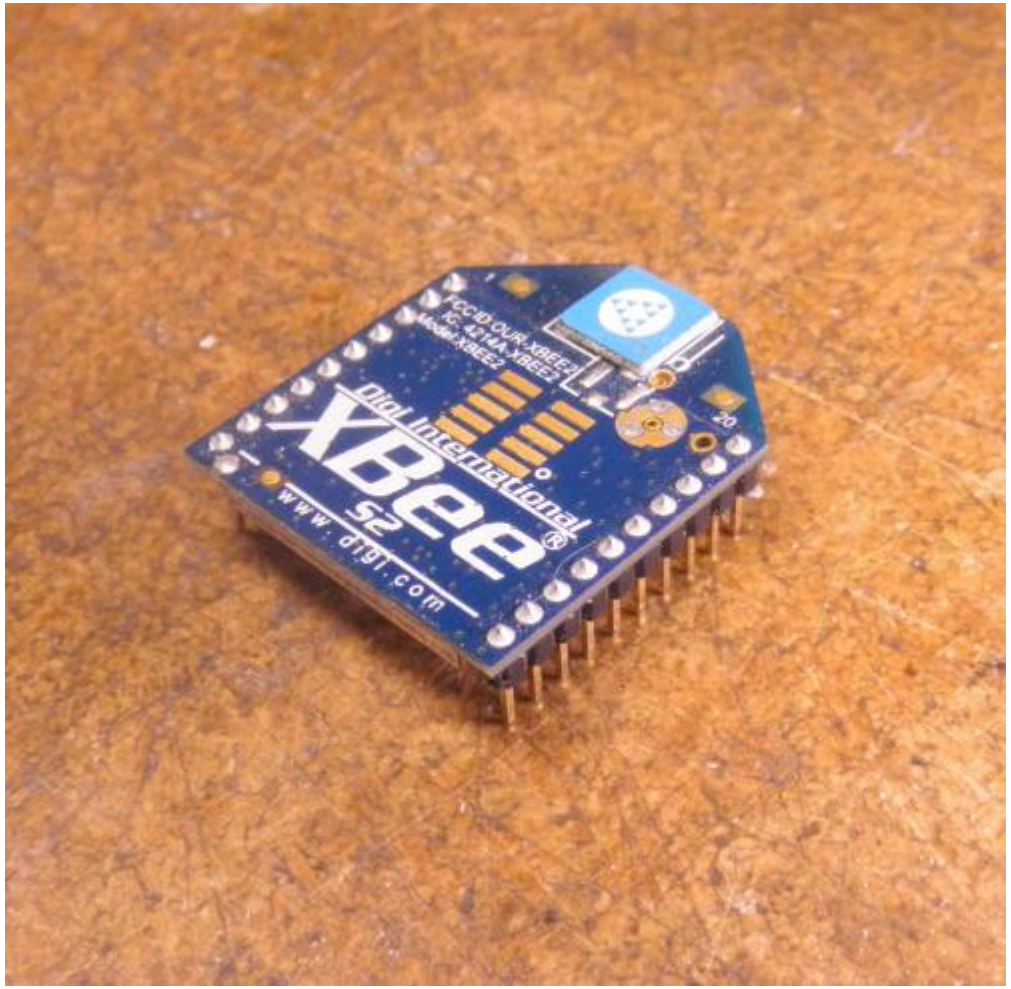

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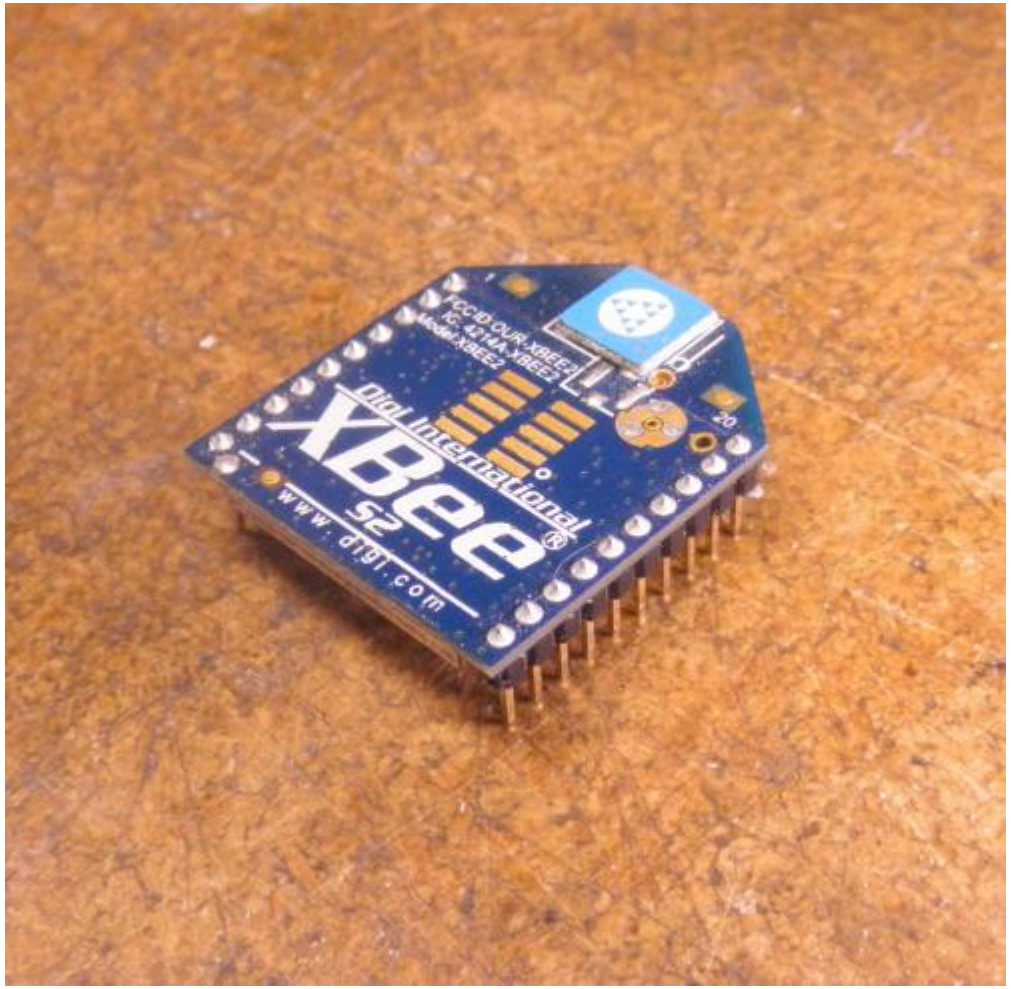

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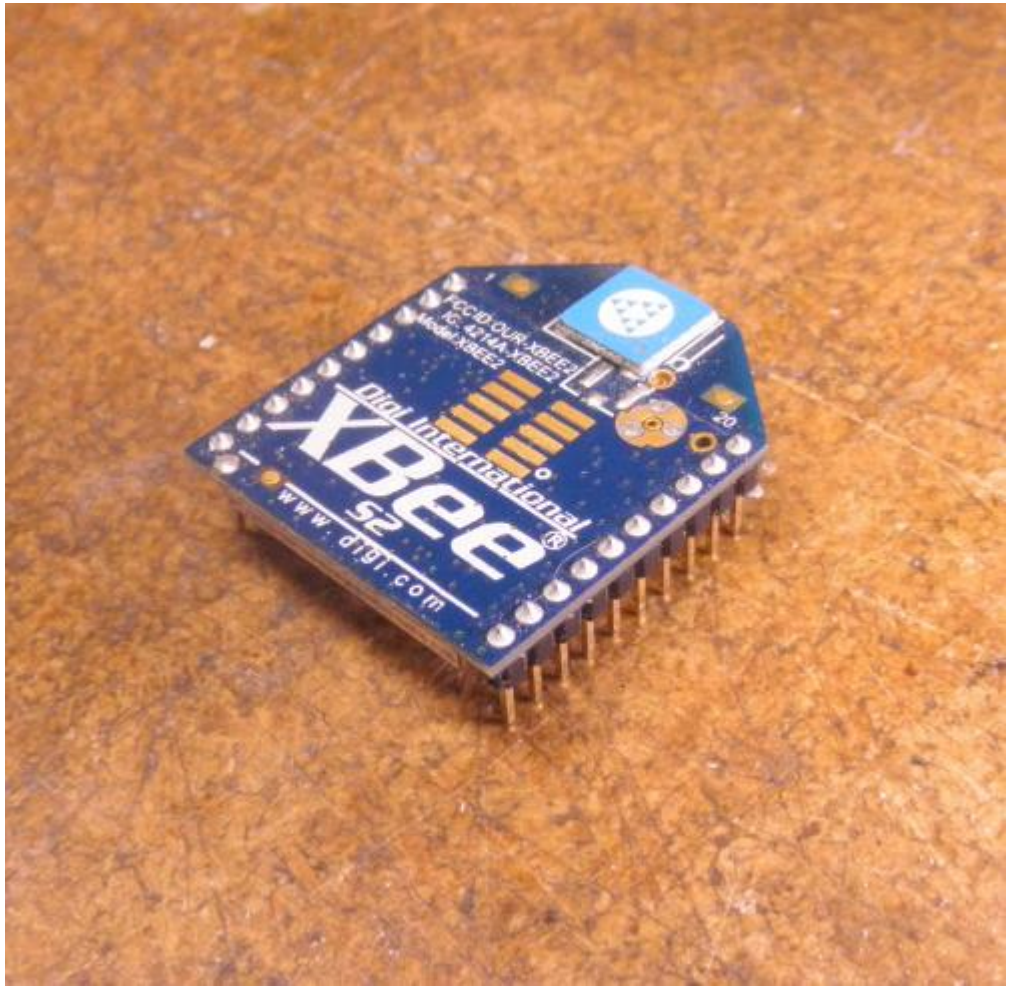
  - power
  - logic level



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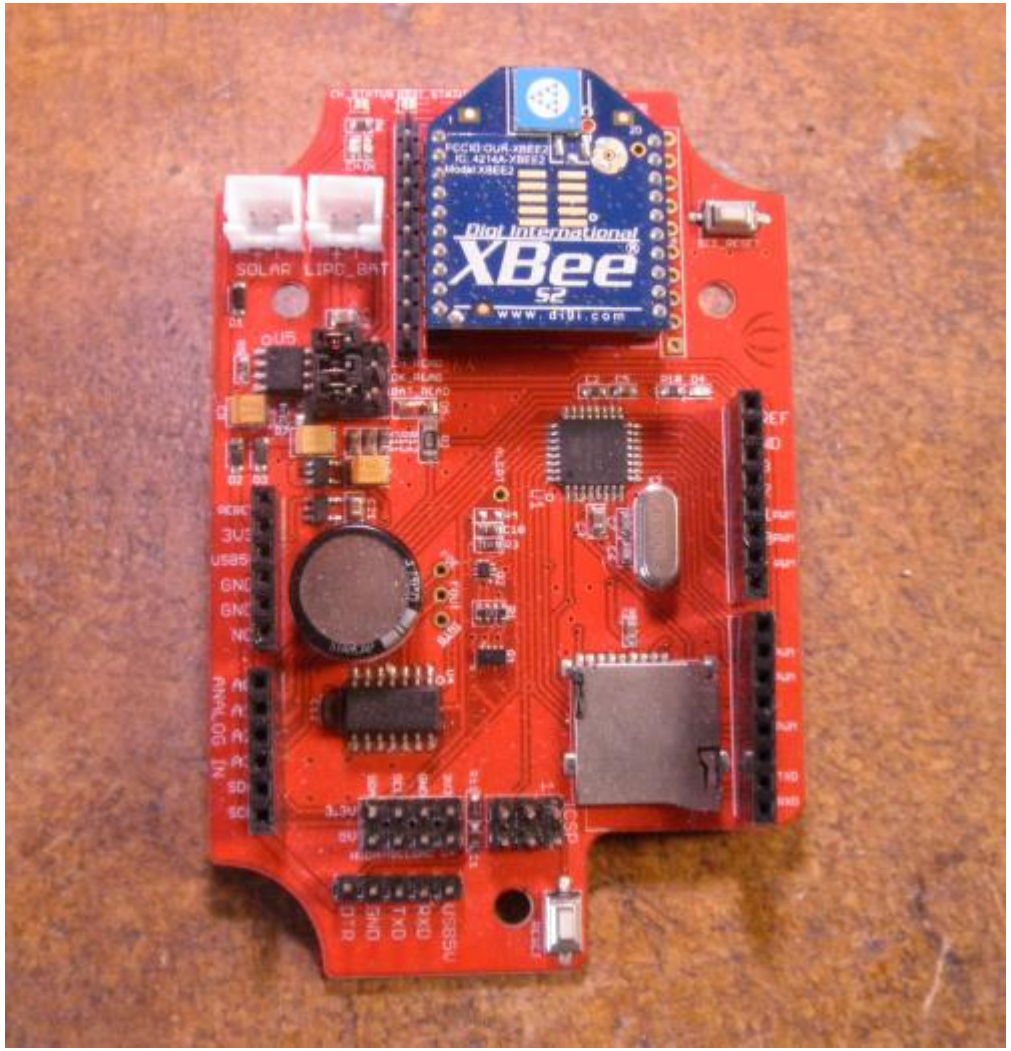
Many microcontroller boards have that adapter built in.



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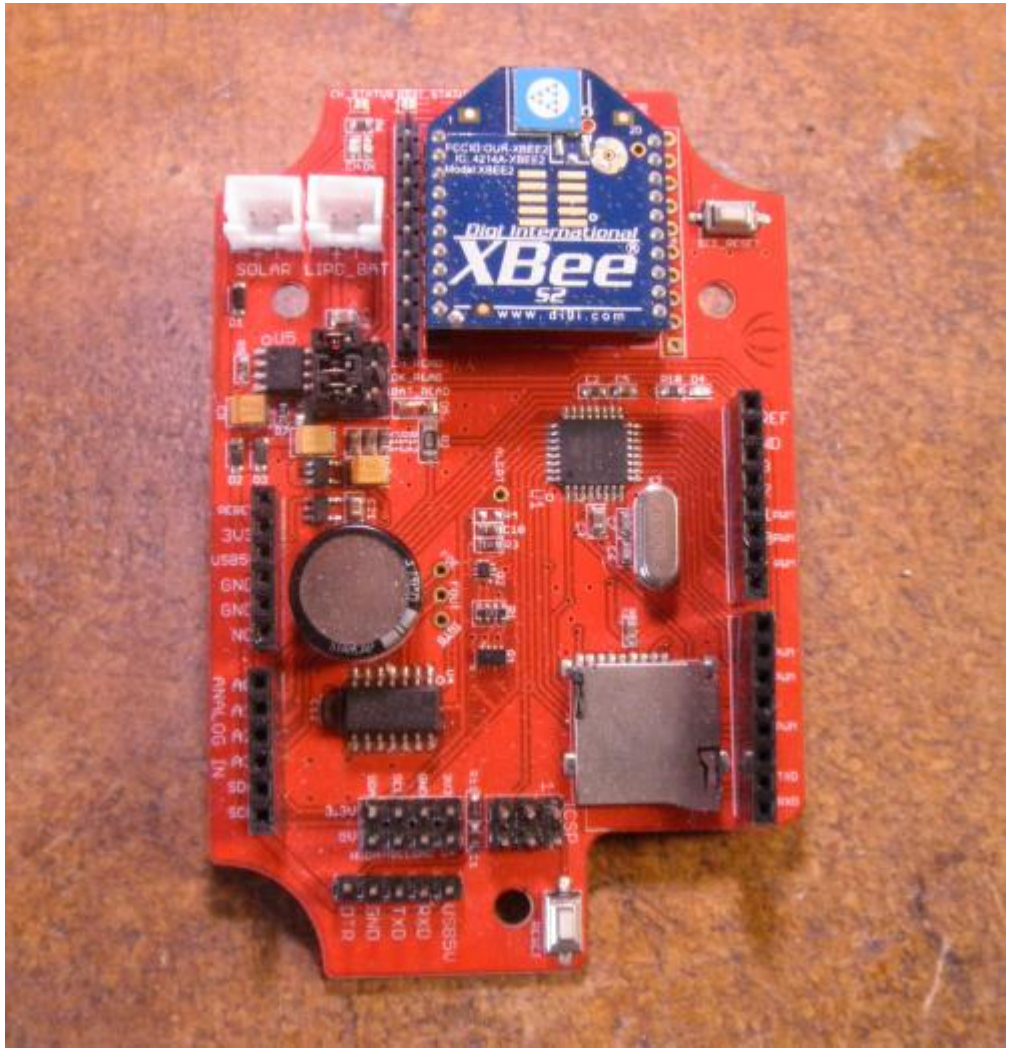

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XBee Programming, Wiring and Use

An interface board is not needed if

- XBee is used without
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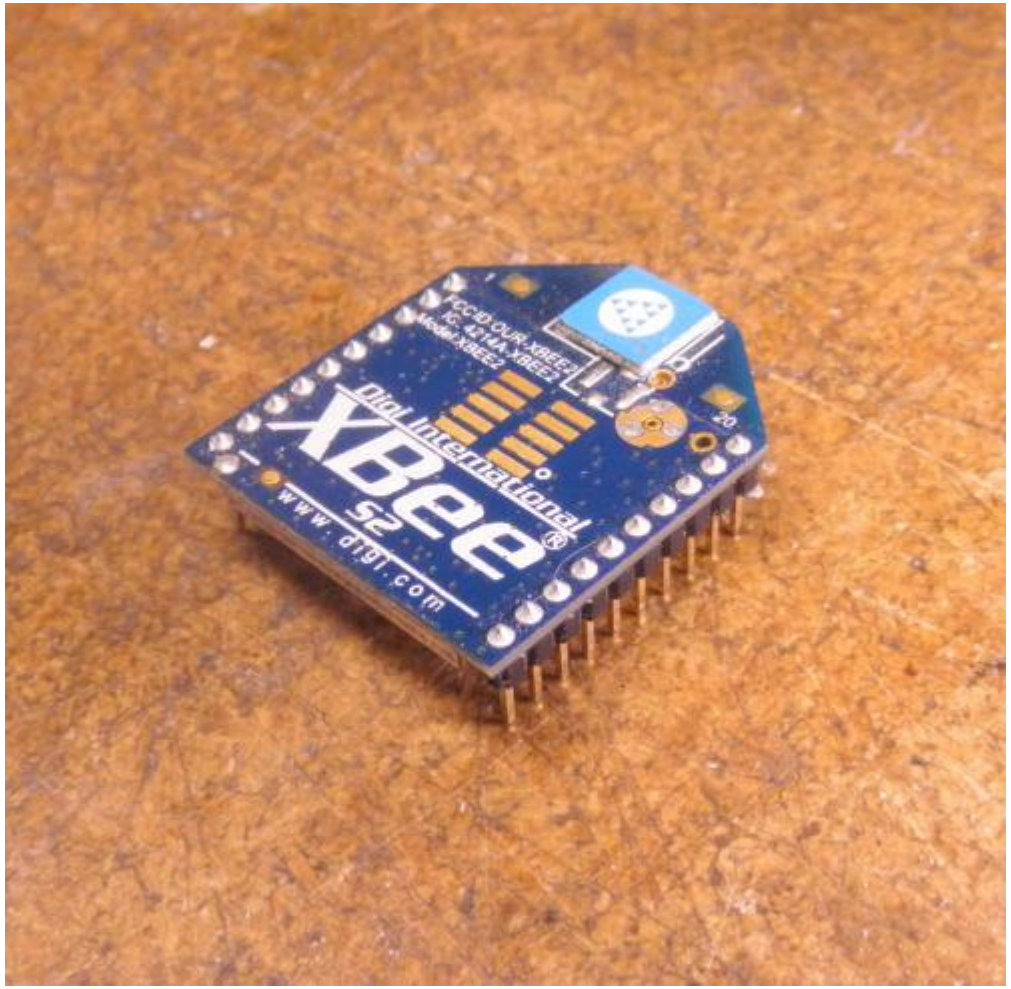

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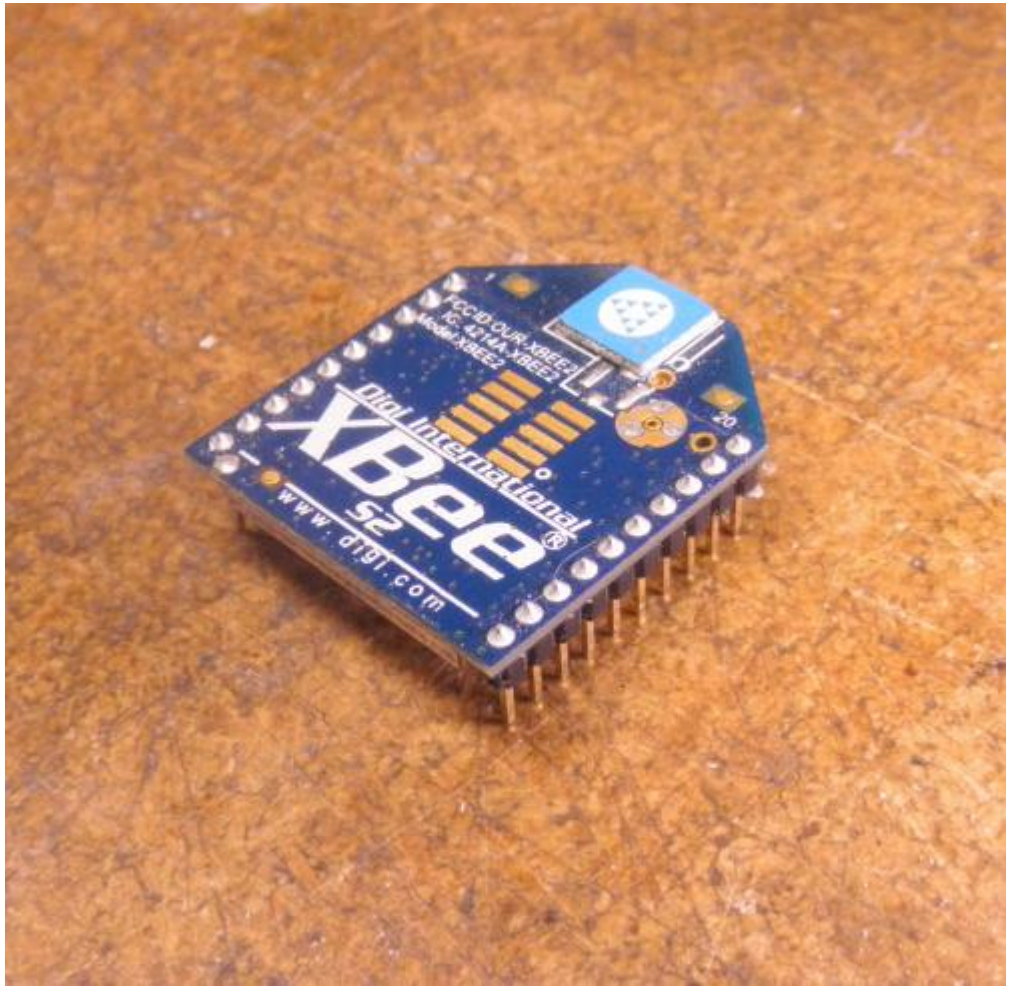
- and you provide the 3 volts.

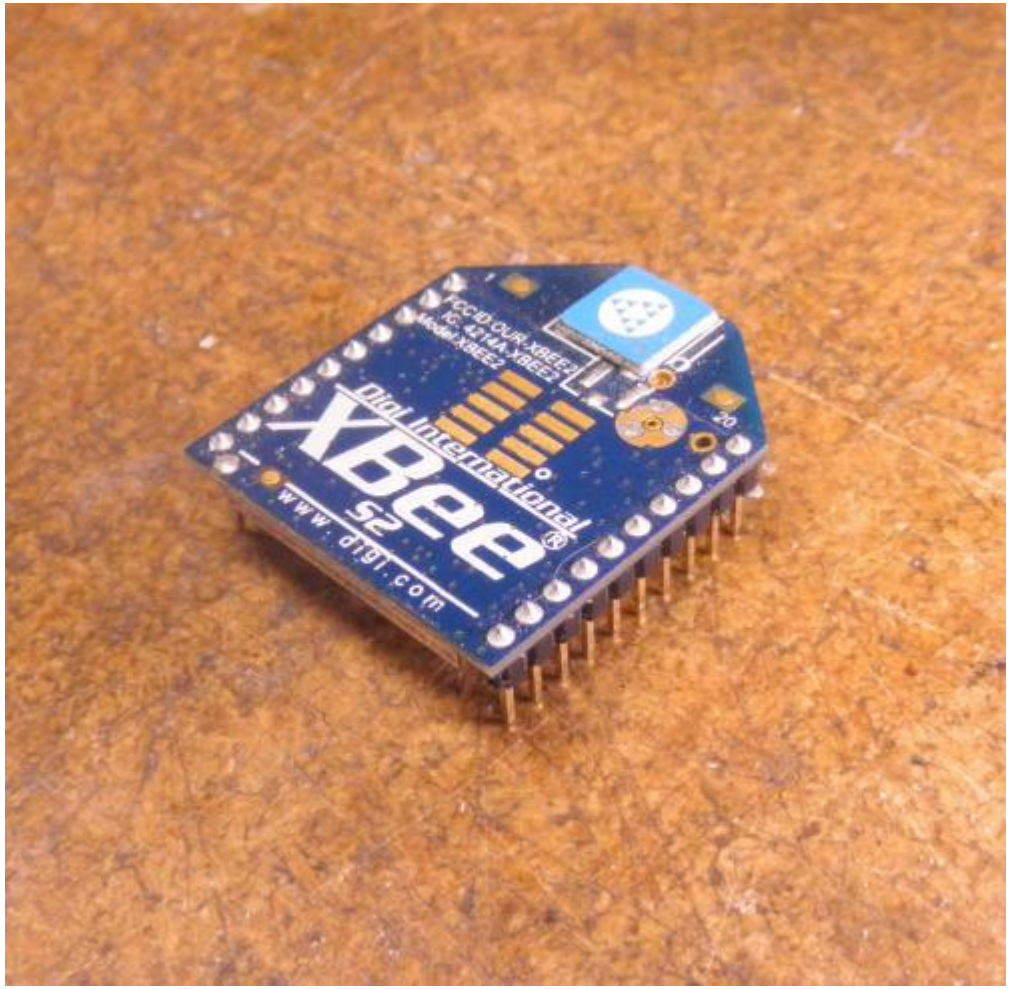


XBee Programming, Wiring and Use

An interface board is not needed if

- XBee is used without
  a micro-controller
- and you provide the 3 volts.

(don’t forget, XBee has its own AtoD)



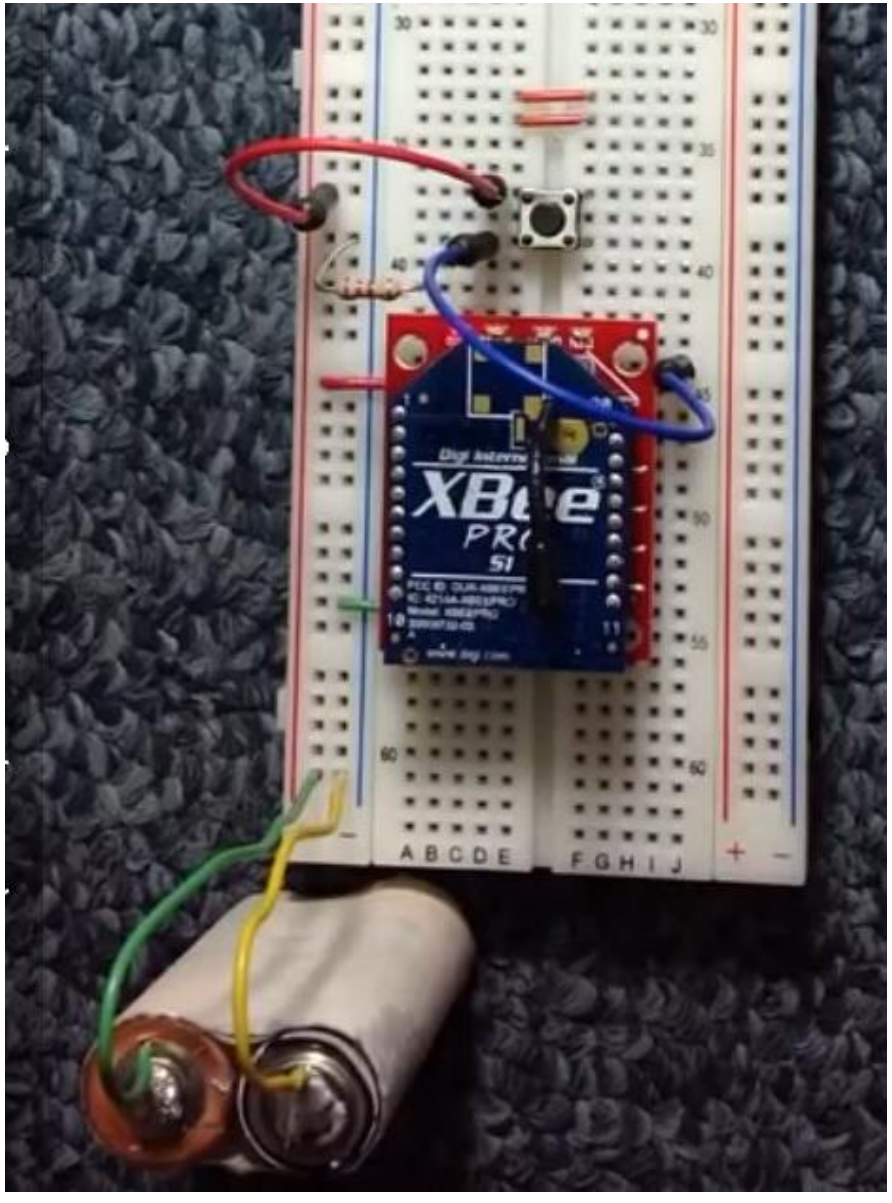
XBee Programming, Wiring and Use

An interface board is not needed if

- XBee is used without
  a micro-controller
- and you provide the 3 volts.

(don't forget, XBee has its own AtoD)

Here the interface board is only used to convert to 0.1".



XBee Programming, Wiring and Use

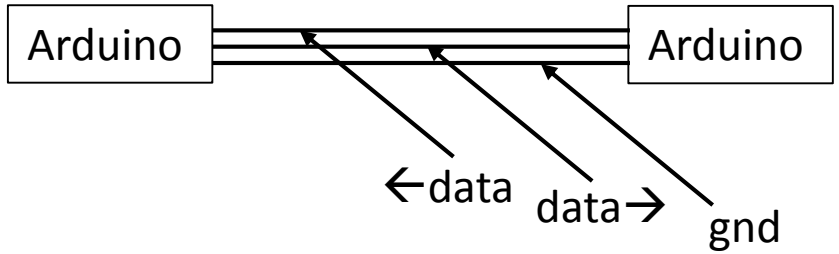
XBee Programming, Wiring and Use

The Most Common
Use of XBee

XBee Programming, Wiring and Use

The Most Common Use of XBee

Transparent Mode



XBee Programming, Wiring and Use

The Most Common Use of XBee

Transparent Mode

XBee Programming, Wiring and Use

The Most Common Use of XBee

Transparent Mode

XBee's default configuration

XBee Programming, Wiring and Use

The Most Common Use of XBee

Transparent Mode

Mesh Network

API Mode

XBee Programming, Wiring and Use

The Most Common Use of XBee

Transparent Mode

Mesh Network

API Mode

No microcontroller

Line Passing Mode

XBee Programming, Wiring and Use

The Most Common Use of XBee

Transparent Mode

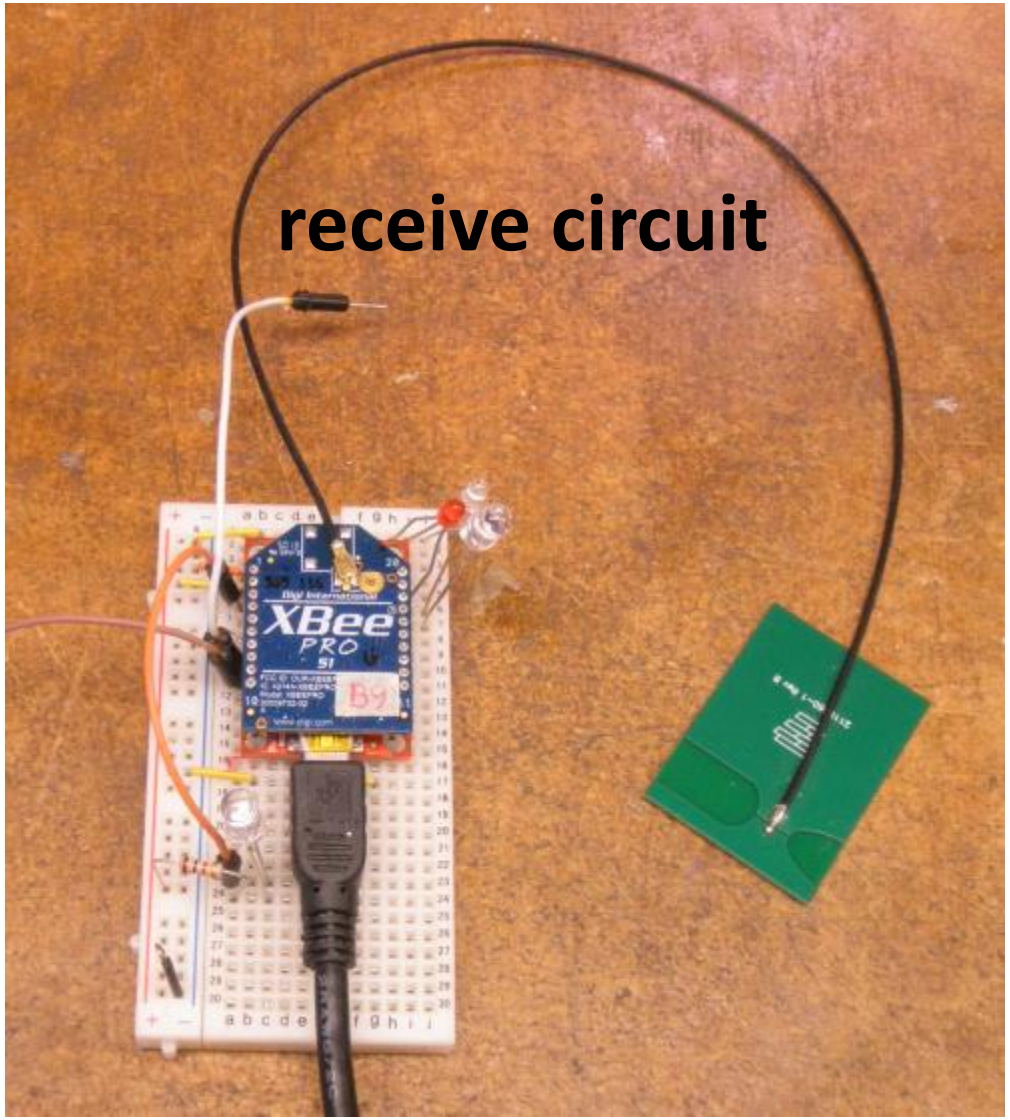
Mesh Network

API Mode

No microcontroller

Line Passing Mode
(virtual wires)

XBee Programming, Wiring and Use



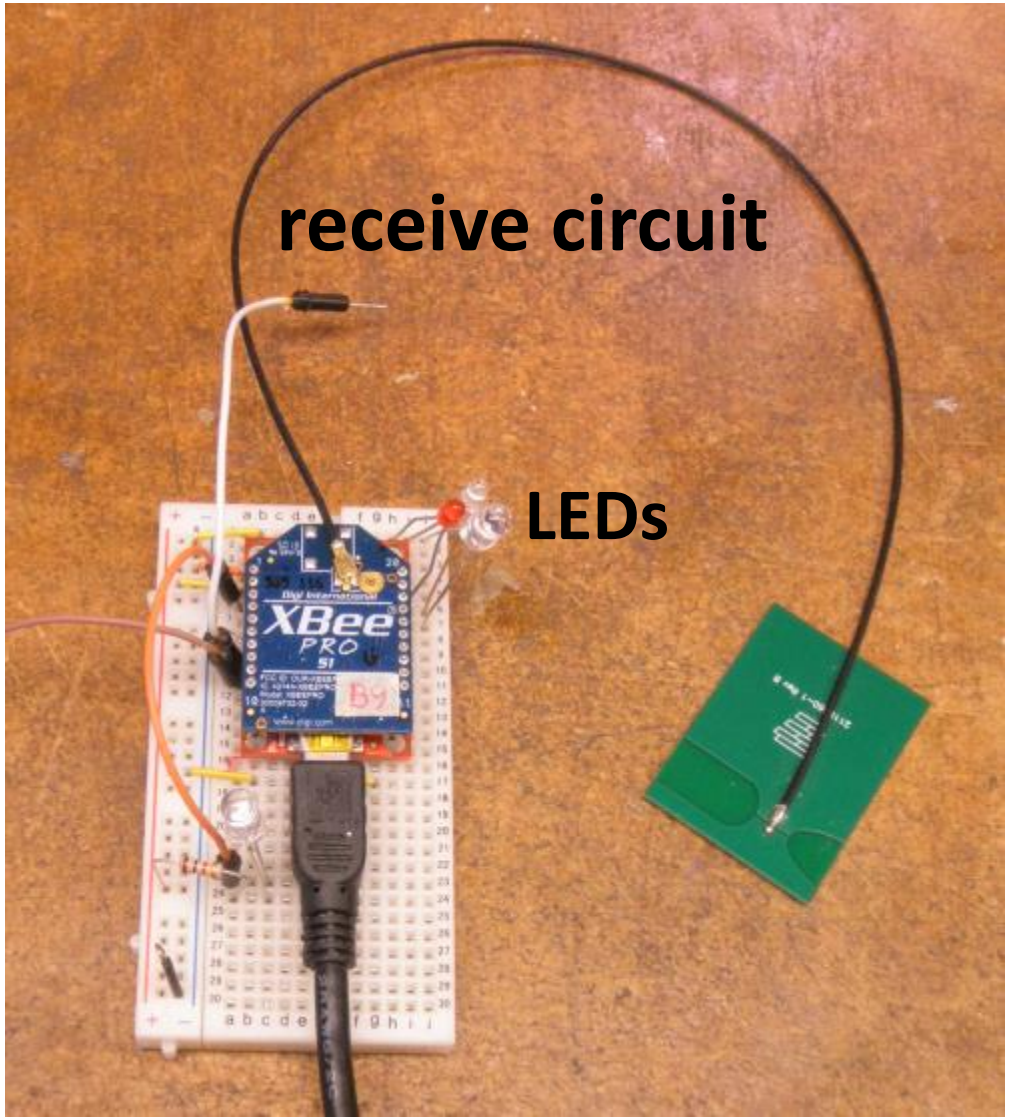
Transparent Mode

Arduino | XBee ⚡ XBee | Arduino

API Mode

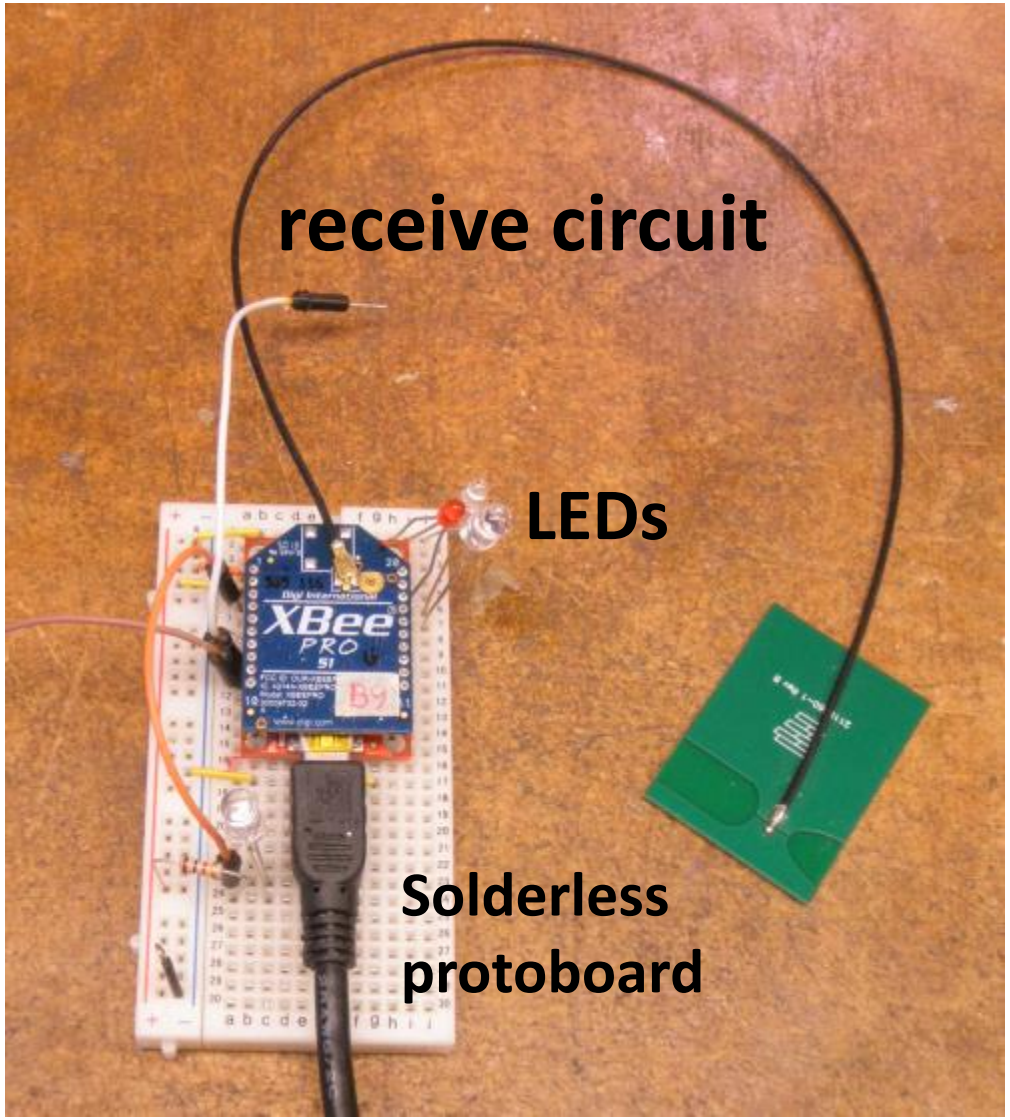
Line Passing Mode

XBee Programming, Wiring and Use



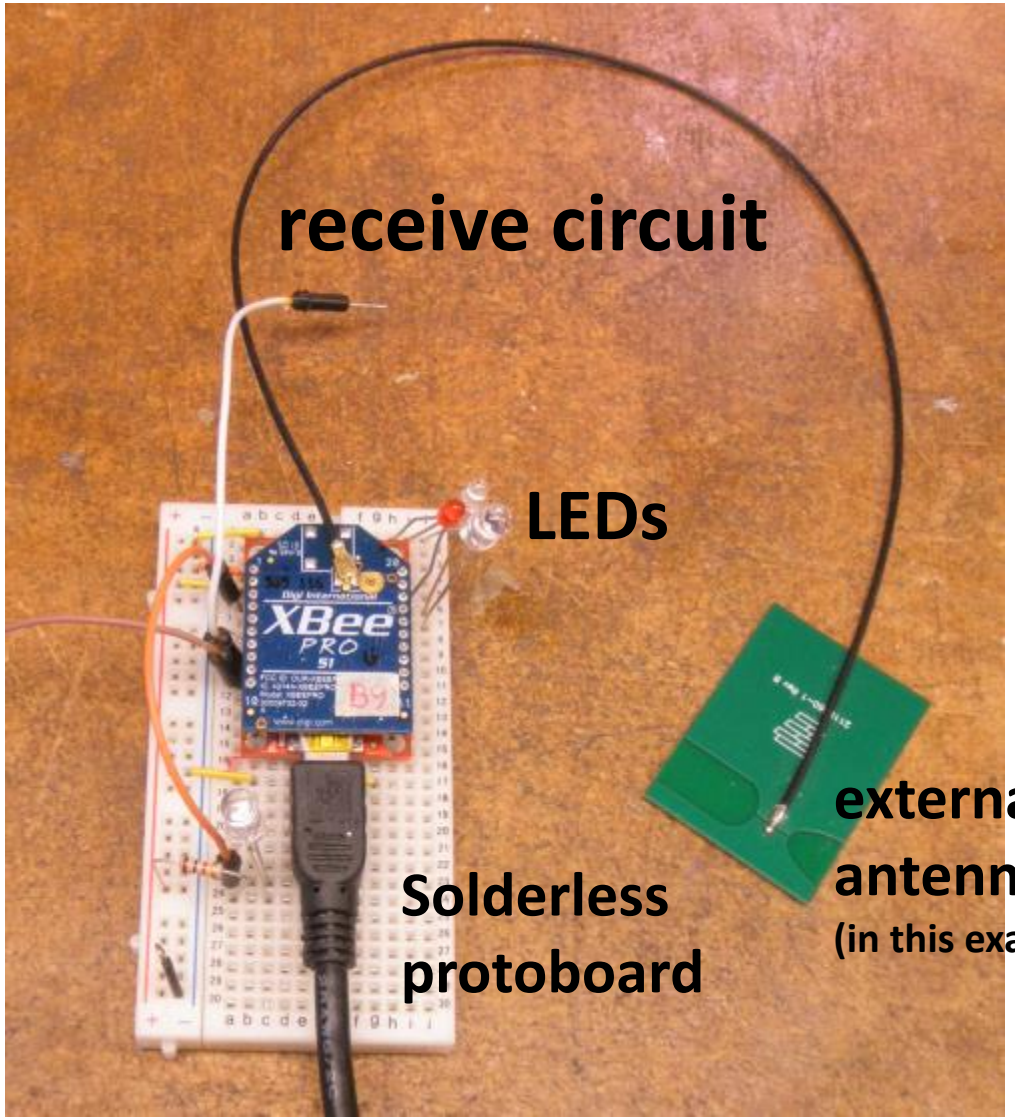
Line Passing Mode

XBee Programming, Wiring and Use



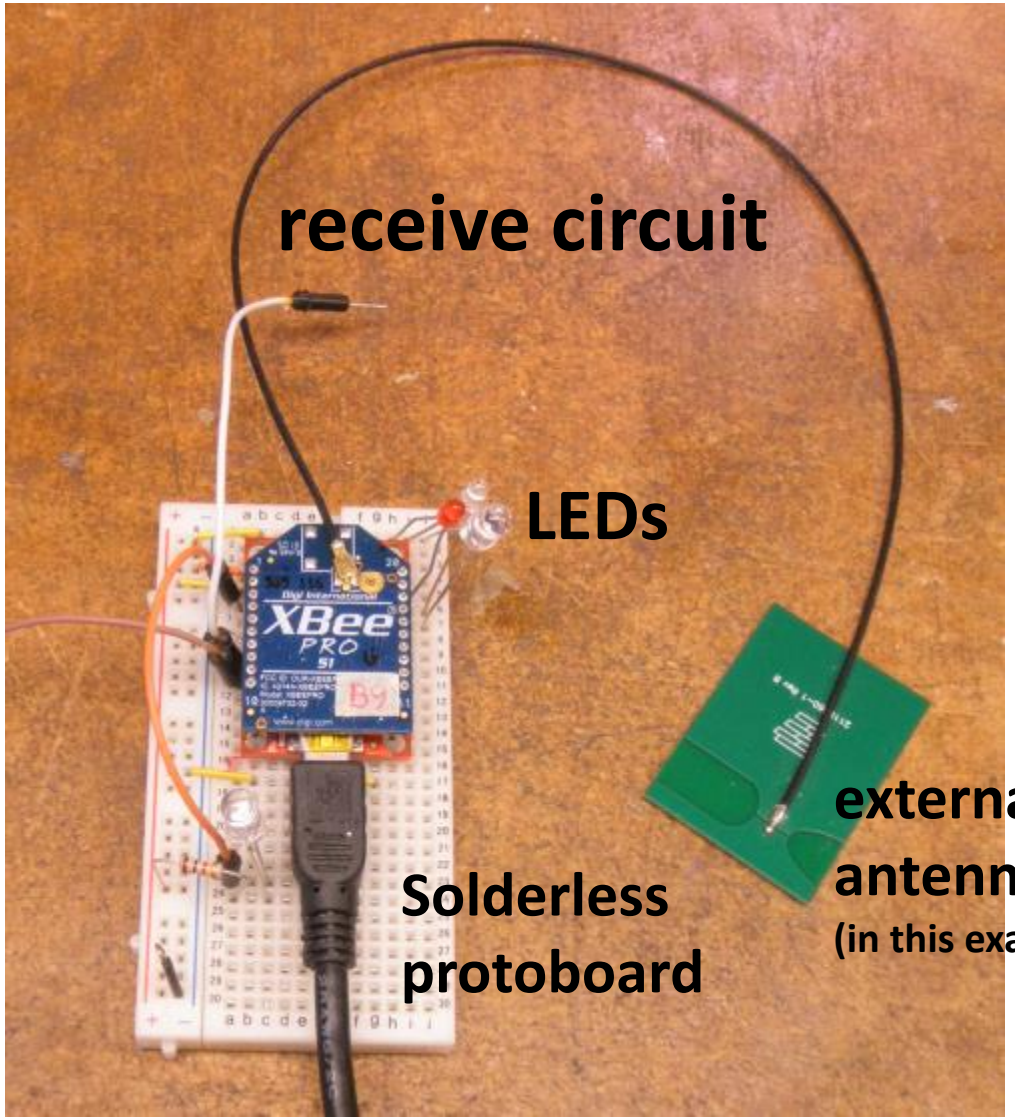
Line Passing Mode

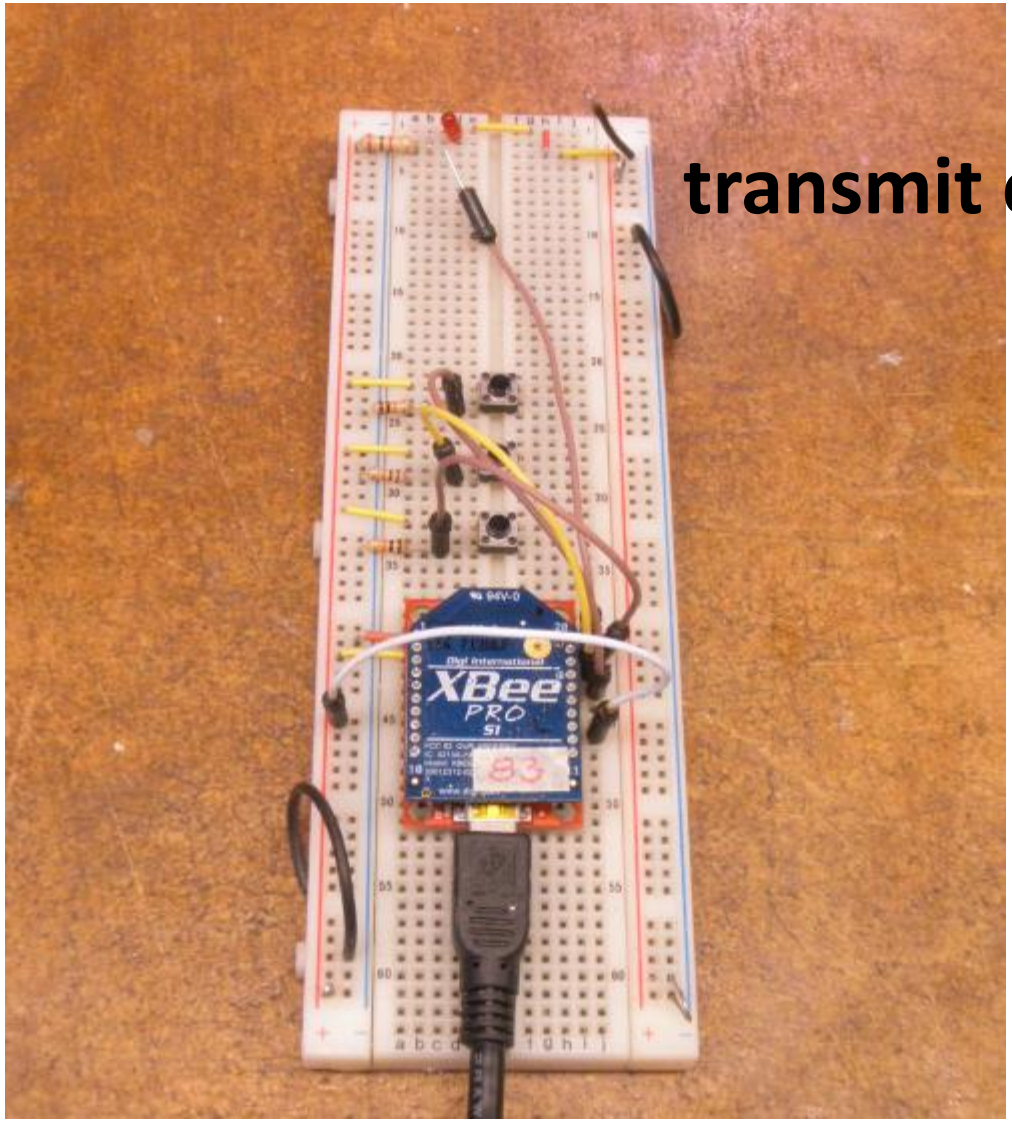
XBee Programming, Wiring and Use



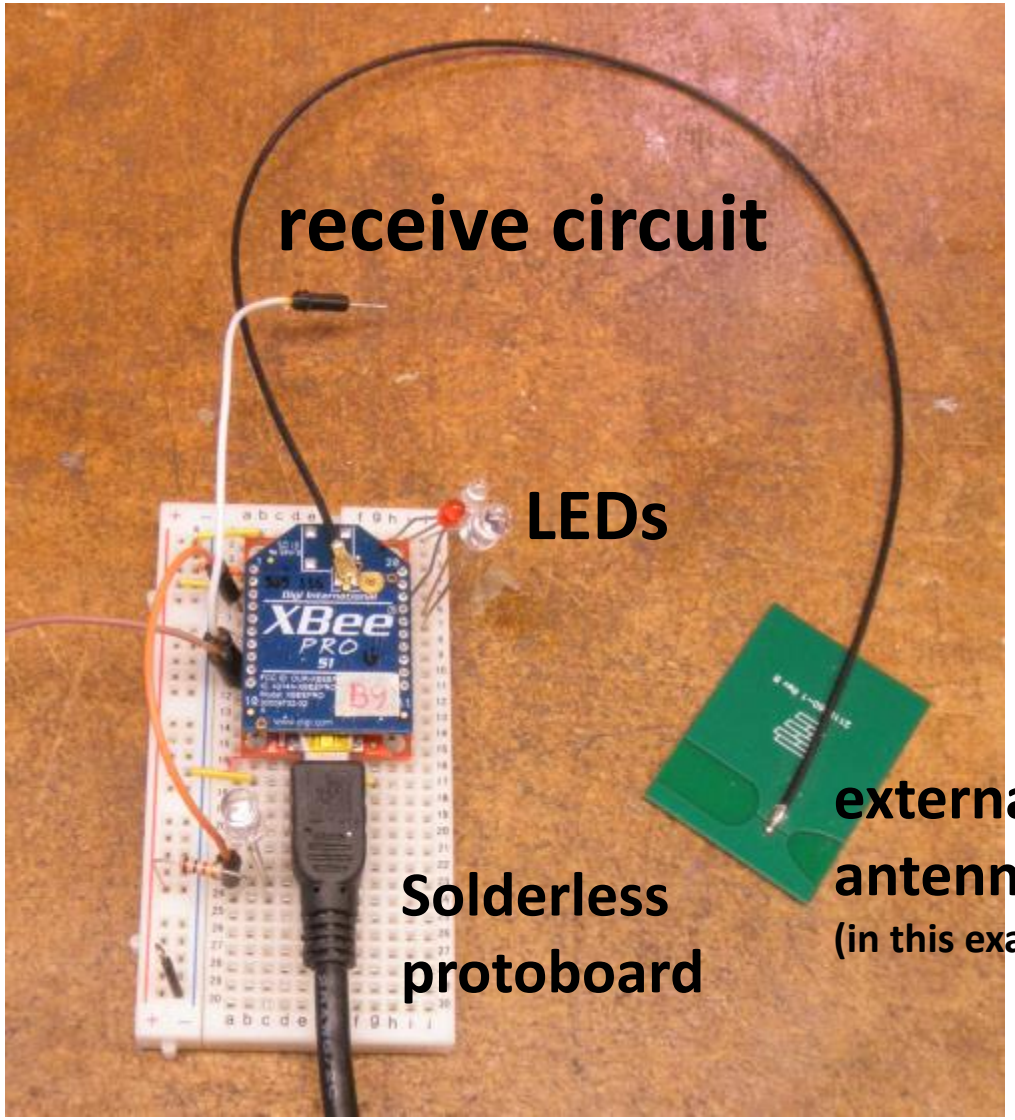
Line Passing Mode

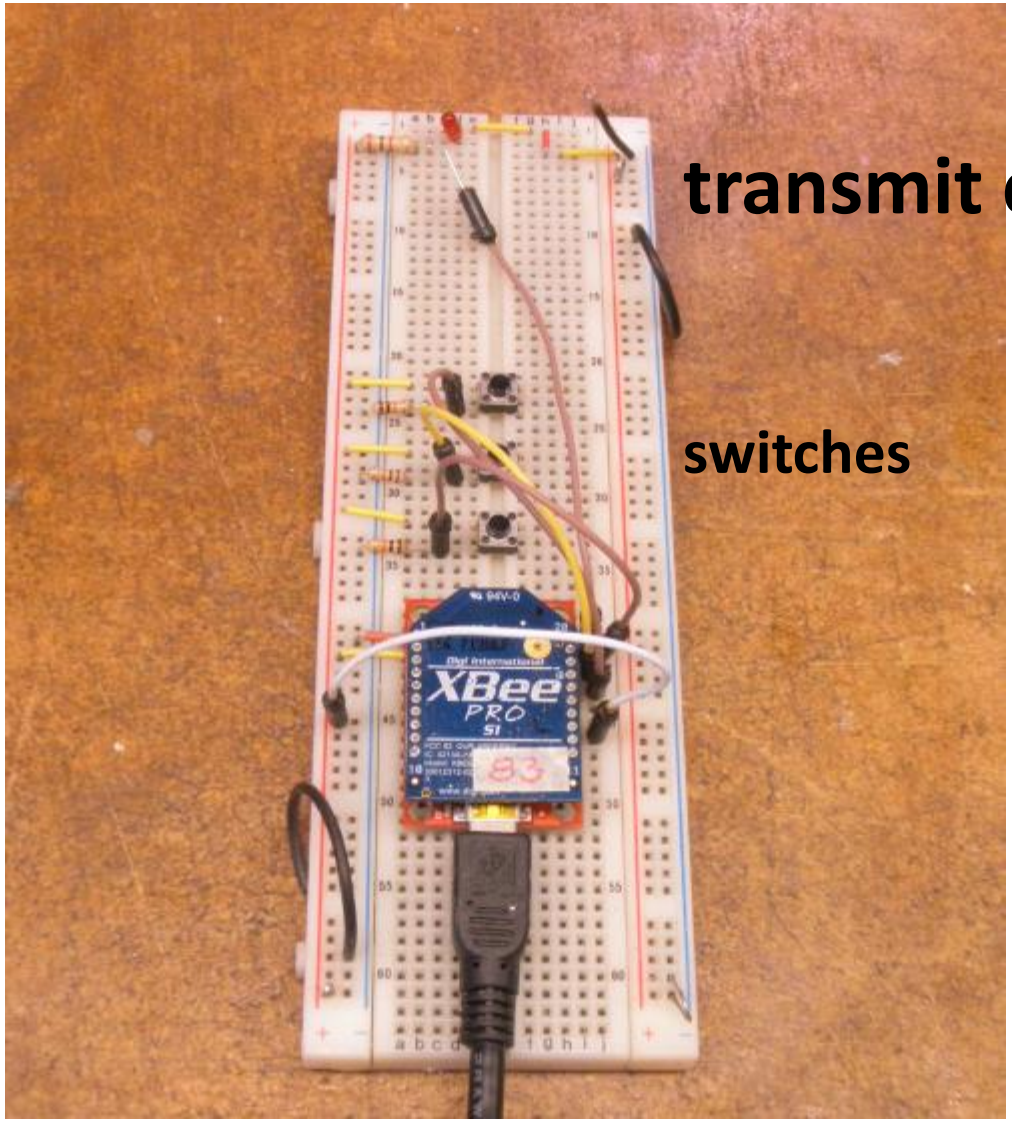
XBee Programming, Wiring and Use





XBee Programming, Wiring and Use





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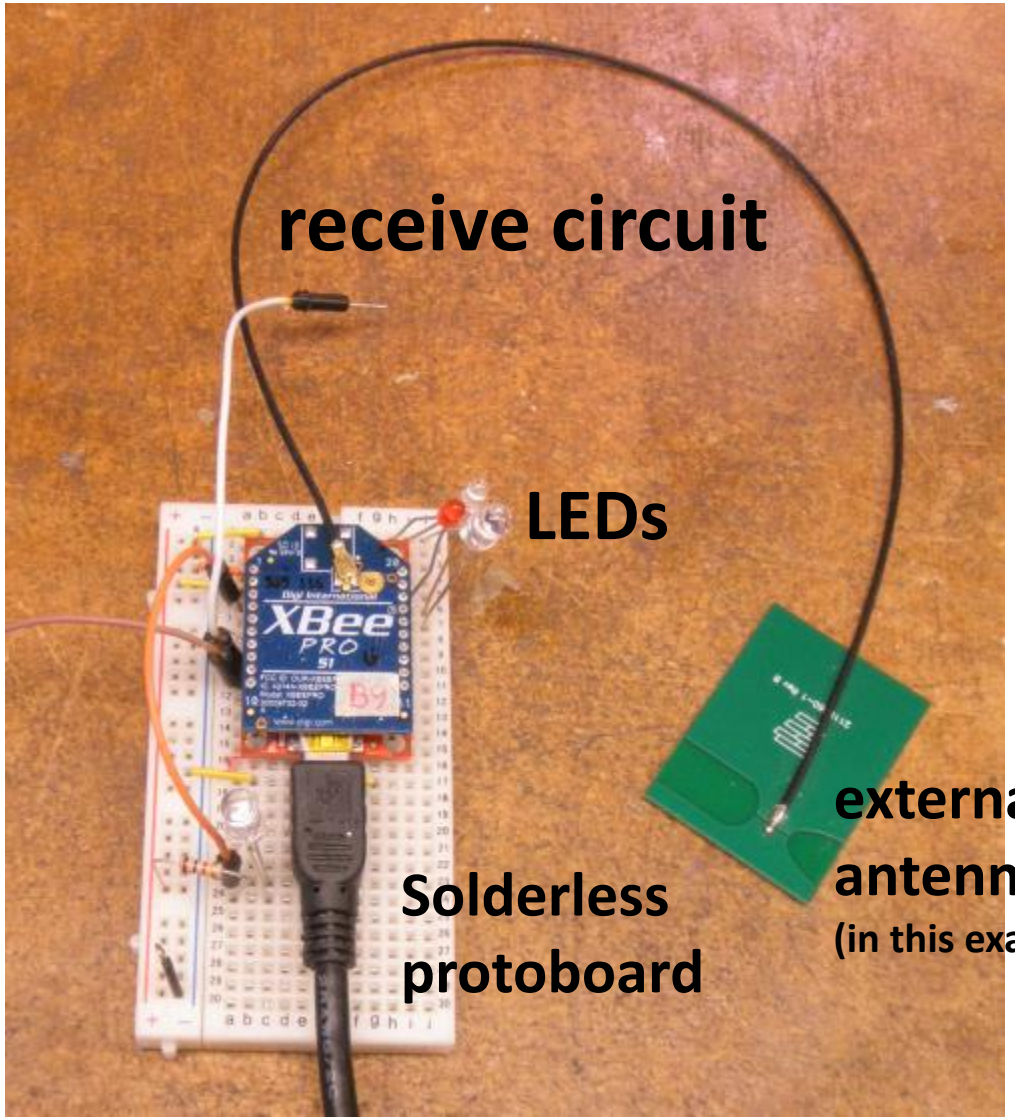

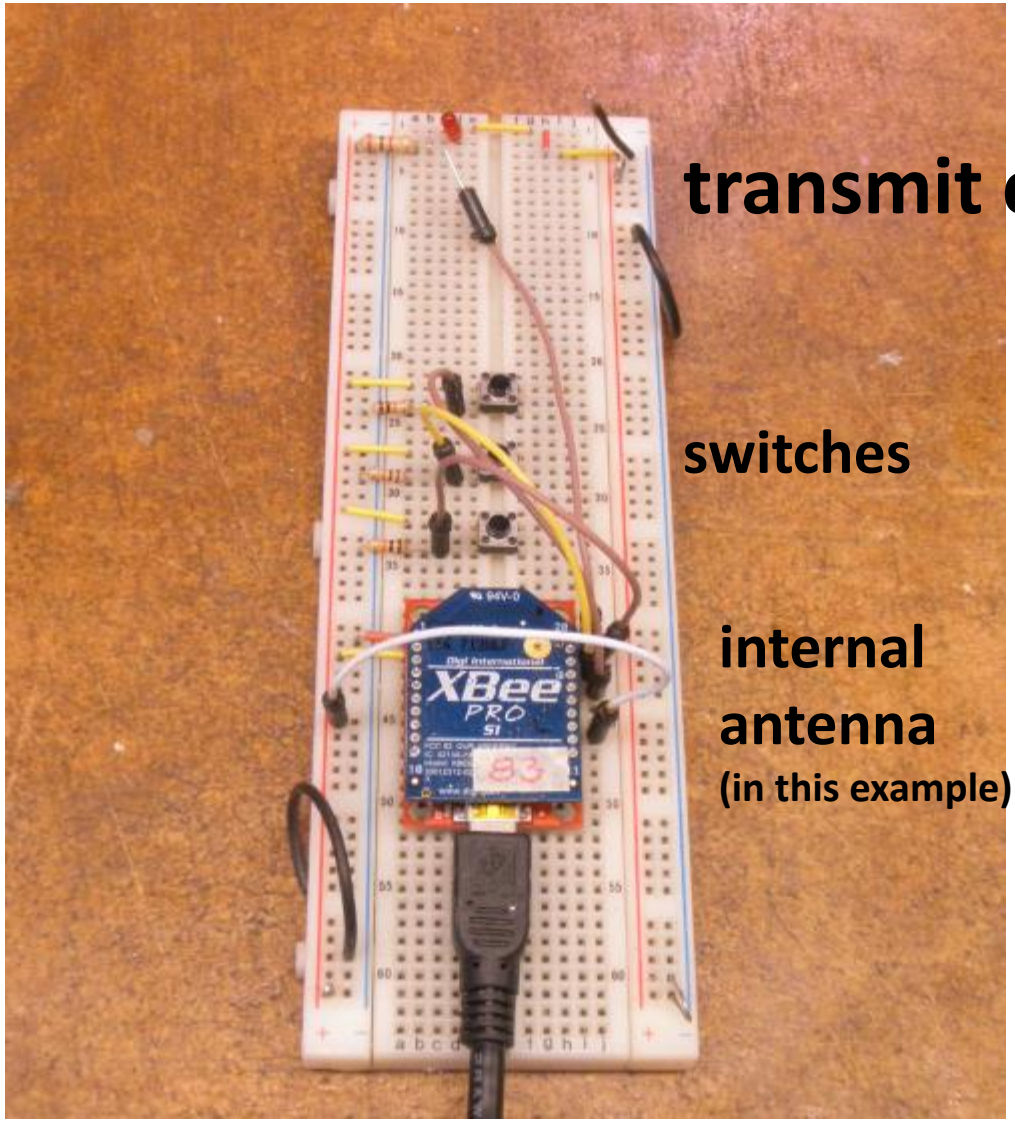

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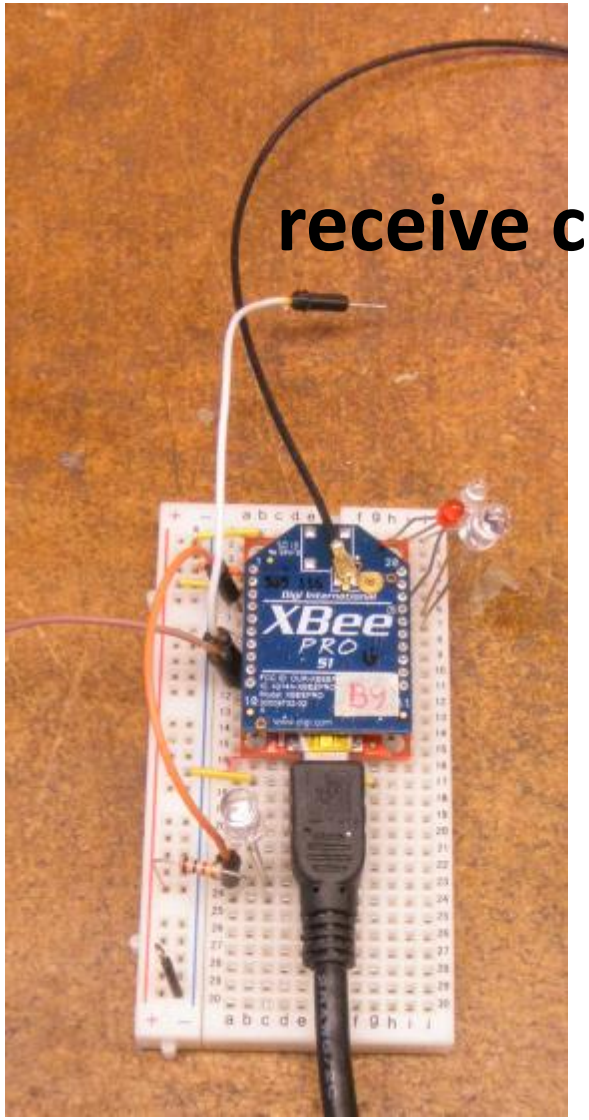
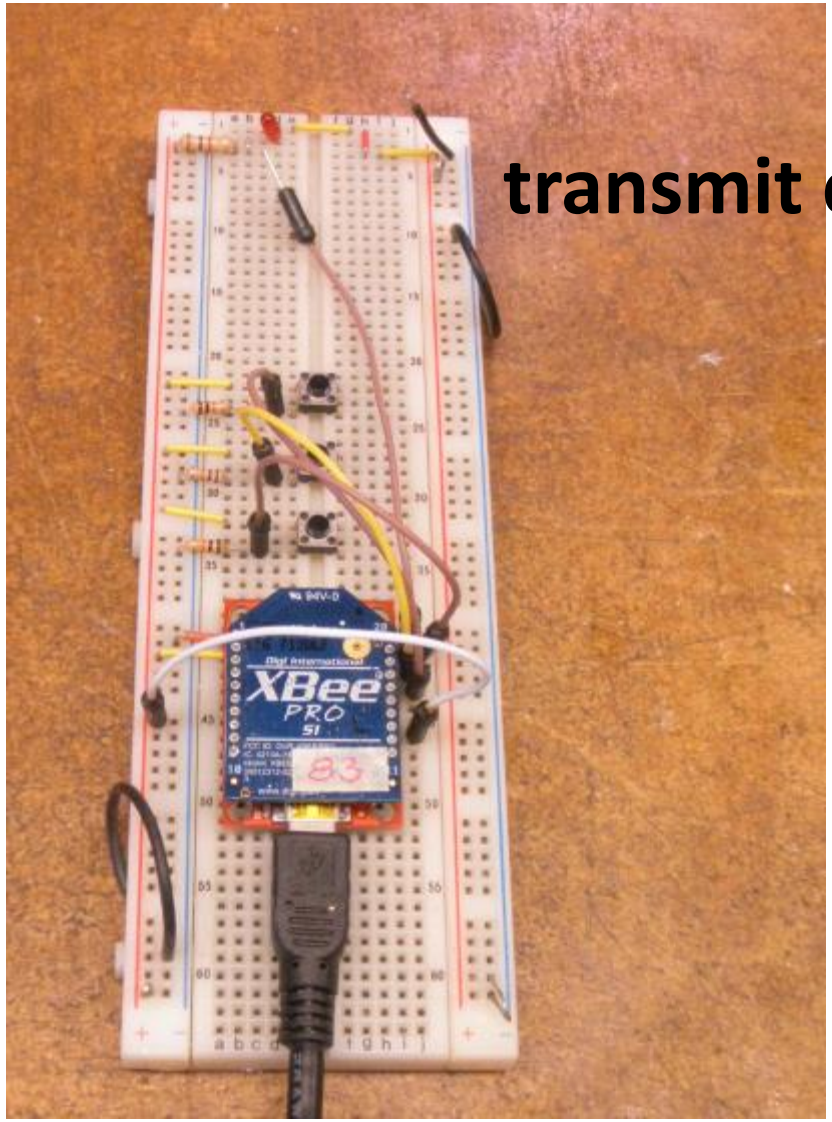


receive circuit

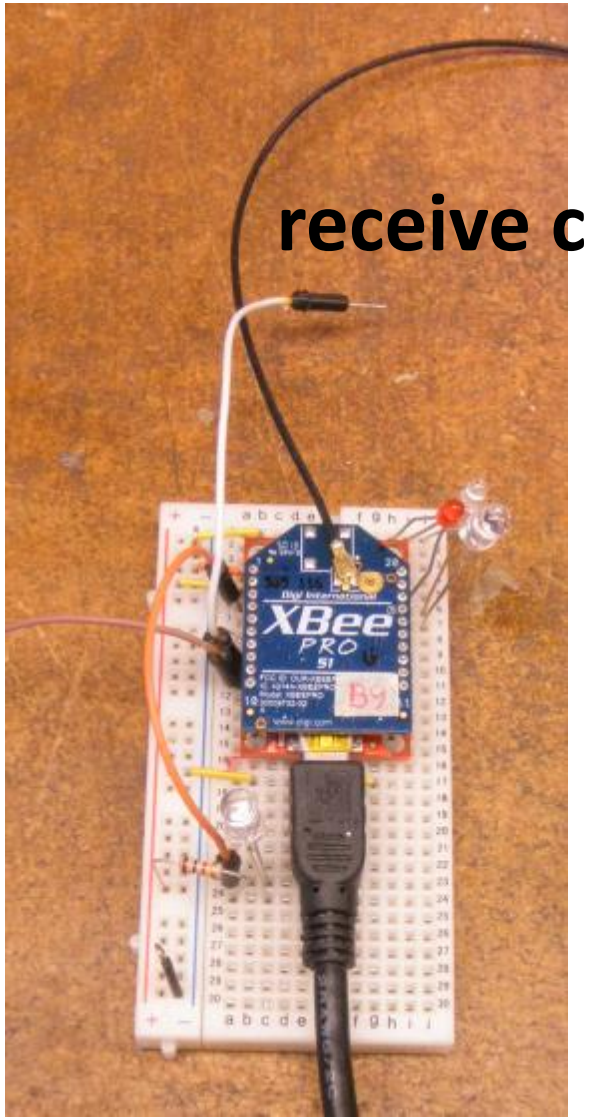
Power

Both are shown here, powered by the 5V in the USB during development.



transmit circuit

XBee Programming, Wiring and Use



receive circuit

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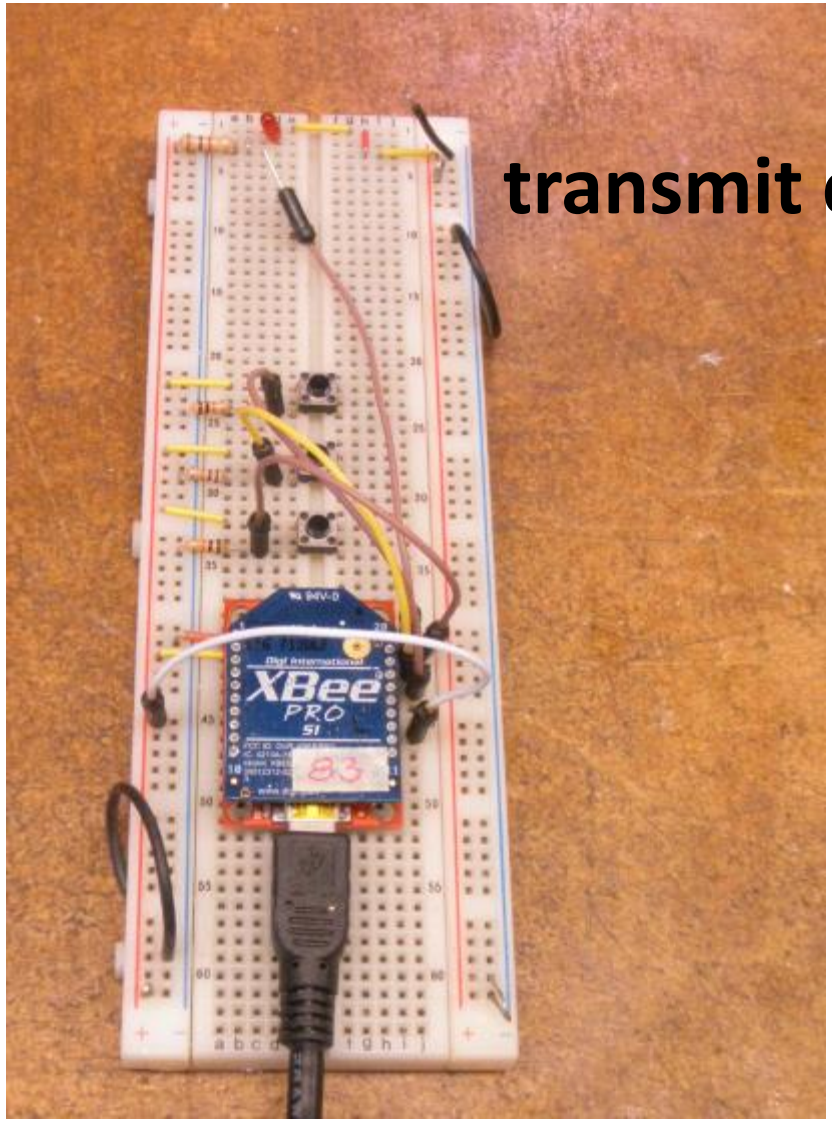
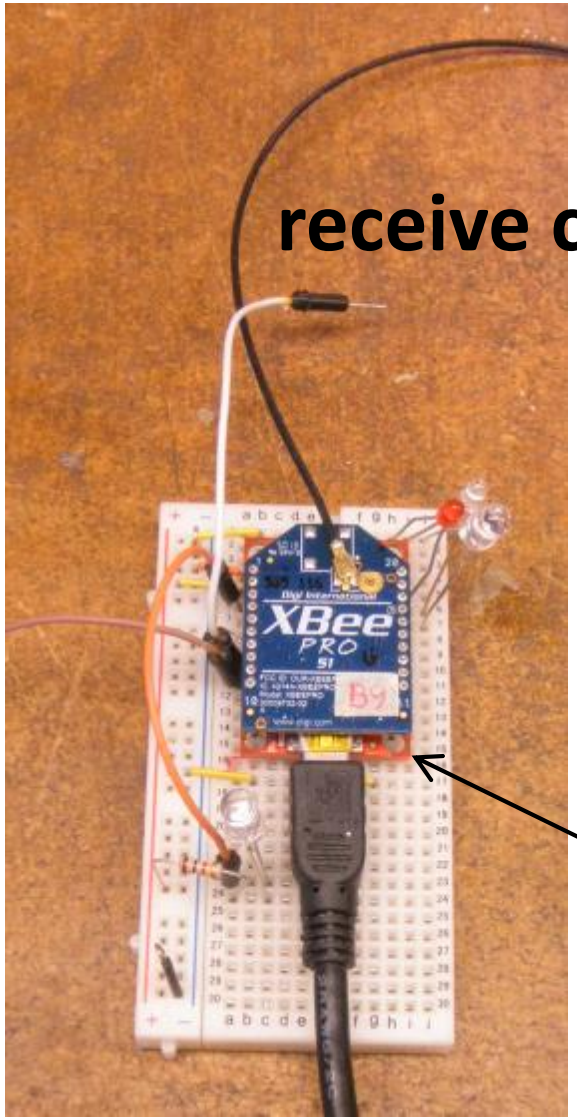
USB to PC connection is also needed to configure the XBee.



transmit circuit

XBee Programming, Wiring and Use



receive circuit

Power

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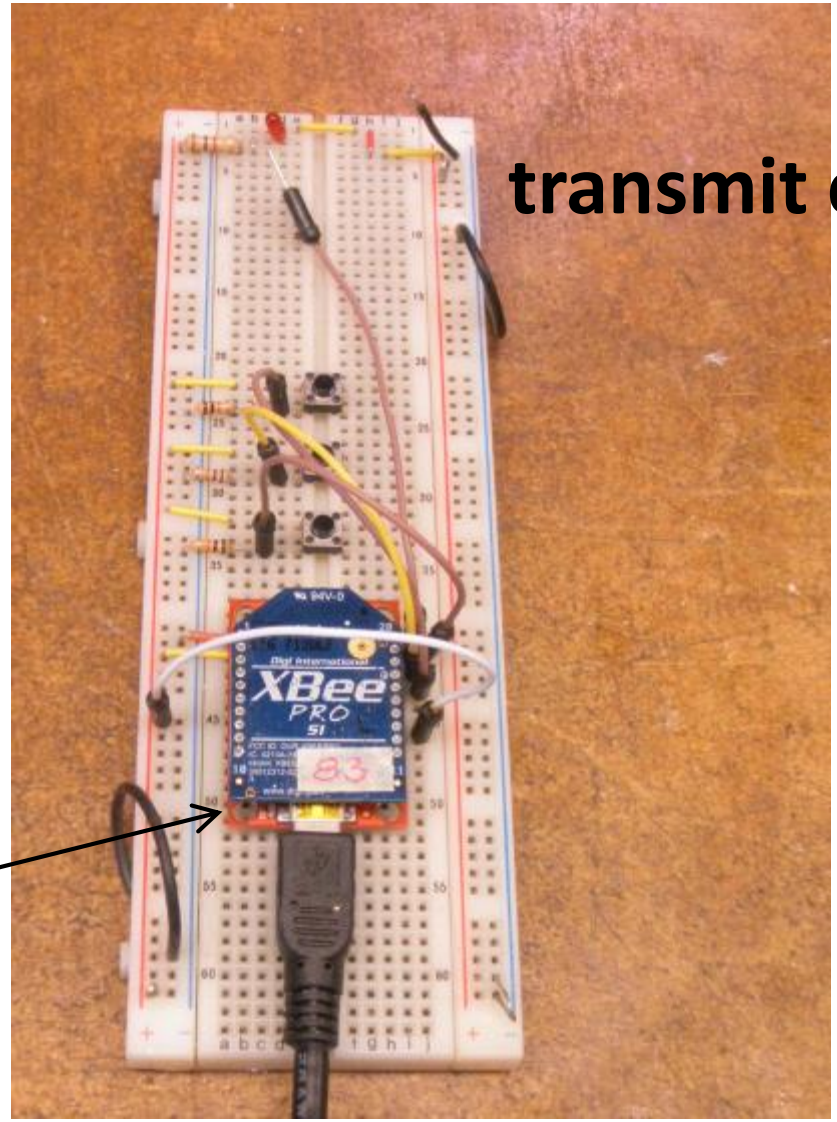
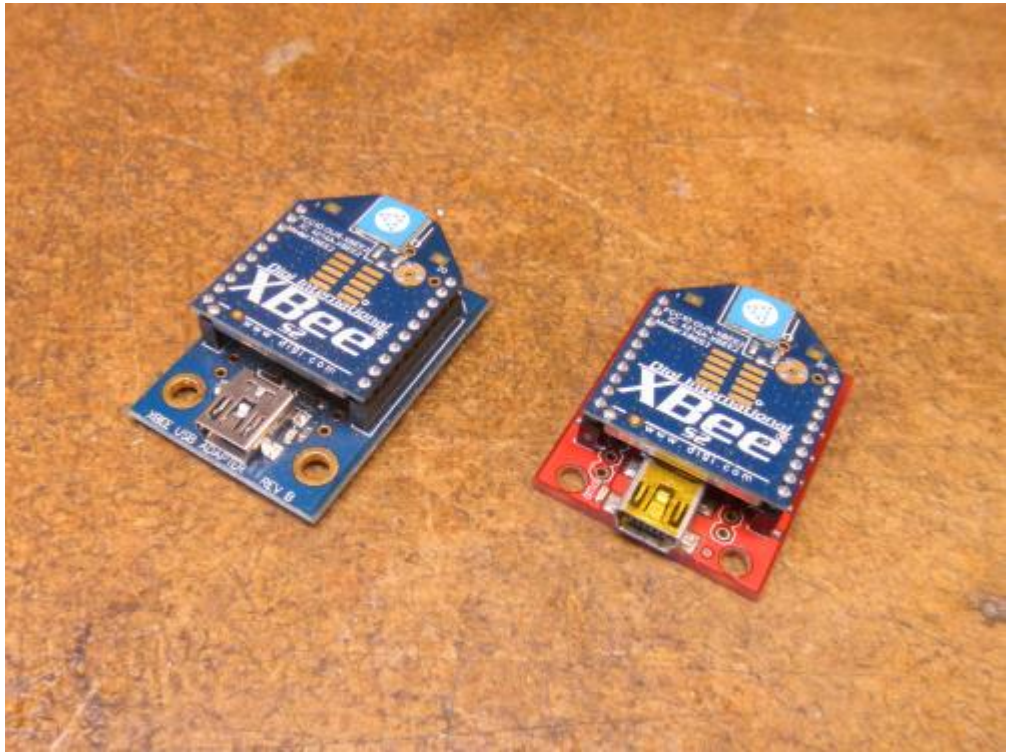
interface boards

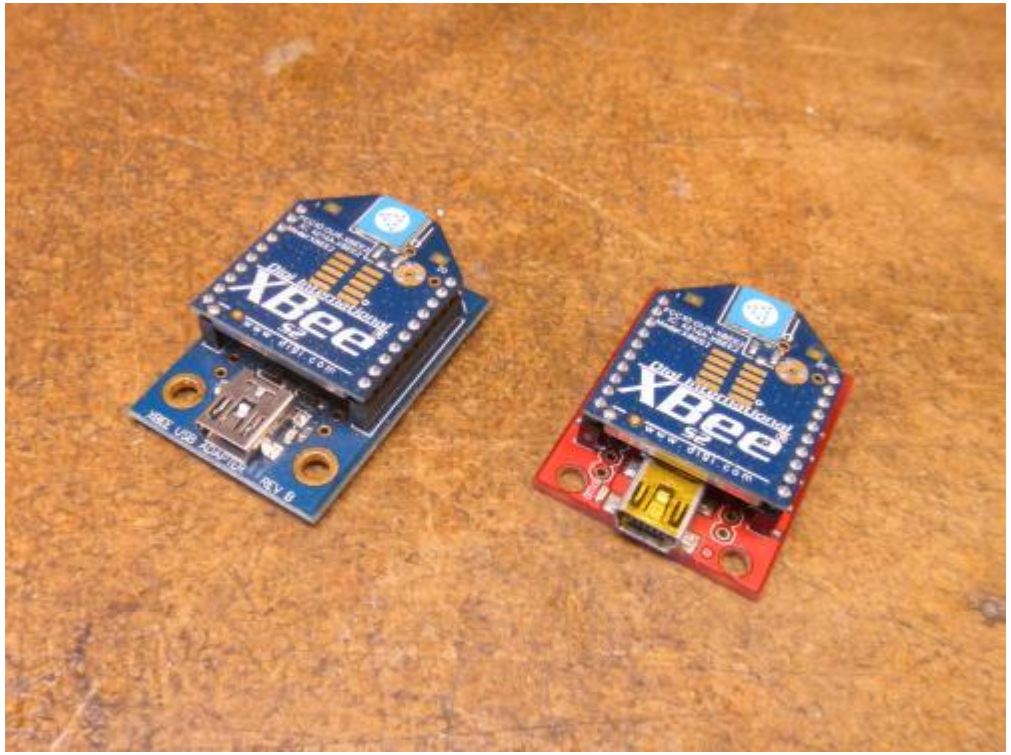


transmit circuit



There are a variety of the interface boards.

On the left is one made by **Parallax.**
On the right by **SparkFun.**



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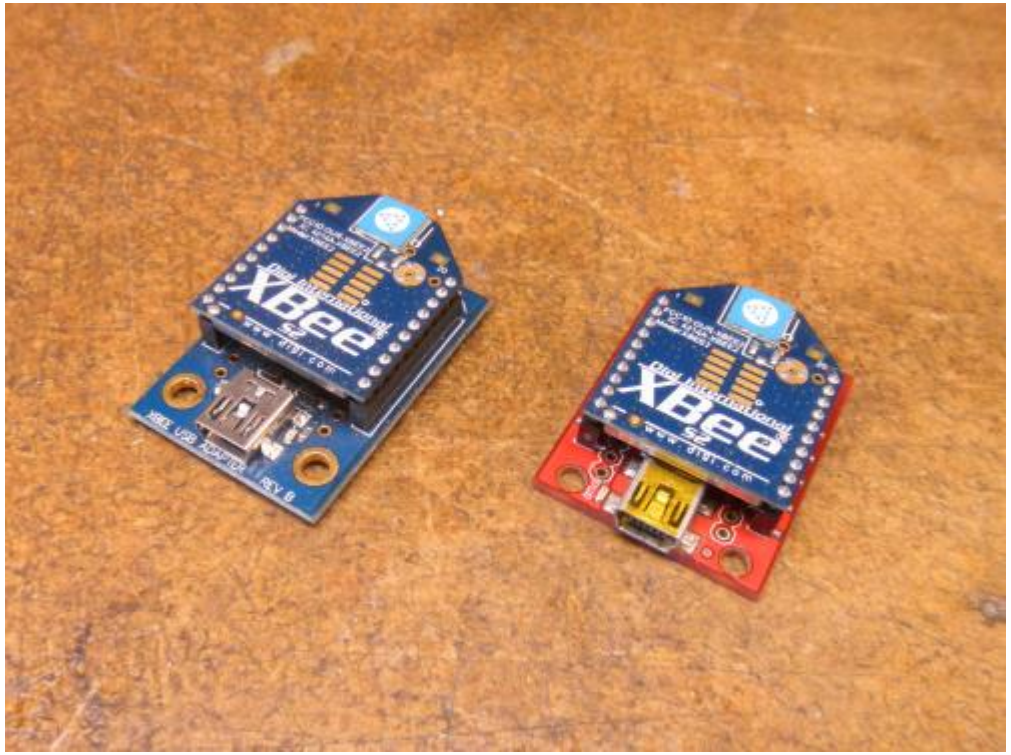

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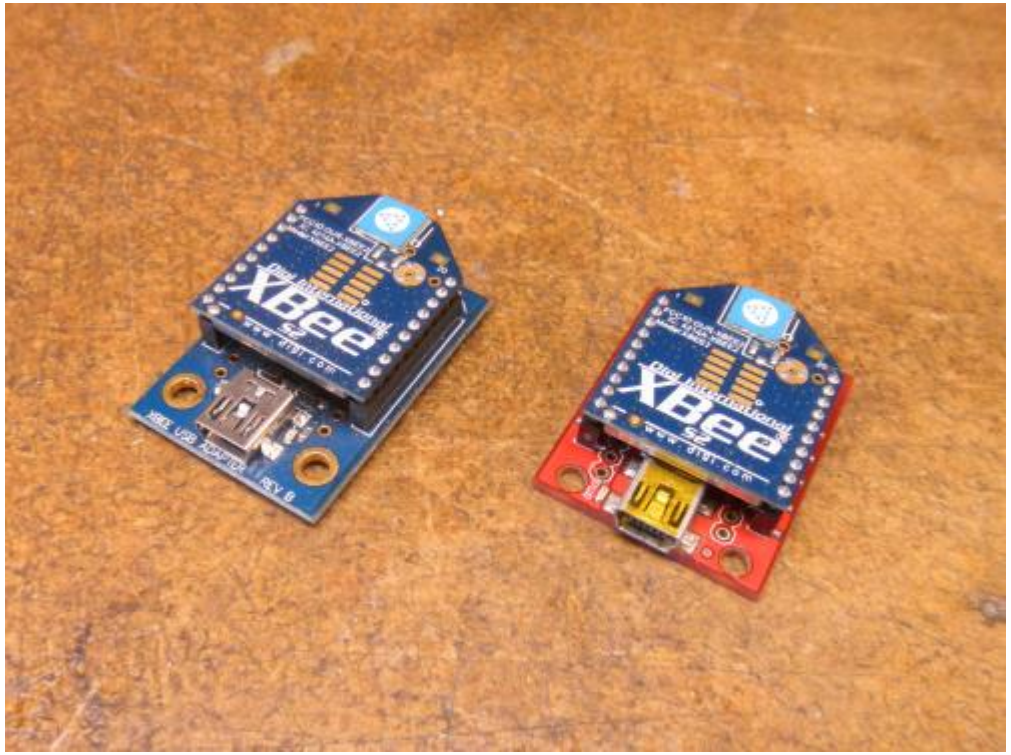

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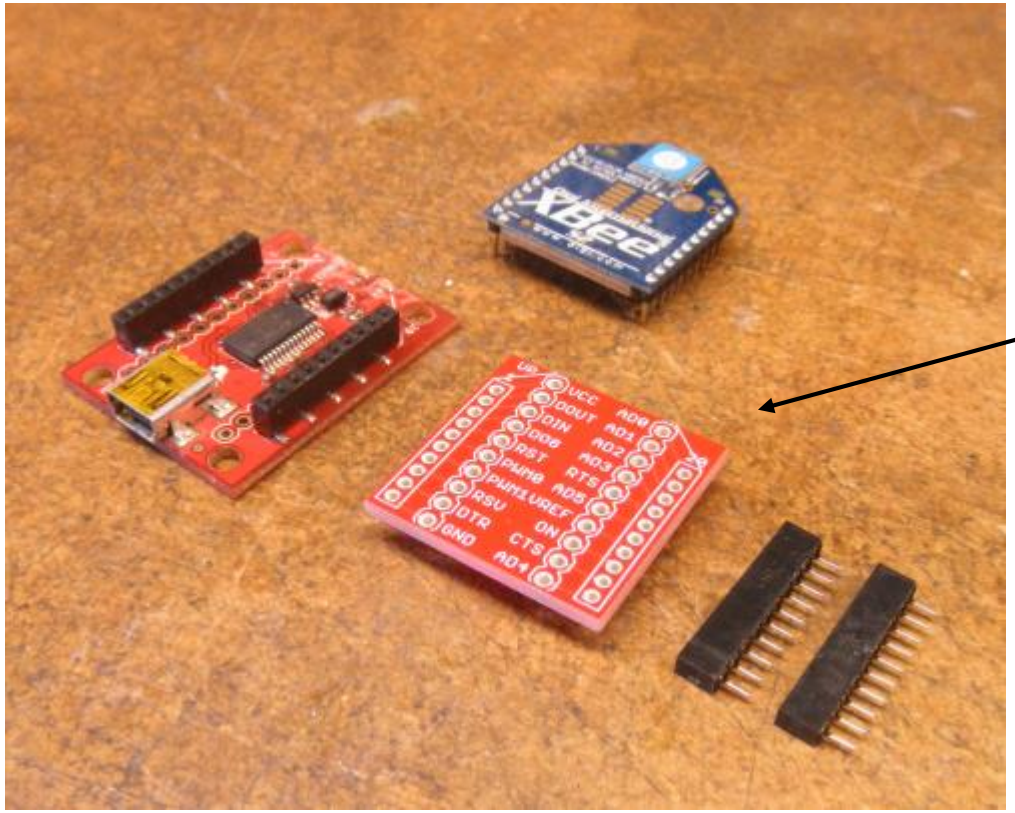
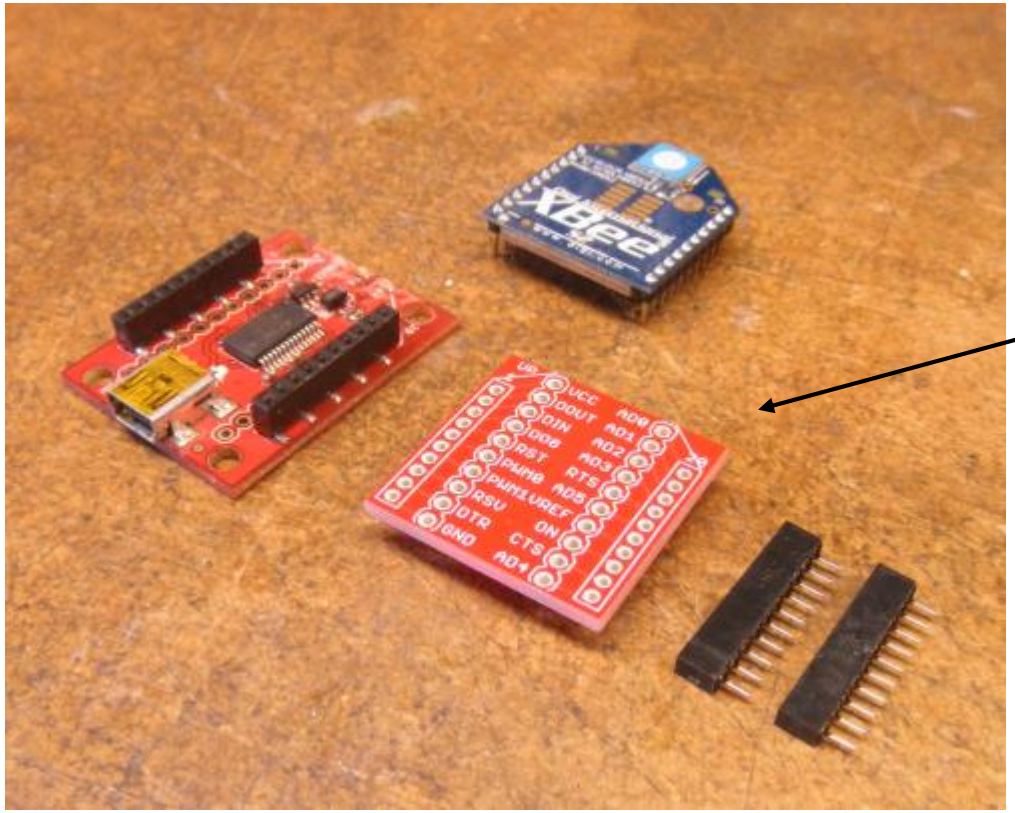
Notice the USB connector on both. These particular interface boards also convert logic level and protocol to that of a PC



The blank Explorer board can have the header (sockets) soldered in to allow the XBee to be removable. Or the XBee can be soldered directly.



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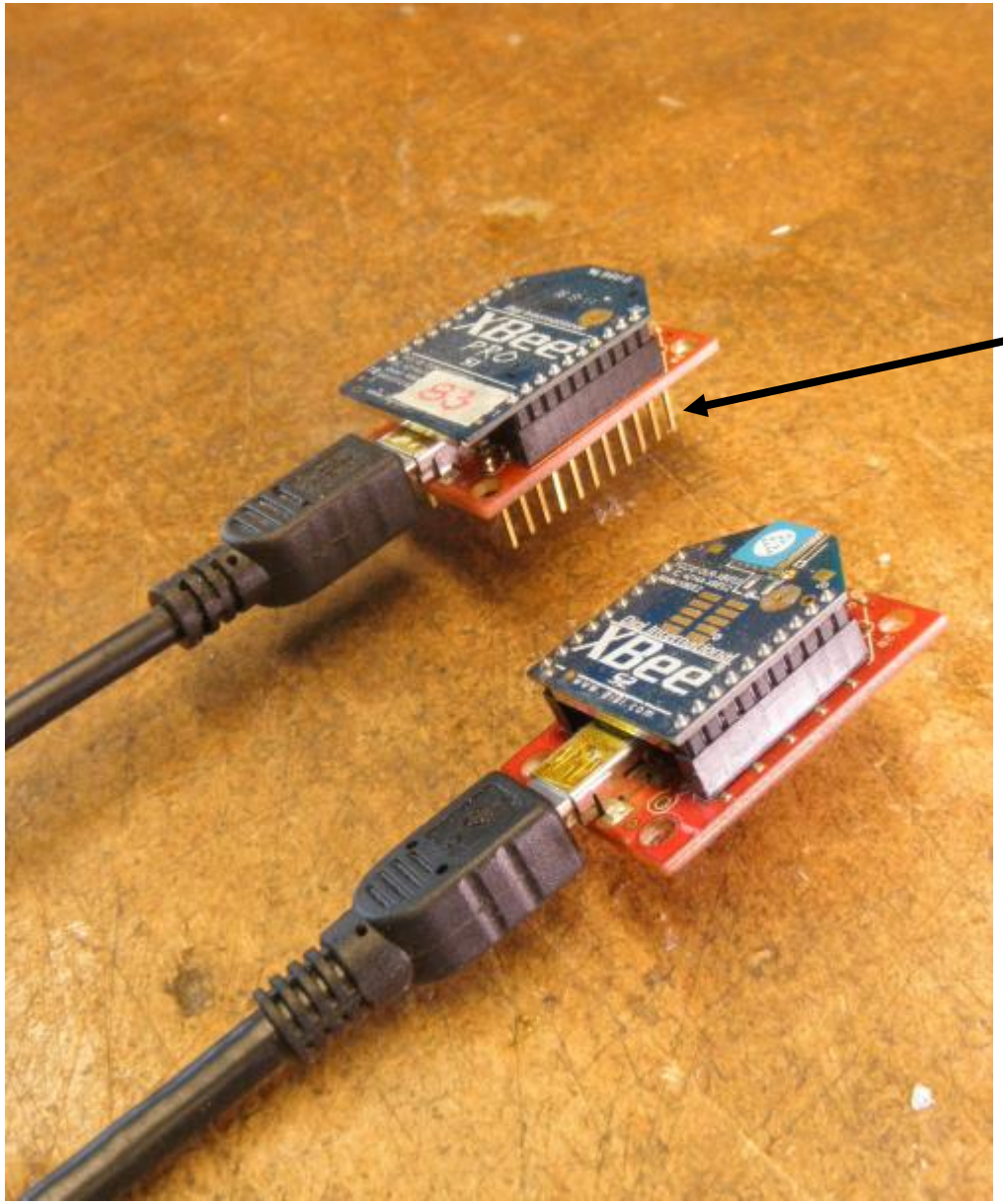
In which case, under this board, you could solder headers making ***the whole assembly*** removable.



- The Explorer board with pins interfaces with proto-boards and/or USB
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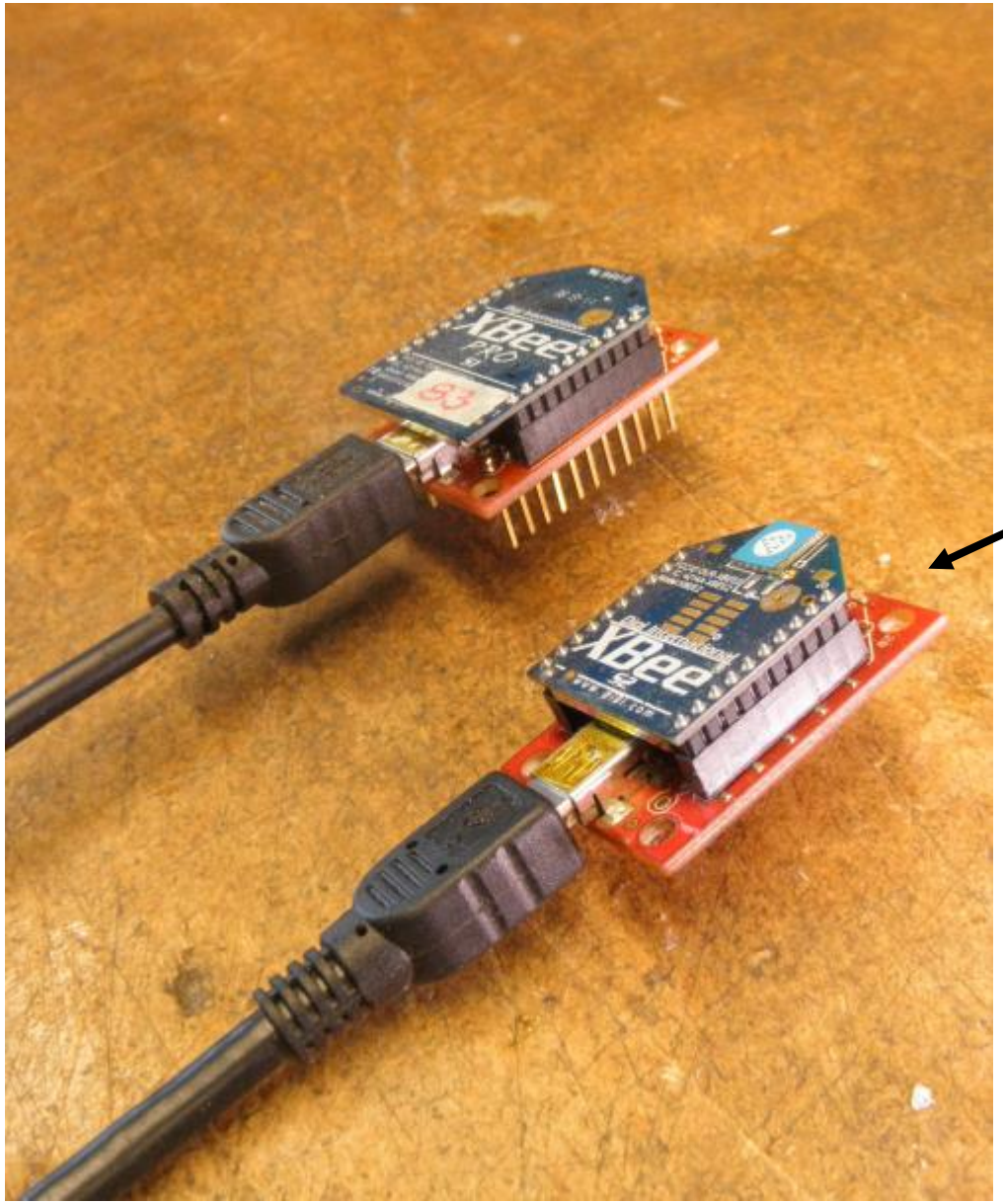
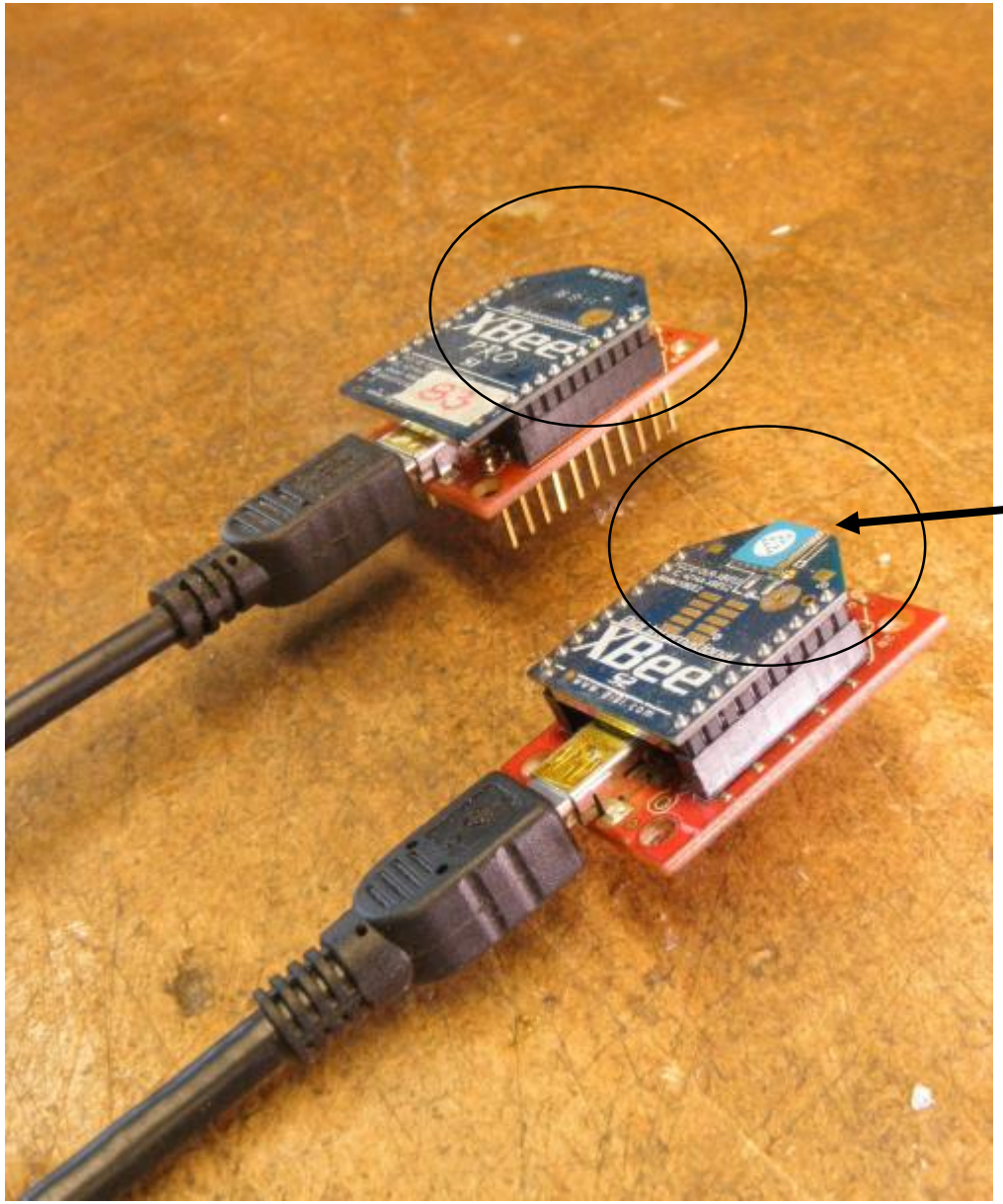
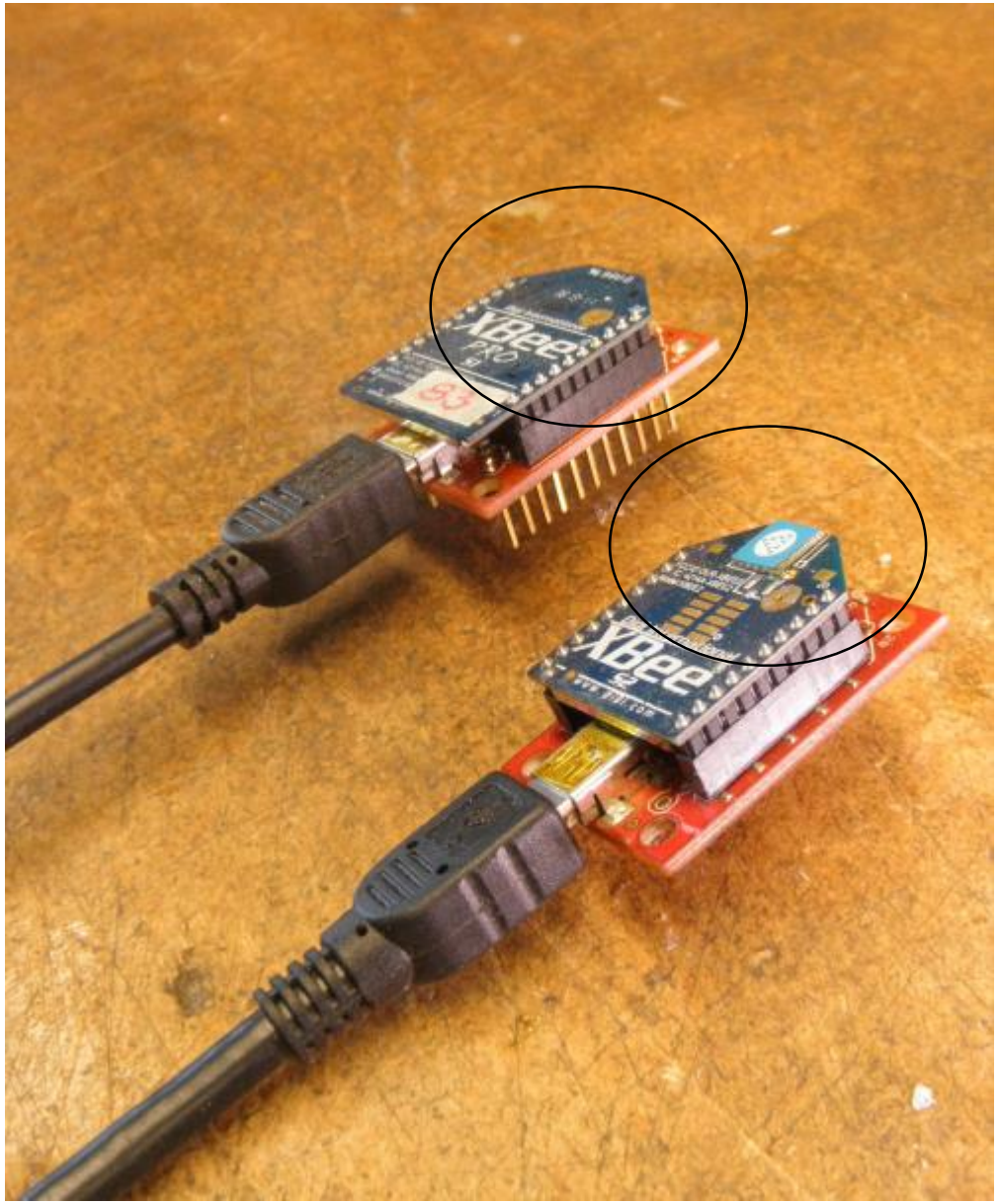


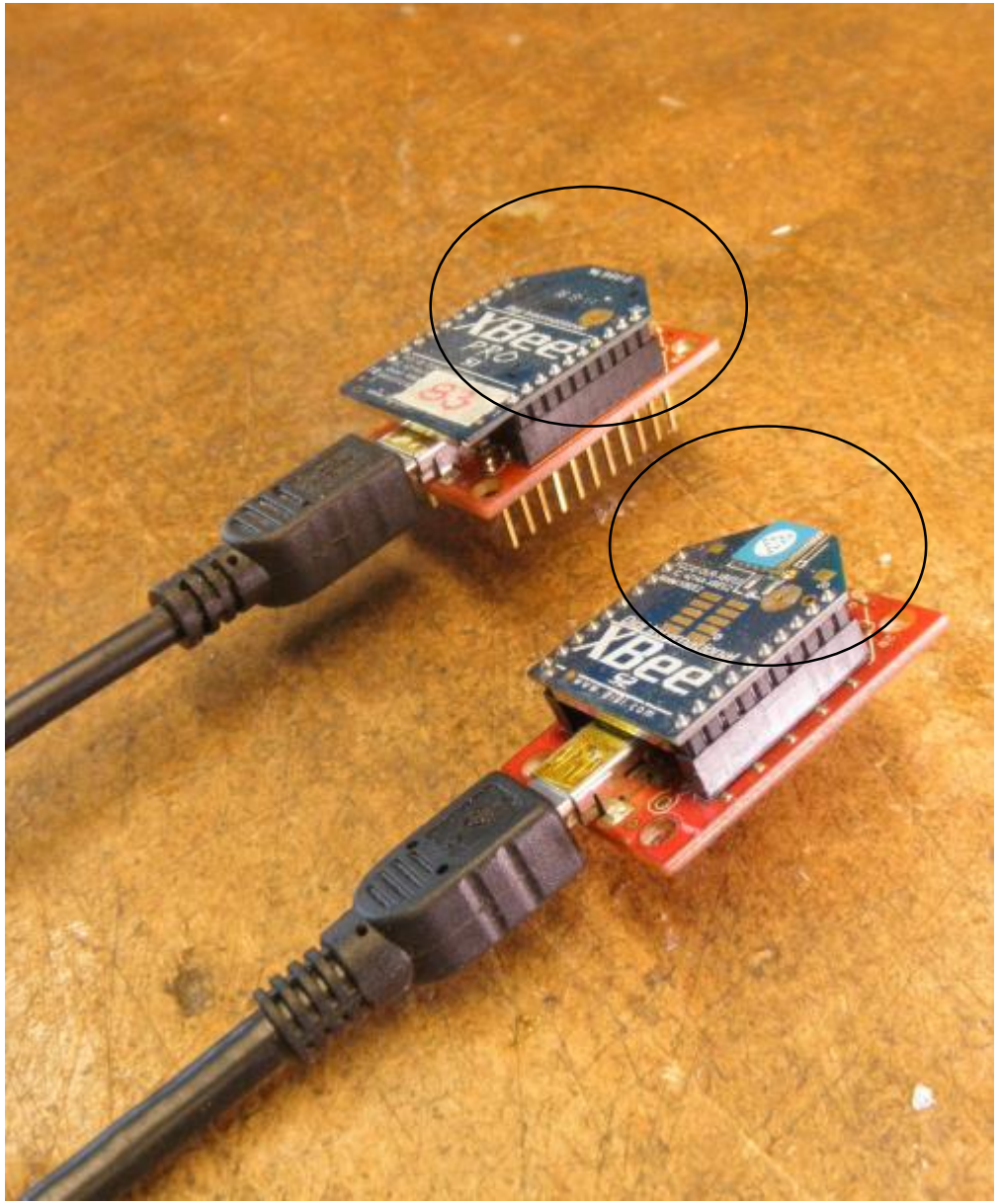
- The Explorer board with pins interfaces with proto-boards and/or USB
- This one without the lower header could be for a “base station” where a laptop records the data.



- The light blue patch is a rather exotic “dielectric” antenna. It has the feature of being equally sensitive in all directions.



- The light blue patch is a rather exotic “dielectric” antenna. It has the feature of being equally sensitive in all directions.
- The other one has a conventional antenna which is part of the printed circuit.
-



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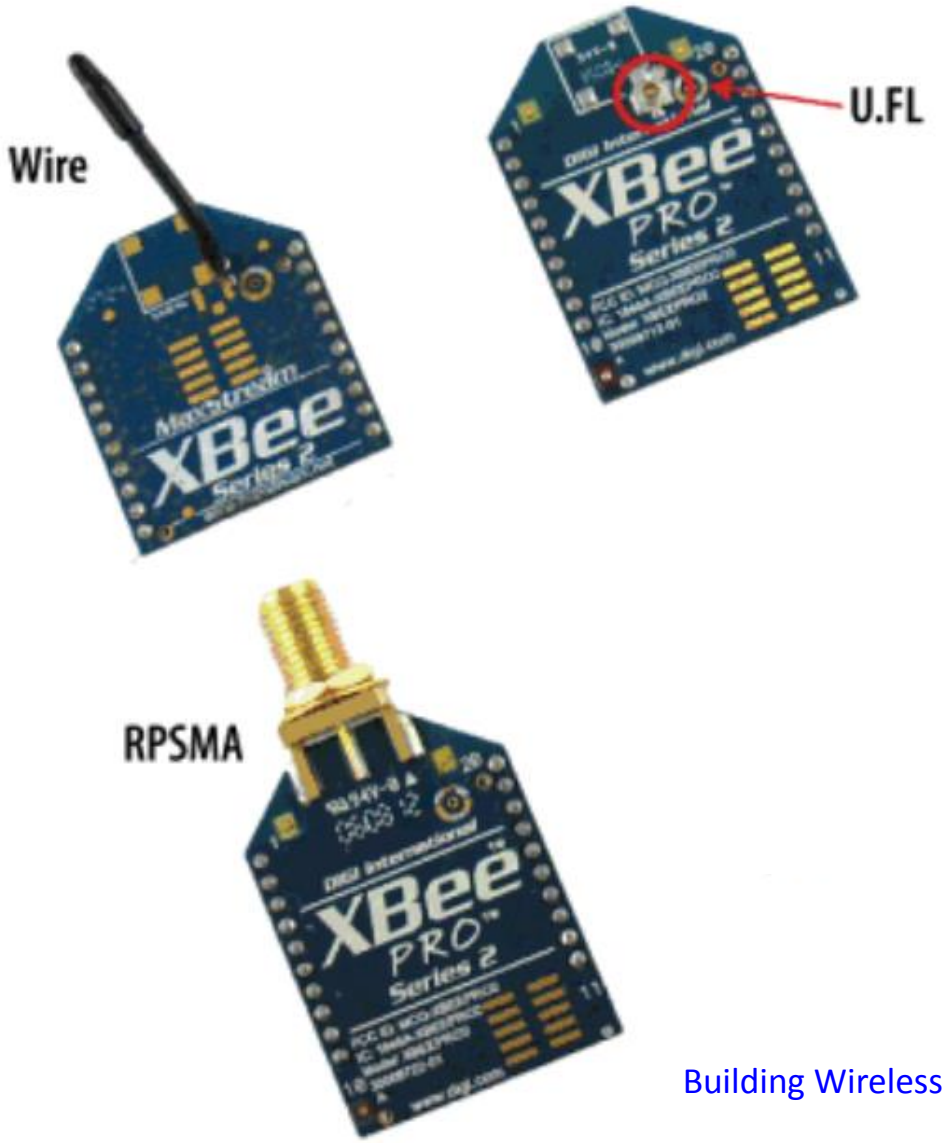

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Building Wireless Sensor Networks: with ZigBee, XBee, Arduino, and Processing By Robert Faludi

IEEE 802.15.4 Protocol

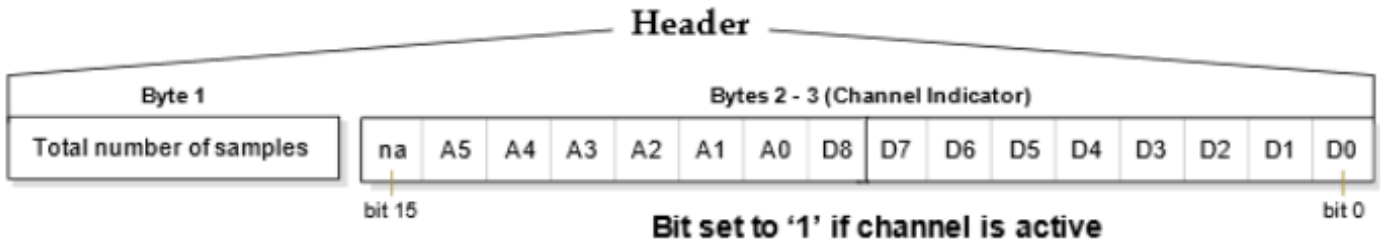
- The RF part is called the Physical Layer
- XBee is available in the 3 ISM bands: 2.4GHz, 915MHz, (866 MHz Europe)
- 16 RF channels to choose from in 2.4GHz; 5MHz apart, 2MHz bandwidth
  - direct-sequence spread spectrum coding allowing simultaneous use of channels
- binary phase-shift keying (BPSK) is used in the 868 and 915 MHz bands,
  - and offset quadrature phase-shift keying (O-QPSK) for 2.4 GHz.
- the raw, over-the-air data rate is 125 Kbps in the 2.4 GHz band
  - 40 Kbps per channel in the 915 MHz band (allows much more range)
- these rates are only with a 5% duty factor, updated 50 sec^{-1}
  - actual speed: 10 bits per analog channel and there's 7 analog channels; 7 x 10 bits x 50 = 3.5 kbps

Serial Data Format

2.2.1. I/O Data Format

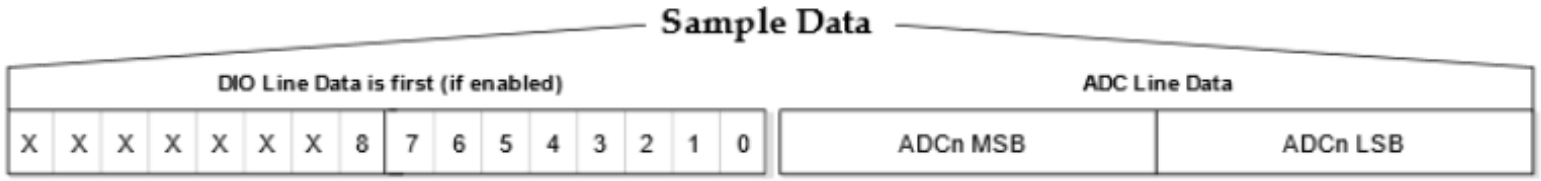
I/O data begins with a header. The first byte of the header defines the number of samples forthcoming. A sample is comprised of input data and the inputs can contain either DIO or ADC. The last 2 bytes of the header (Channel Indicator) define which inputs are active. Each bit represents either a DIO line or ADC channel.

Figure 2-04. Header



Sample data follows the header and the channel indicator frame is used to determine how to read the sample data. If any of the DIO lines are enabled, the first 2 bytes are the DIO data and the ADC data follows. ADC channel data is stored as an unsigned 10-bit value right-justified on a 16-bit boundary.

Figure 2-05. Sample Data



Serial Data Format

Format for sending data to a PC

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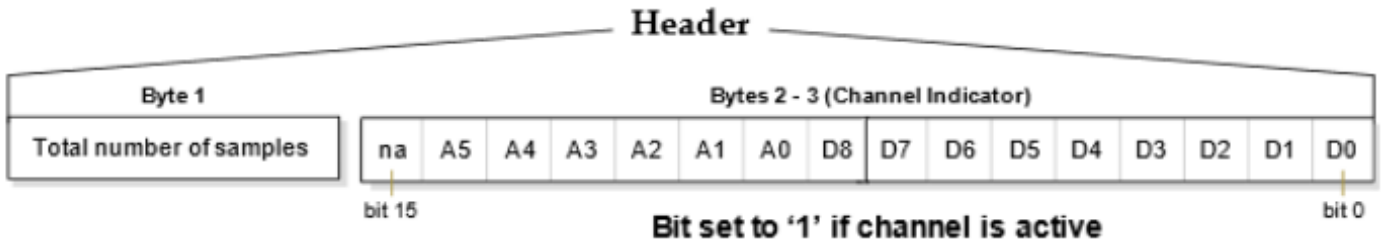

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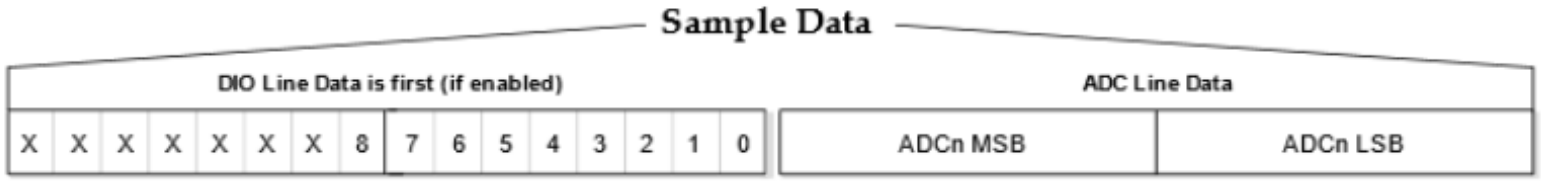

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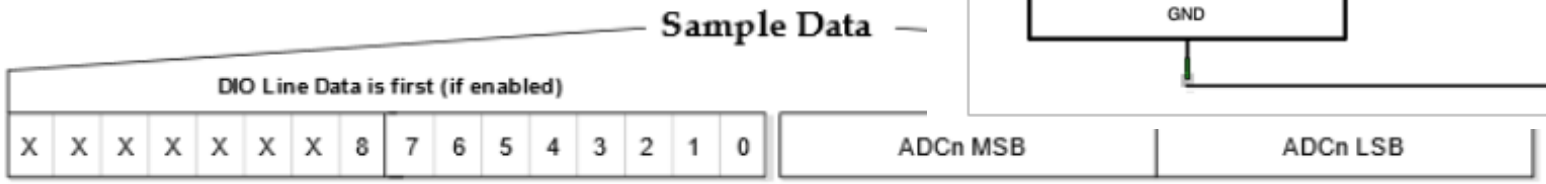

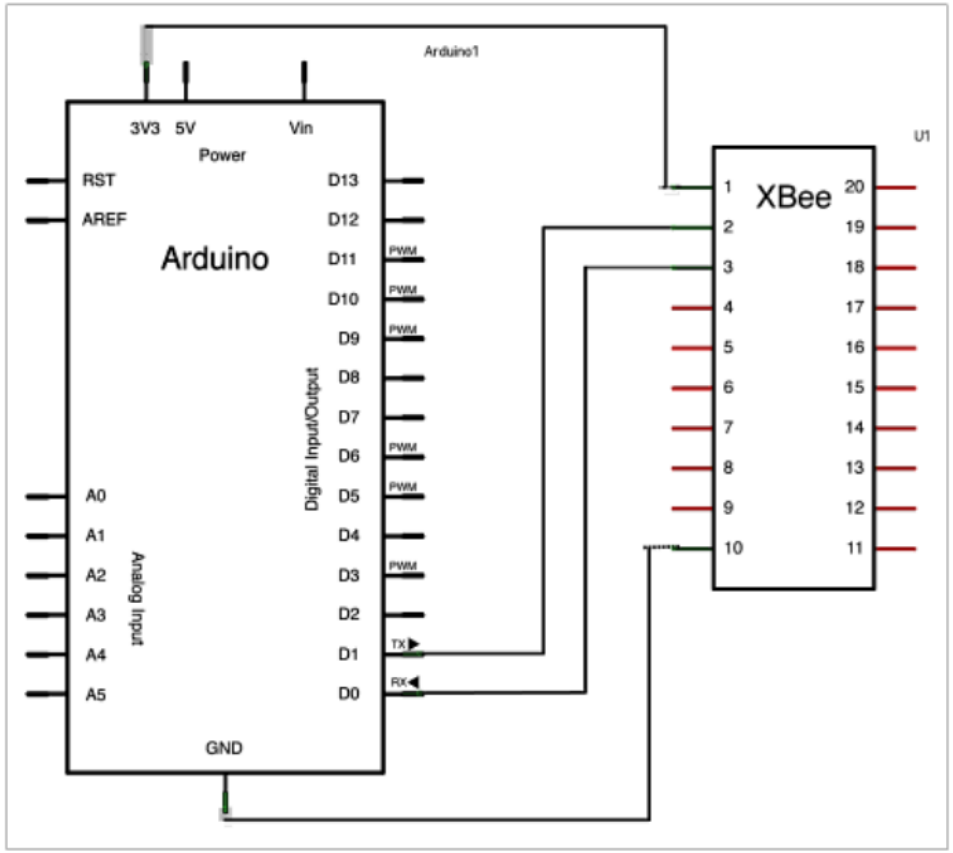

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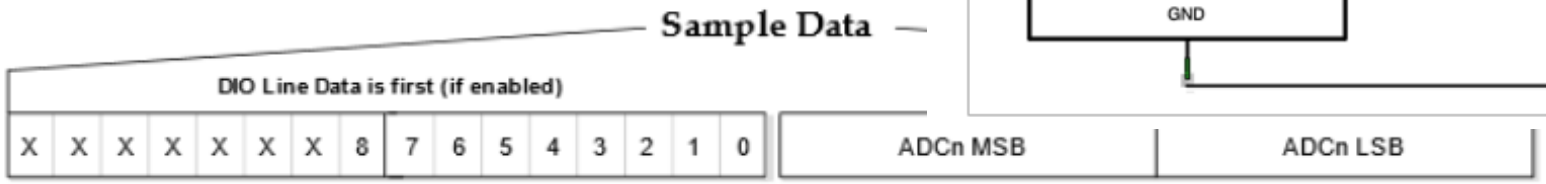

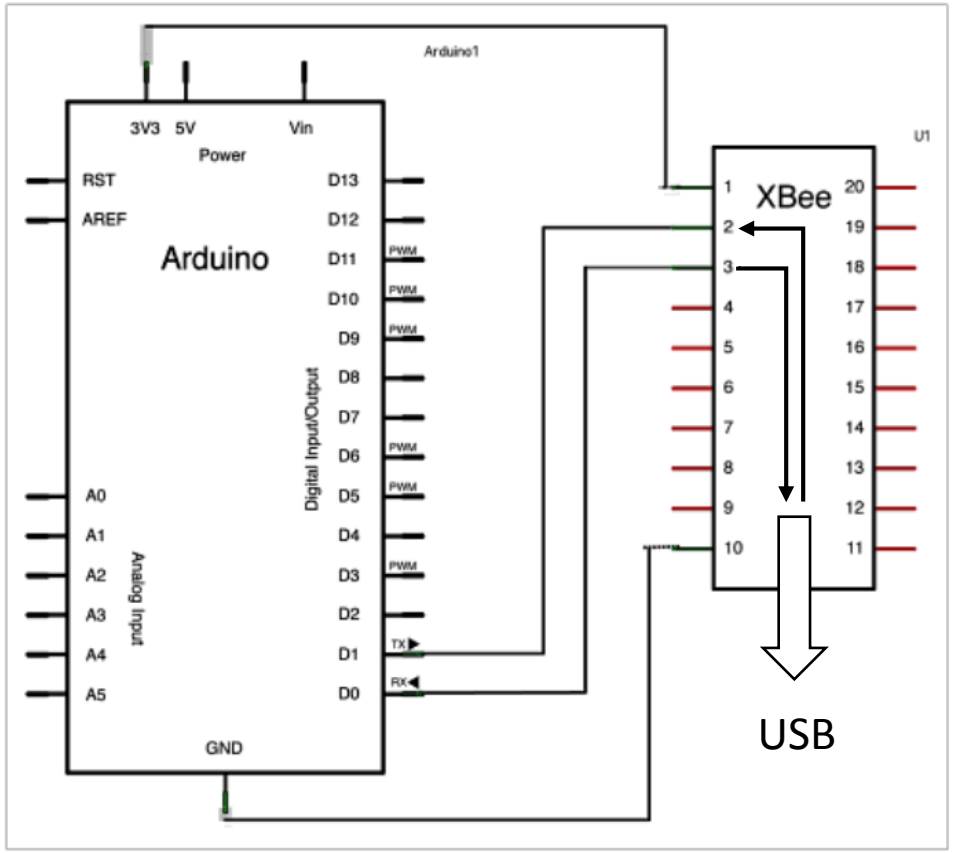

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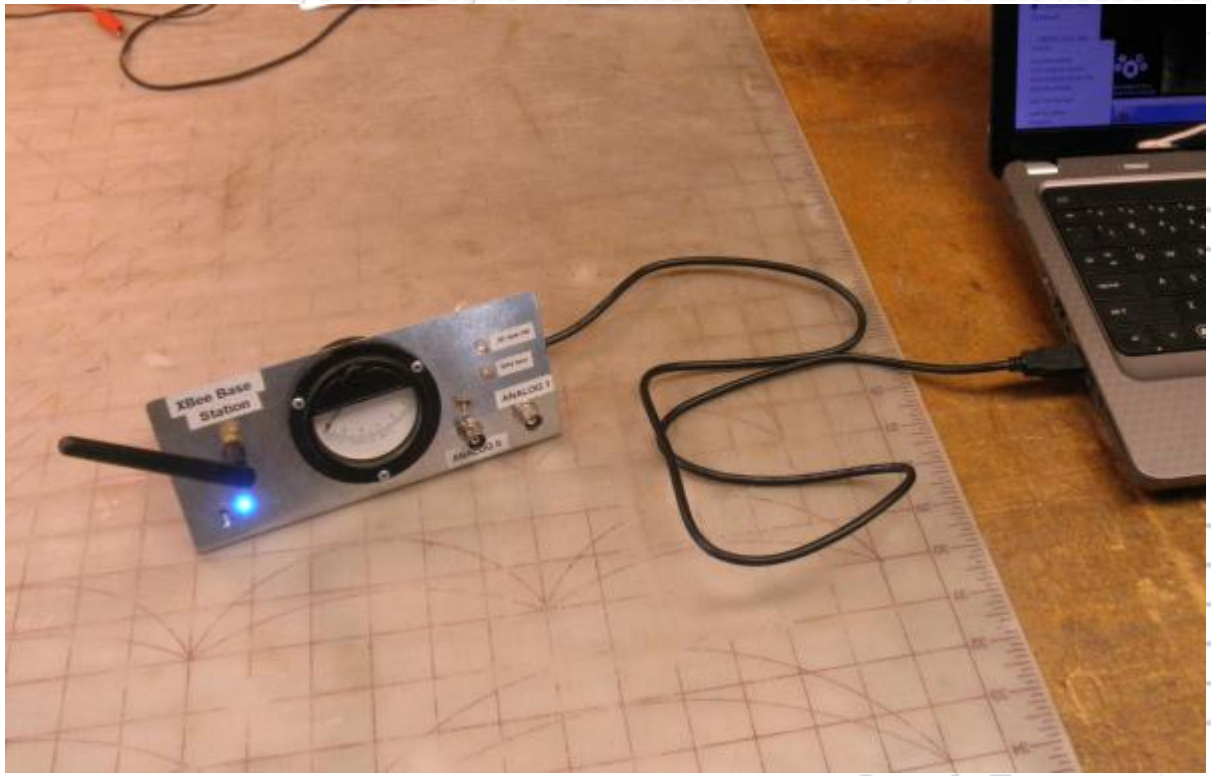
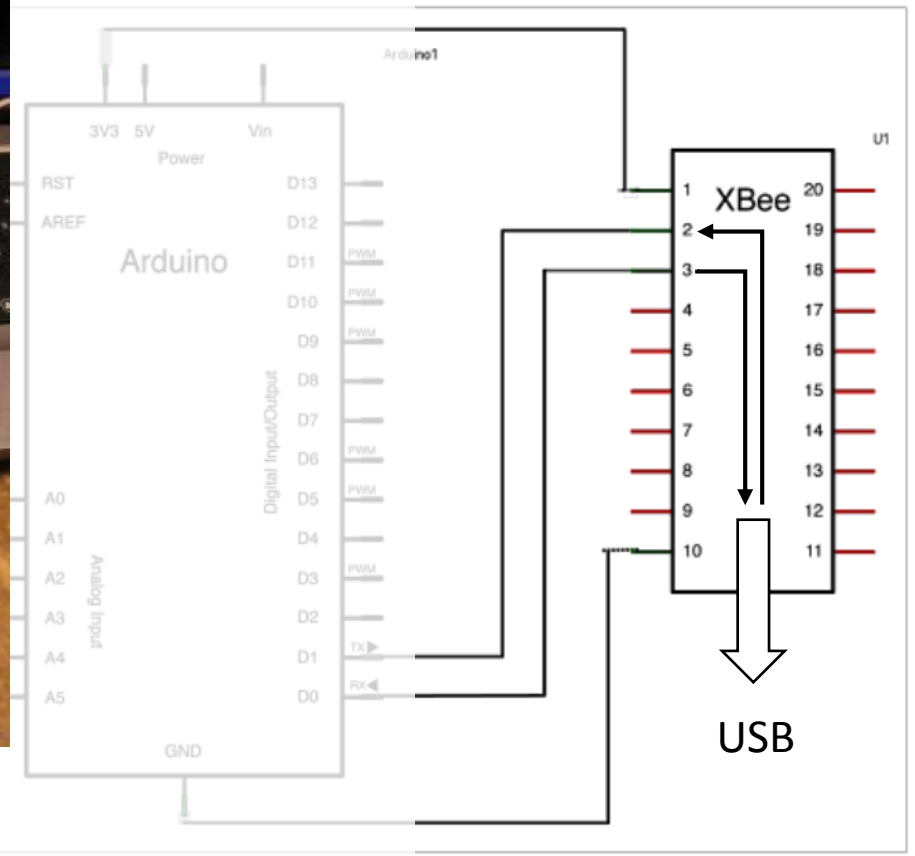




2.2.1. I/O Data Format

I/O data begins with a header. The first byte of the header defines the number of samples forth-

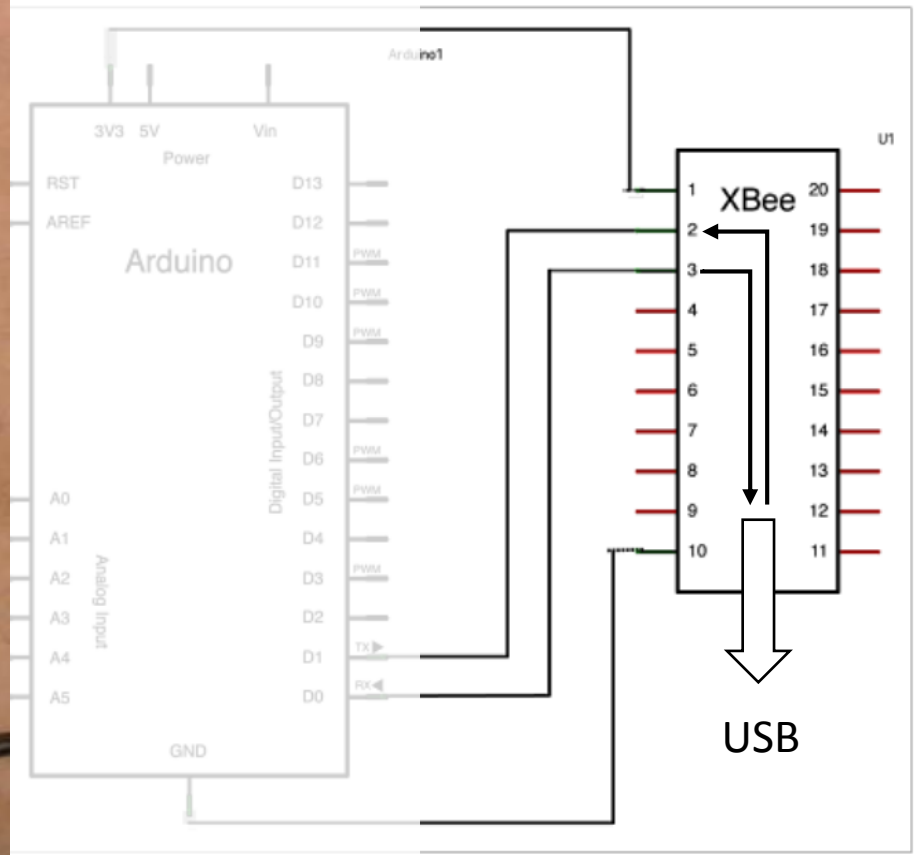
Sample Data

DIO Line Data is first (if enabled)

X	X	X	X	X	X	X	8	7	6	5	4	3	2	1	0	ADCn MSB	ADCn LSB

Serial Data Format

Format for sending data to a PC



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ADCn MSB															
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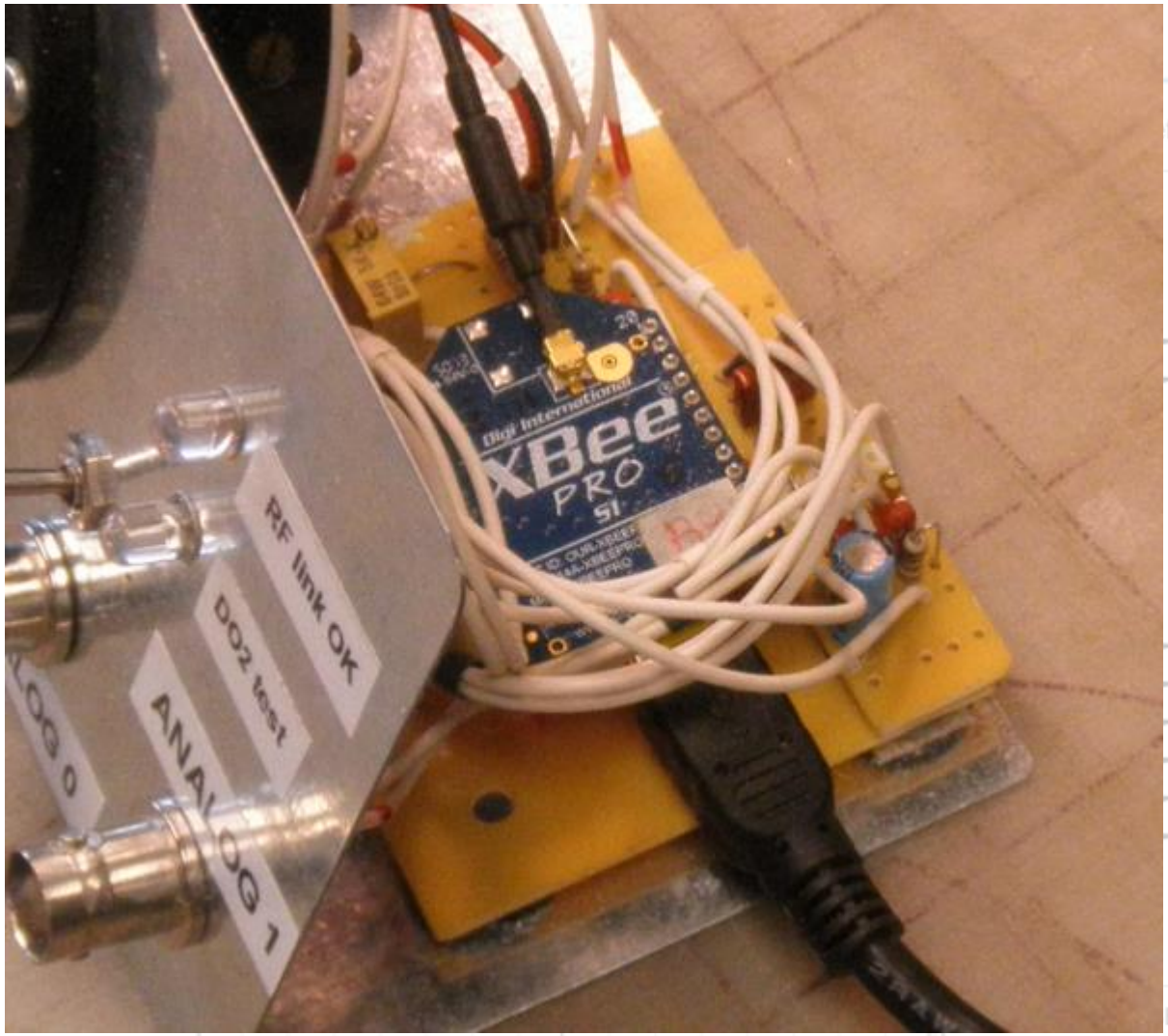
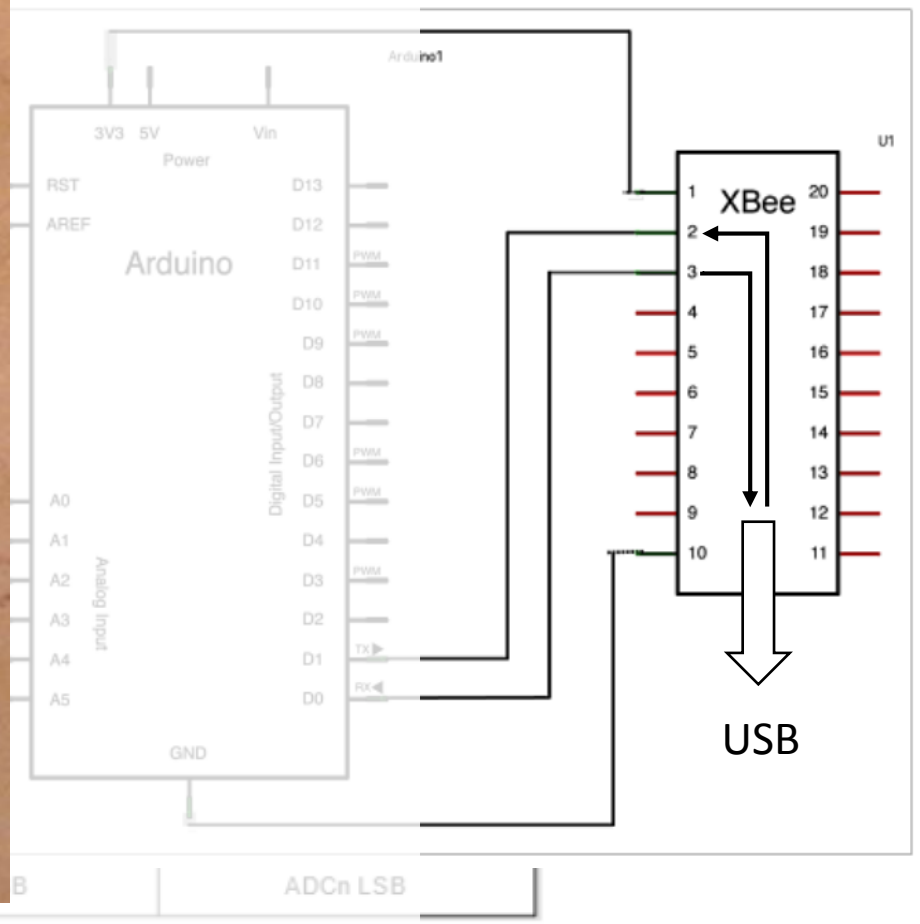
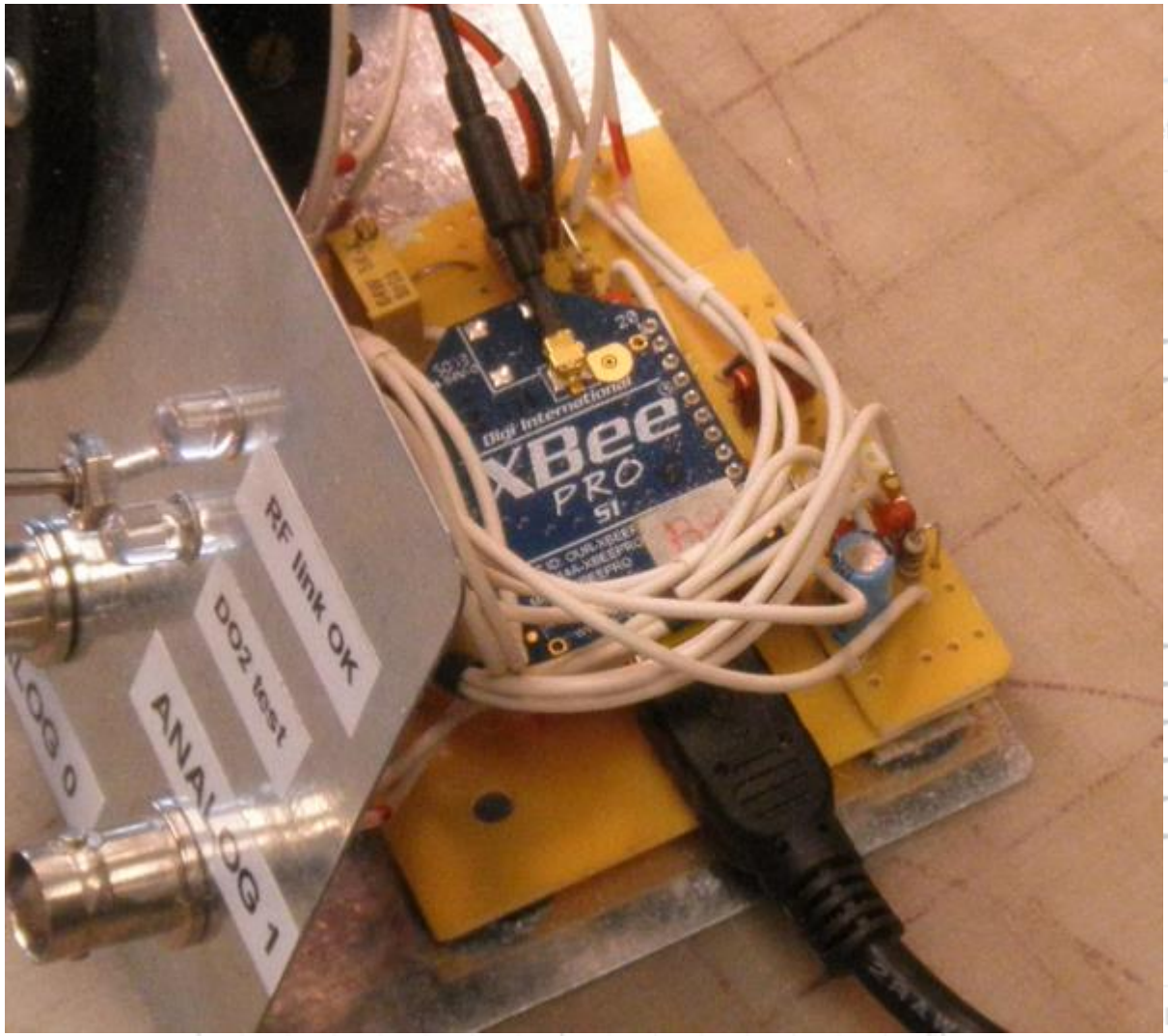
Format for sending data to a PC





Serial Data Format

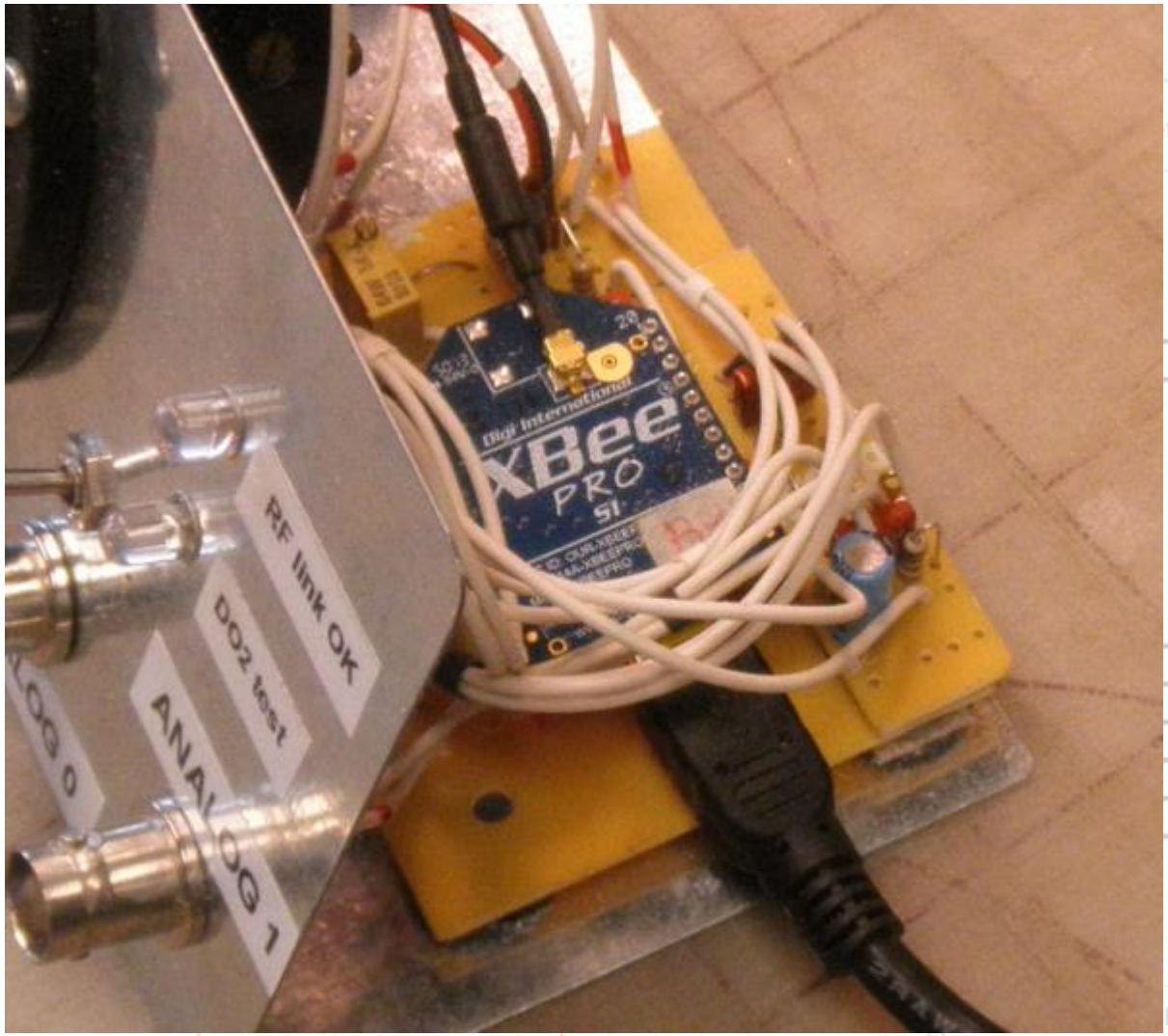
Format for sending data to a PC



I am not skilled in software enough to do this.

Serial Data Format

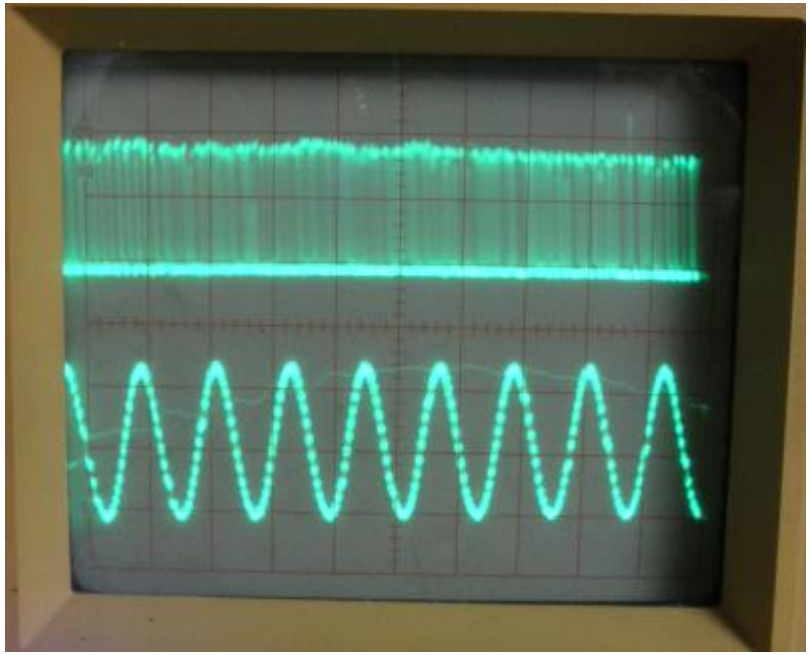
Format for sending data to a PC



I am not skilled in software enough to do this. Yet.

What a Sinewave Looks Like After Going Through the XBees.

What a Sinewave Looks Like After Going Through the XBees.



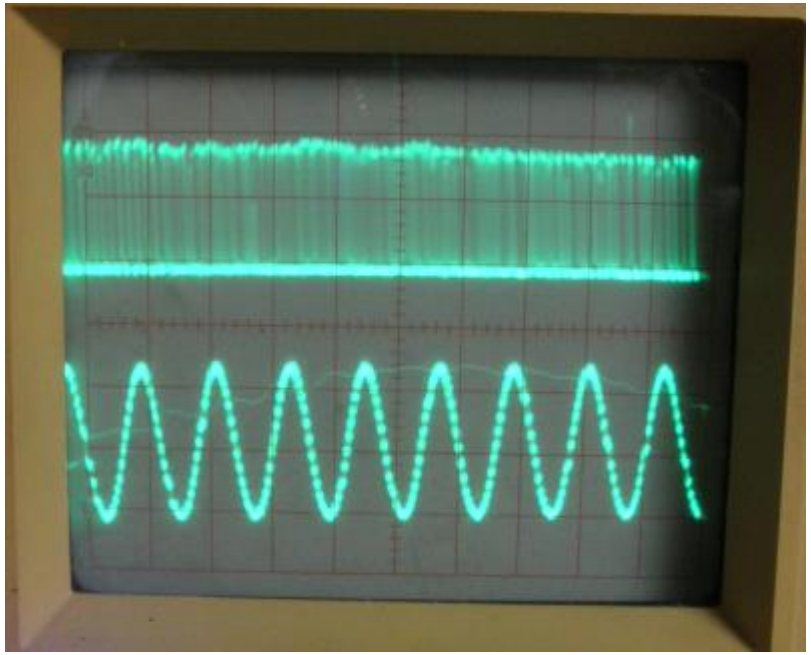
RF Pulses

Analog Output

1 sec/cm

1 Hz

What a Sinewave Looks Like After Going Through the XBees.



1 sec/cm

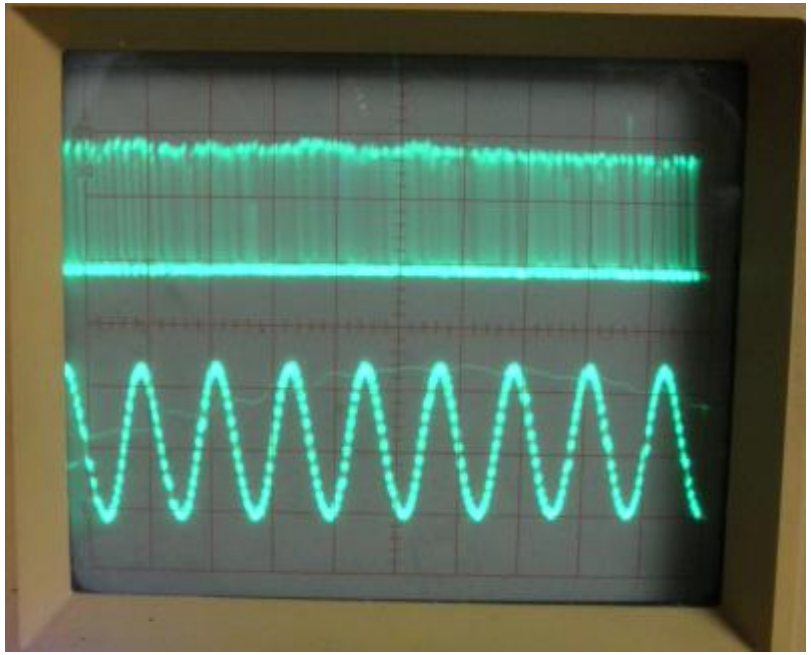
RF Pulses

Analog Output

top trace is RF output of “sending” XBee.

1 Hz

What a Sinewave Looks Like After Going Through the XBees.



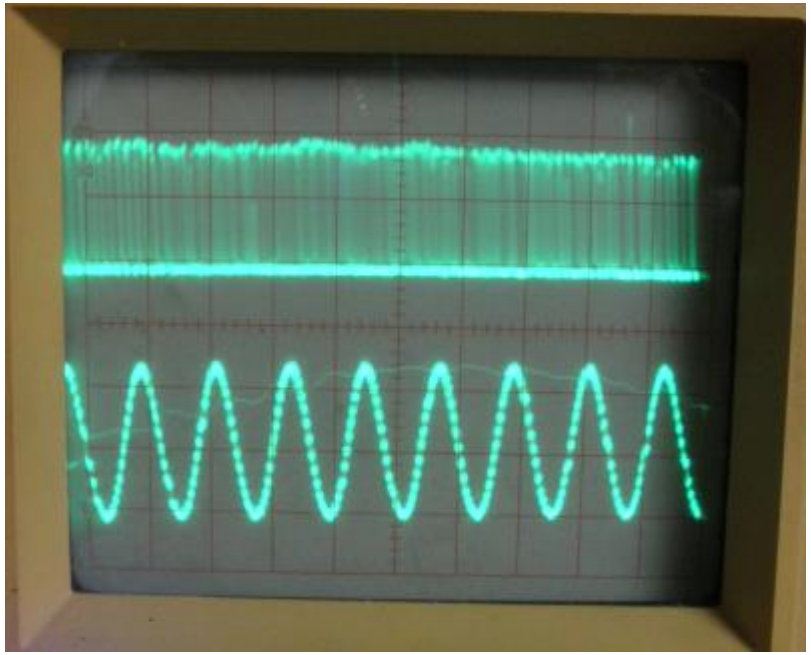
1 sec/cm

RF Pulses — top trace is RF output of “sending” XBee.

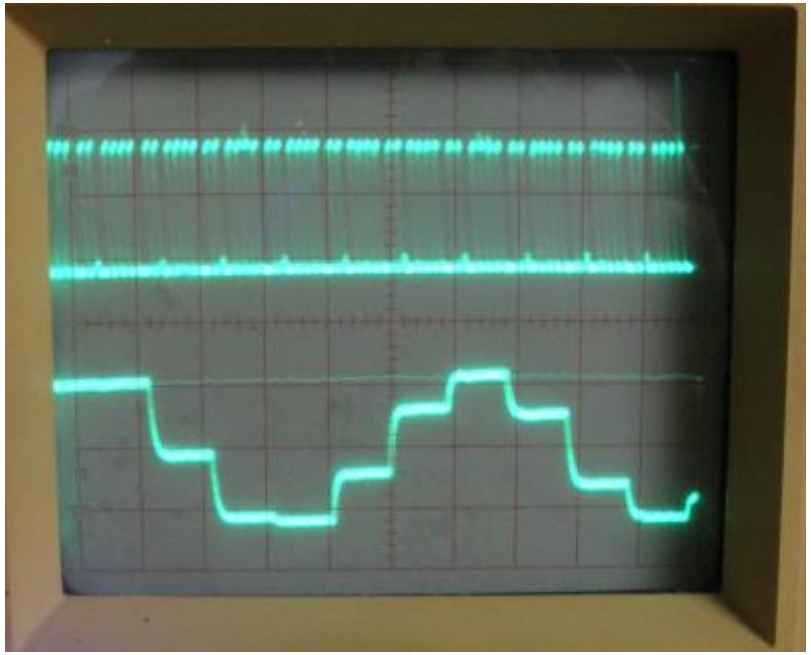
Analog Output — bottom trace is analog output of “receiving” XBee.

1 Hz

What a Sinewave Looks Like After Going Through the XBees.



1 sec/cm

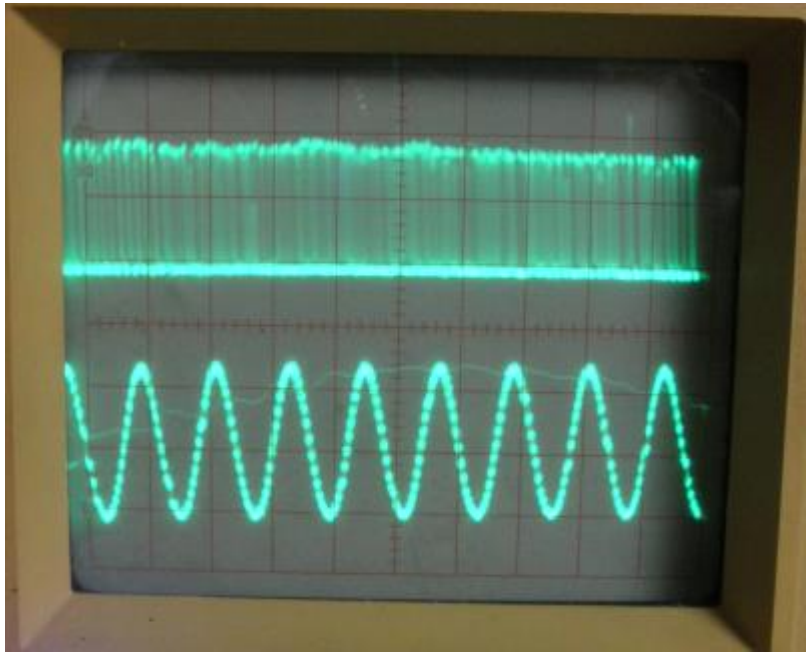


20 ms/cm

1 Hz

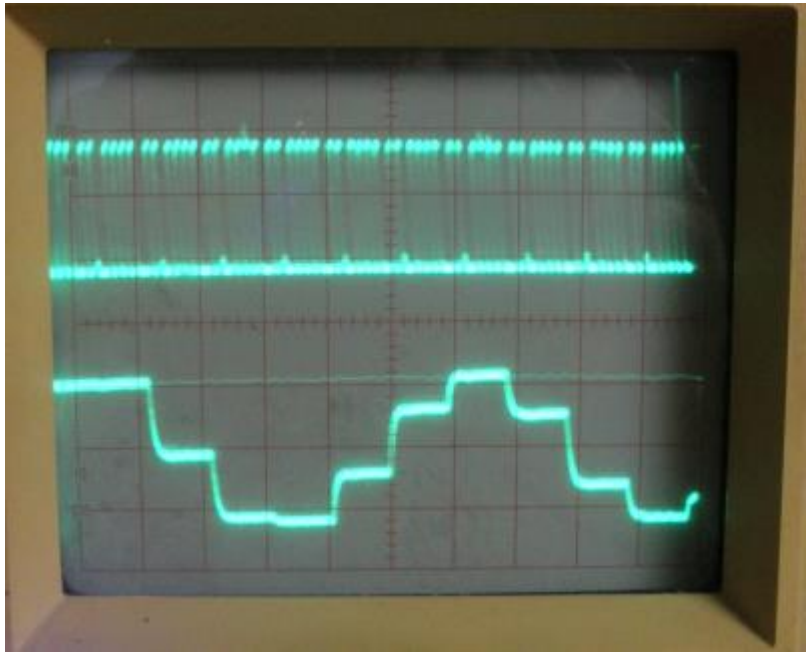
7 Hz

What a Sinewave Looks Like After Going Through the XBees.



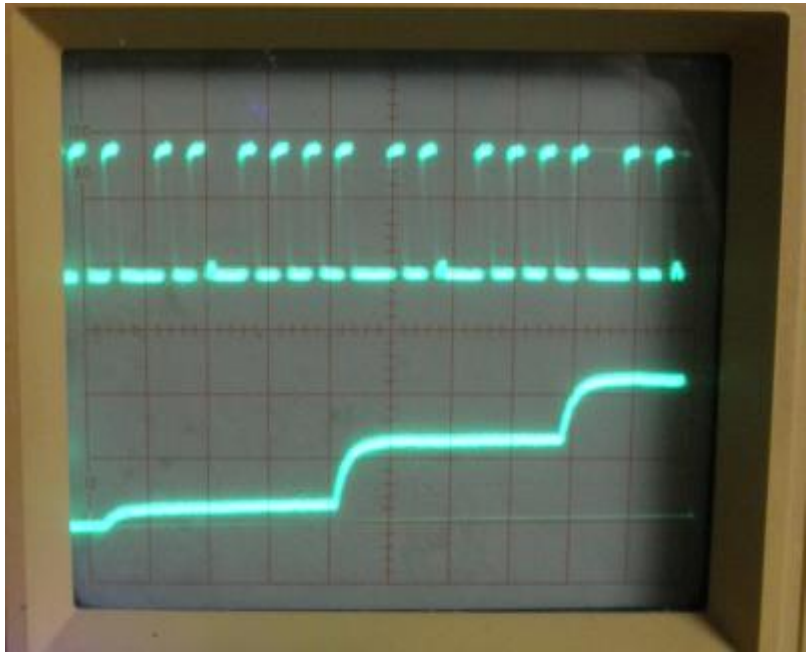
1 sec/cm

1 Hz



20 ms/cm

7 Hz



5 ms/cm

7 Hz

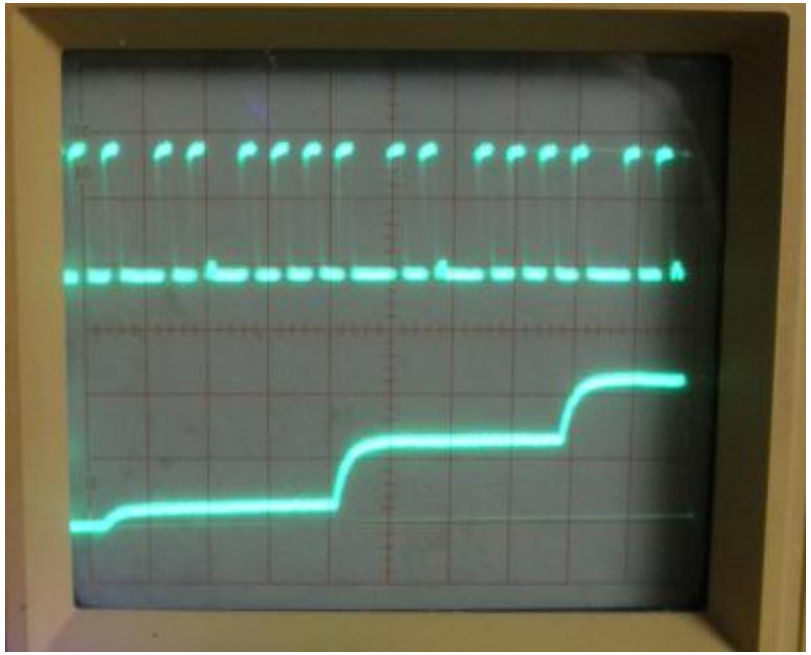
What a Sinewave Looks Like After Going Through the XBees.

1 sec/cm

1 Hz

20 ms/cm

7 Hz



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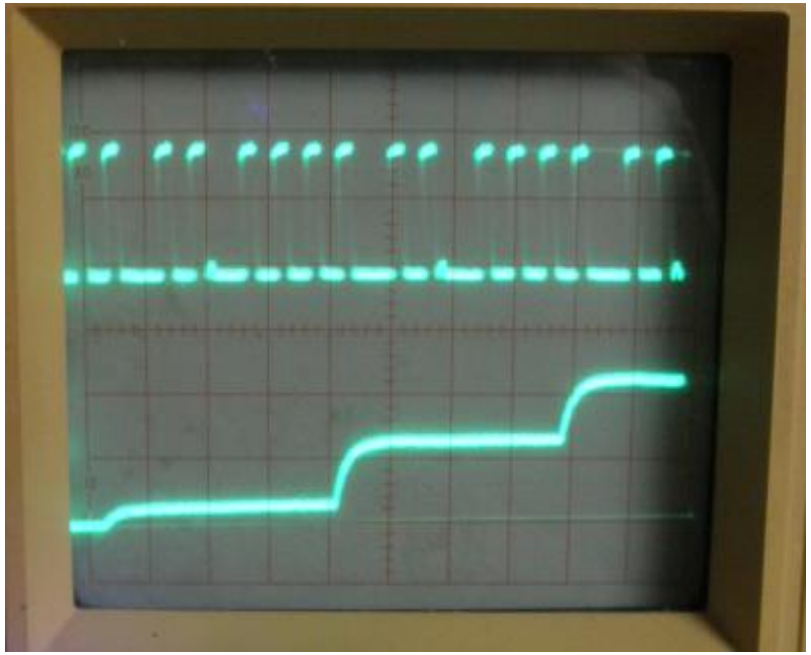
1 sec/cm

1 Hz

20 ms/cm

7 Hz



5 ms/cm

The RF output is a group of pulses.

7 Hz

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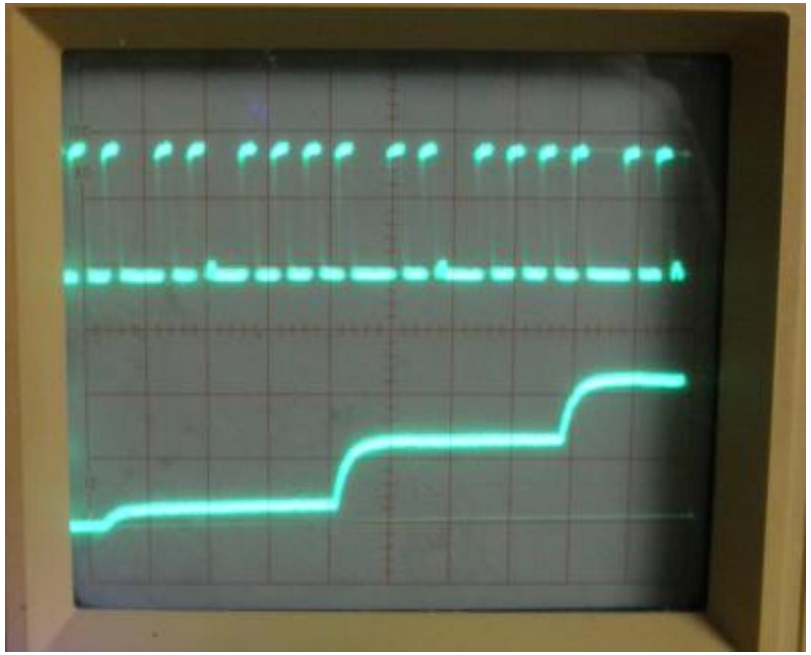

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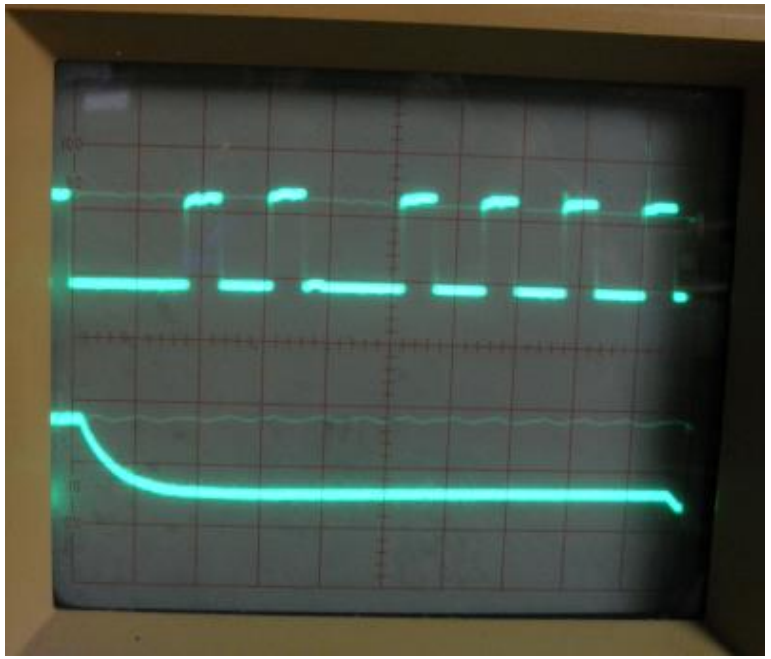
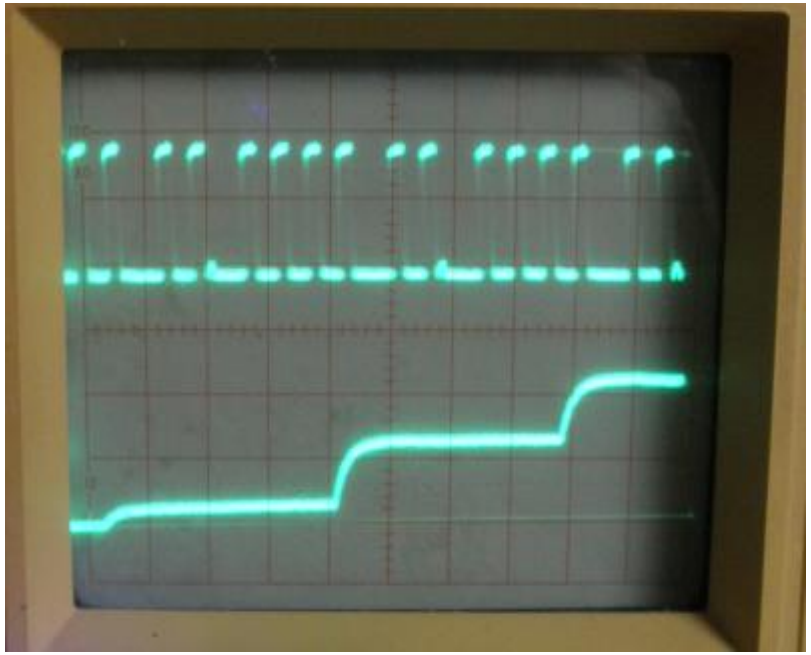


2 ms/cm

shows a complete XBee cycle

7 Hz



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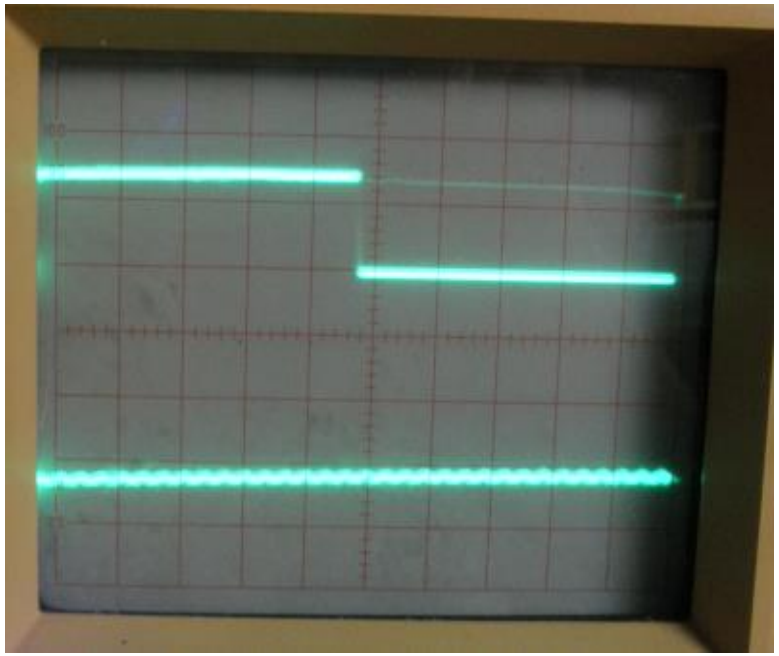
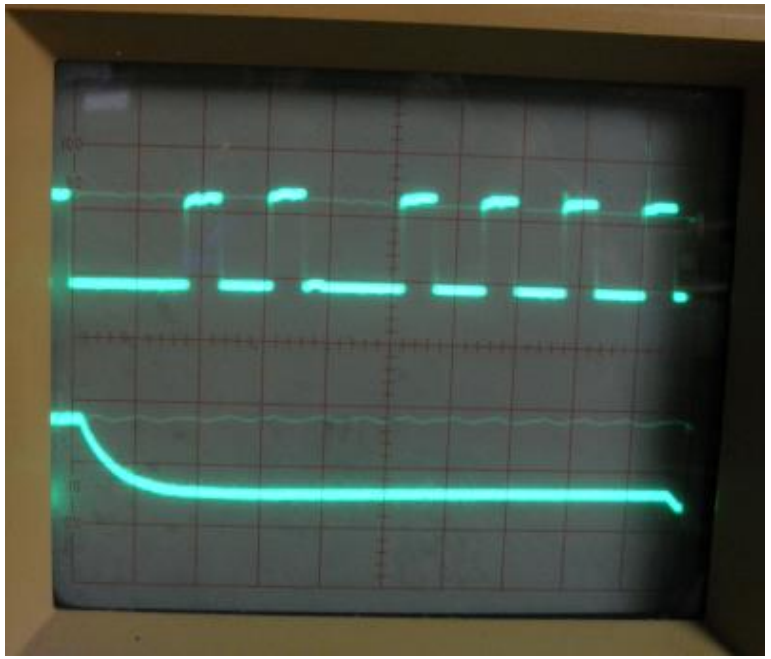


0.2 ms/cm

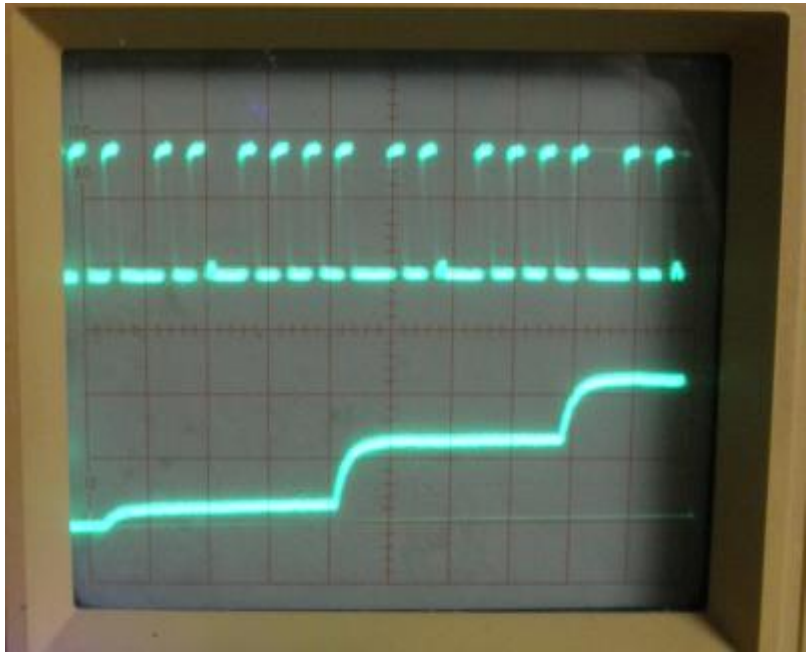
7 Hz



2 ms/cm

shows a complete XBee cycle

7 Hz



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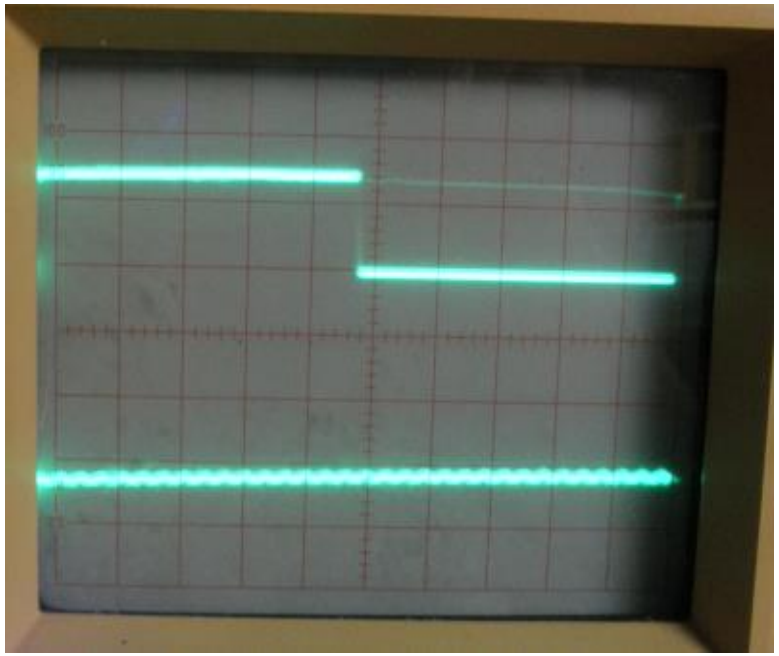
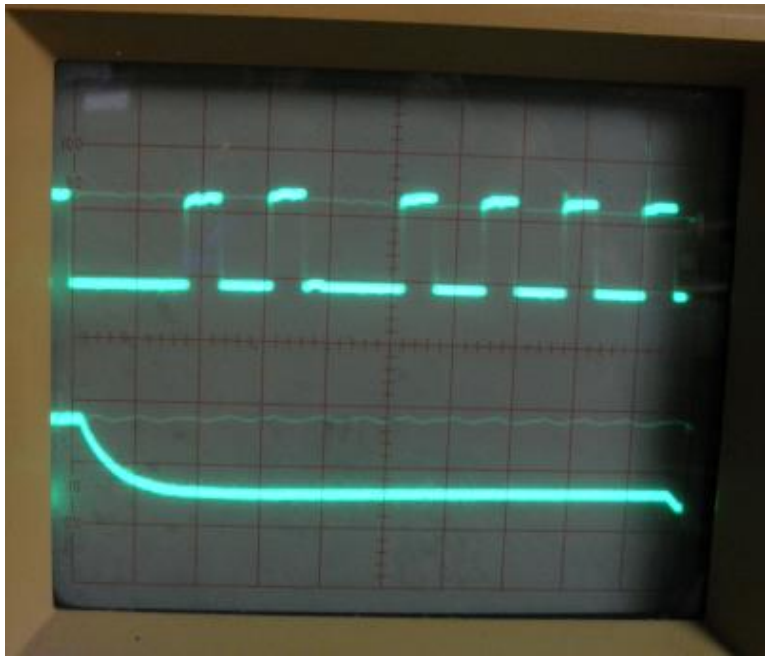


0.2 ms/cm

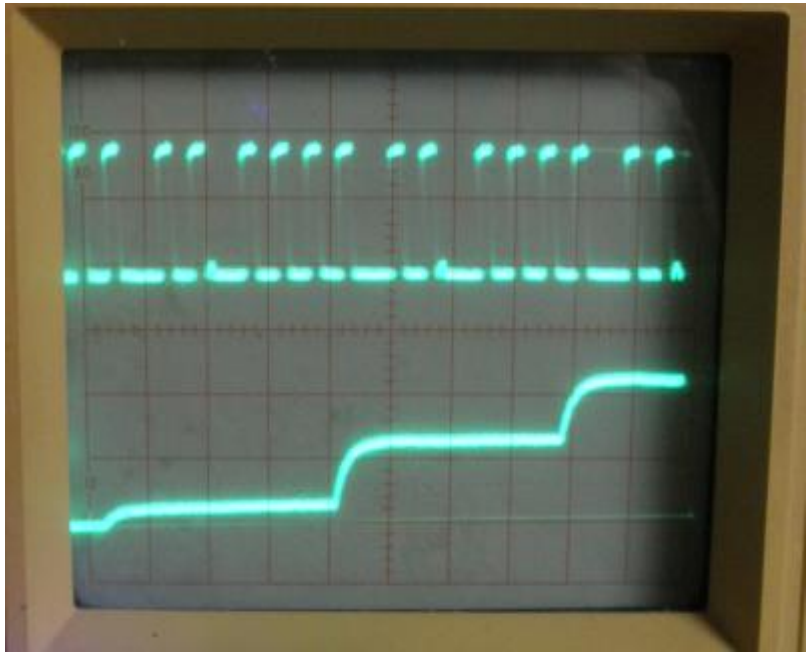
7 Hz



2 ms/cm

shows a complete XBee cycle

7 Hz



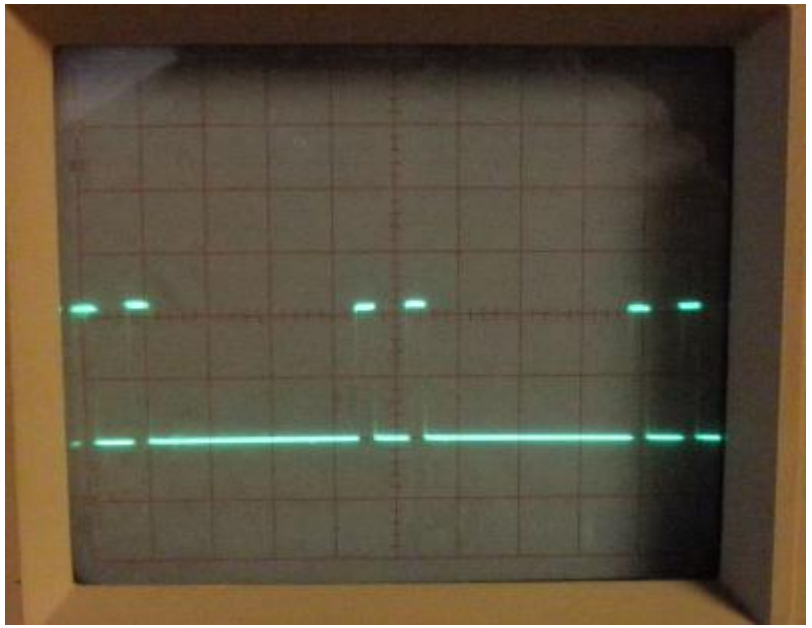
5 ms/cm

The RF output is a group of pulses.

7 Hz

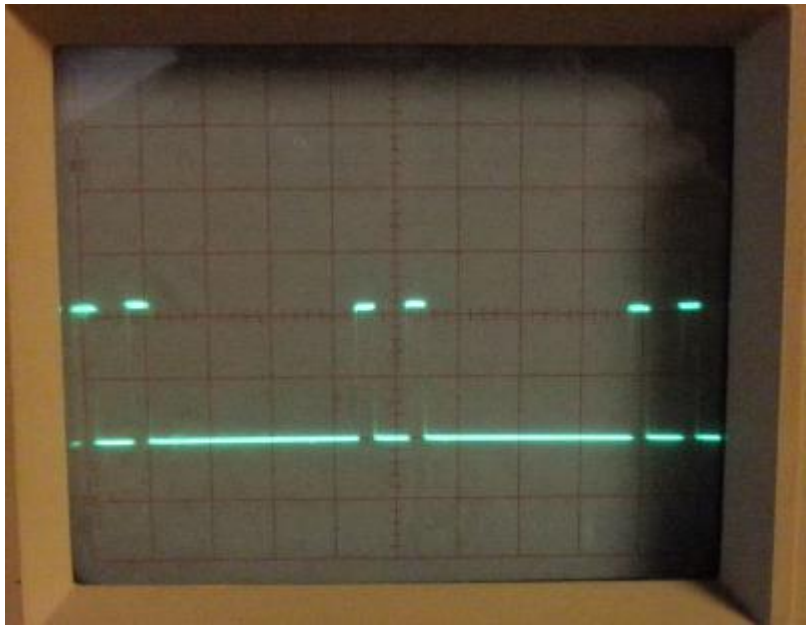
Faster time base reveals no detail within the RF pulses.

DSM2 (Model Airplane Radio Control)

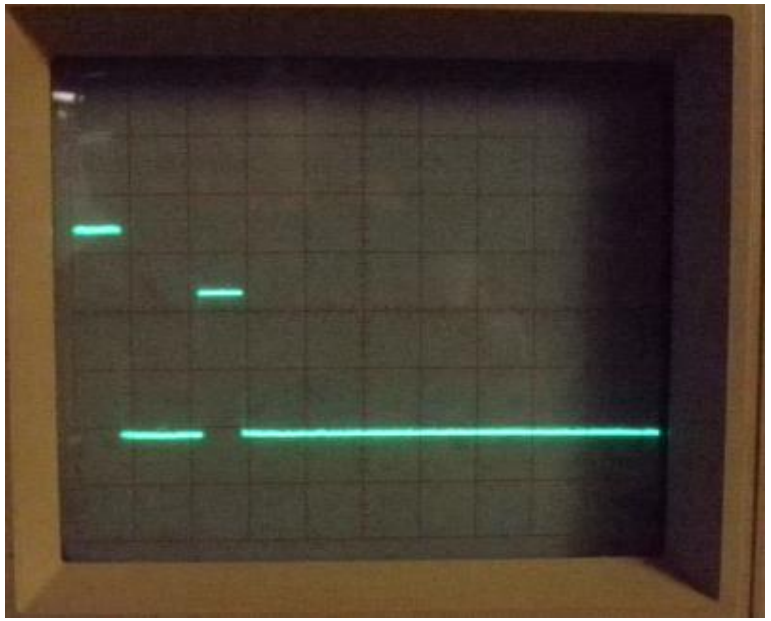


5 ms/cm

DSM2 (Model Airplane Radio Control)

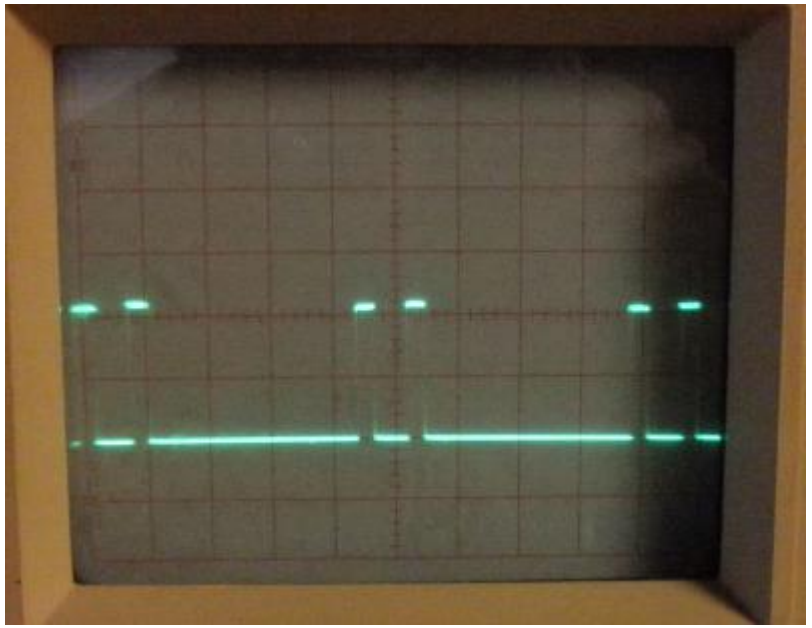


5 ms/cm

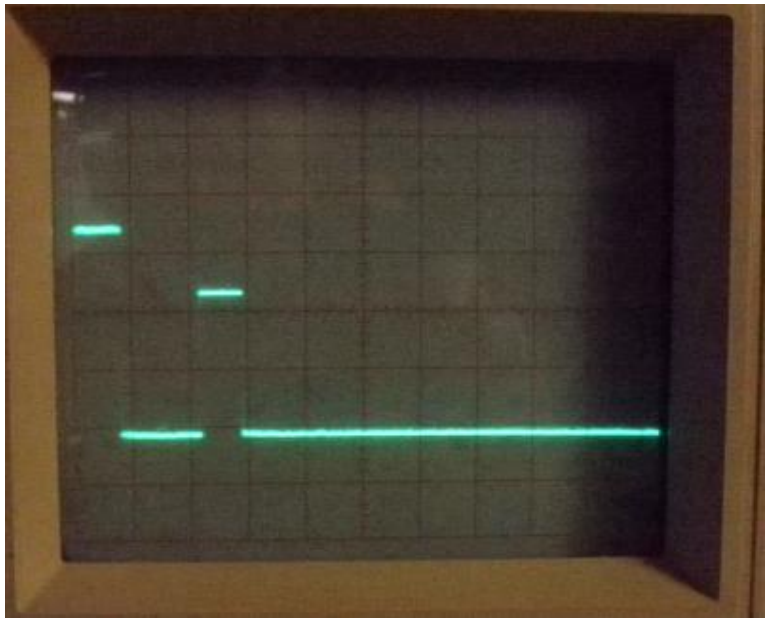


2 ms/cm

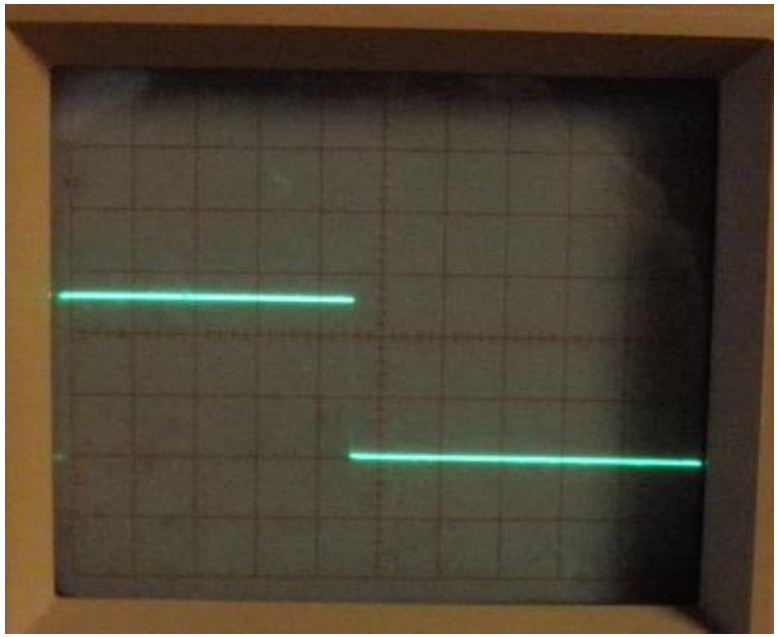
DSM2 (Model Airplane Radio Control)



5 ms/cm

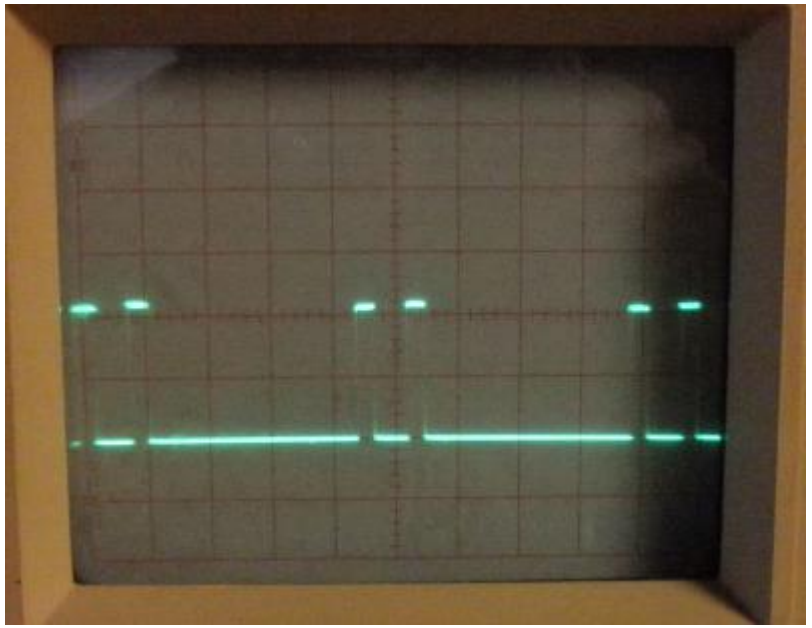


2 ms/cm

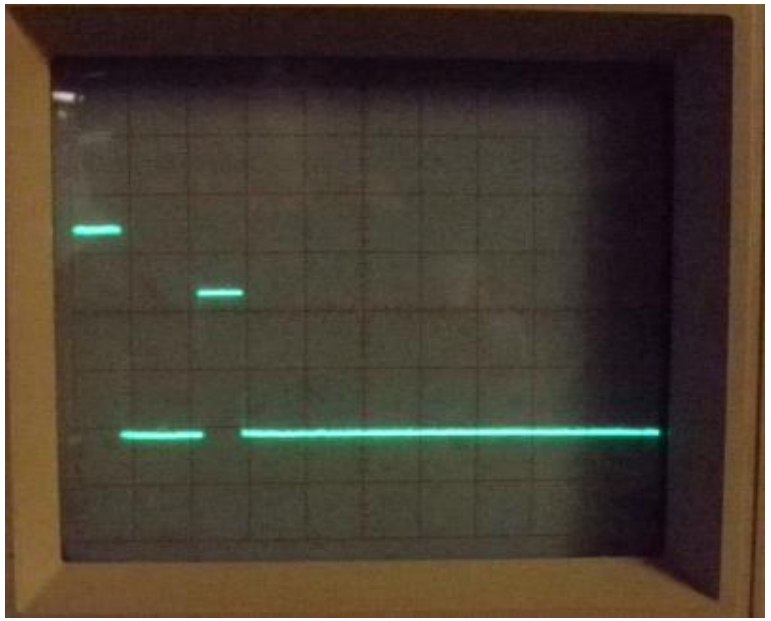


.2 ms/cm

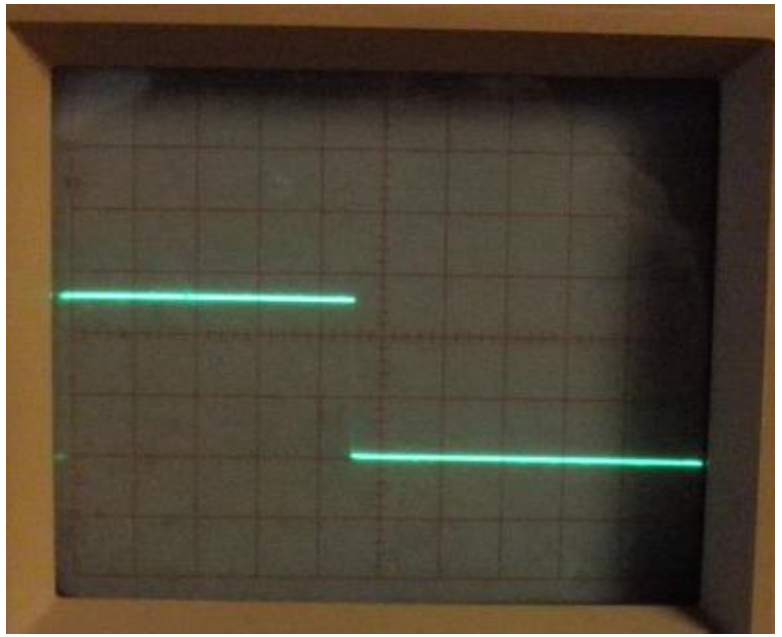
DSM2 (Model Airplane Radio Control)



5 ms/cm



2 ms/cm



.2 ms/cm

Again, no detail can be seen within each RF pulse.

Belkin Wireless Router: 802.11 2.4 GHz 300 Mbps

compared to XBee's .125 Mbps

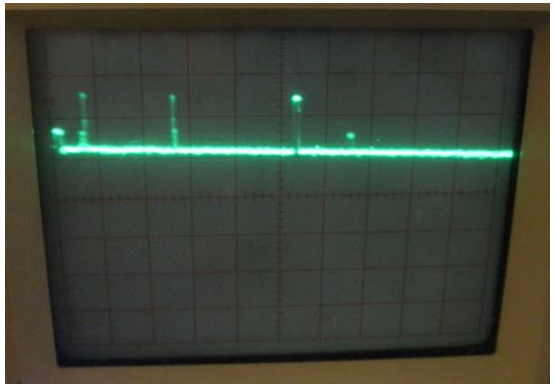
Belkin Wireless Router: 802.11 2.4 GHz 300 Mbps

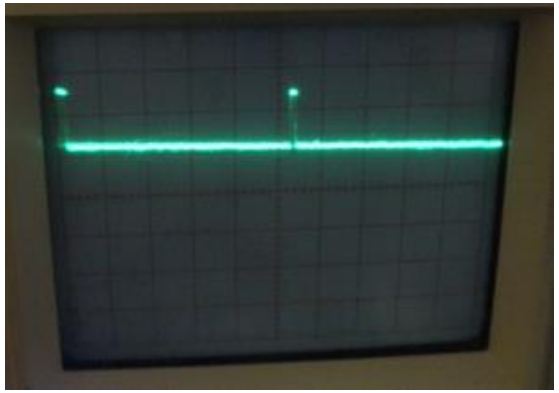
compared to XBee's .125 Mbps

music

nothing

20msec/cm



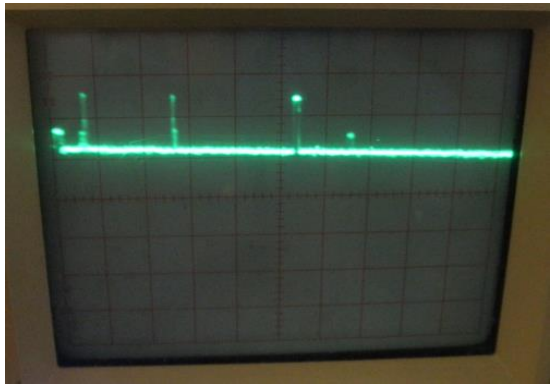


Belkin Wireless Router: 802.11 2.4 GHz 300 Mbps

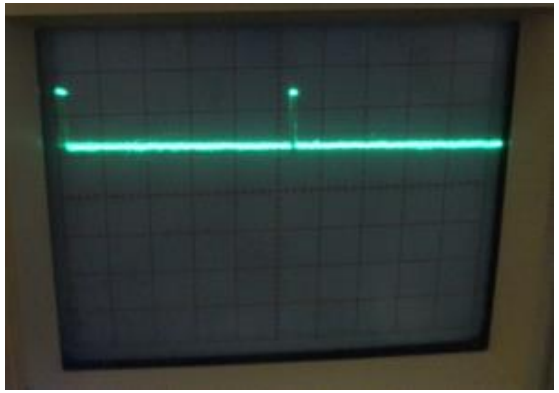
compared to XBee's .125 Mbps

20msec/cm

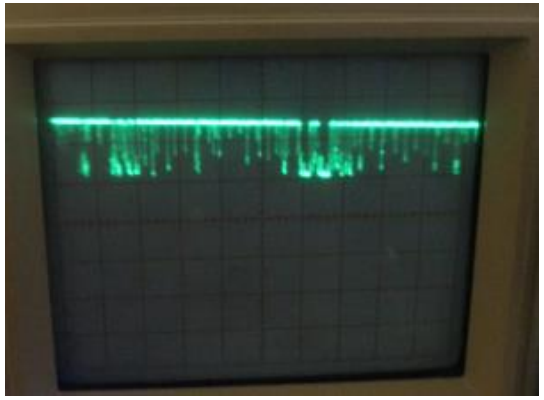
music



nothing

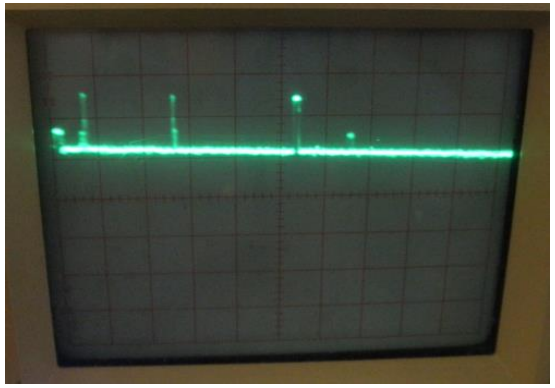
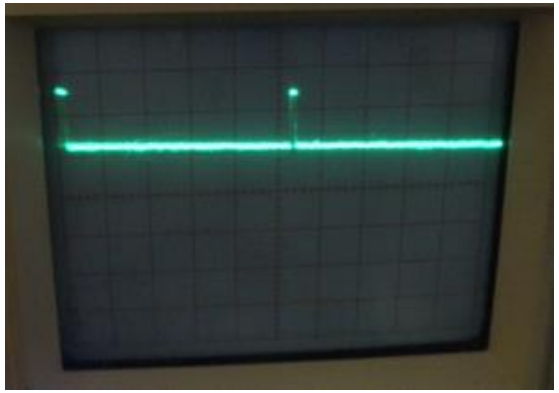
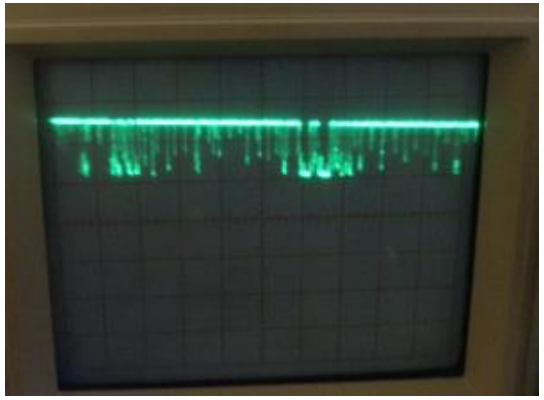
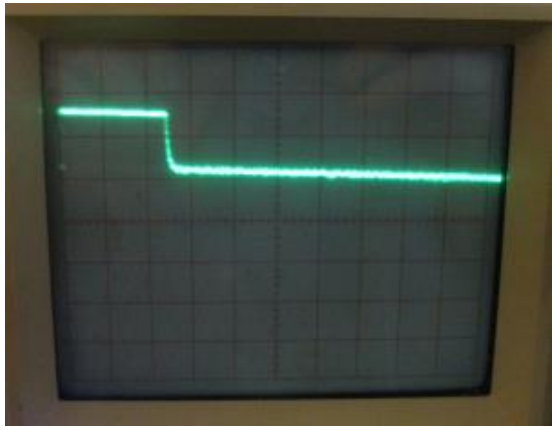
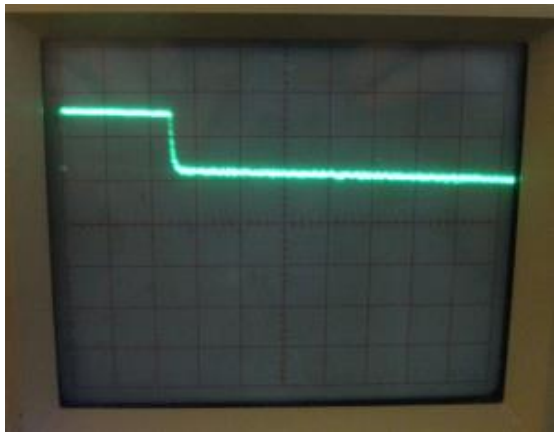
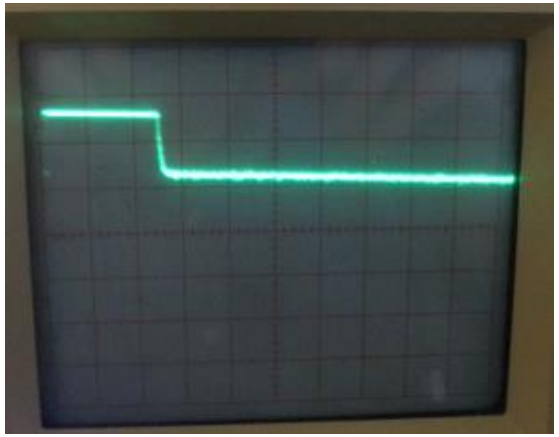


video



Belkin Wireless Router: 802.11 2.4 GHz 300 Mbps

compared to XBee's .125 Mbps

	music	**nothing**	**video**
20msec/cm			
100µsec/cm			

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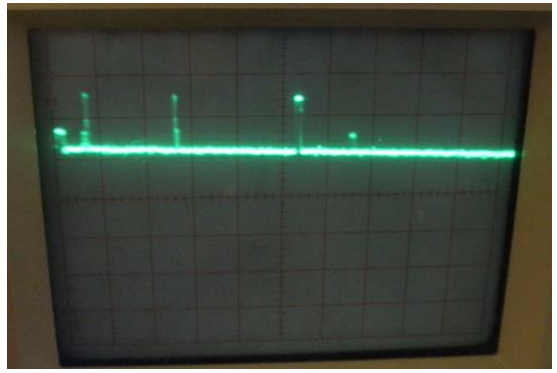
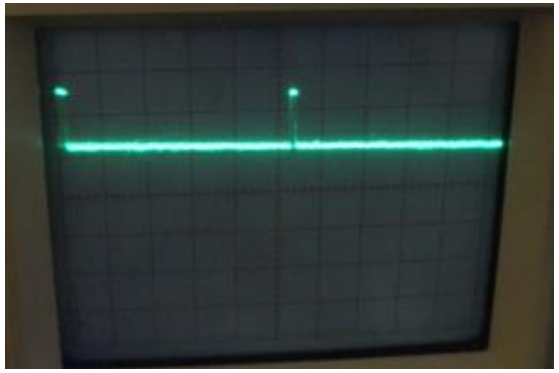
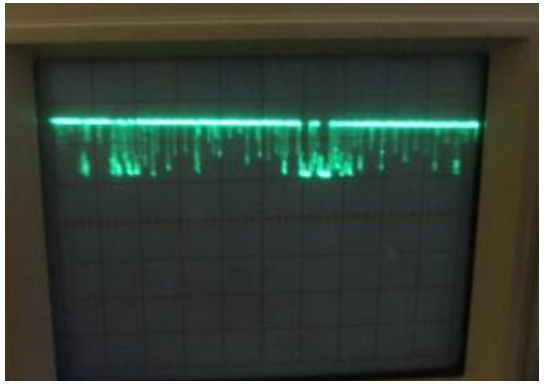
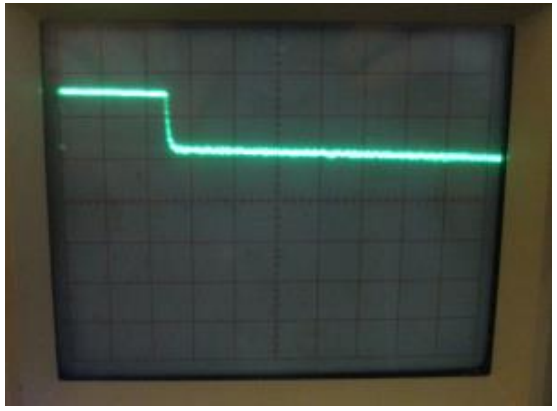
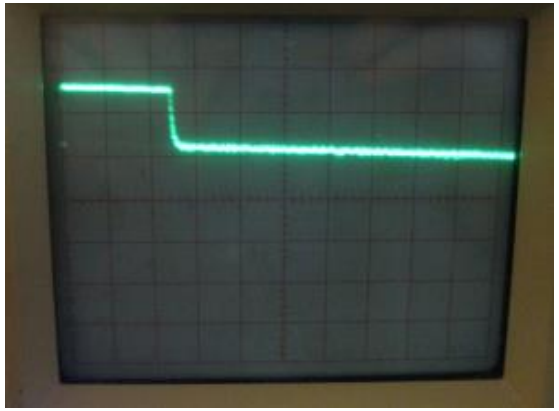
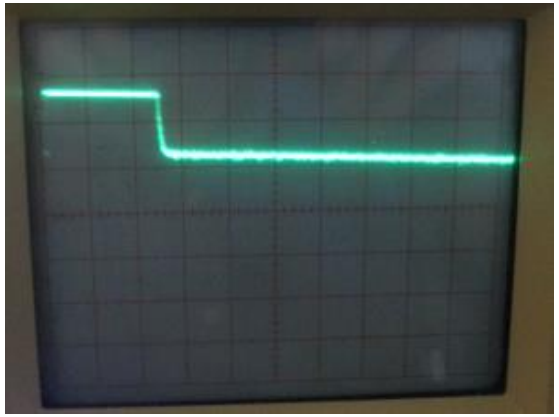
music **nothing** **video**

20msec/cm

Again: no detail within each RF pulse

100µsec/cm

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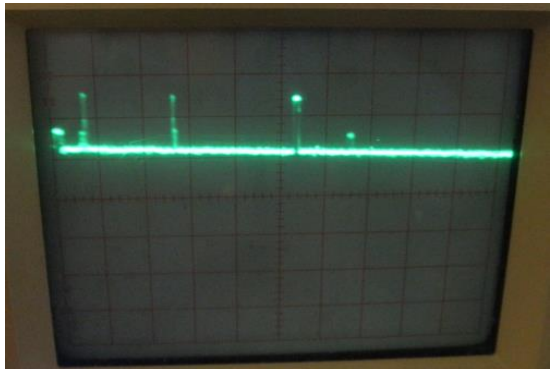
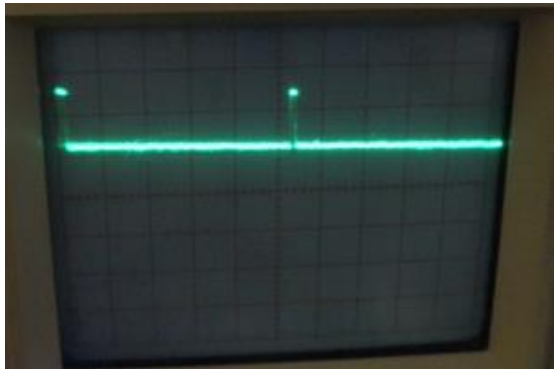
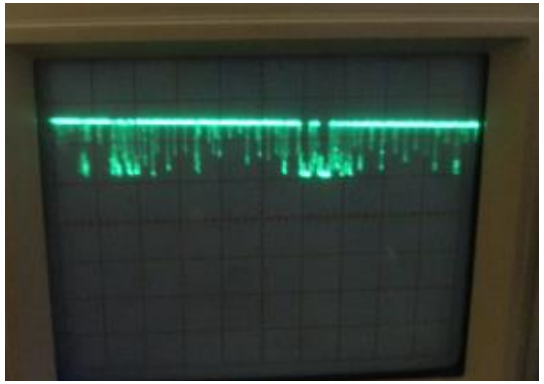
compared to XBee's .125 Mbps

music **nothing** **video**

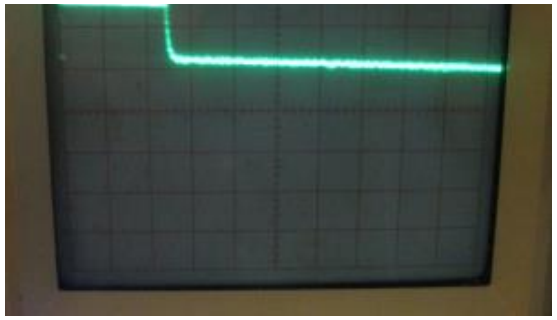
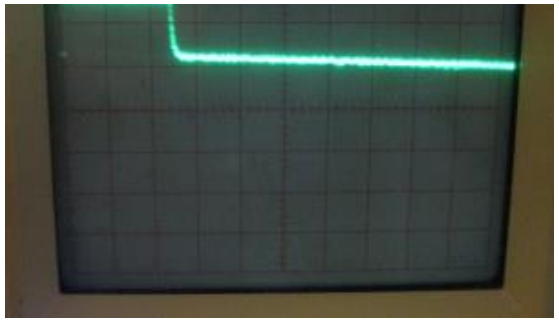
20msec/cm

Again: no detail within each RF pulse

it as if… white noise, 100% modulation

100µsec/cm


Direct Sequence, Spread Spectrum

Mortimer Rogoff

U.S. Patent Nov. 27, 1979 Sheet 1 of 3 4,176,316

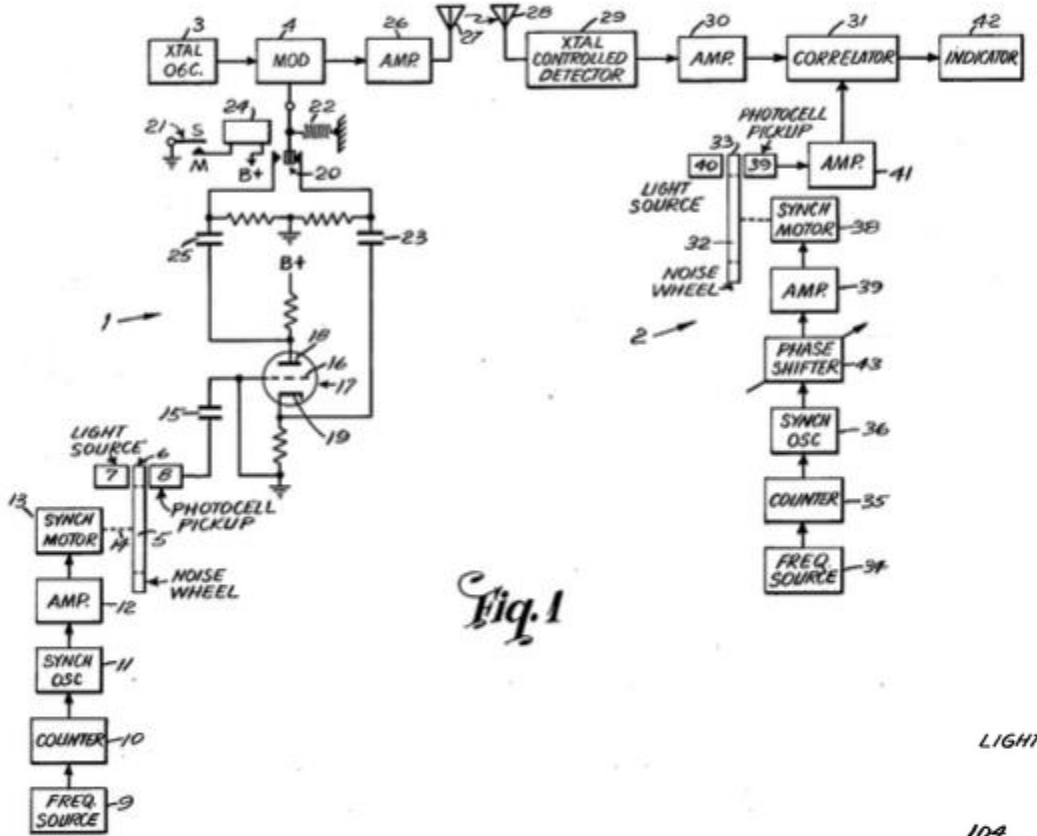


Fig. 1

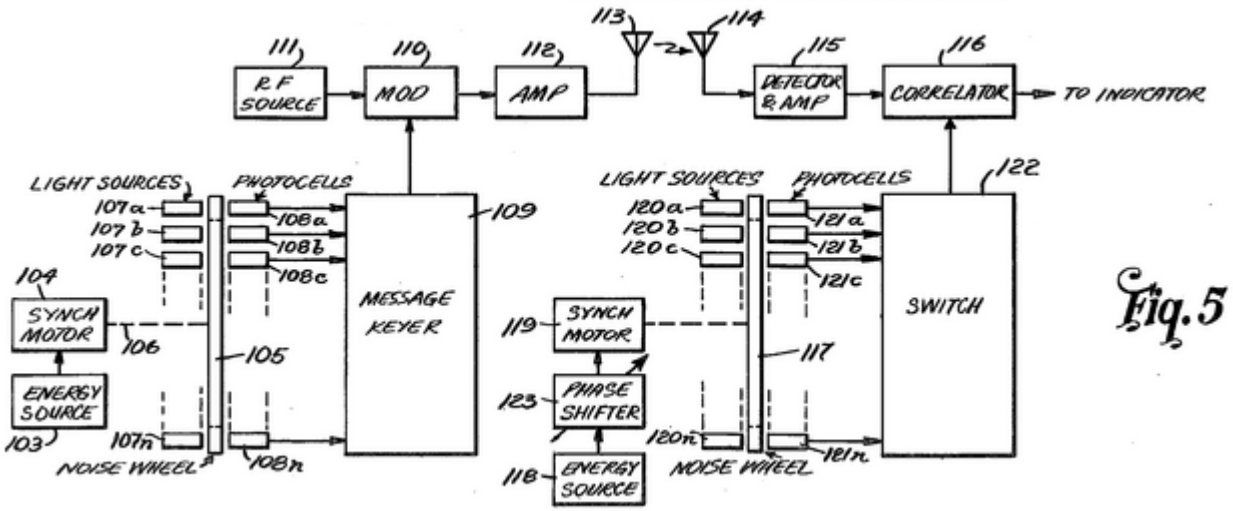


Fig. 5

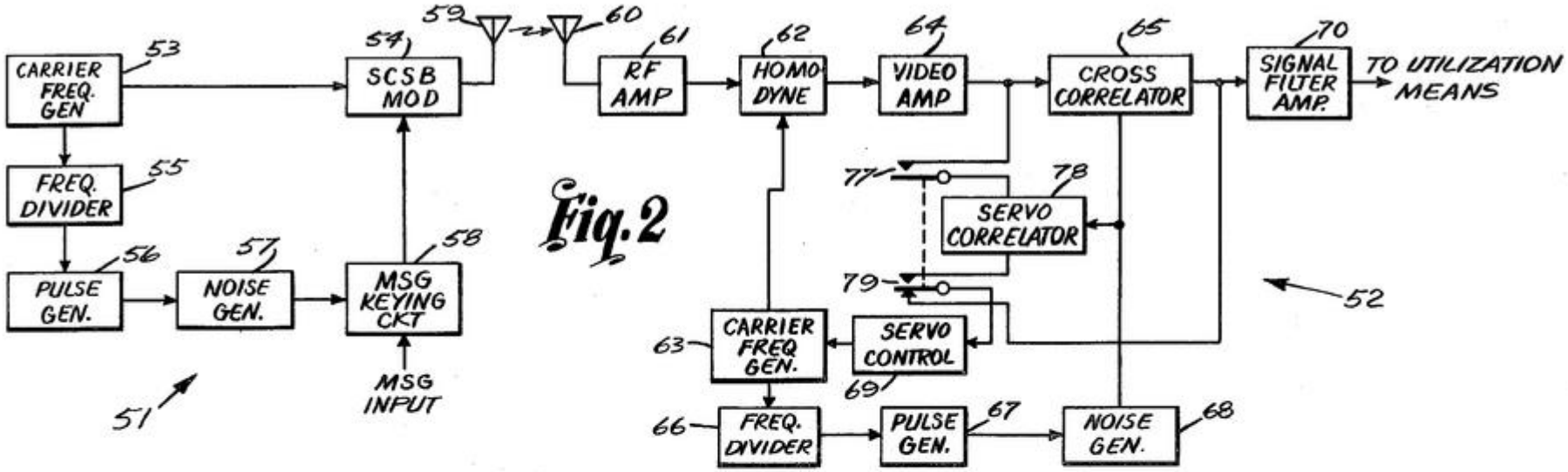


Fig. 2

Fig. 3A

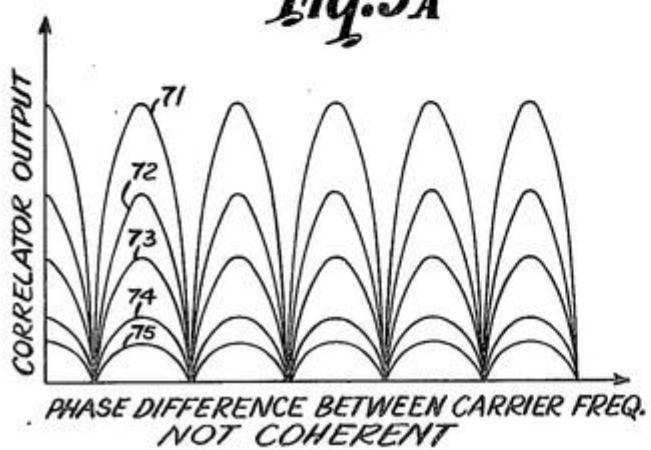
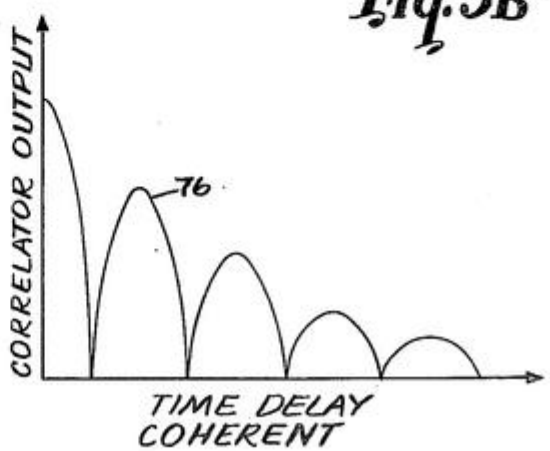


Fig. 3B



Mortimer Rogoff

↓

Secure single sideband communication system using modulated noise subcarrier

Patent number: 4176316

Abstract: 10. A transmitter for a secret communication system comprising a source of carrier frequency energy, a source of cyclically repetitive noise energy, means to synchronize the cyclical repetition rate of said noise energy with a sub-multiple of the frequency of said carrier frequency energy, means to reverse the phase of portions of said noise energy in accordance with a predetermined message code, means to modulate said carrier frequency energy with said encoded noise energy and means to transmit the suppressed carrier single sideband component of said carrier modulation.

Type: Grant

Filed: March 30, 1953

Issued: November 27, 1979

Assignee: International Telephone & Telegraph Corp.

Inventors: Louis A. DeRosa, Mortimer Rogoff

Prior Art

- Added multiple tones louder than the information modulation
-

Prior Art

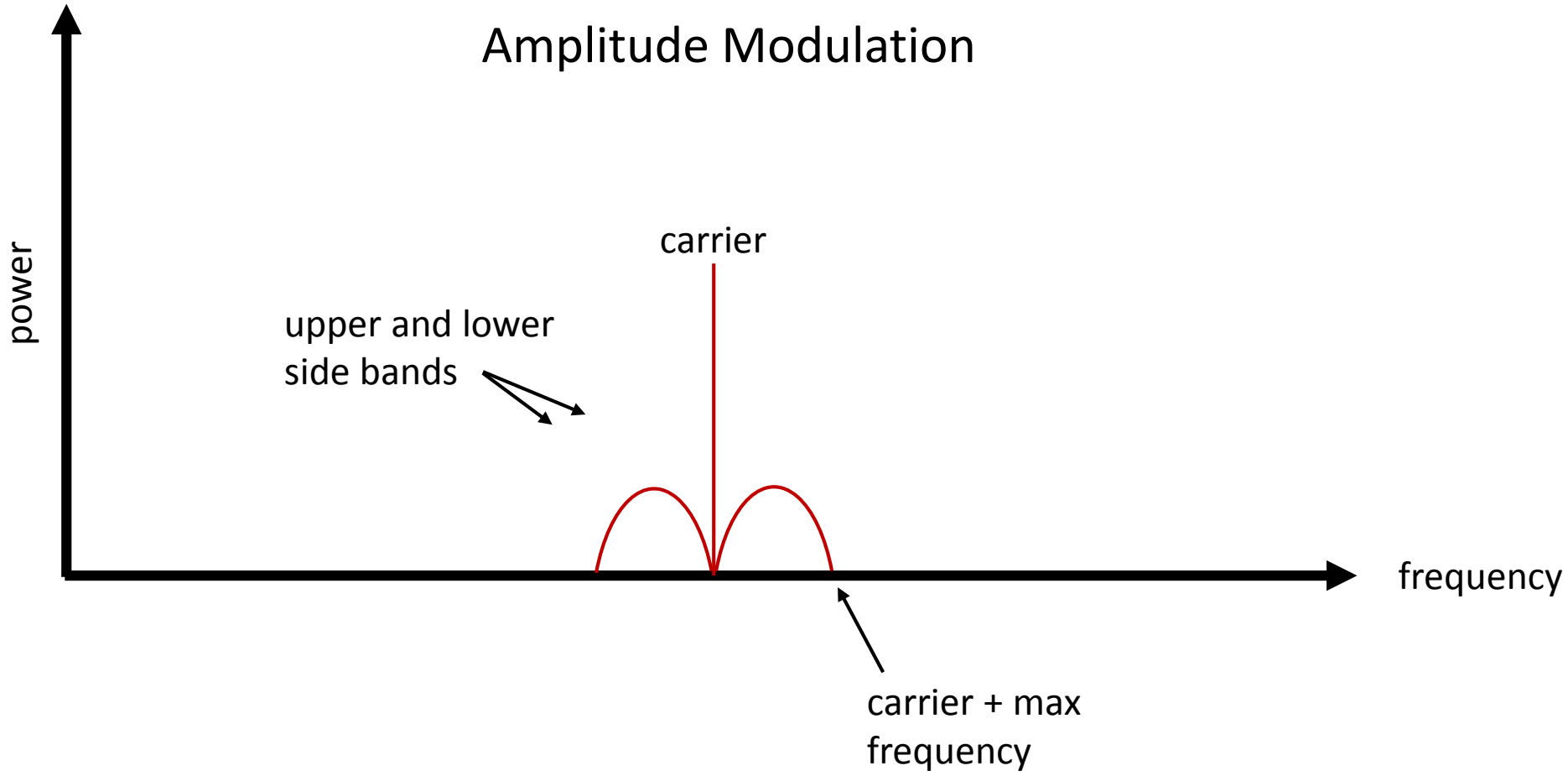
- Added multiple tones louder than the information modulation
- Flash transmission where you compress time and expand it

Prior Art

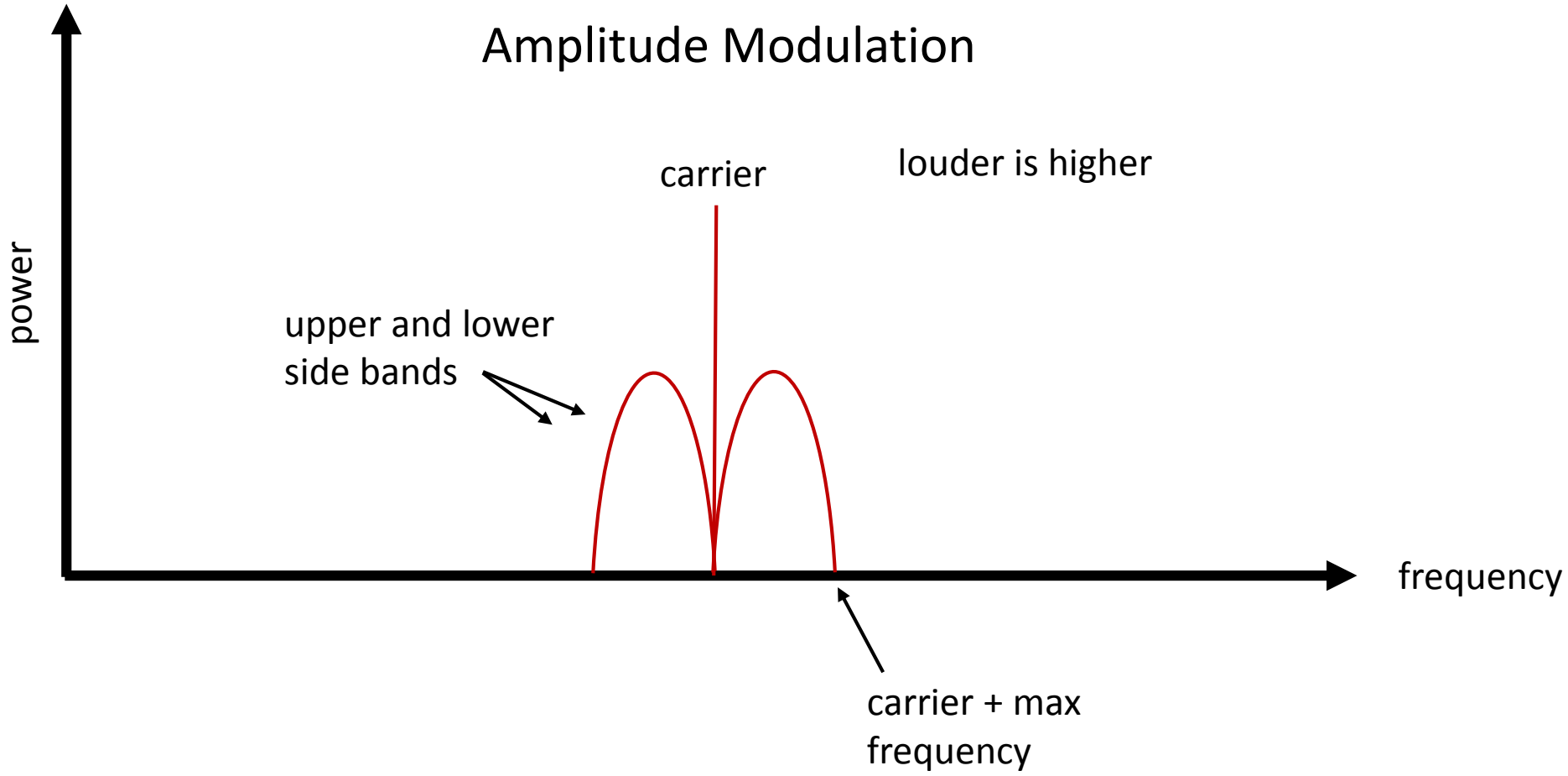
- Added multiple tones louder than the information modulation
- Flash transmission where you compress time and expand it

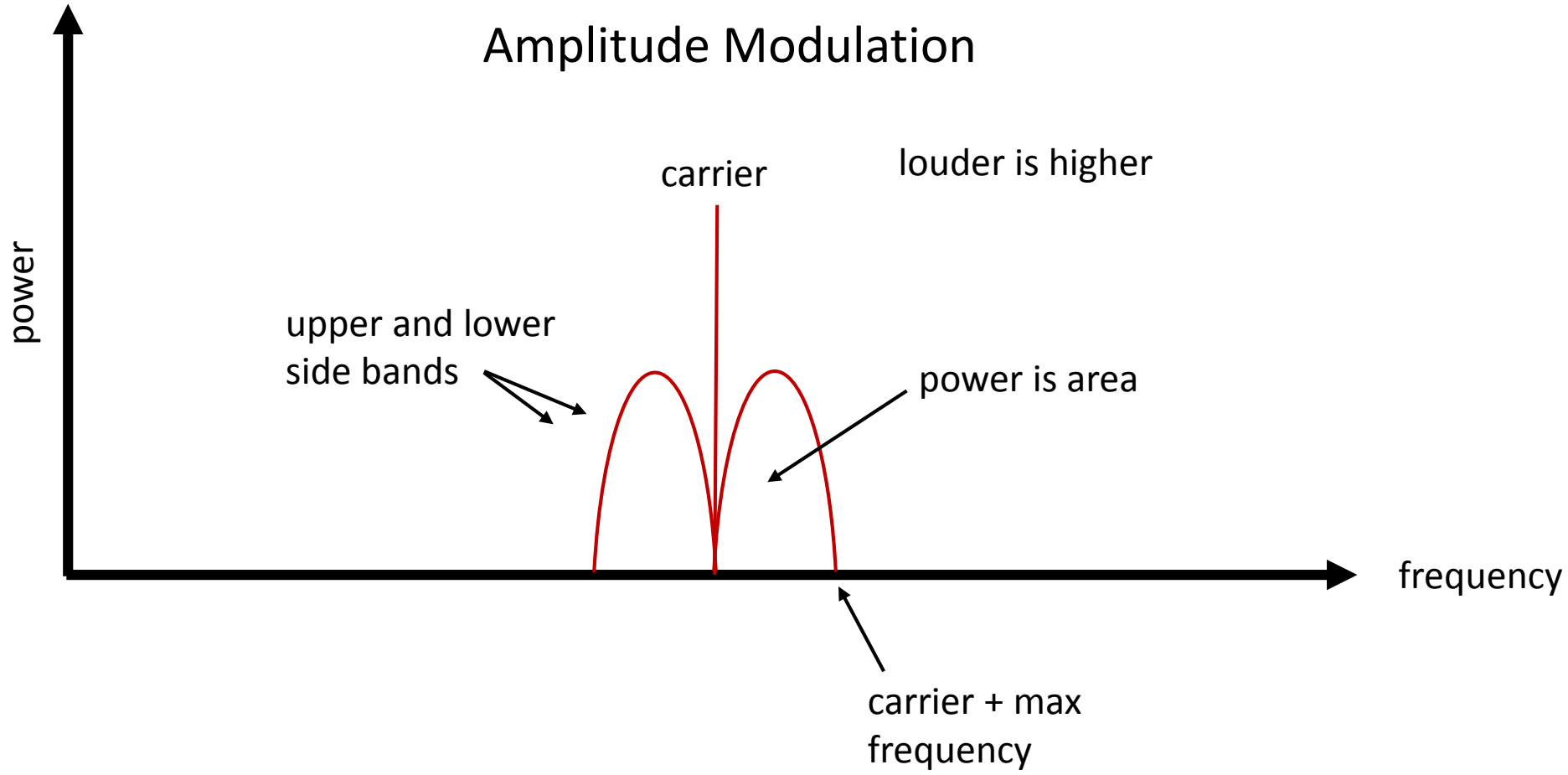
Both could be undone and both reveal themselves.

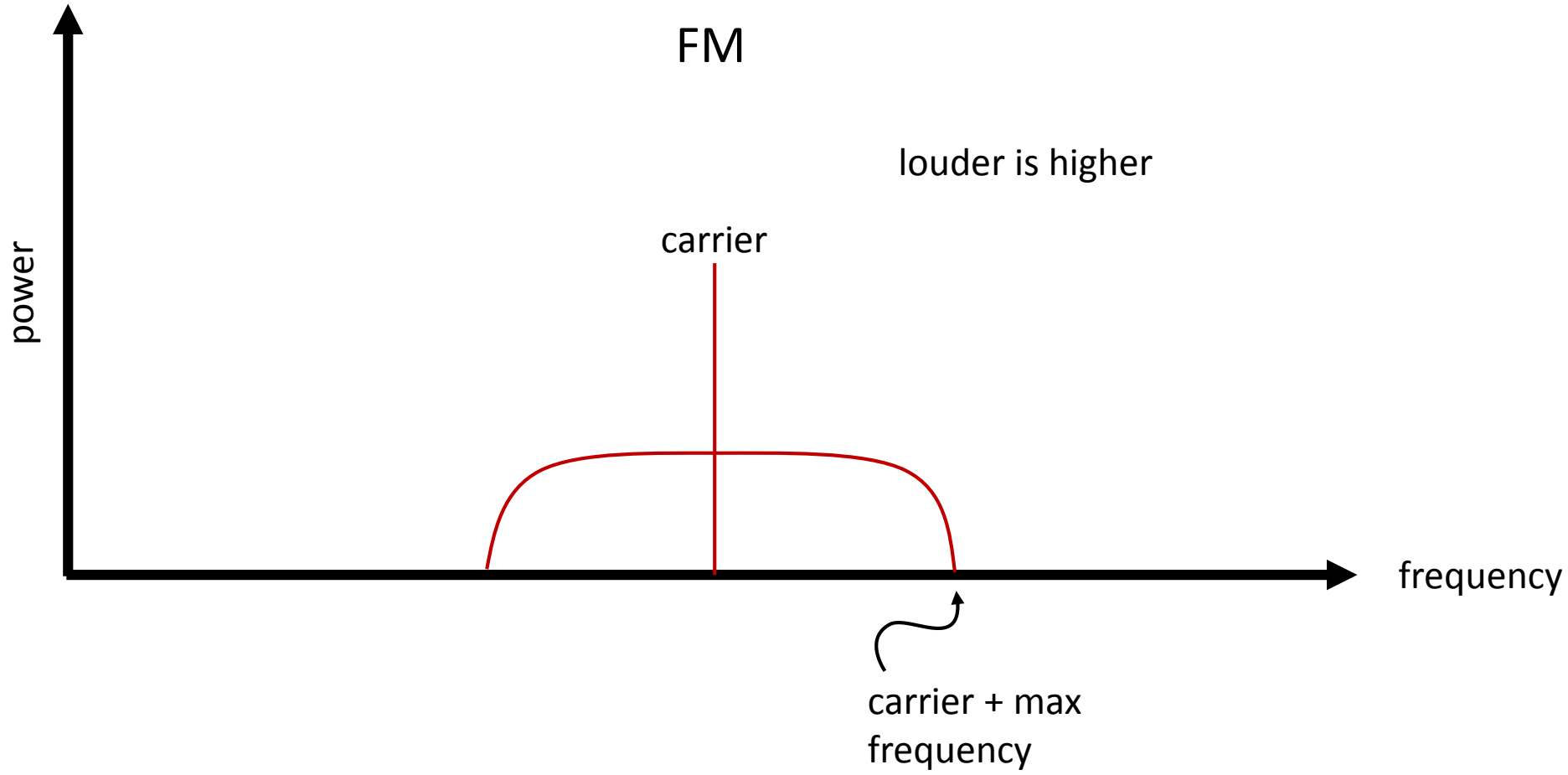
Amplitude Modulation

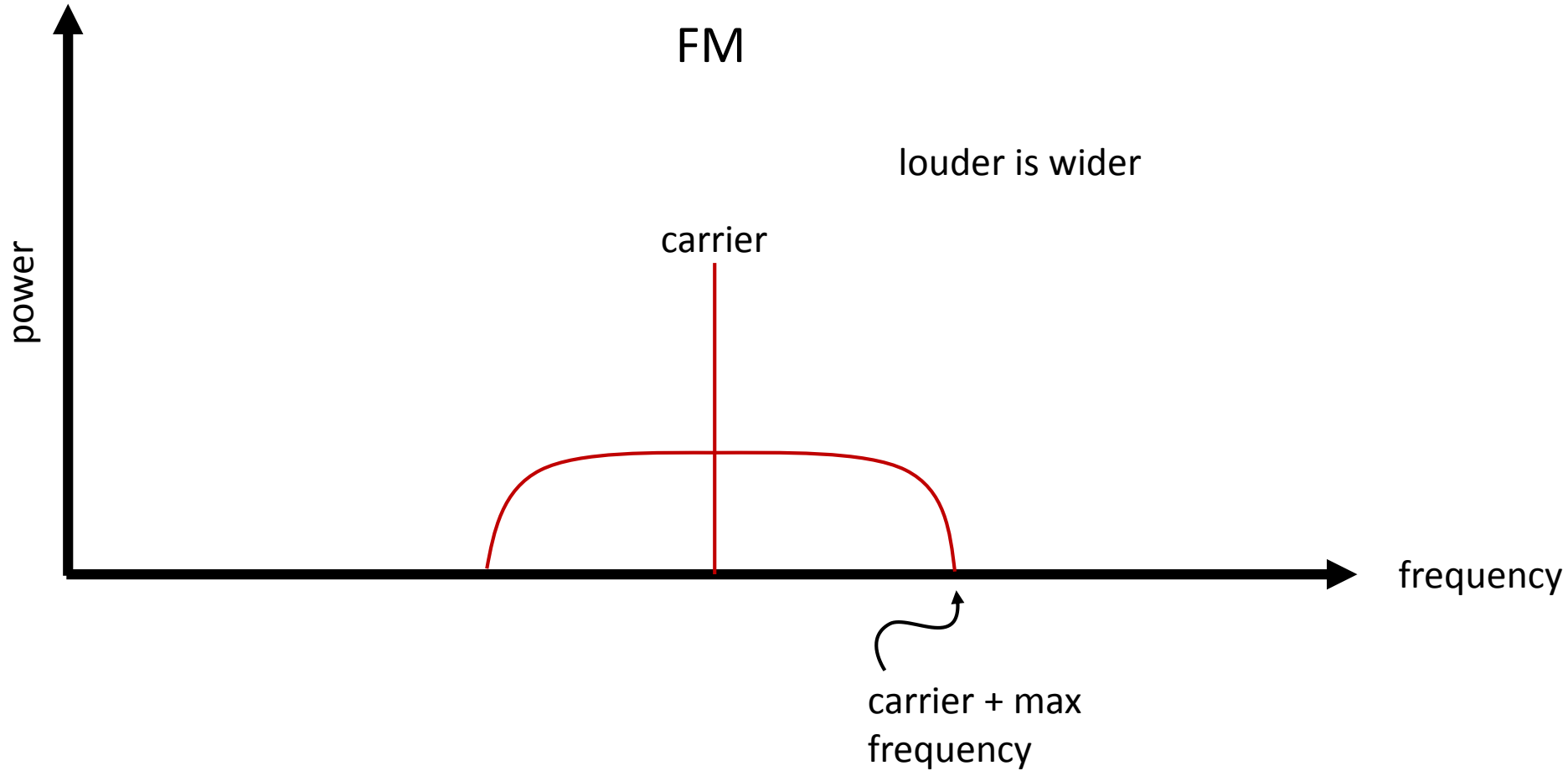


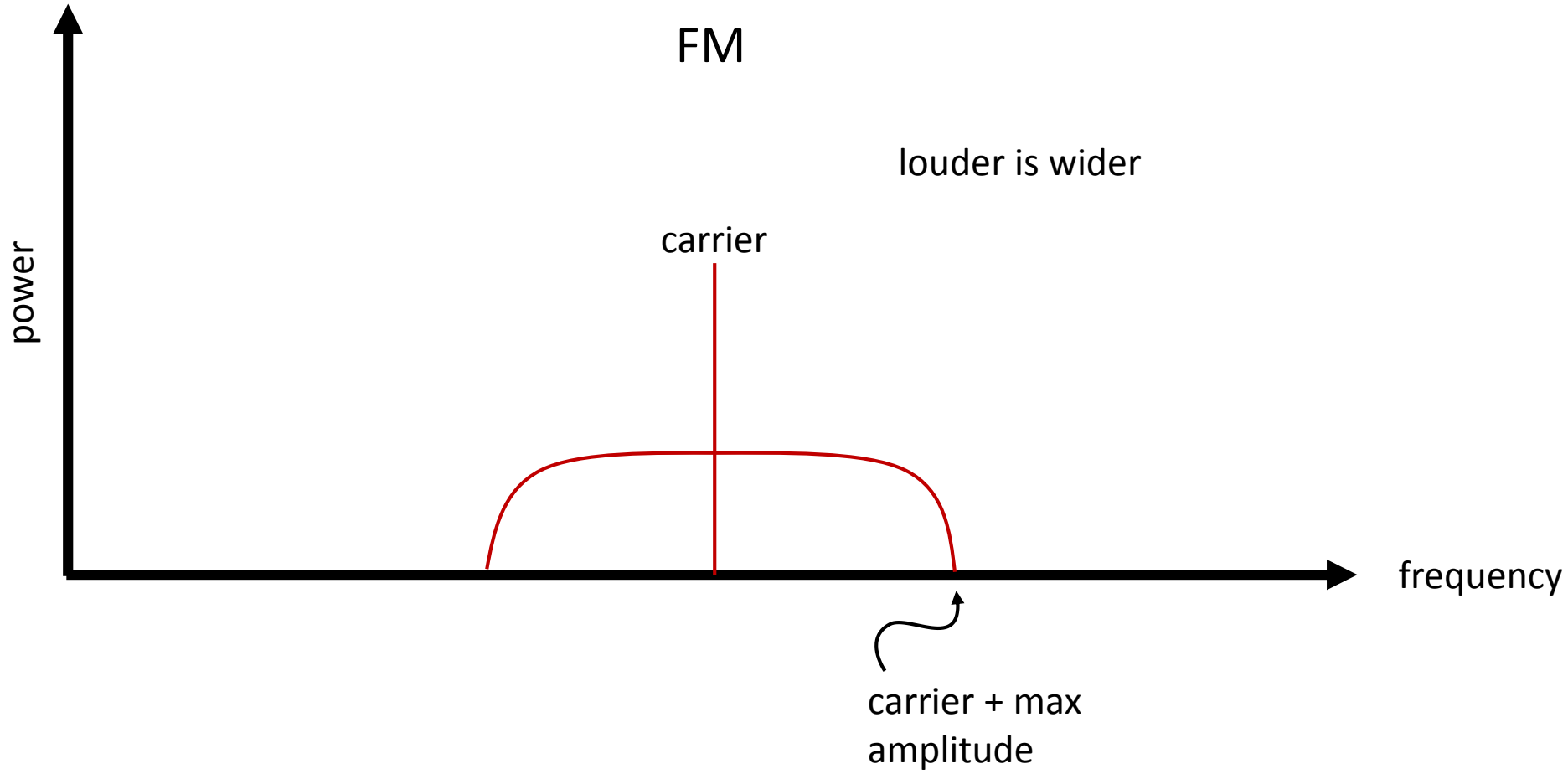
Amplitude Modulation

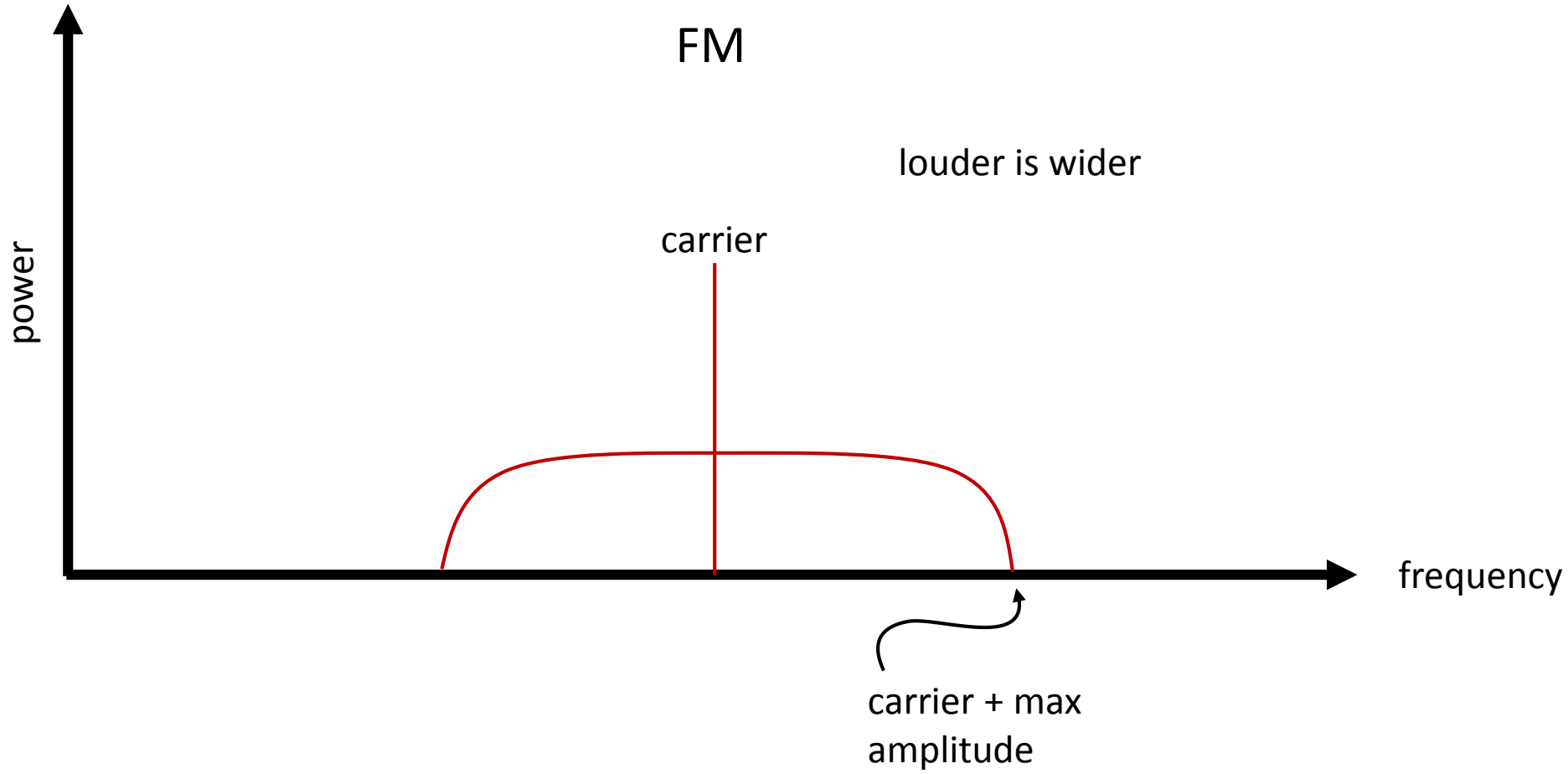


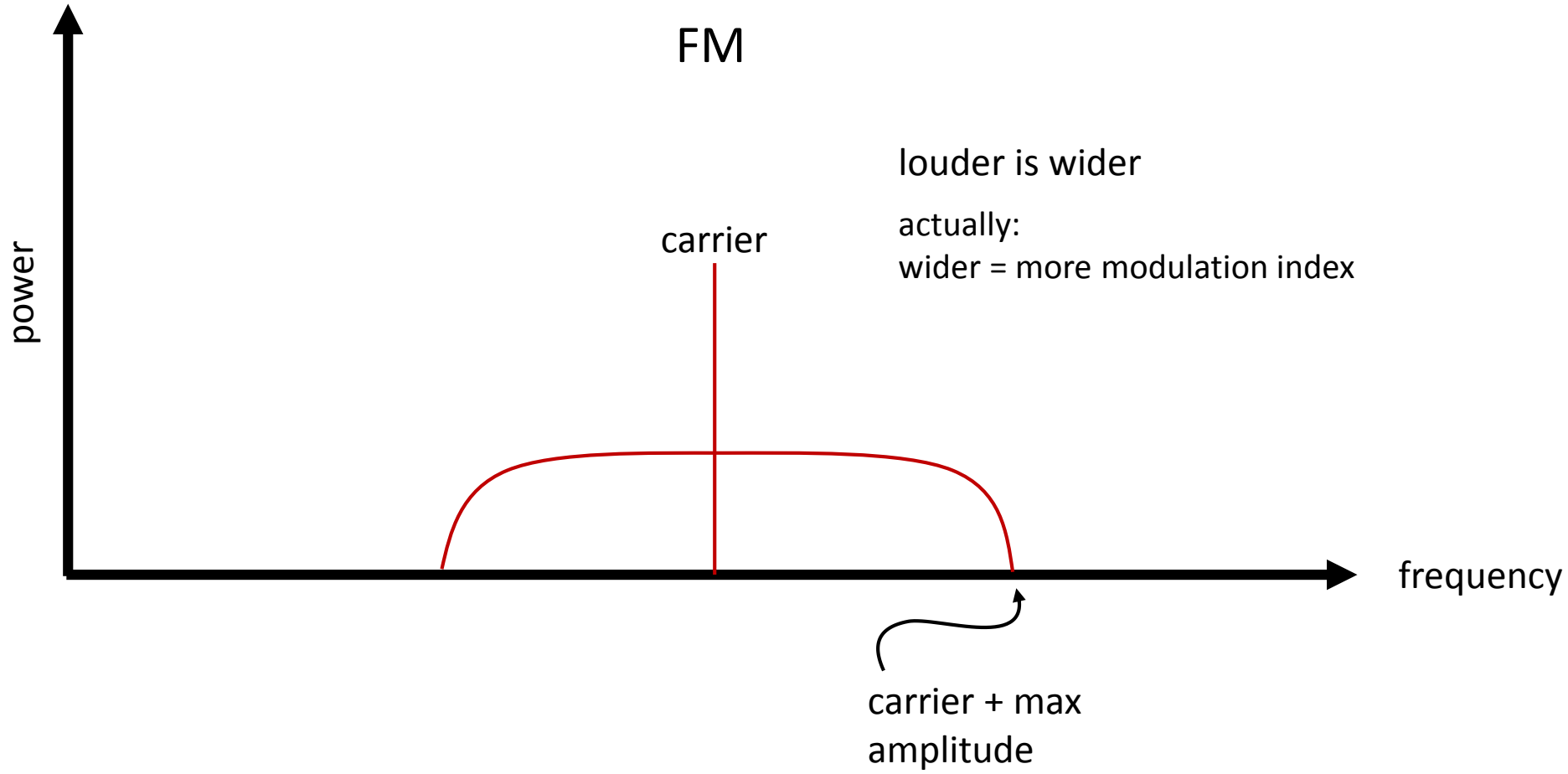

Amplitude Modulation
power
carrier
louder is higher
upper and lower
side bands
power is area
frequency
carrier + max
frequency

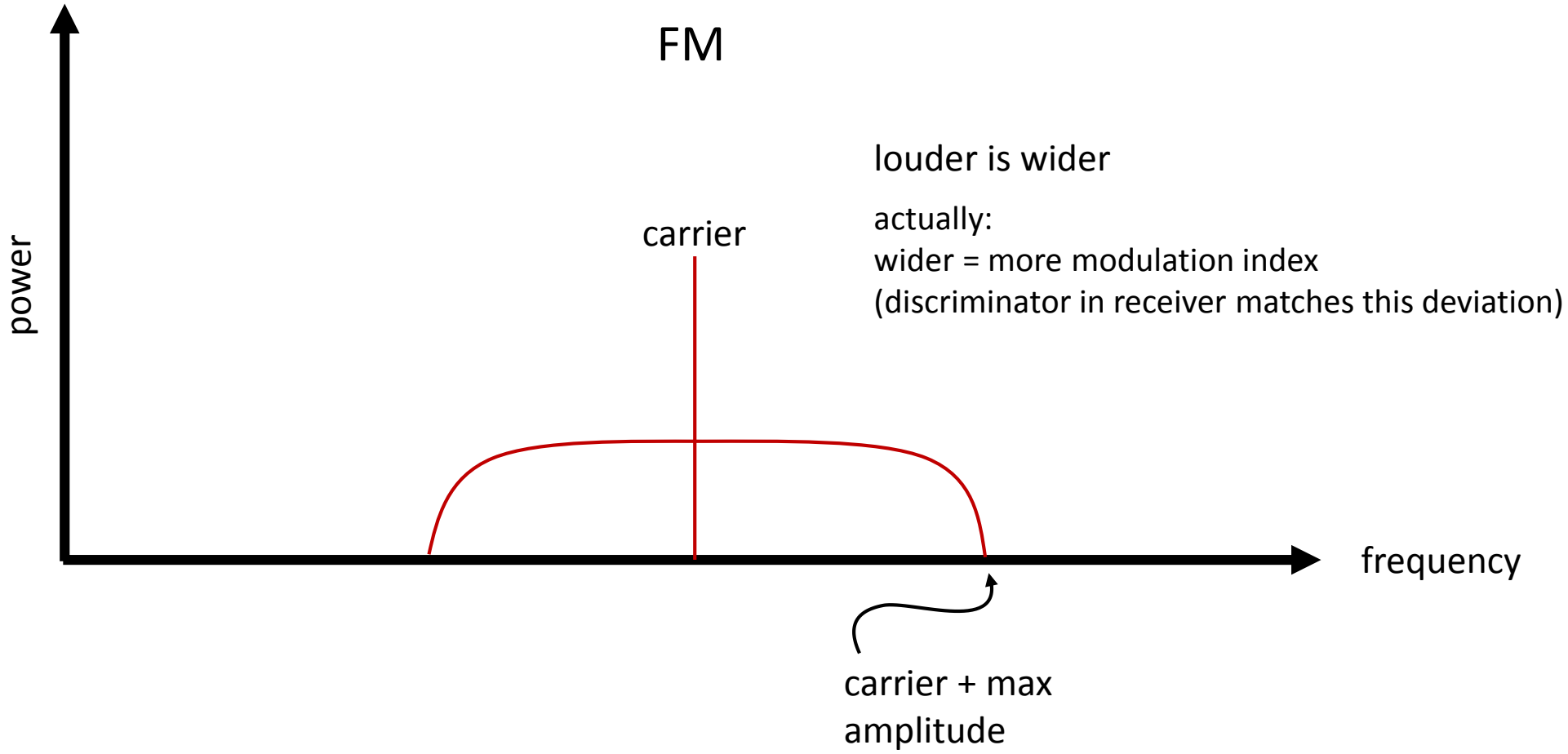

FM
louder is higher
carrier
power
frequency
carrier + max
frequency

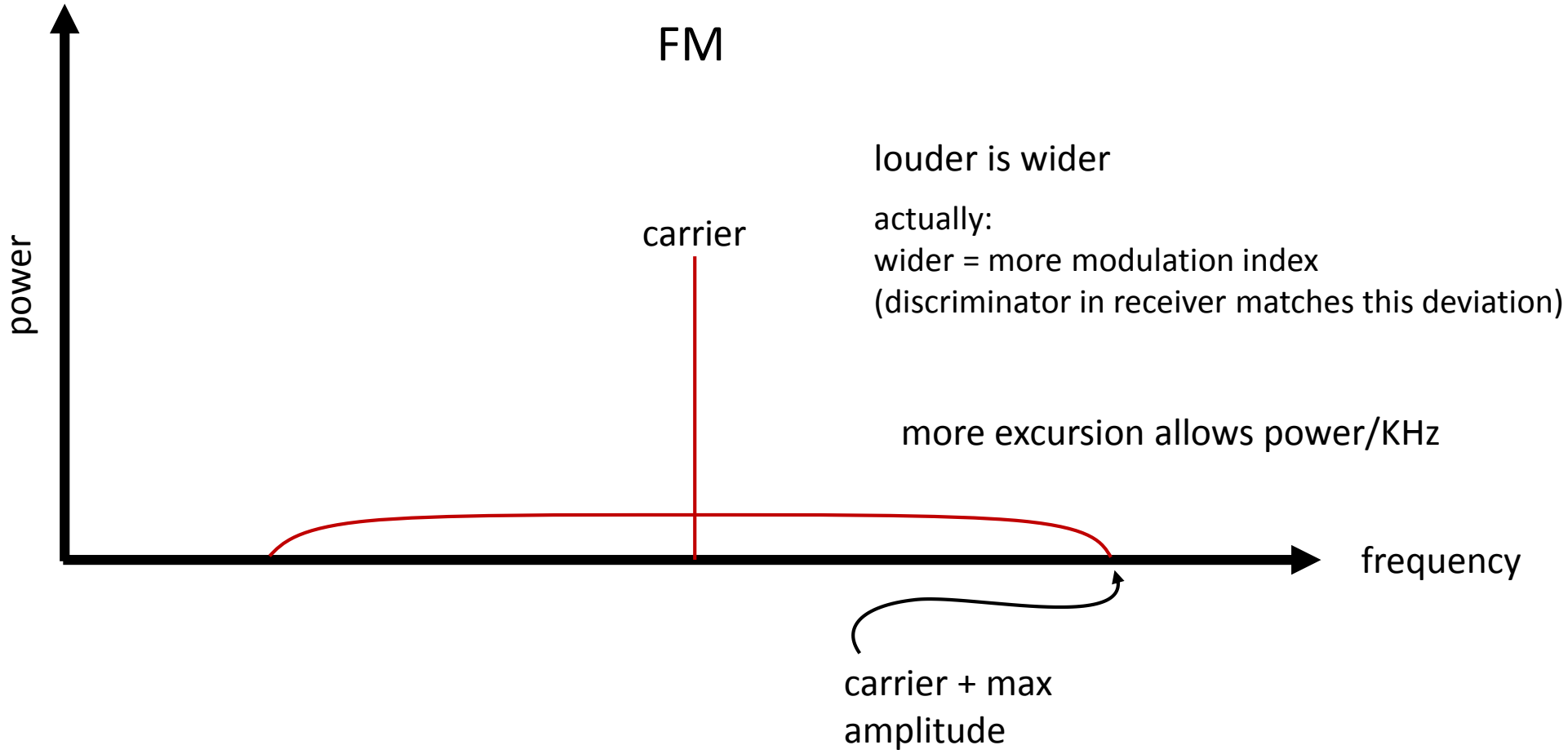

FM
louder is wider
carrier
power
frequency
carrier + max
frequency


FM
louder is wider
carrier
power
frequency
carrier + max
amplitude

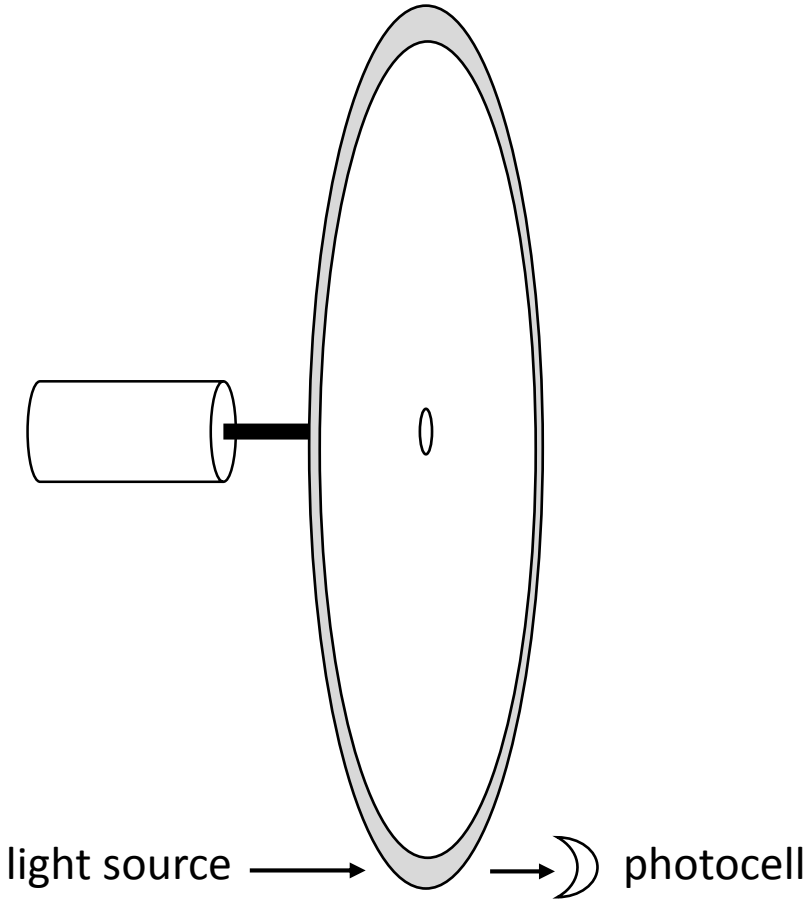

FM
louder is wider
carrier
power
frequency
carrier + max
amplitude

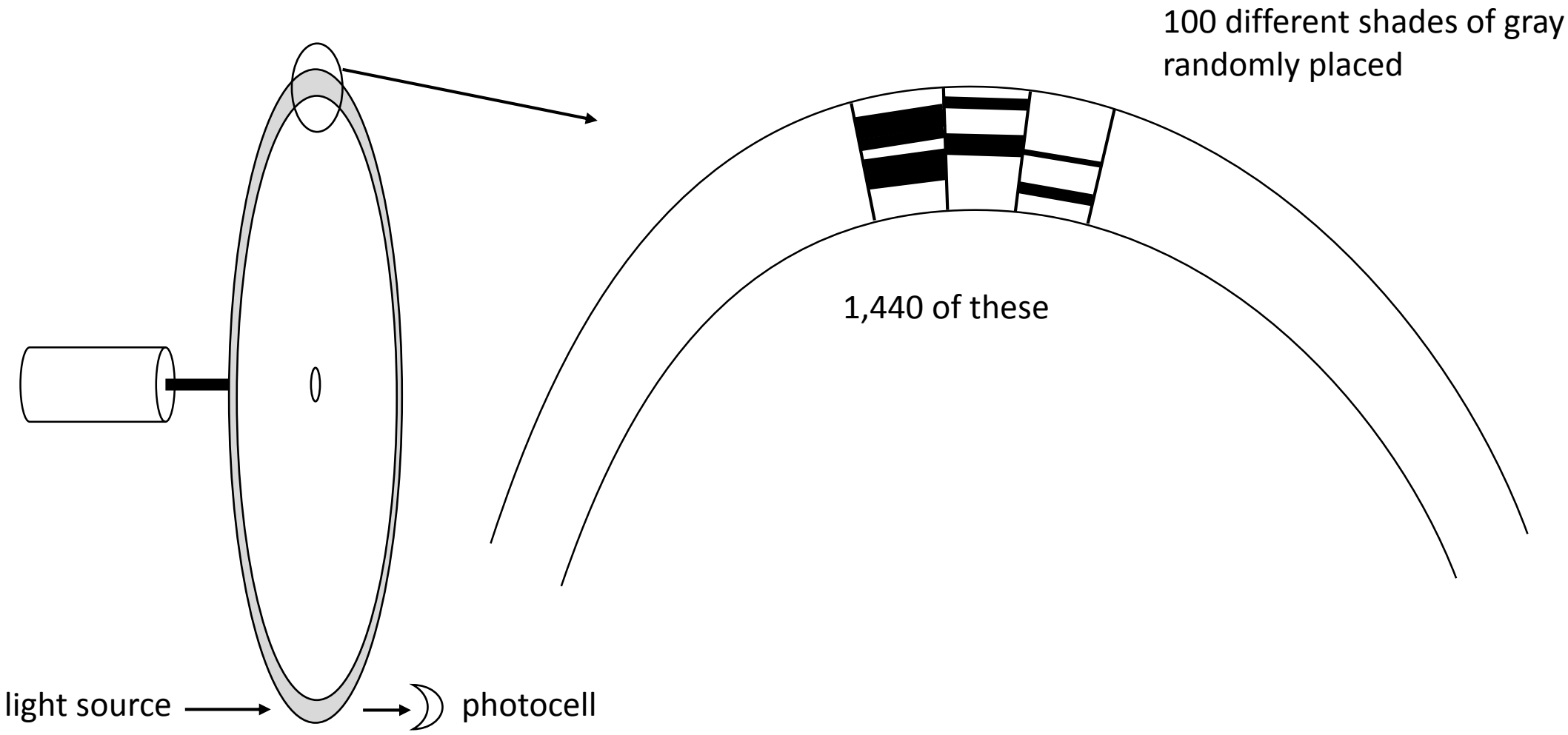

FM
louder is wider
actually:
wider = more modulation index
carrier
power
frequency
carrier + max
amplitude

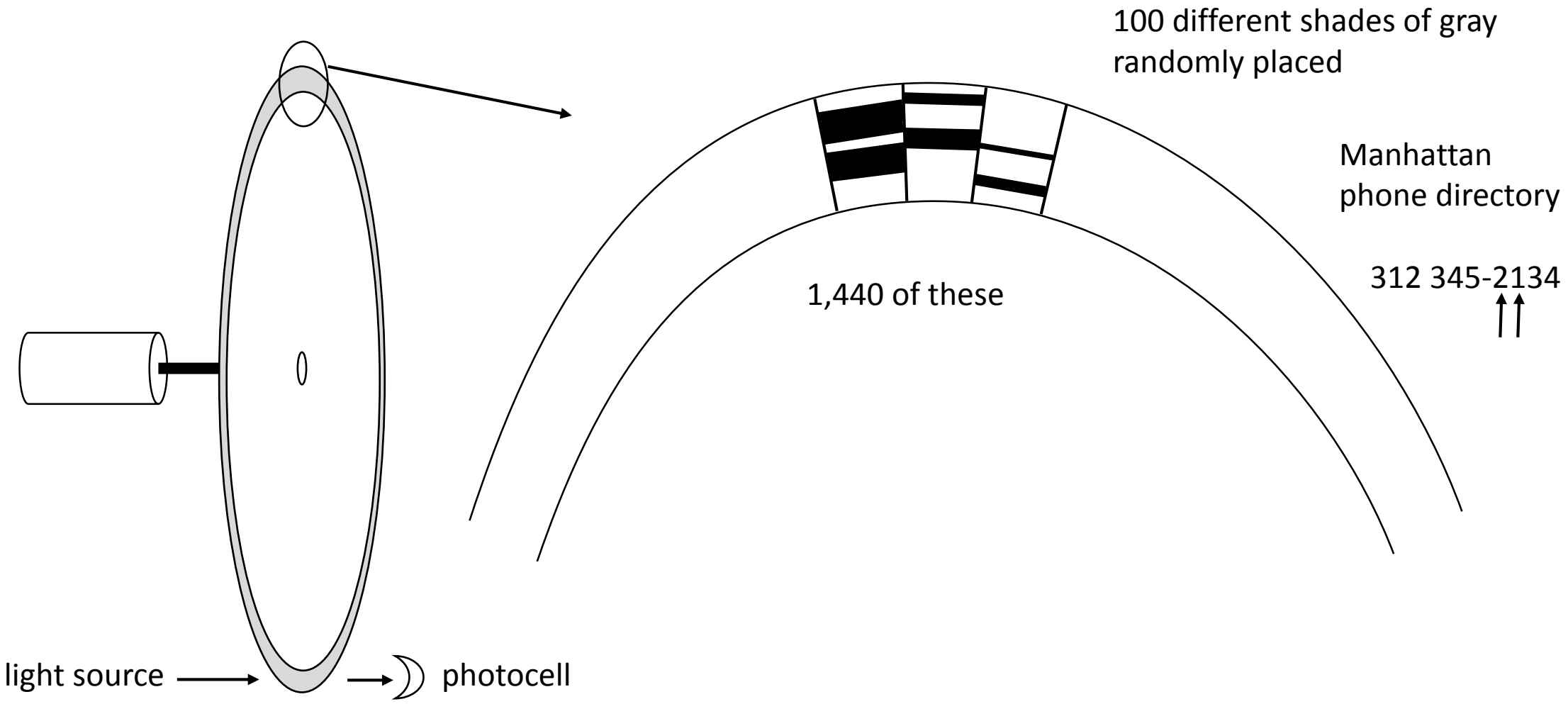

FM
power
carrier
louder is wider
actually:
wider = more modulation index
(discriminator in receiver matches this deviation)
frequency
carrier + max
amplitude

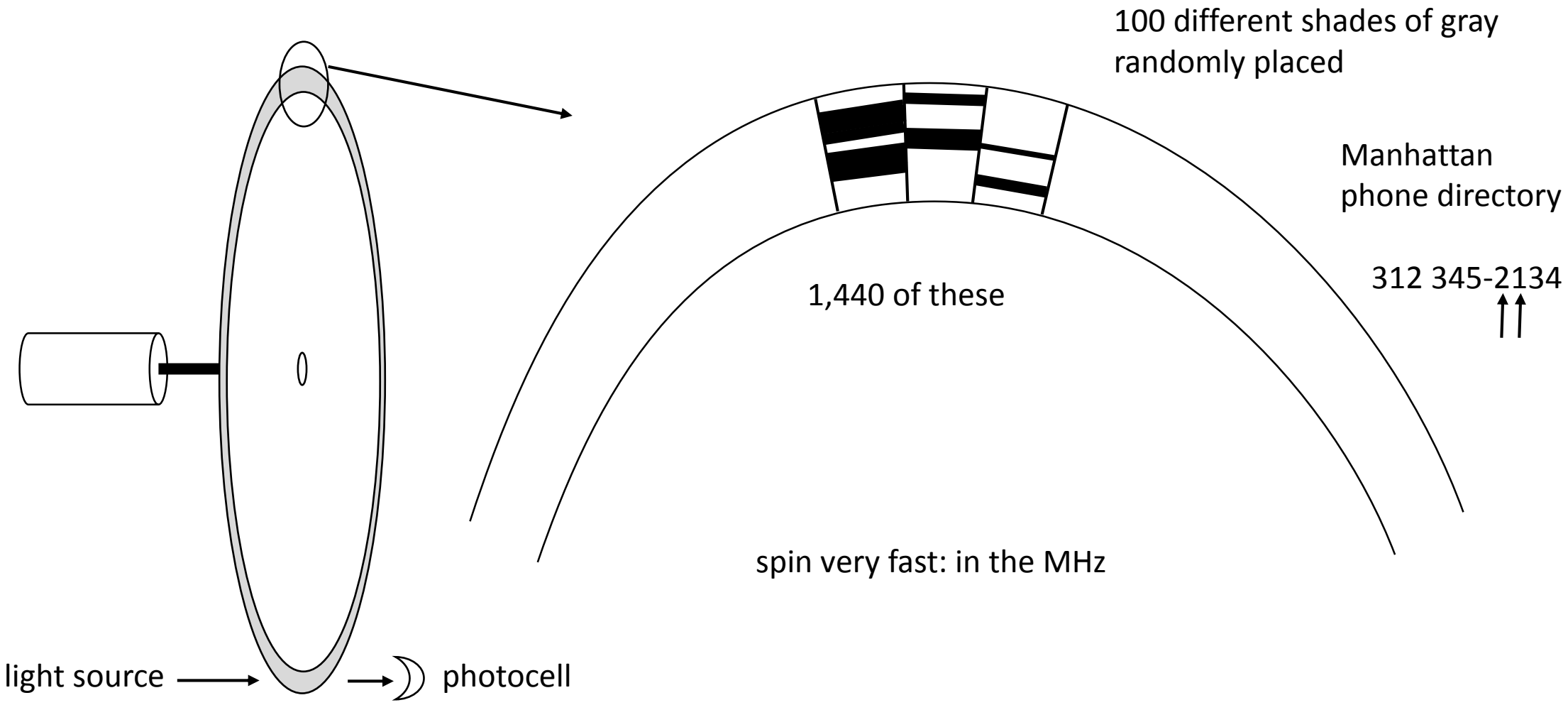

FM
power
carrier
louder is wider
actually:
wider = more modulation index
(discriminator in receiver matches this deviation)
more excursion allows power/KHz
frequency
carrier + max
amplitude

Mortimer’s Invention

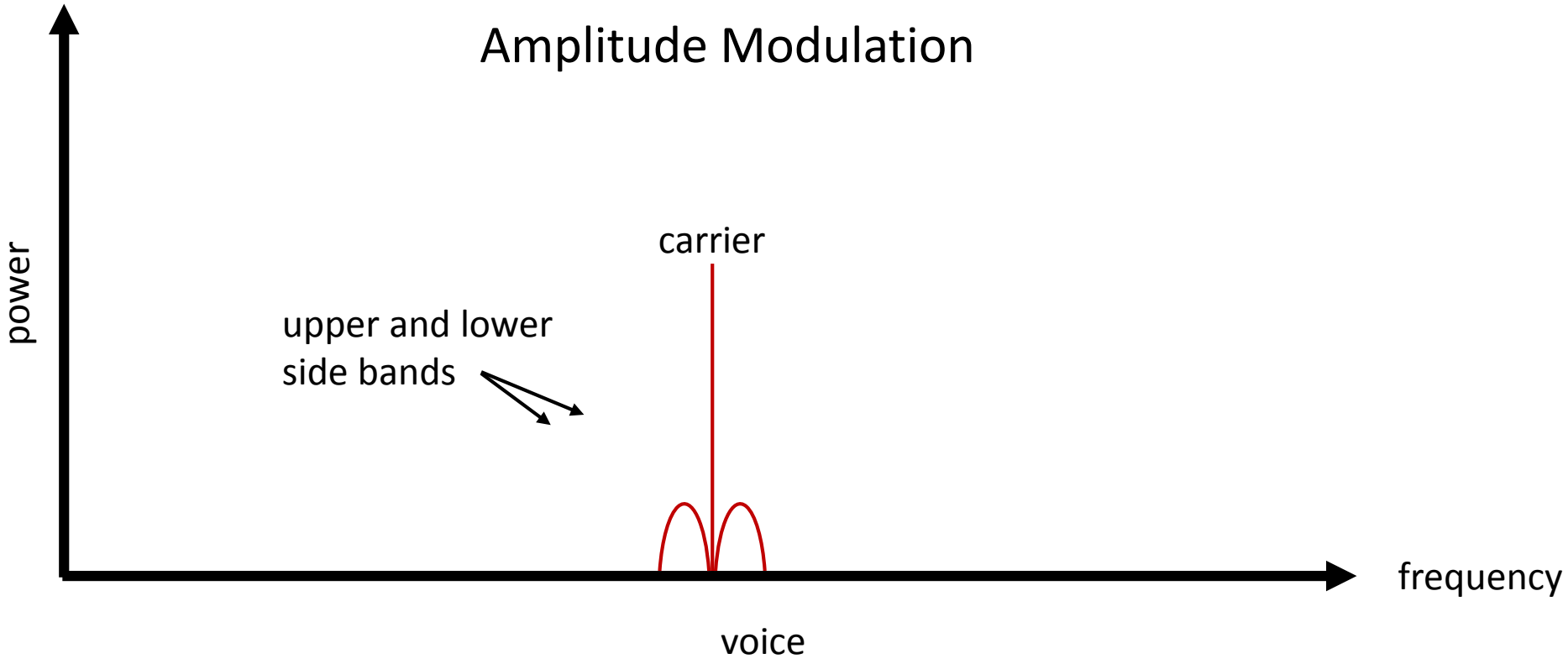


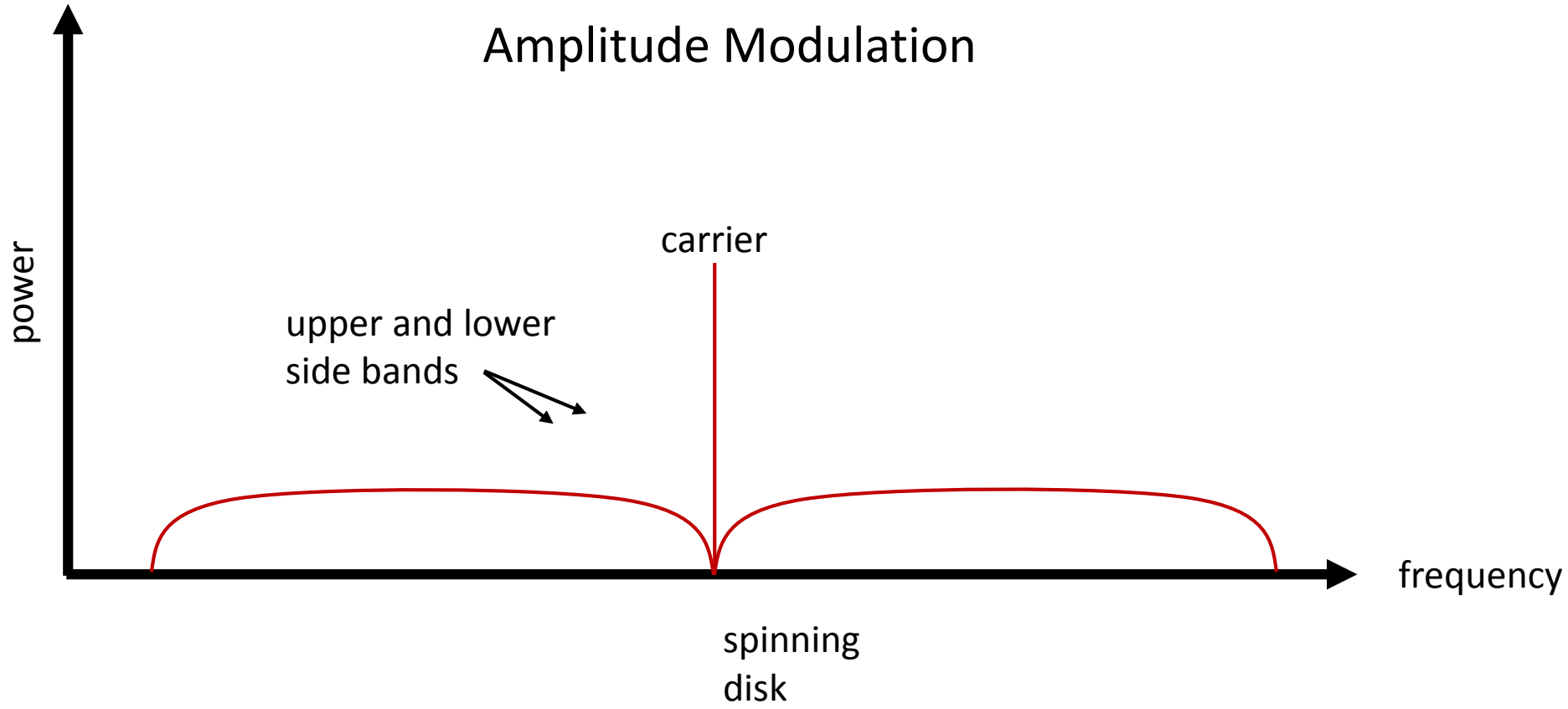

100 different shades of gray
randomly placed
1,440 of these
light source
photocell


100 different shades of gray
randomly placed
Manhattan
phone directory
312 345-2134
1,440 of these
light source
photocell


100 different shades of gray
randomly placed
Manhattan
phone directory
312 345-2134
1,440 of these
spin very fast: in the MHz
light source
photocell

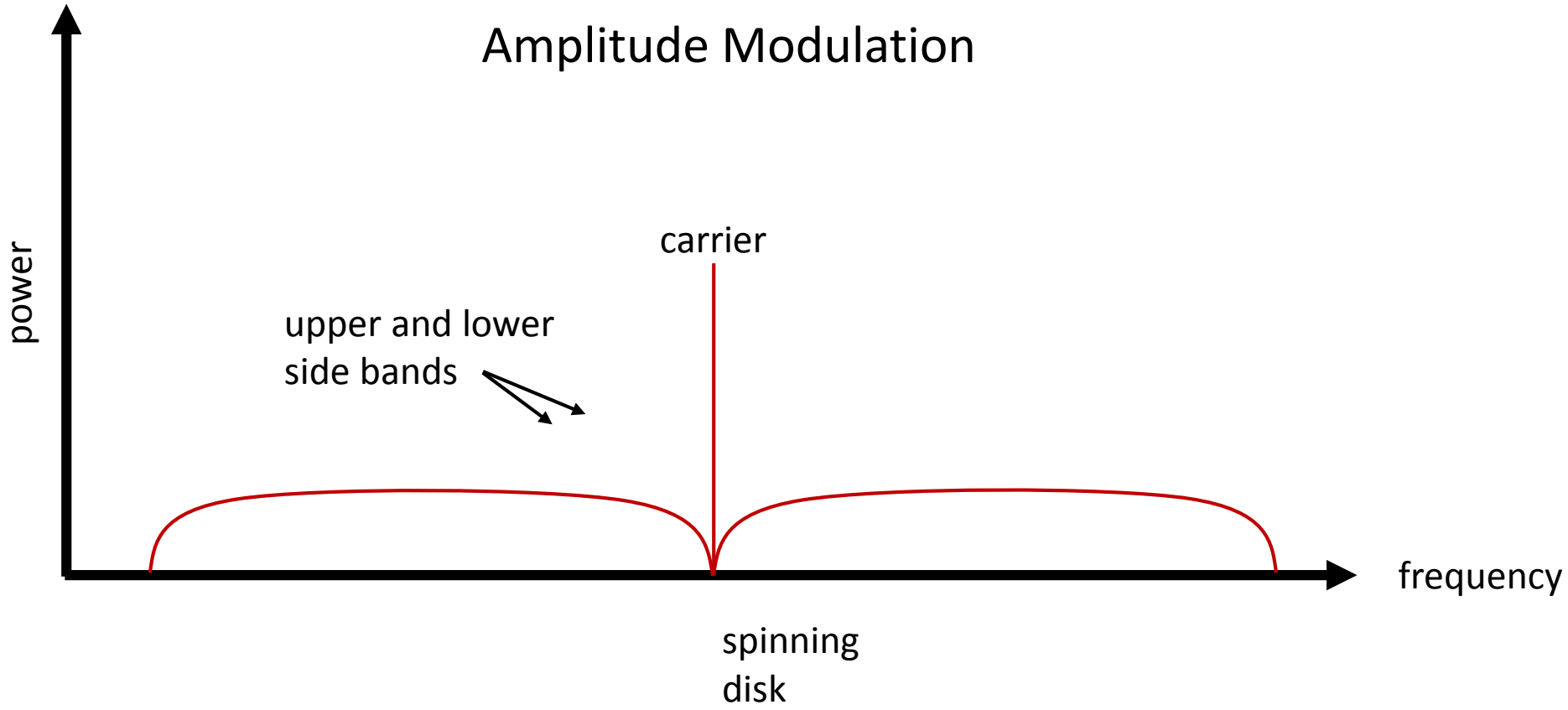
Amplitude Modulation




Amplitude Modulation
power
carrier
upper and lower
side bands
frequency
spinning
disk

Spread Spectrum

Amplitude Modulation



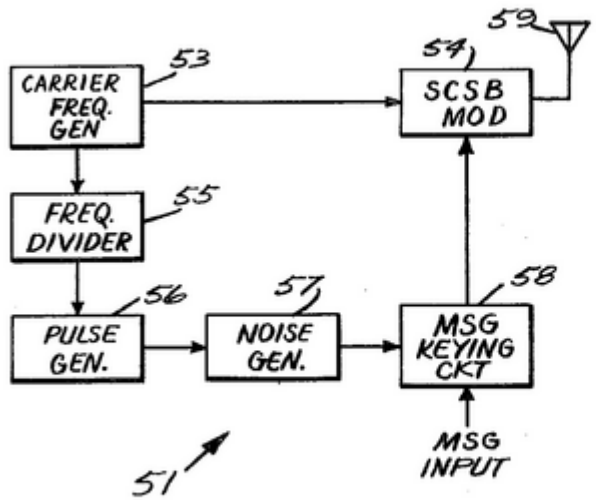
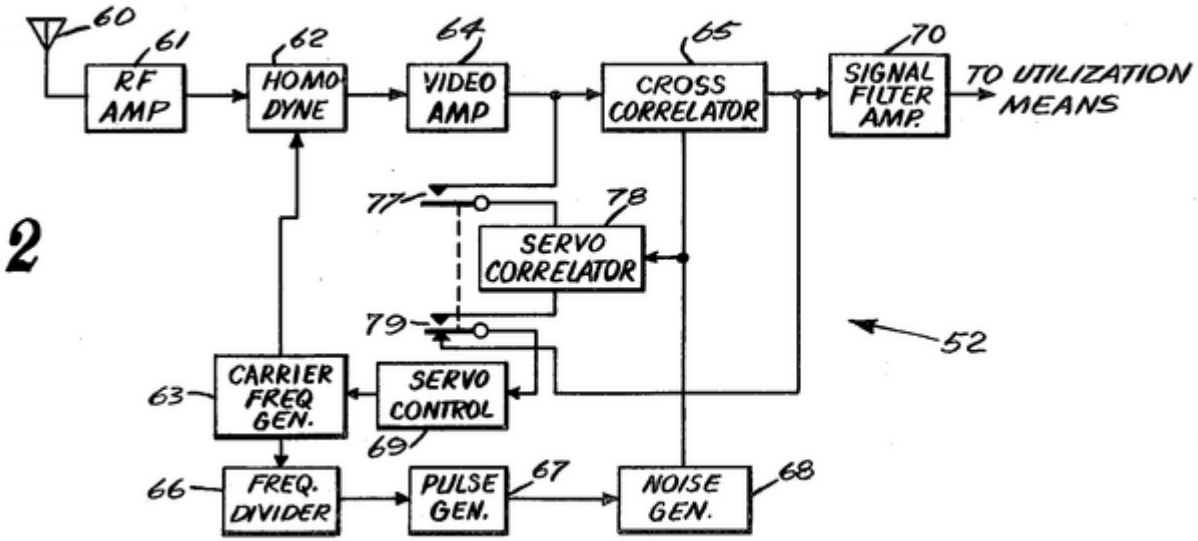
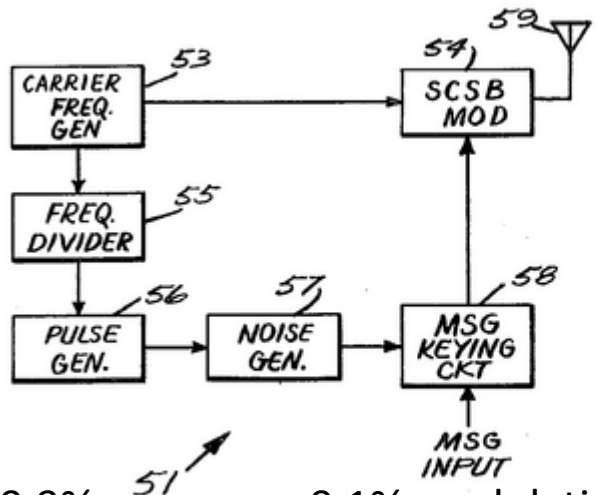

CARRIER FREQ. GEN
53
54
SCSB MOD
59
FREQ. DIVIDER
55
PULSE GEN.
56
NOISE GEN.
57
MSG KEYING CKT
58
MSG INPUT
51

Fig. 2

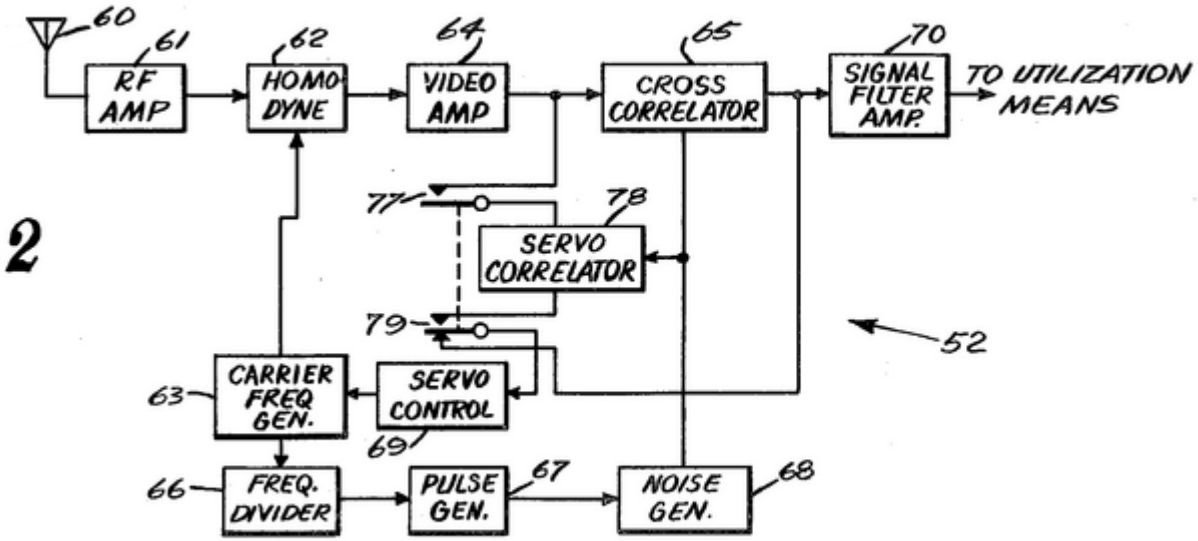

60
RF AMP
61
HOMO DYNE
62
VIDEO AMP
64
CROSS CORRELATOR
65
SIGNAL FILTER AMP.
70
TO UTILIZATION MEANS
77
78
SERVO CORRELATOR
79
52
CARRIER FREQ GEN.
63
SERVO CONTROL
69
FREQ. DIVIDER
66
PULSE GEN.
67
NOISE GEN.
68



99.9% modulation

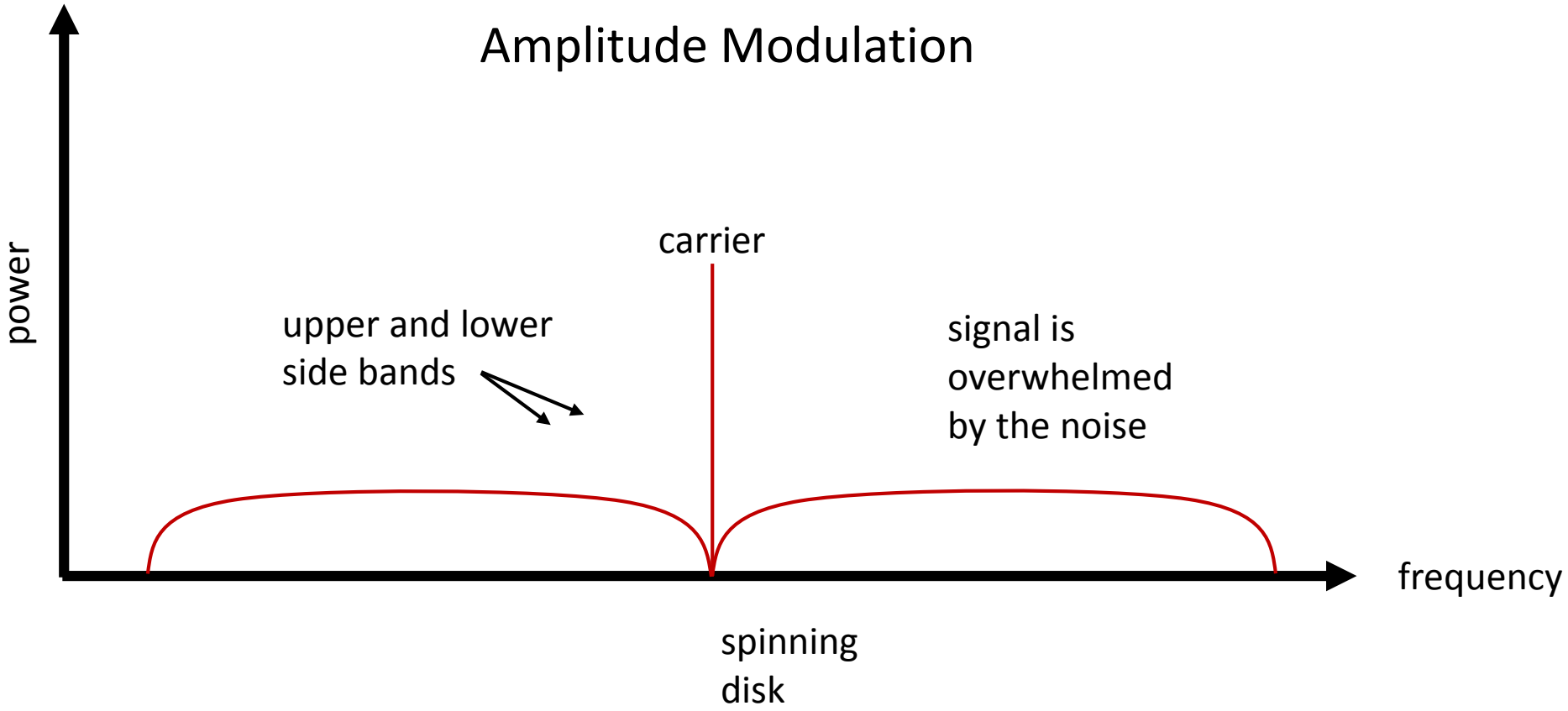
0.1% modulation

Fig. 2



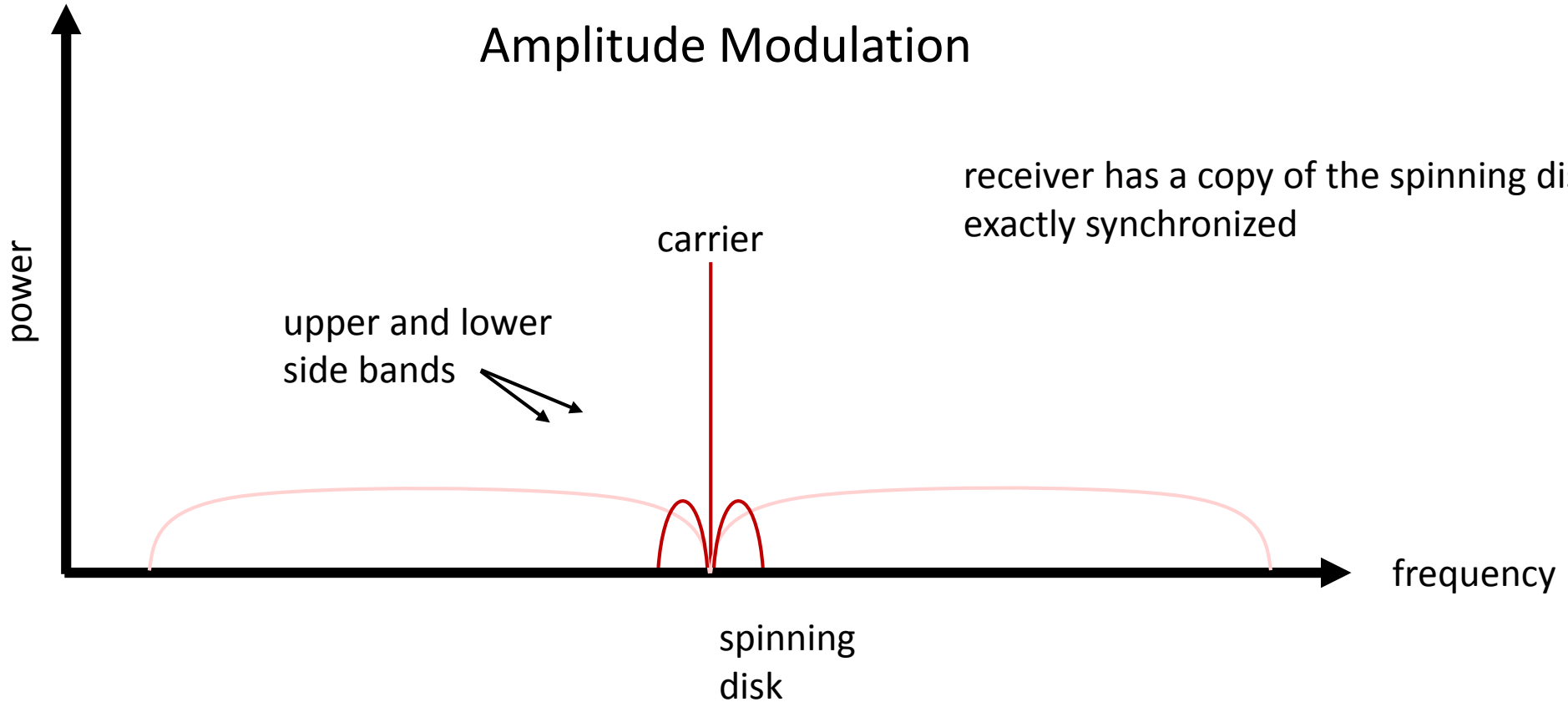
Spread Spectrum

Amplitude Modulation



Spread Spectrum

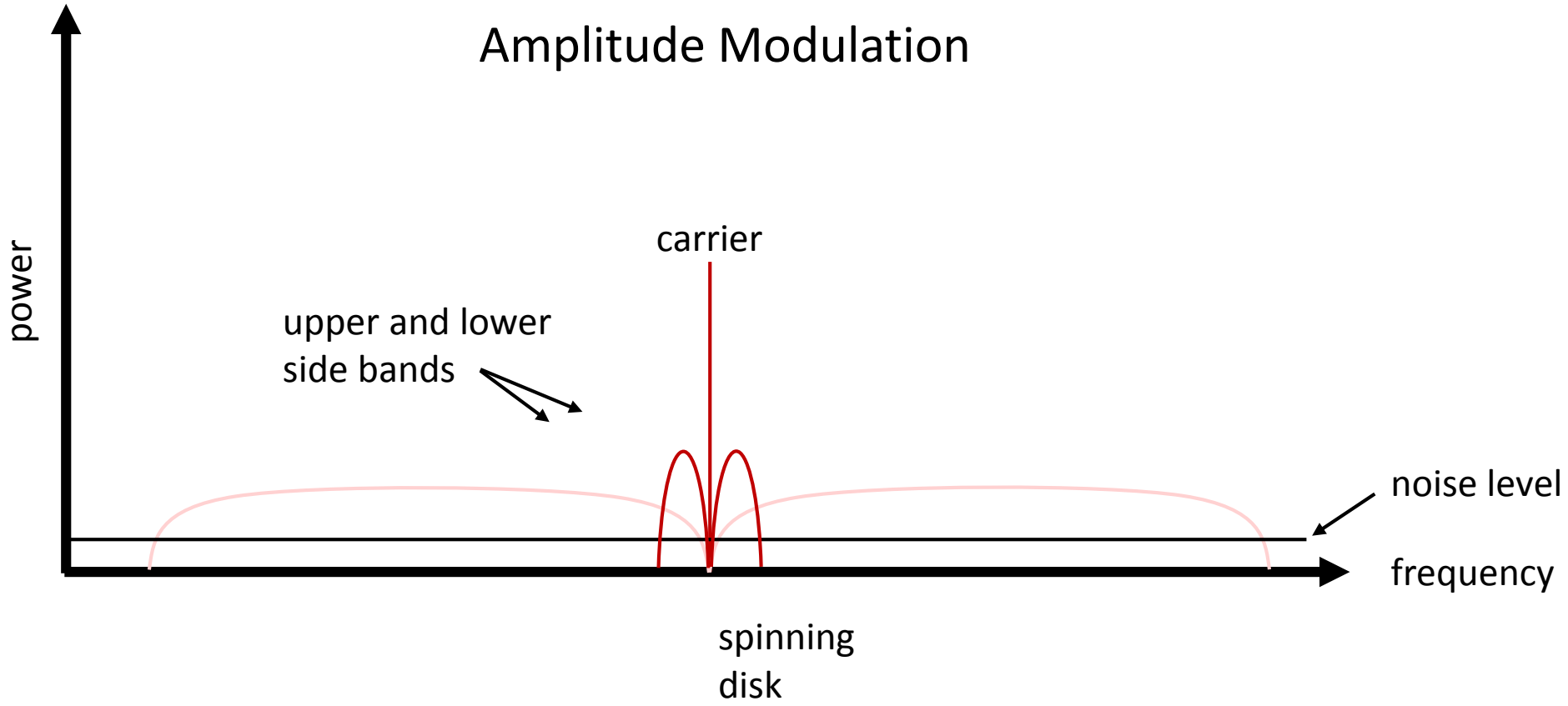
Amplitude Modulation



receiver has a copy of the spinning disk,
exactly synchronized

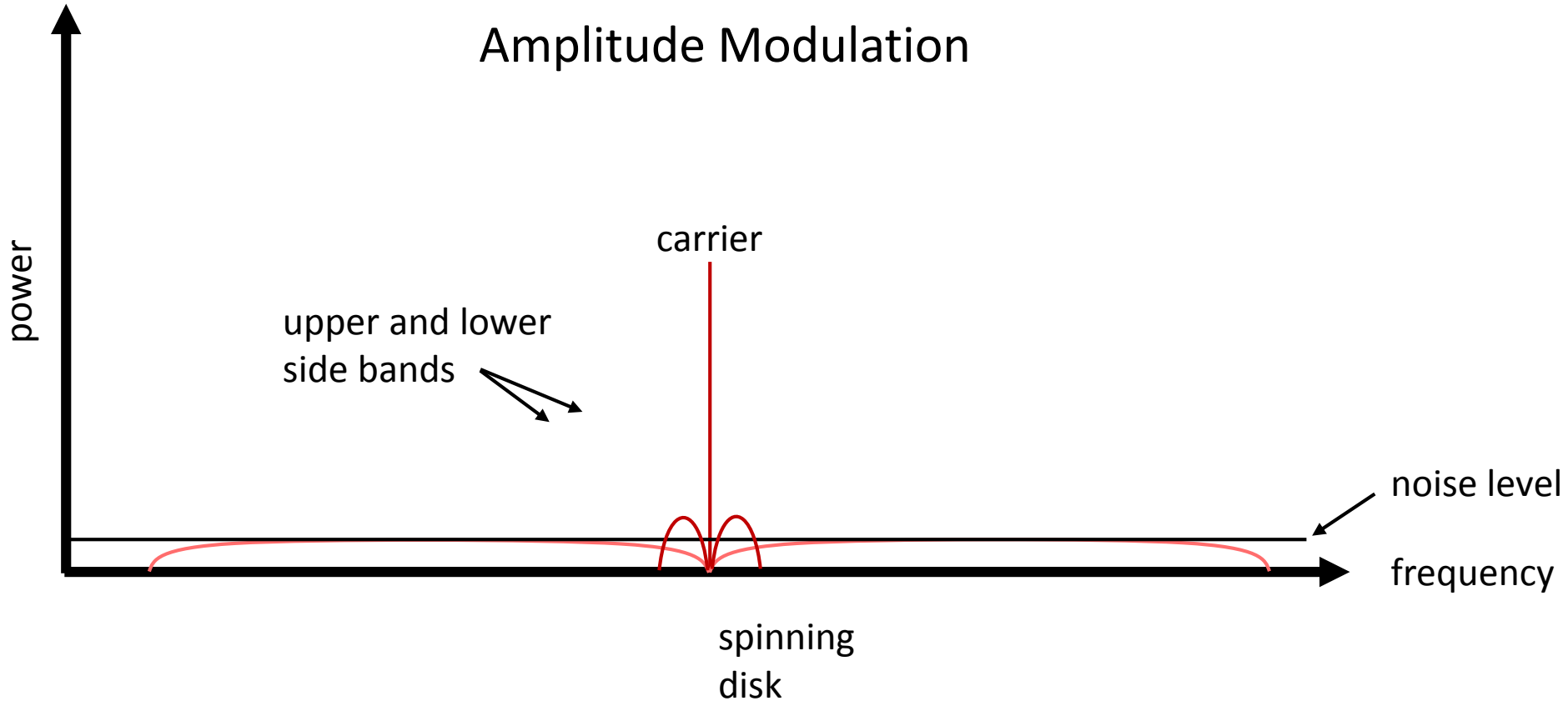
Spread Spectrum

Amplitude Modulation



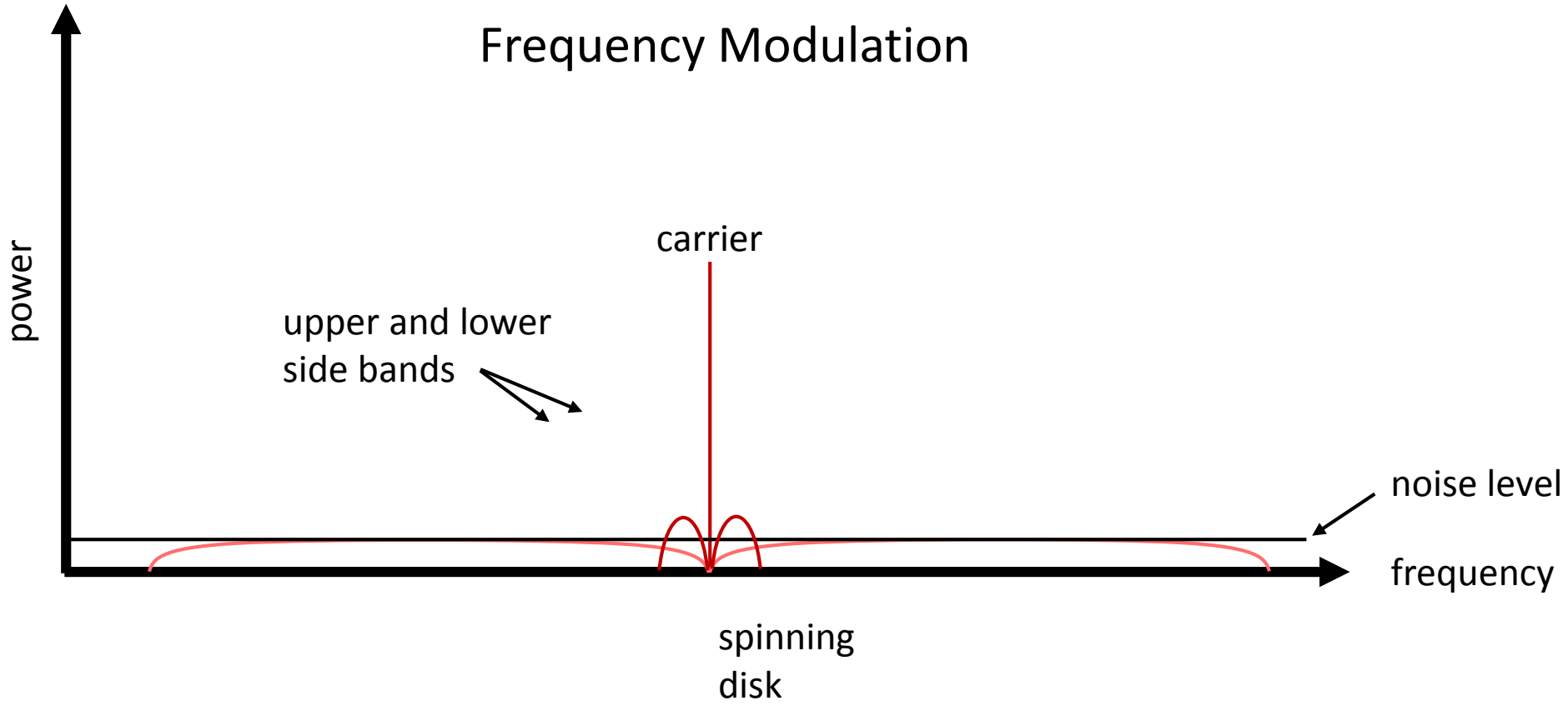
Spread Spectrum

Amplitude Modulation



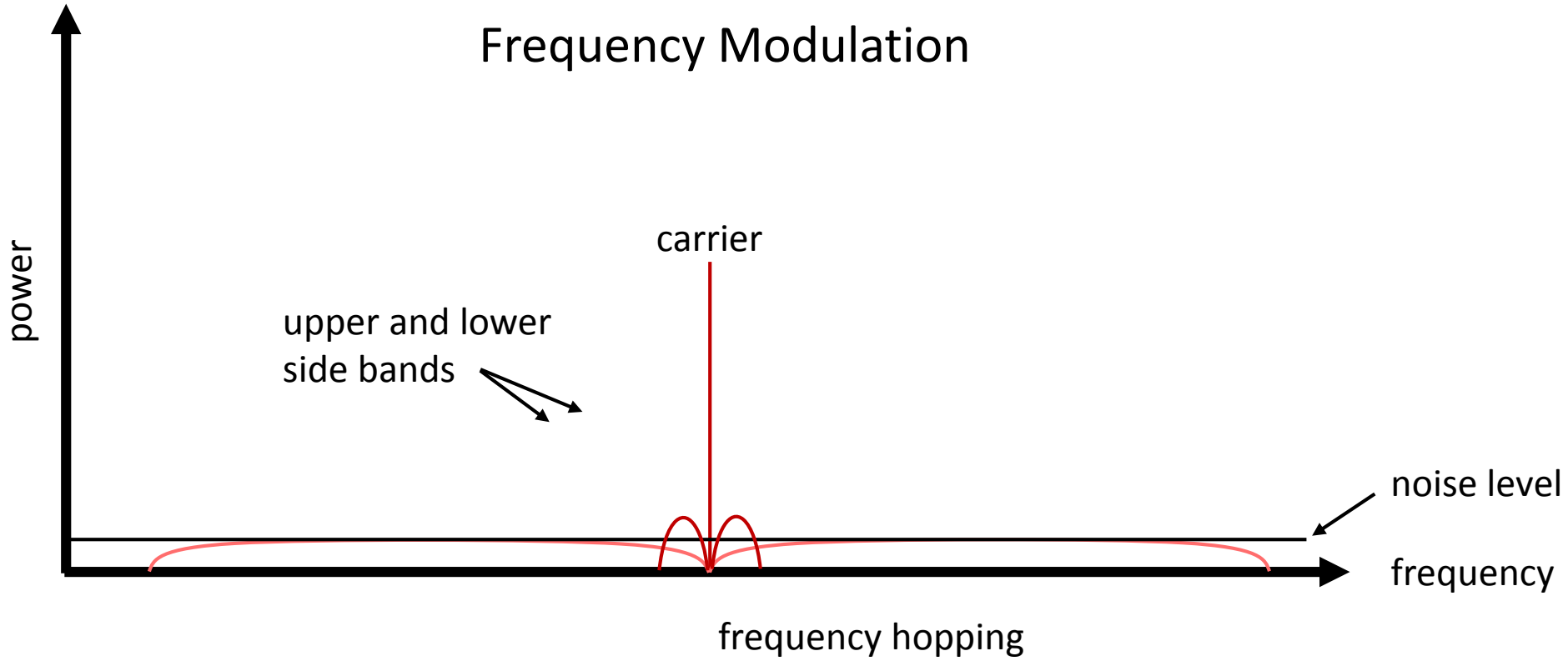
Spread Spectrum

Frequency Modulation



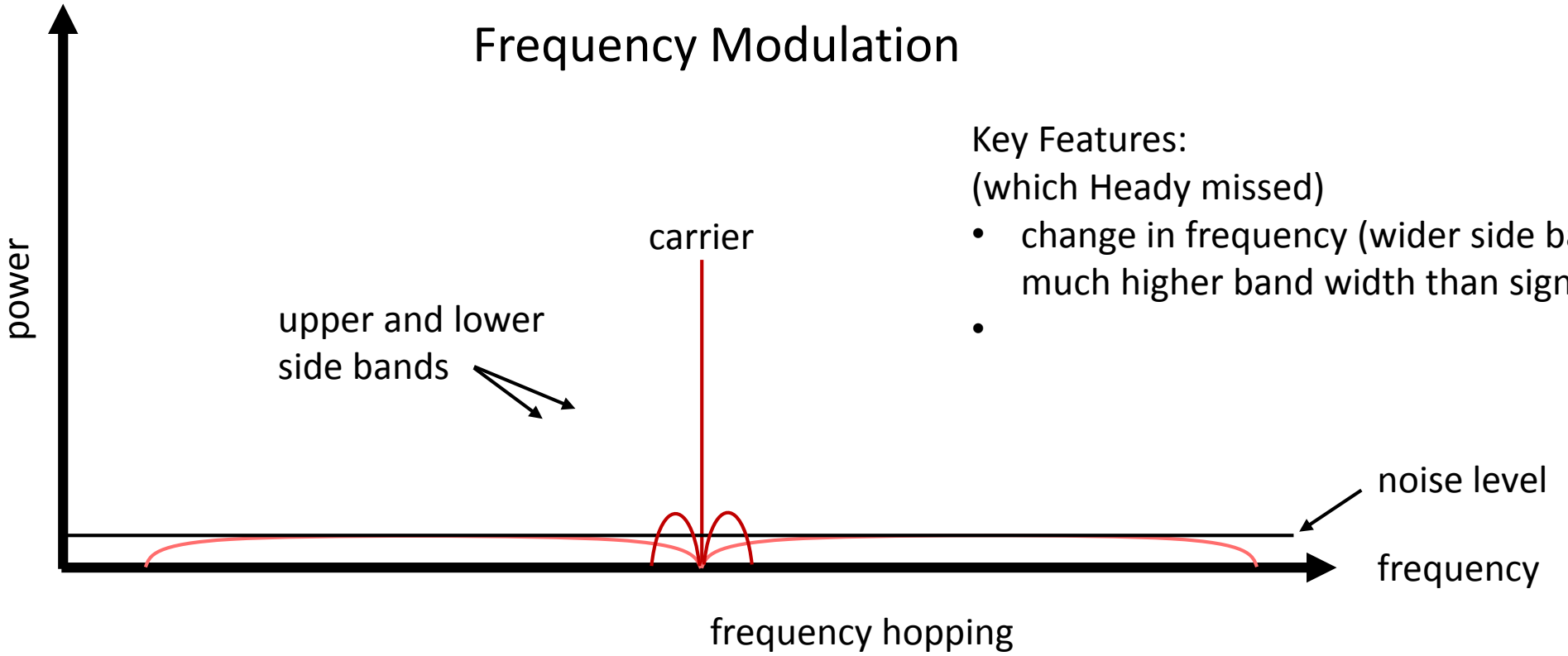
Spread Spectrum

Frequency Modulation



Spread Spectrum

Frequency Modulation

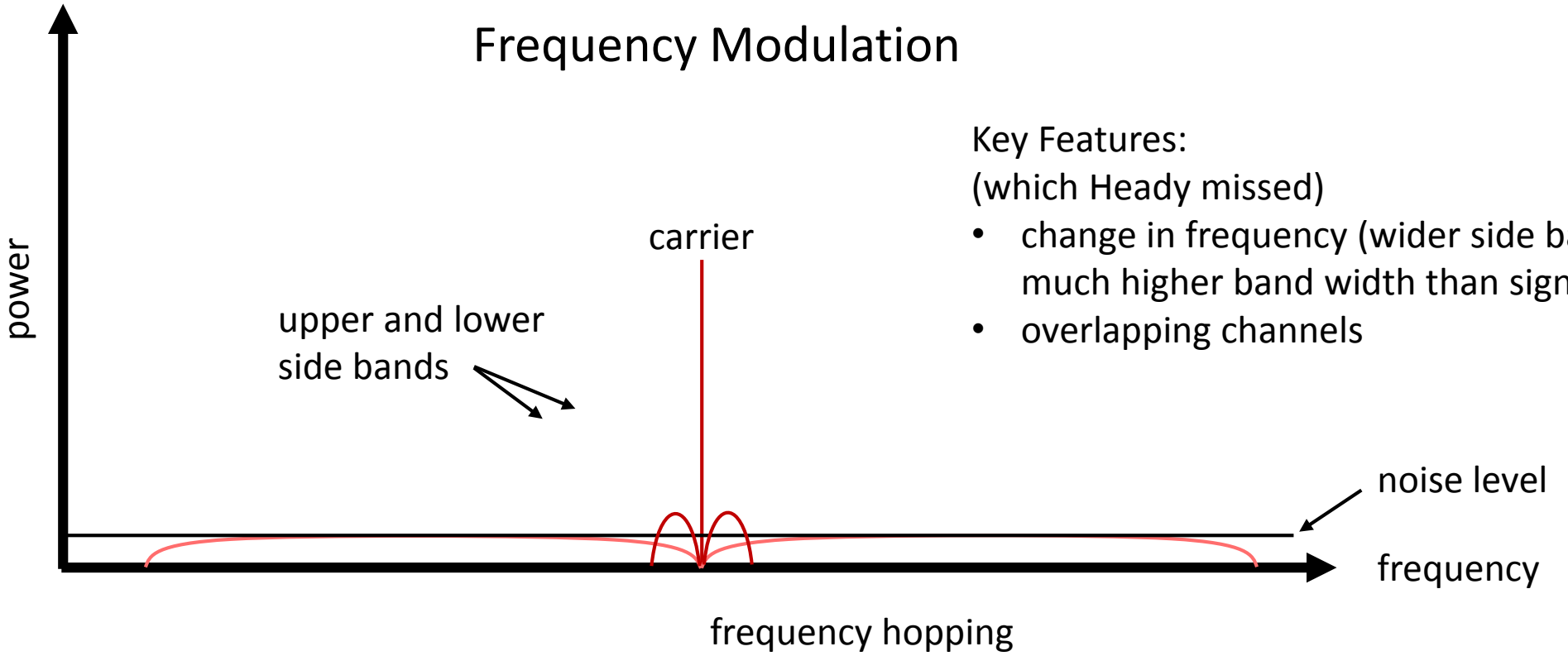


Key Features:
(which Heady missed)

- change in frequency (wider side band) is a much higher band width than signal
-

Spread Spectrum

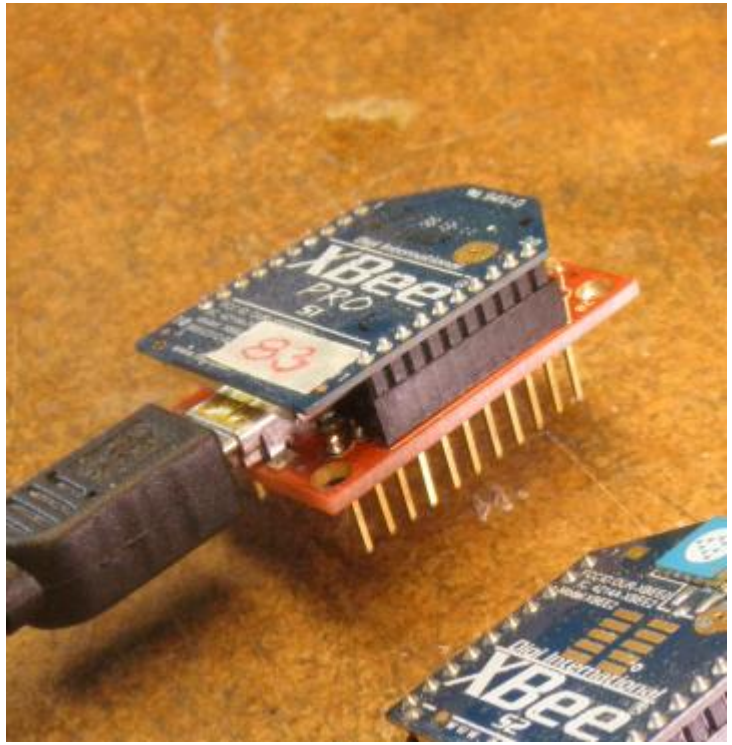
Frequency Modulation



Key Features:
(which Heady missed)

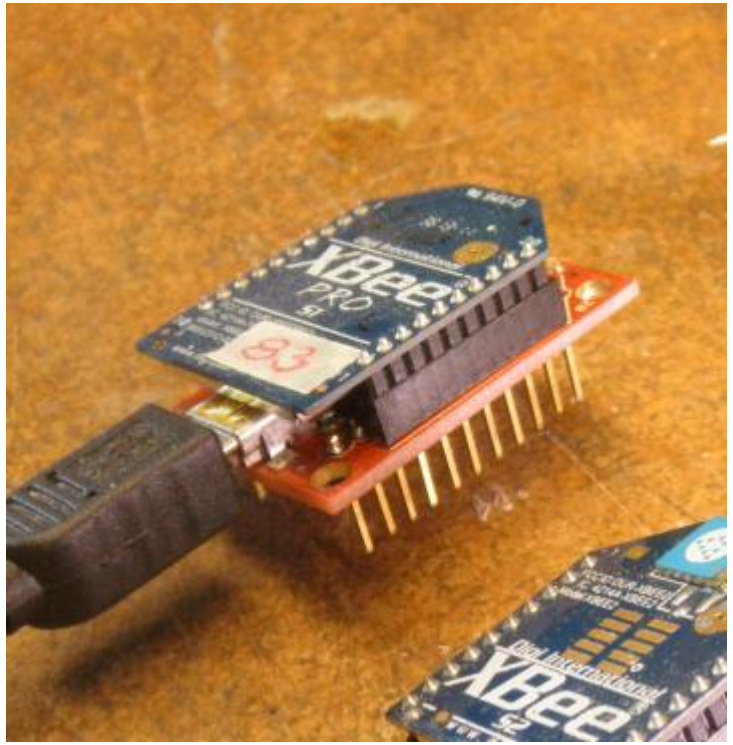
- change in frequency (wider side band) is a much higher band width than signal
- overlapping channels

Now Begins the Tutorial that Teaches XBee Wiring and Configuration



Confusion:

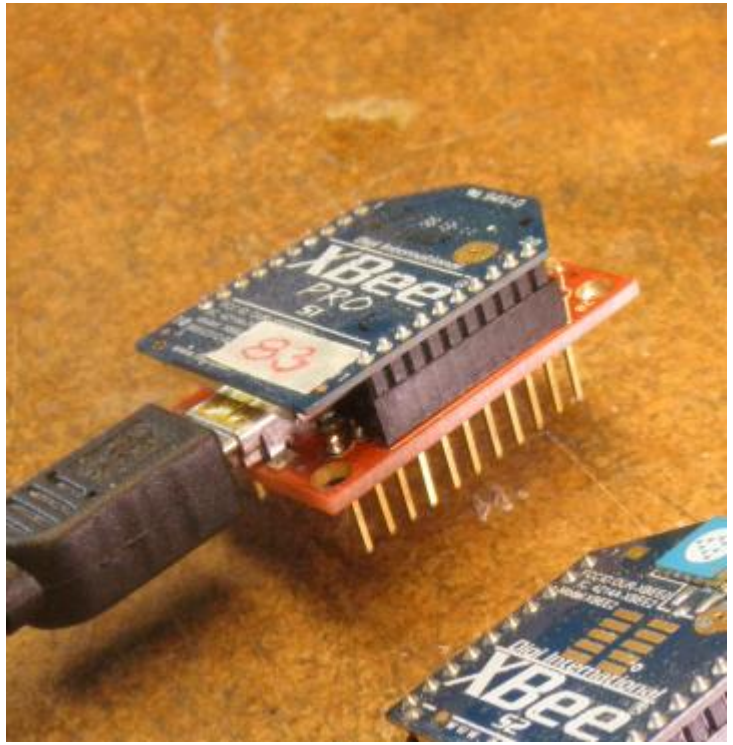
Pin numbers on the Explorer do not correspond to pin numbers on the XBee.



Confusion:

Pin numbers on the Explorer do not correspond to pin numbers on the XBee.

Rely on graphic notes, not logic or memorization.

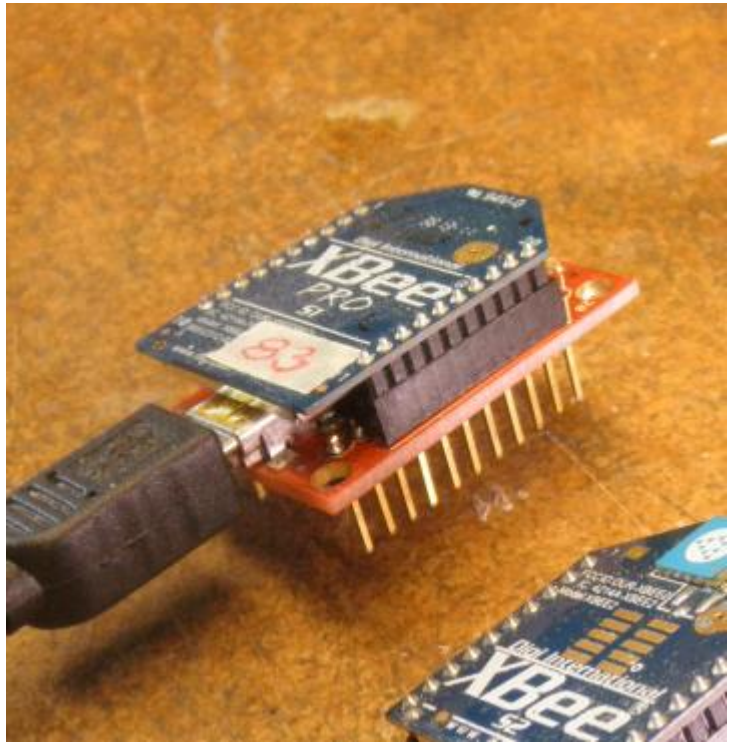


Confusion:

Pin numbers on the Explorer do not correspond to pin numbers on the XBee.

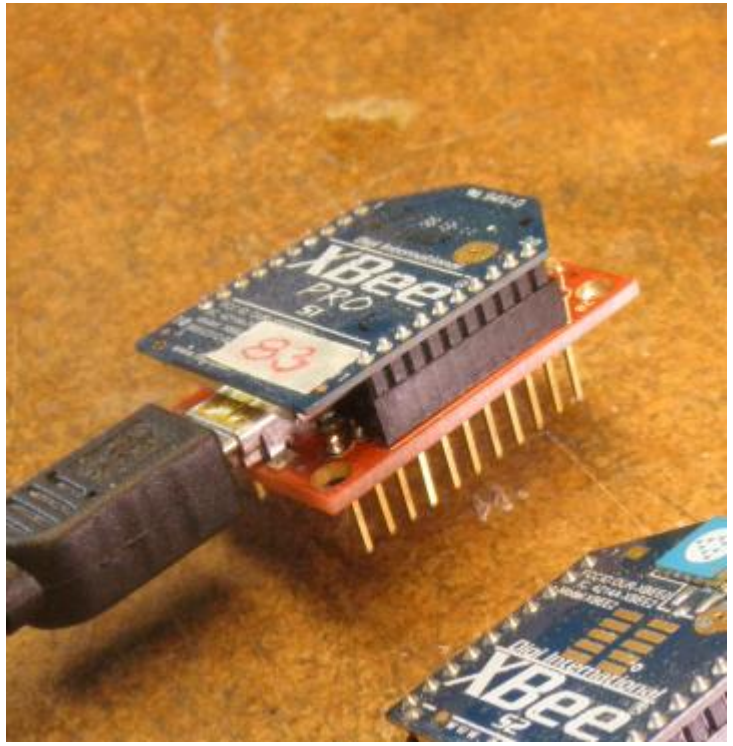
Rely on graphic notes, not logic or memorization.

Most work with XBees and certainly all initial work with XBees will be with an interface board.



Rely on graphic notes, not logic or memorization.

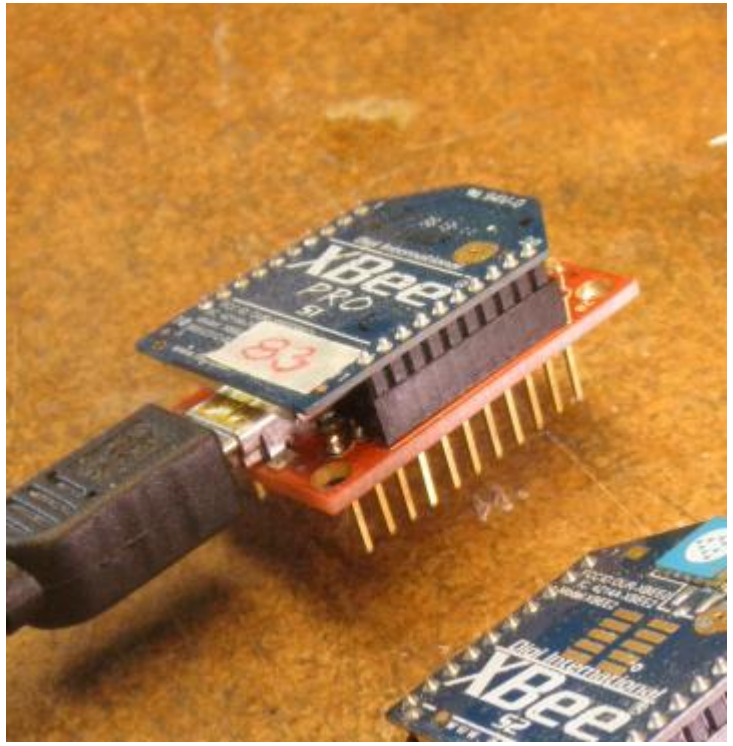
Most work with XBees and certainly all initial work with XBees will be with an interface board.



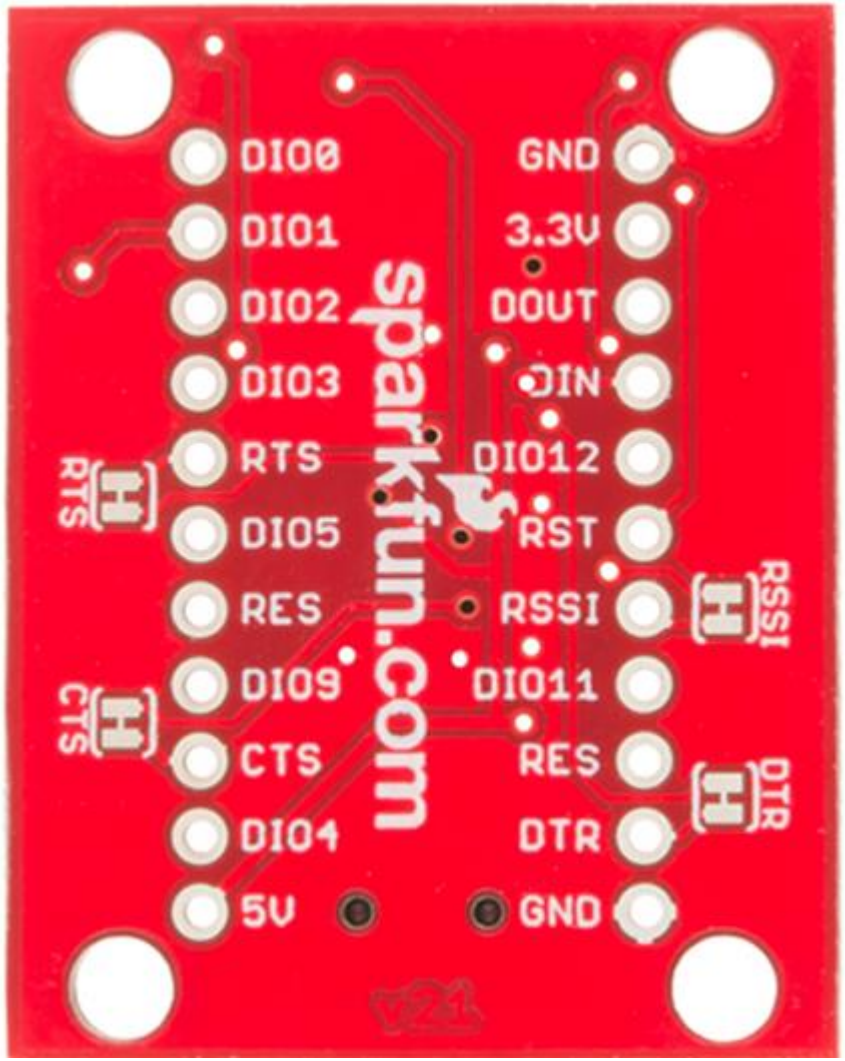
You can use the back side of a spare Explorer for which pins to use.

Rely on graphic notes, not logic or memorization.

Most work with XBees and certainly all initial work with XBees will be with an interface board.



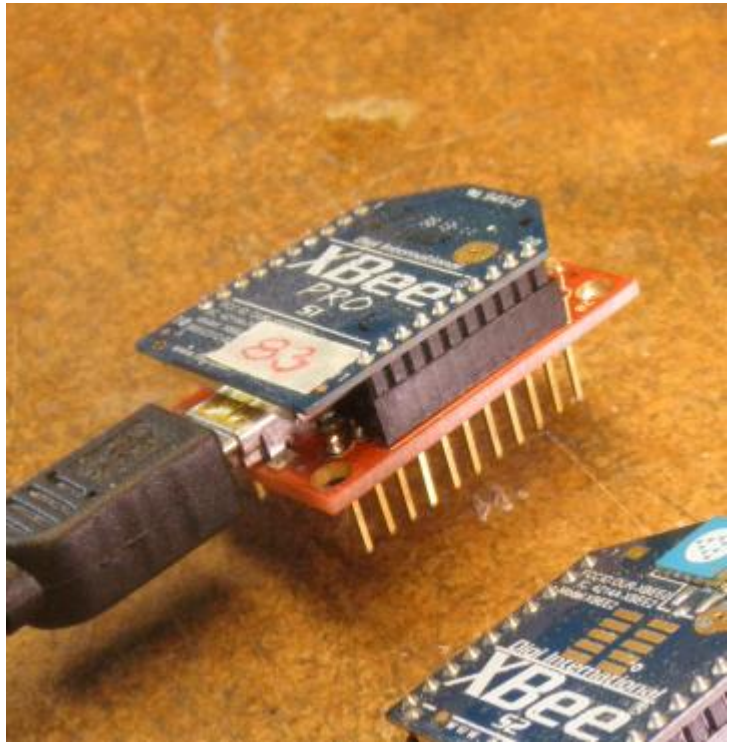
back side of explorer



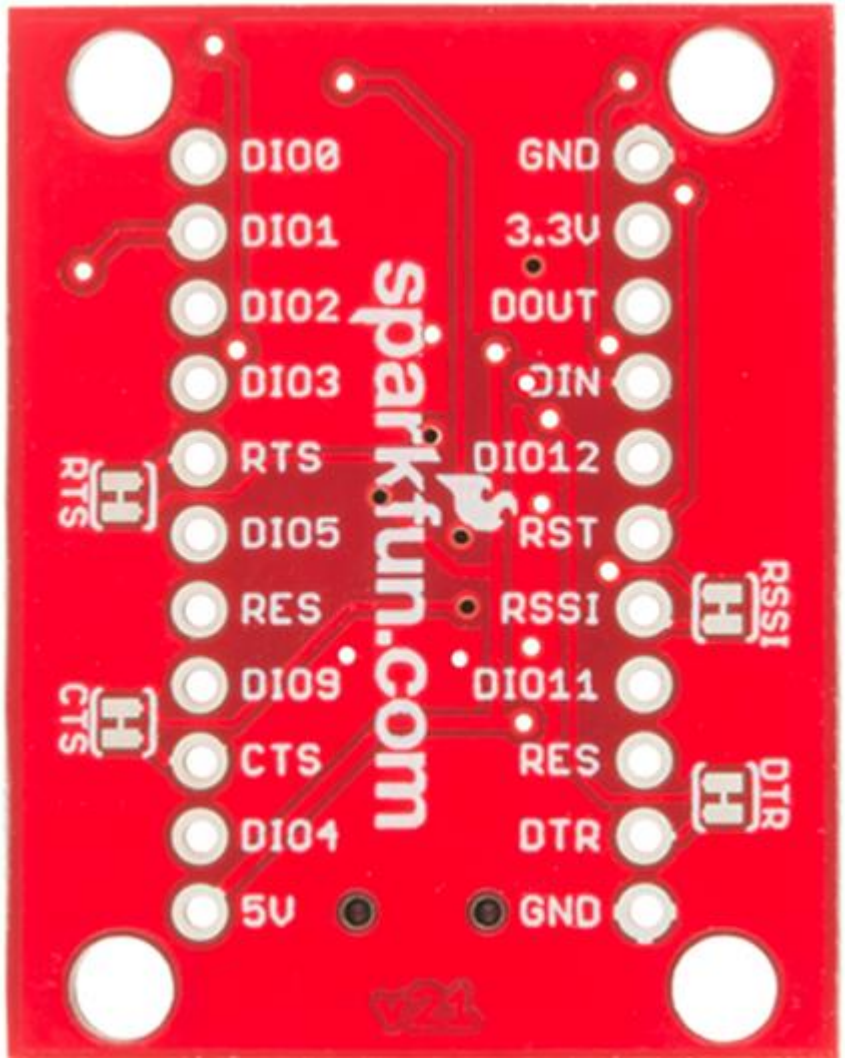
Rely on graphic notes, not logic or memorization.

Most work with XBees and certainly all initial work with XBees will be with an interface board.

Since this slide show is about initial work ONLY Explorer pin numbers will be referenced.



back side of explorer

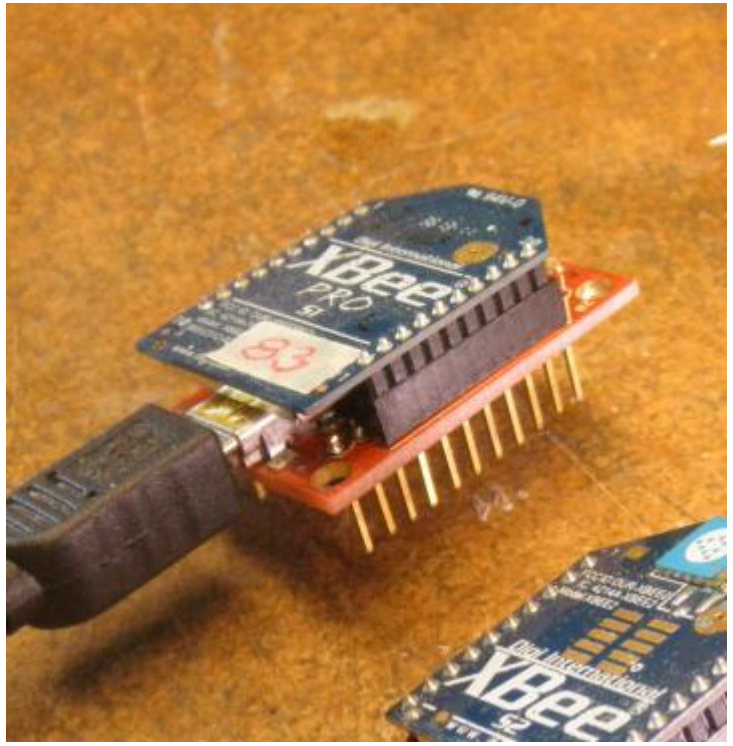


Rely on graphic notes, not logic or memorization.

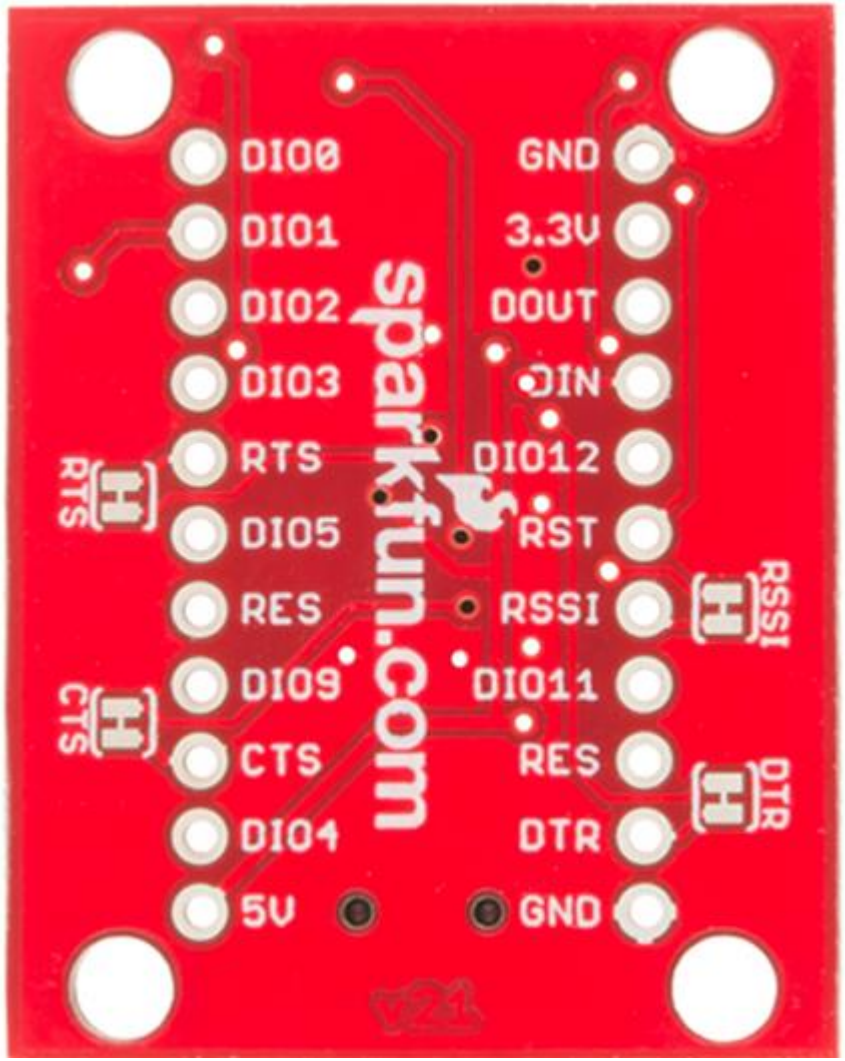
Most work with XBees and certainly all initial work with XBees will be with an interface board.

Since this slide show is about initial work ONLY Explorer pin numbers will be referenced.

Never XBee pin numbers.

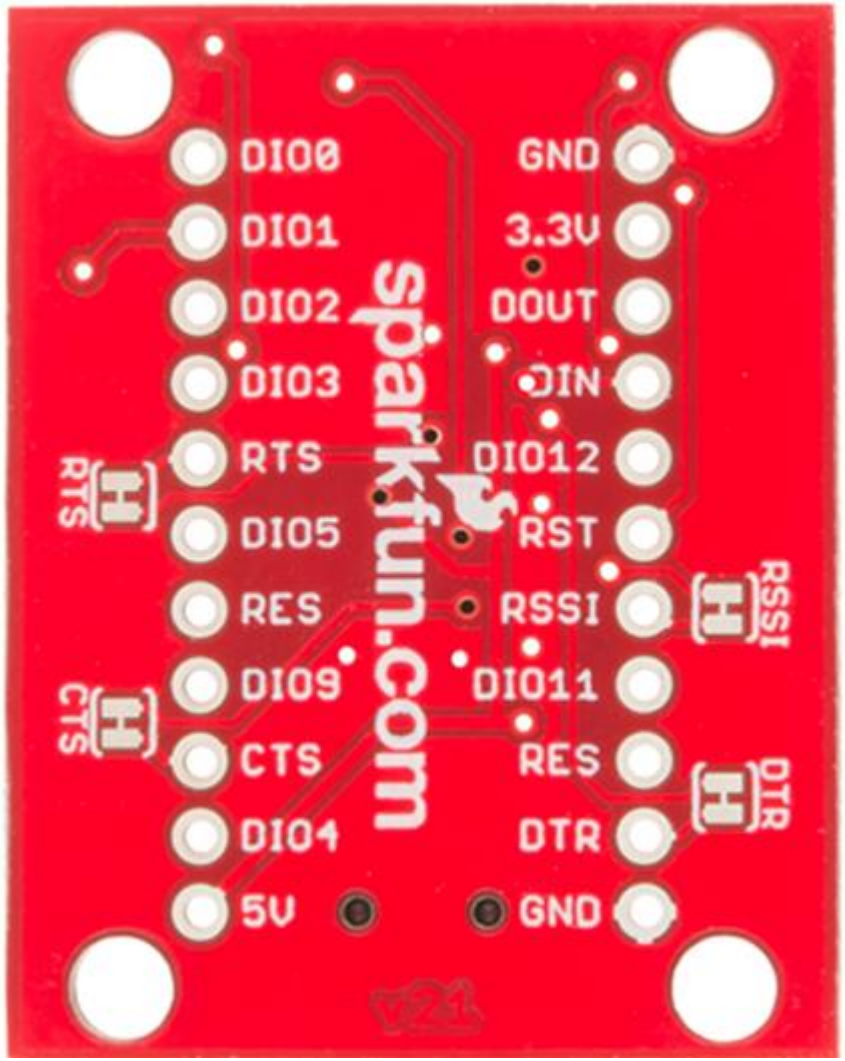


back side of explorer



Rely on graphic notes, not logic or memorization.

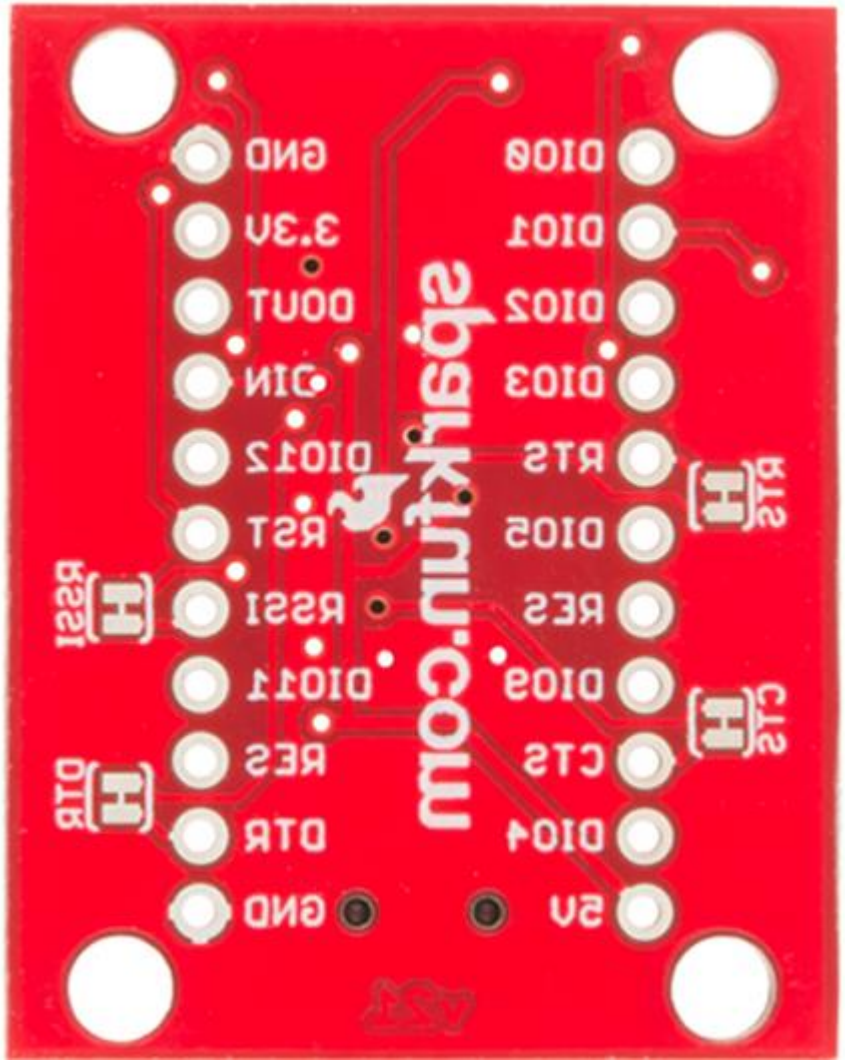
back side of explorer



watch this . . .

Rely on graphic notes, not logic or memorization.

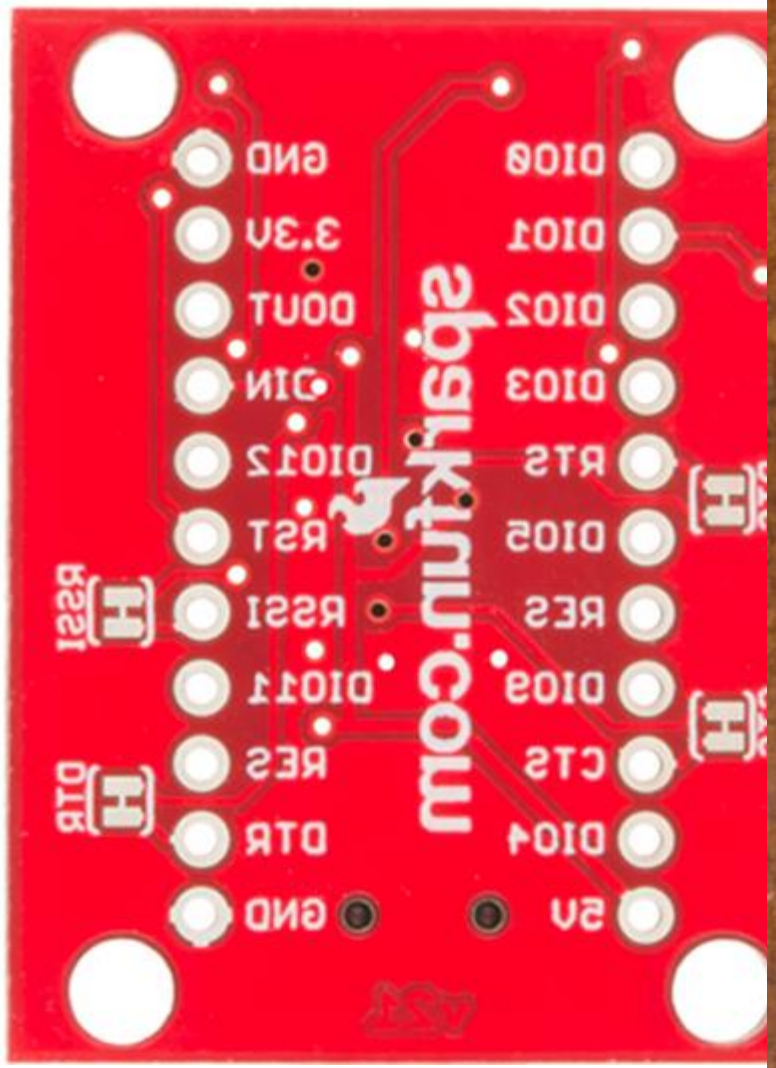
flipped over

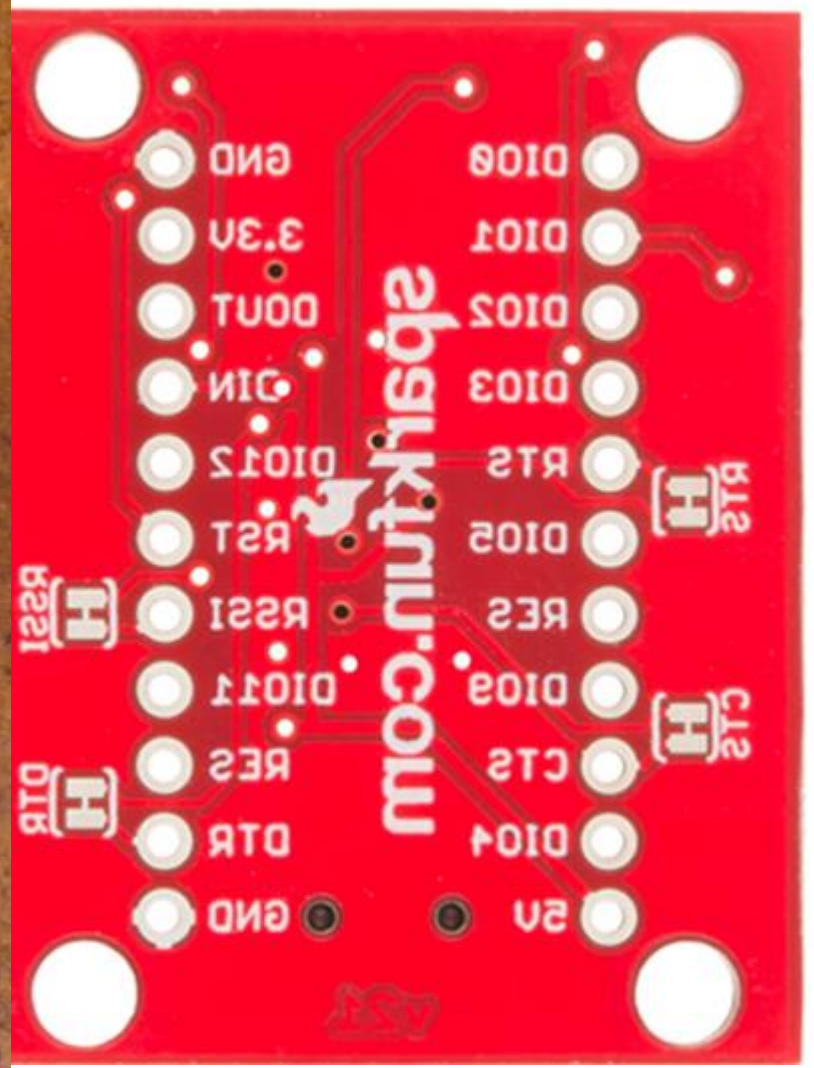


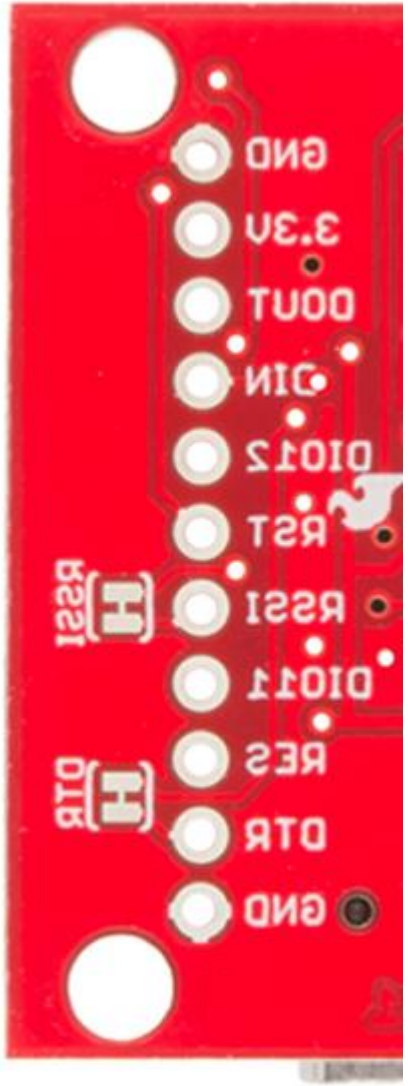
watch this . . .

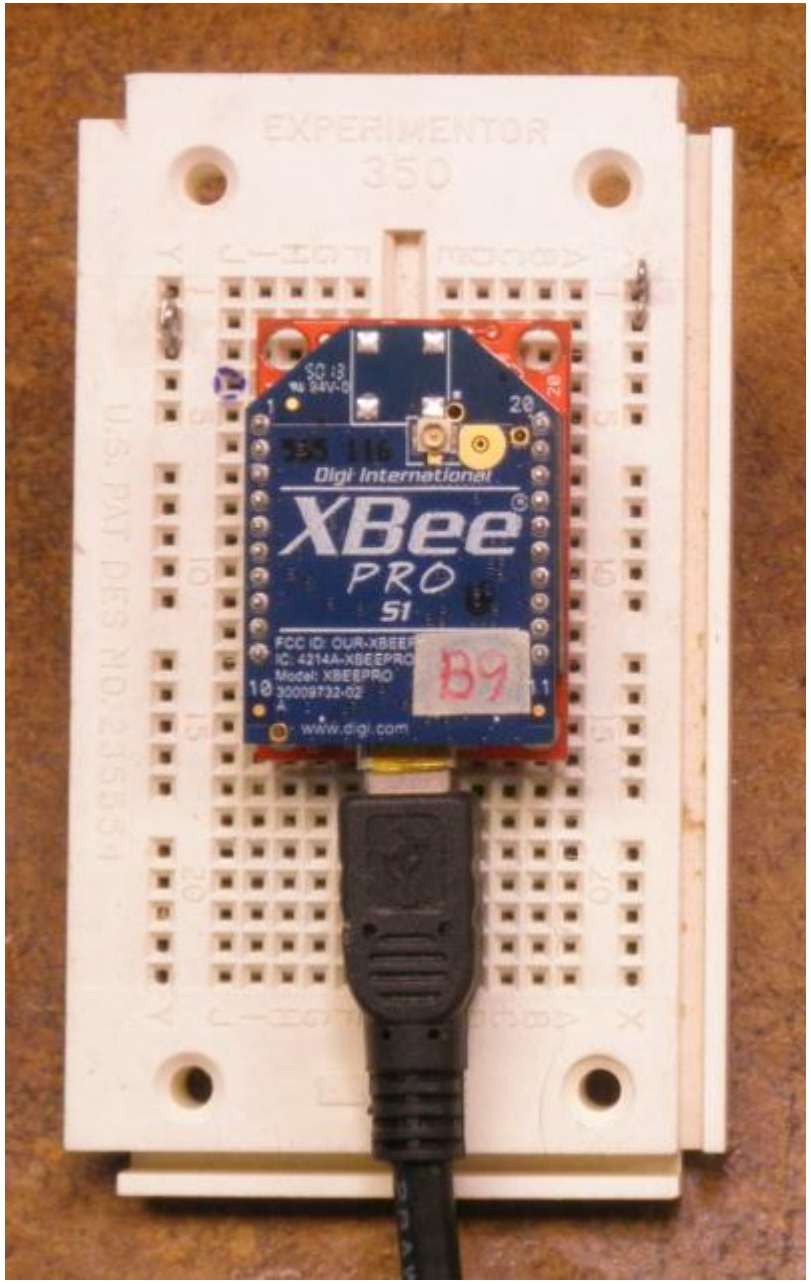
Rely on graphic notes, not logic or memorization.

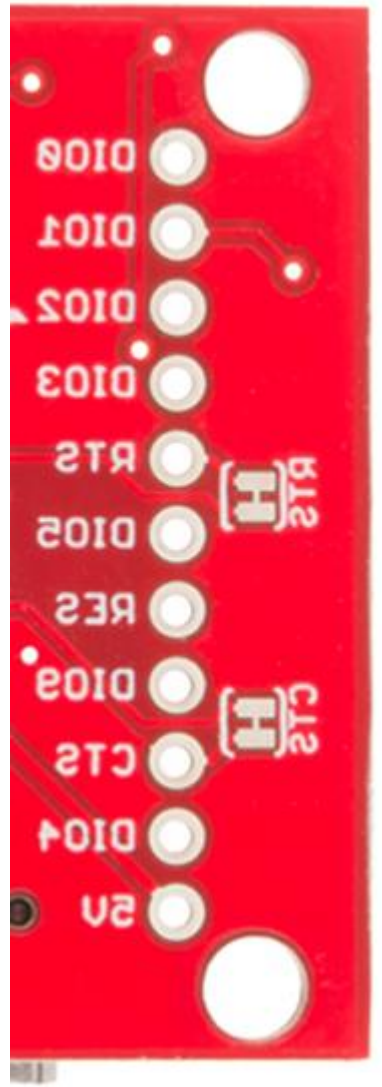
flipped over

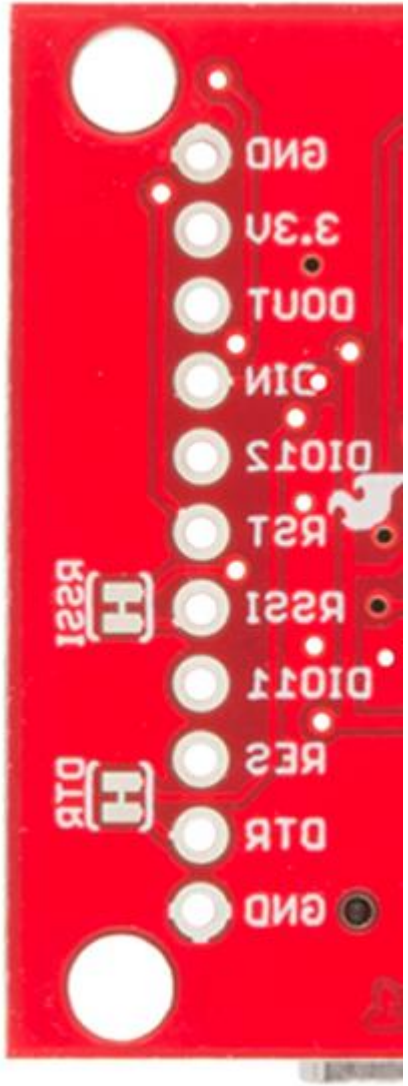




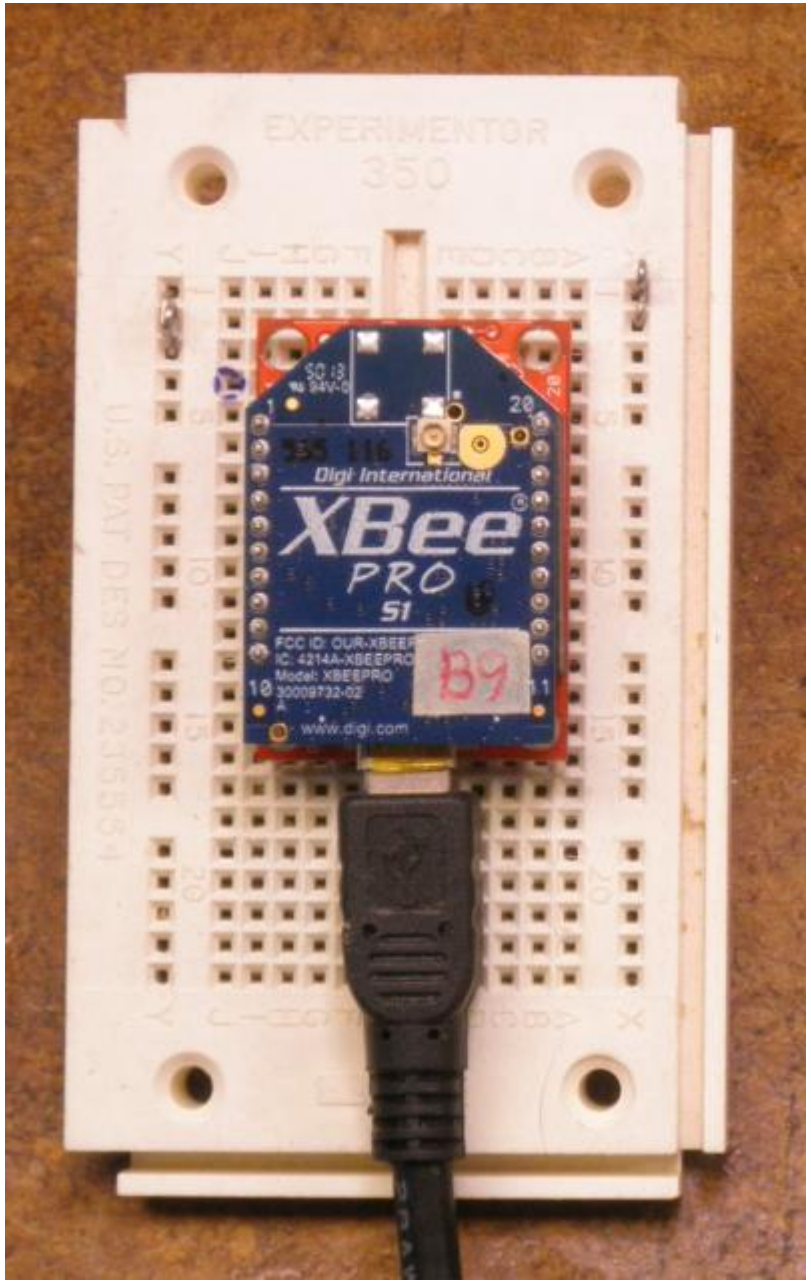

GND
3.3V
DOUT
DIN
DIO12
RST
RSSI
DIO11
RES
DTR
GND
RSSI
DTR


EXPERIMENTOR
350
Digi International
XBee
PRO
S1
B9
www.digi.com

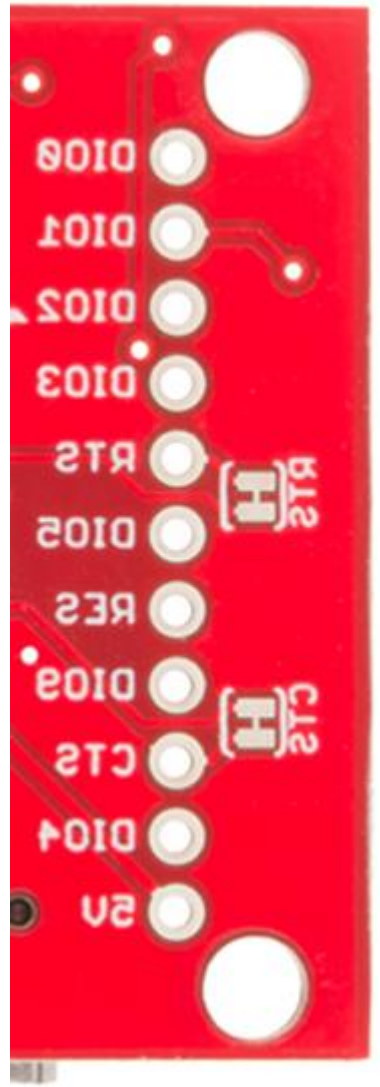

DIO0
DIO1
DIO2
DIO3
RTS
DIO5
RES
DIO6
CTS
DIO4
5V
RTS
CTS



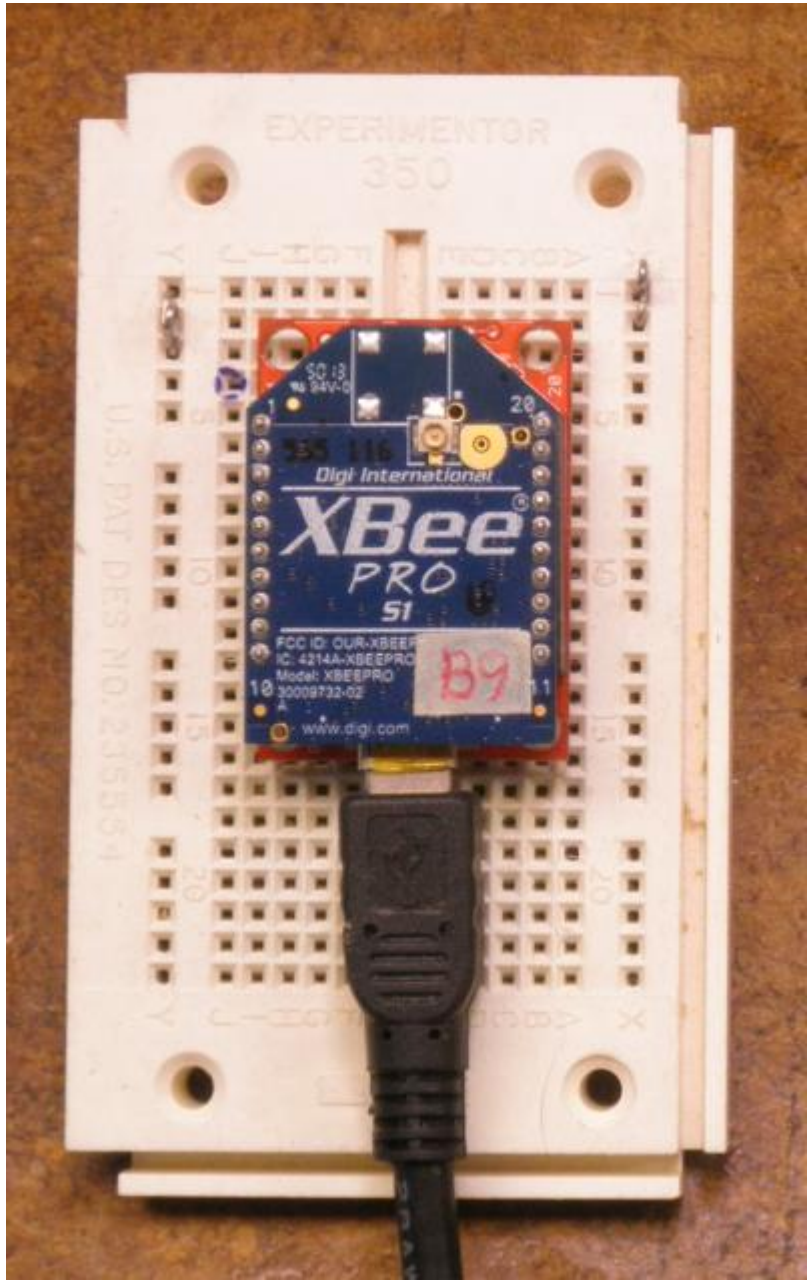
GND
3.3V (out)
DOUT
DIN
DIO12
RST
RSSI
DIO11
RES
DTR
GND



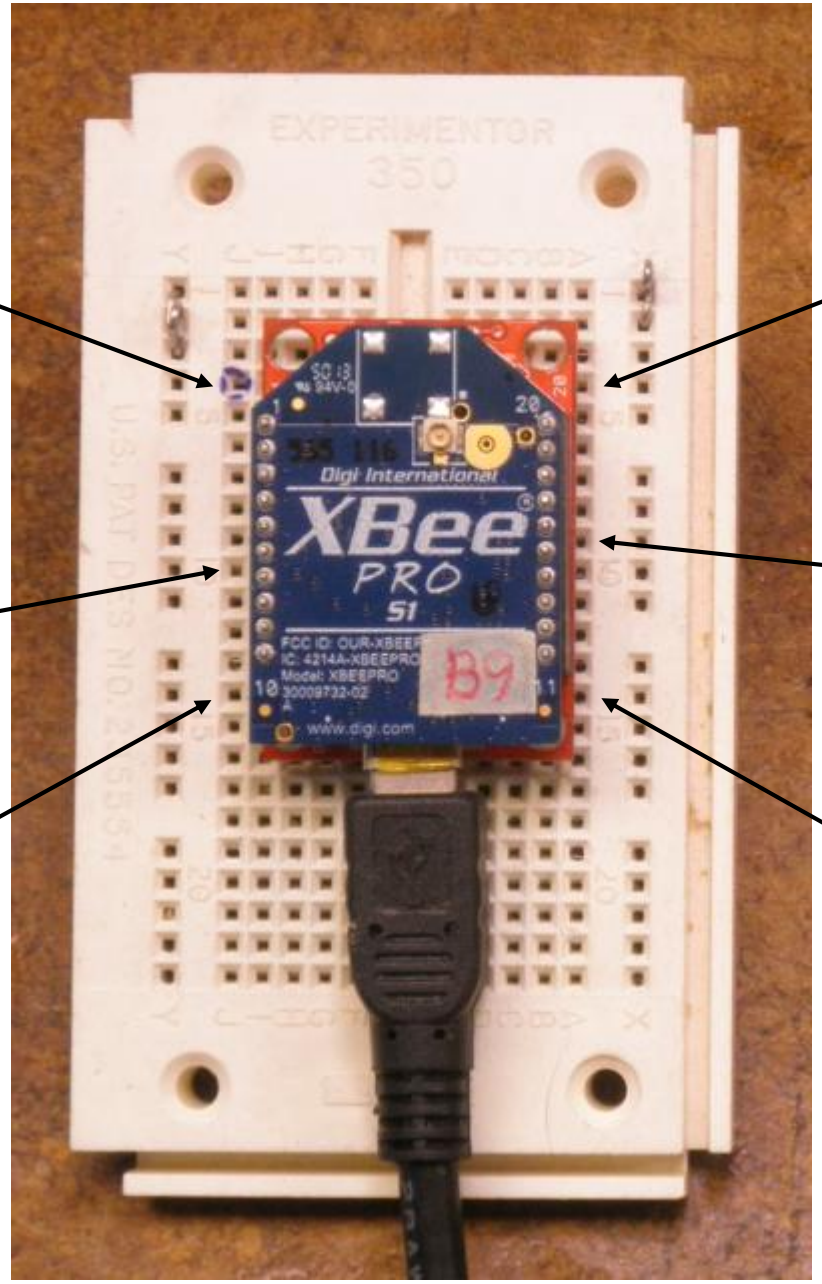
DIO0
DIO1
DIO2
DIO3
RTS
DIO5
RES
DIO6
CTS
DIO4
5.0 V

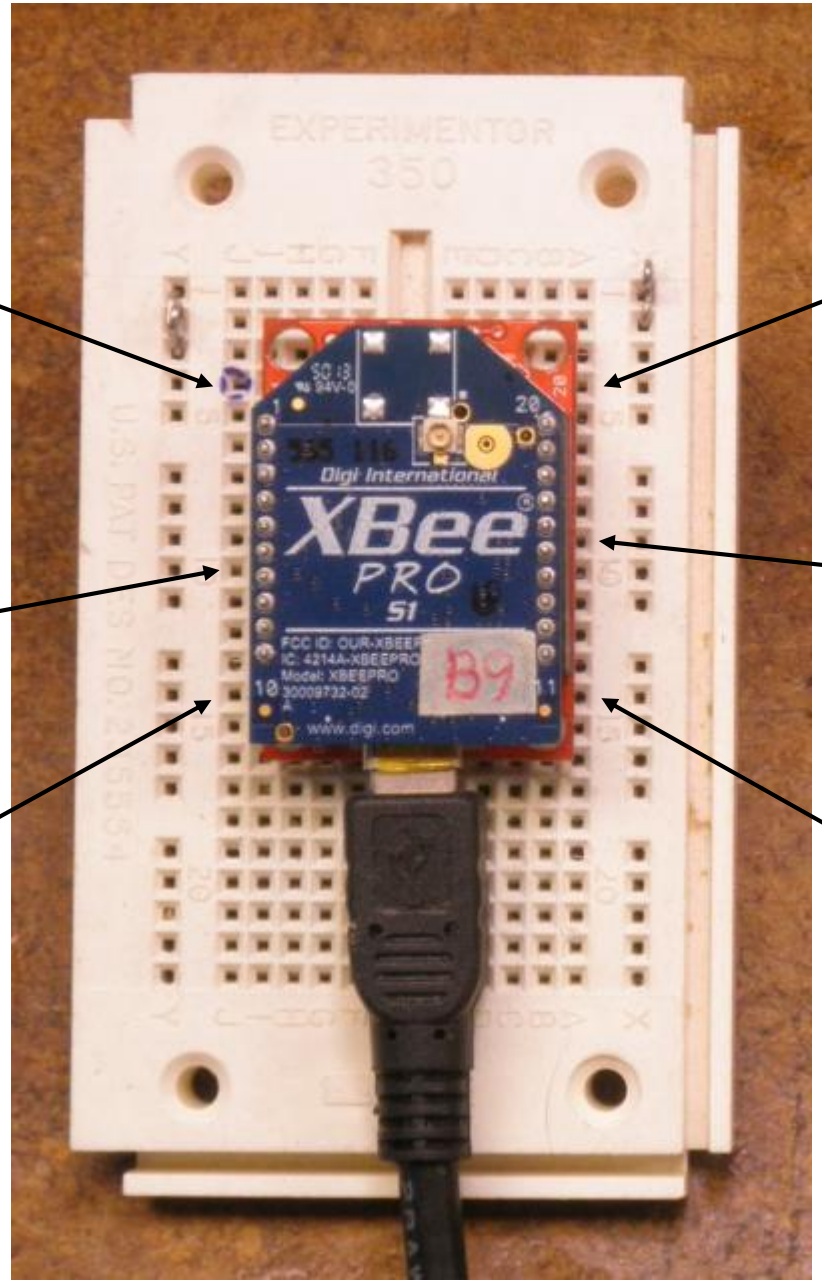


GND	DIO0
3.3V (out)	DIO1
DOUT	DIO2
DIN	DIO3
DIO12	RTS
RST	DIO5
RSSI	RES
DIO11	DIO6
RES	CTS
DTR	DIO4
GND	5.0 V

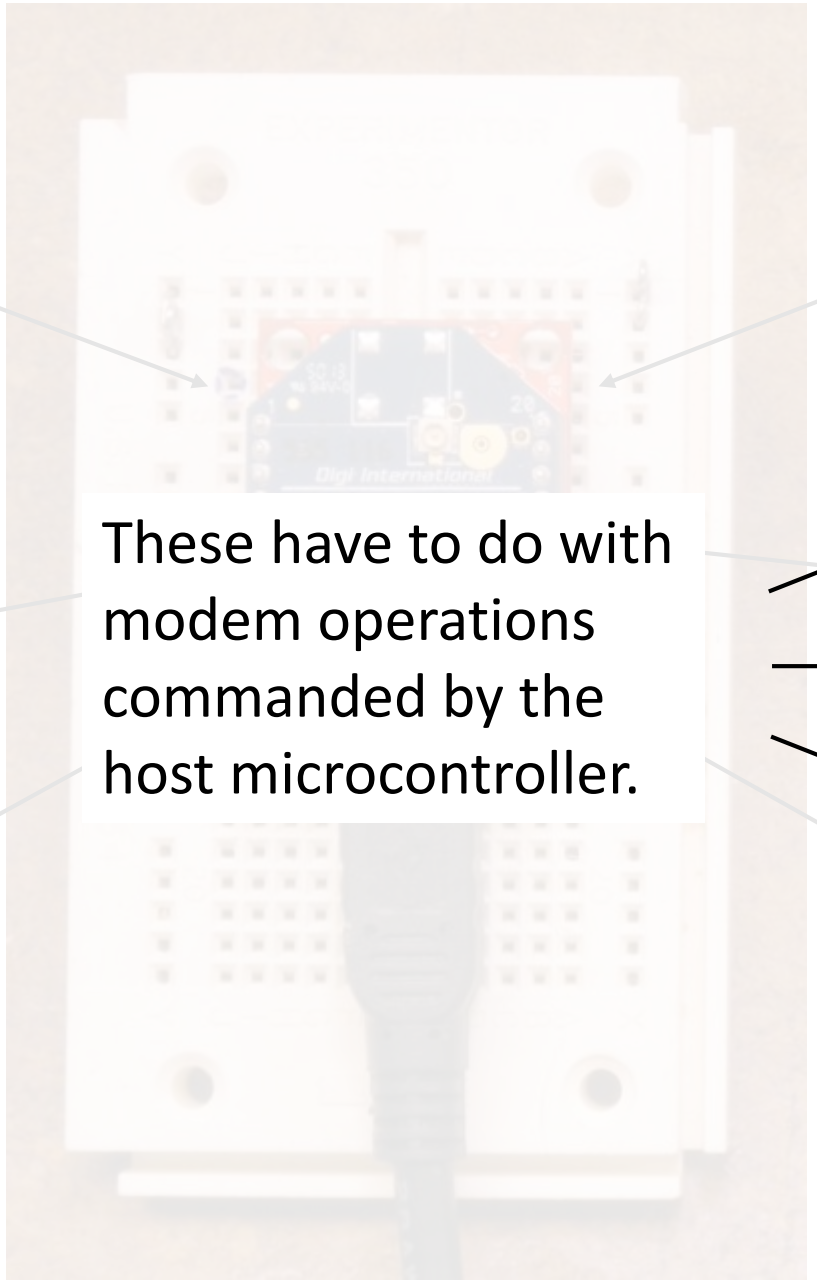


1	GND			DIO0	1
2	3.3V (out)			DIO1	2
3	DOUT			DIO2	3
4	DIN			DIO3	4
5	DIO12		RTS	DIO6	5
6	/reset			DIO5	6
7	RSSI		RES	Vref	7
8	DIO11			DIO6	8
9	(reserved)		CTS	DIO7	9
10	/DTR			DIO4	10
11	GND			5.0 V	11





1	GND		DIO0	1
2	3.3V (out)		DIO1	2
3	DOUT	alternate functions	DIO2	3
4	DIN		DIO3	4
5	DIO12	RTS	DIO6	5
6	/reset		DIO5	6
7	RSSI	RES	Vref	7
8	DIO11		DIO6	8
9	(reserved)	CTS	DIO7	9
10	/DTR		DIO4	10
11	GND		5.0 V	11



1 GND
2 3.3V (out)
3 DOUT
4 DIN
5 DIO12
6 /reset
7 RSSI
8 DIO11
9 (reserved)
10 /DTR
11 GND

DIO0 1
DIO1 2
DIO2 3
DIO3 4
DIO6 5
DIO5 6
Vref 7
DIO6 8
DIO7 9
DIO4 10
5.0 V 11

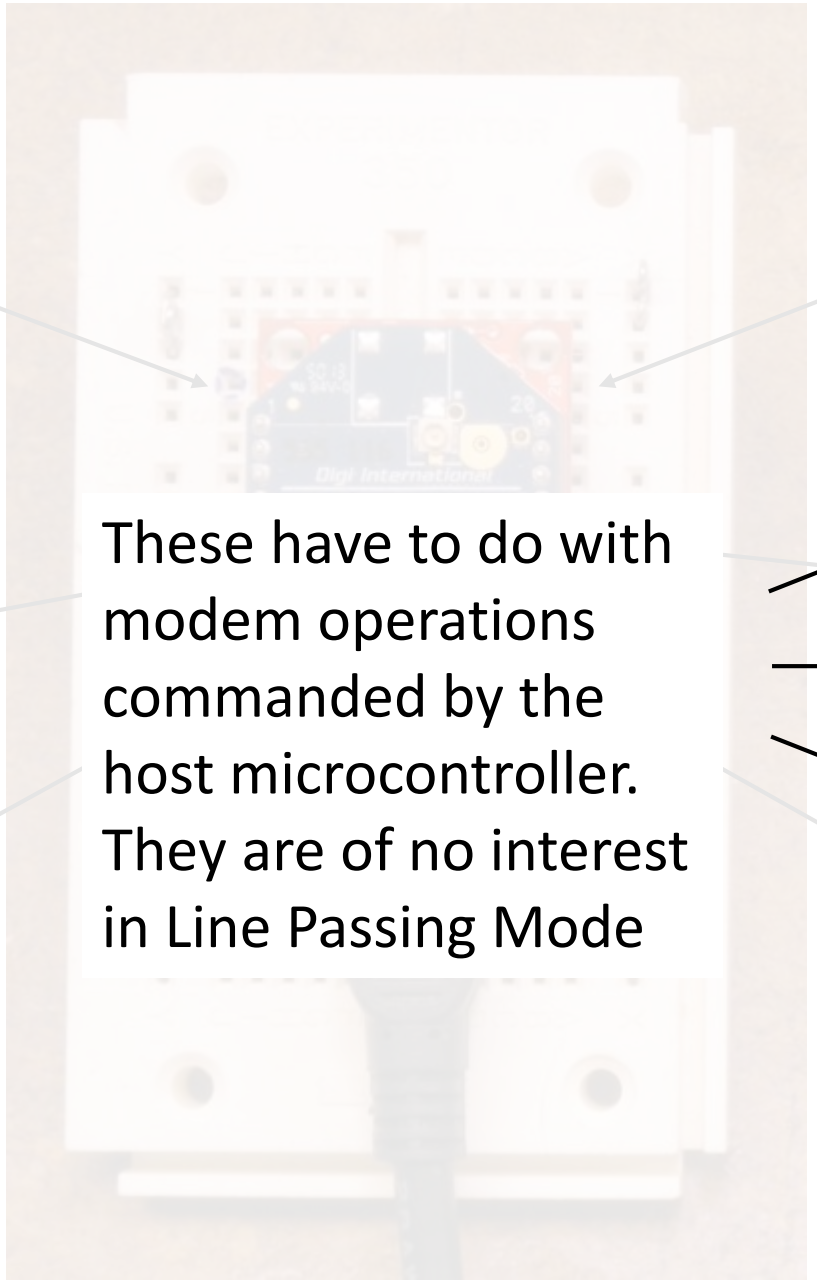
alternate functions

These have to do with modem operations commanded by the host microcontroller.

RTS

RES

CTS



1 GND
2 3.3V (out)
3 DOUT
4 DIN
5 DIO12
6 /reset
7 RSSI
8 DIO11
9 (reserved)
10 /DTR
11 GND

DIO0 1
DIO1 2
DIO2 3
DIO3 4
DIO6 5
DIO5 6
Vref 7
DIO6 8
DIO7 9
DIO4 10
5.0 V 11

alternate functions

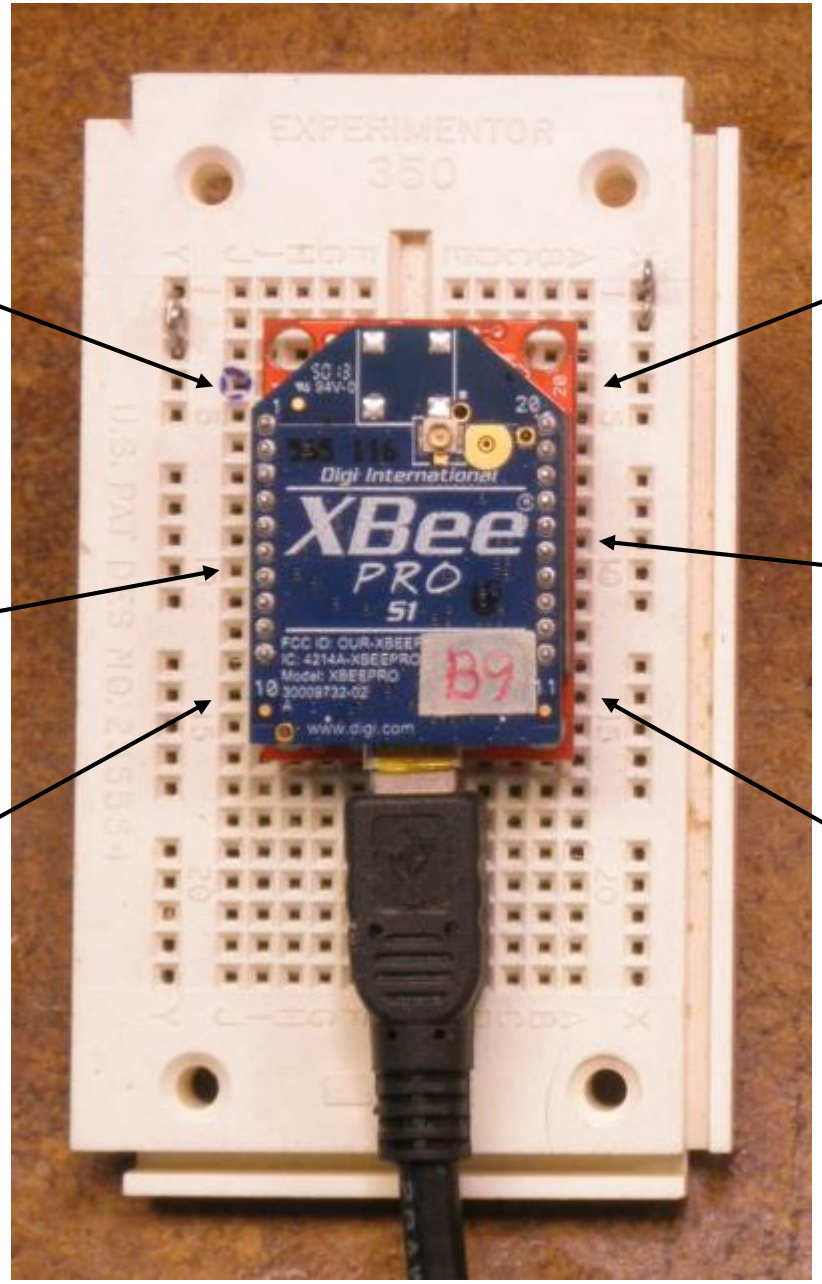
These have to do with modem operations commanded by the host microcontroller. They are of no interest in Line Passing Mode

RTS

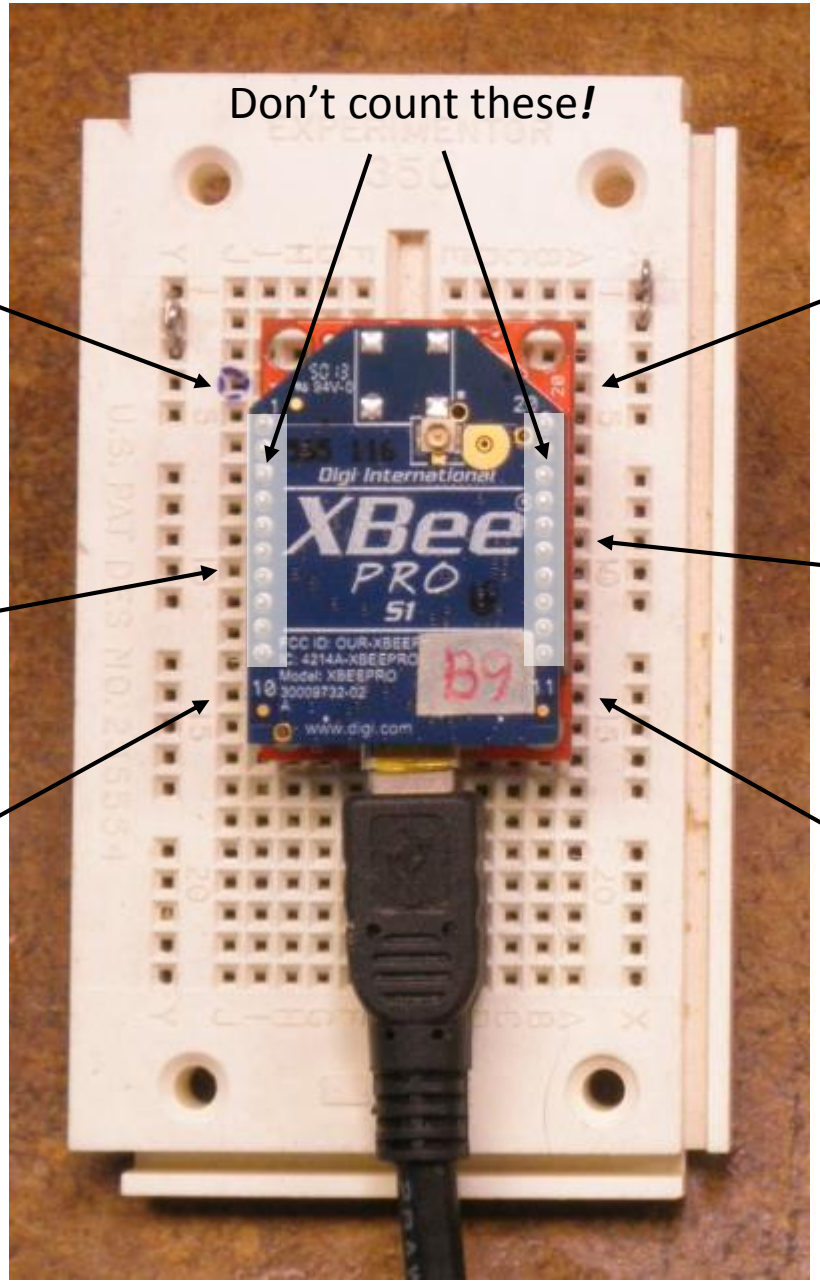
RES

CTS

left side		right side	
1	GND		DIO0 1
2	3.3V (out)		DIO1 2
3	DOUT		DIO2 3
4	DIN		DIO3 4
5	DIO12	RTS	DIO6 5
6	/reset		DIO5 6
7	RSSI	RES	Vref 7
8	DIO11		DIO6 8
9	(reserved)	CTS	DIO7 9
10	/DTR		DIO4 10
11	GND		5.0 V 11



1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND



	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

Between Two Arduinos

1	GND		DIO0	1
2	3.3V (out)		DIO1	2
3	DOUT		DIO2	3
4	DIN		DIO3	4
5	DIO12	RTS	DIO6	5
6	/reset		DIO5	6
7	RSSI	RES	Vref	7
8	DIO11		DIO6	8
9	(reserved)	CTS	DIO7	9
10	/DTR		DIO4	10
11	GND		5.0 V	11

Between Two Arduinos

1	GND			DIO0 1
2	3.3V (out)	← **These four are all you need.**		DIO1 2
3	DOUT			DIO2 3
4	DIN			DIO3 4
5	DIO12		RTS	DIO6 5
6	/reset			DIO5 6
7	RSSI		RES	Vref 7
8	DIO11			DIO6 8
9	(reserved)		CTS	DIO7 9
10	/DTR			DIO4 10
11	GND			5.0 V 11

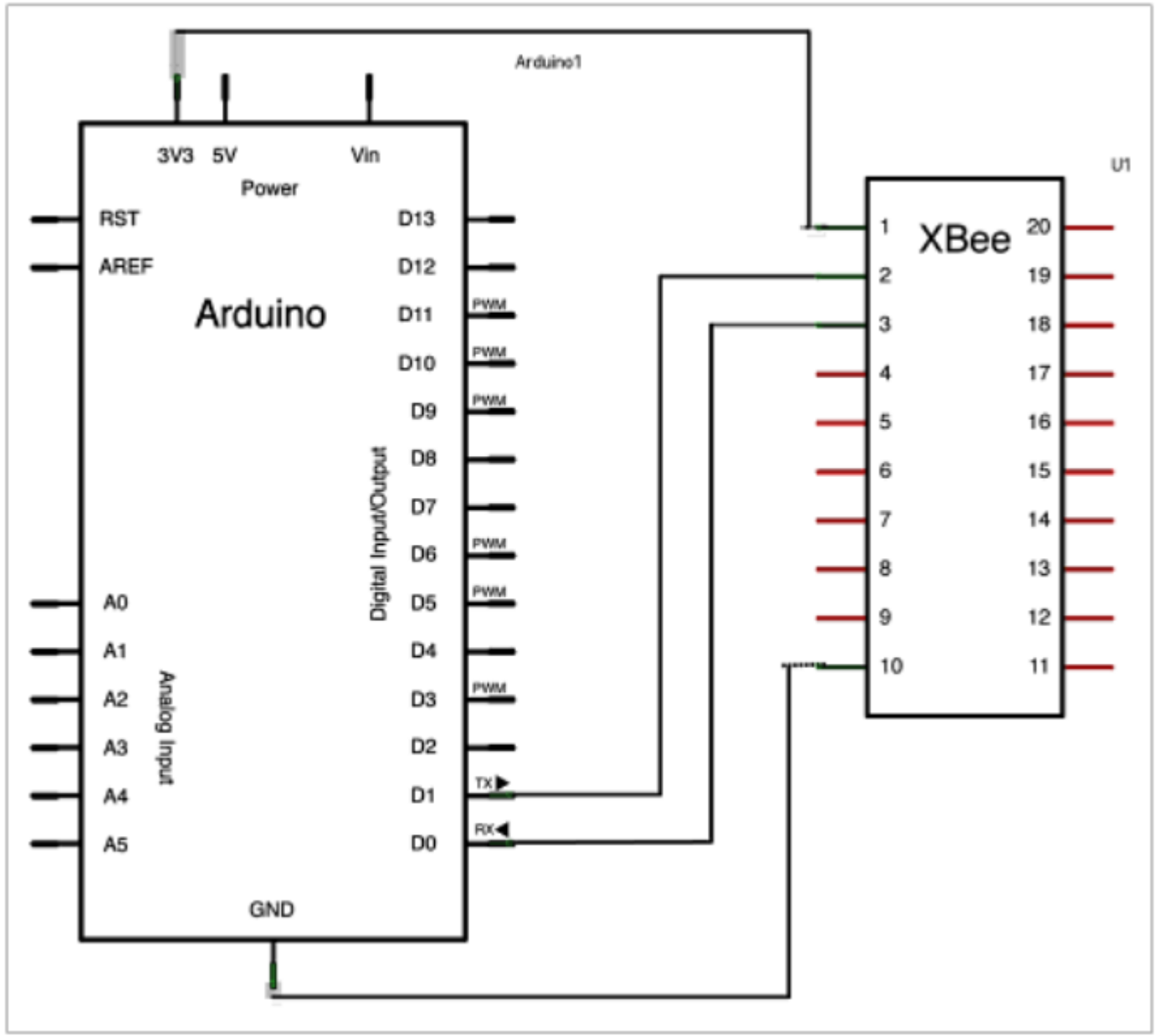
Between Two Arduinos

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

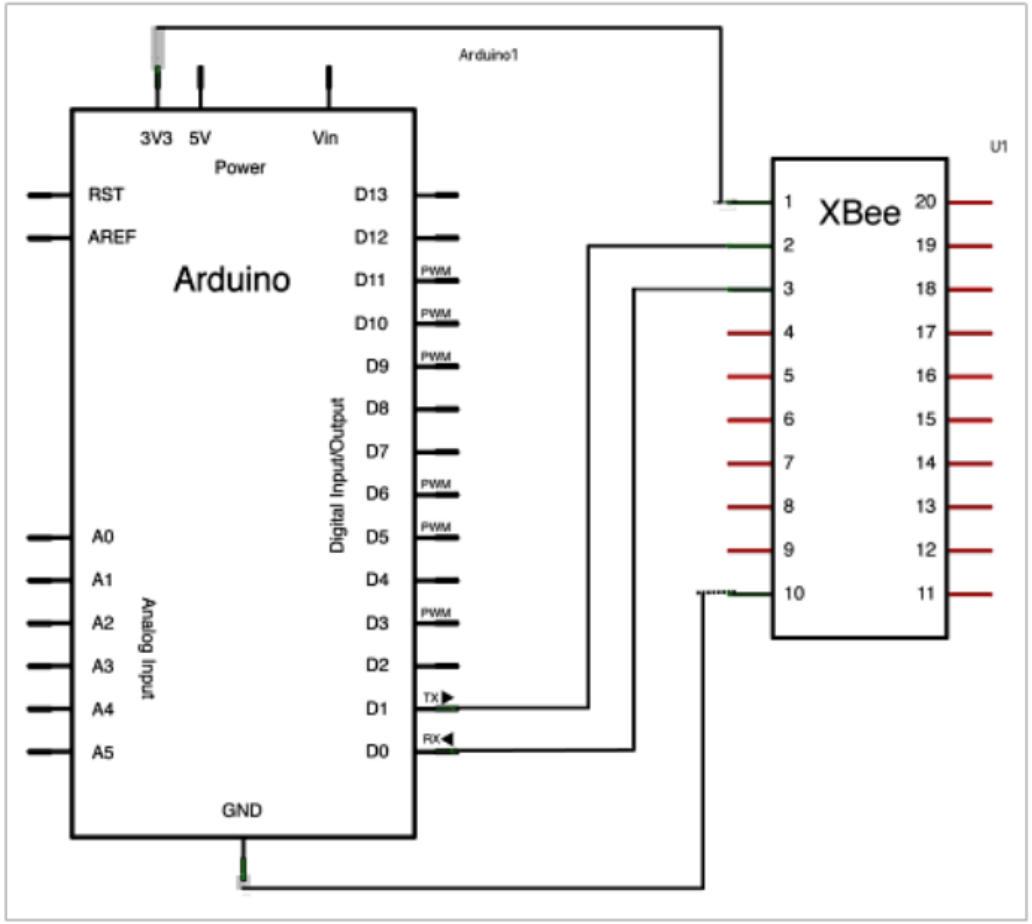
These four are all you need.

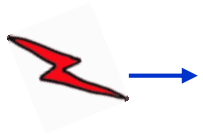
(This mode is the default for configuring the XBees too.)

	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

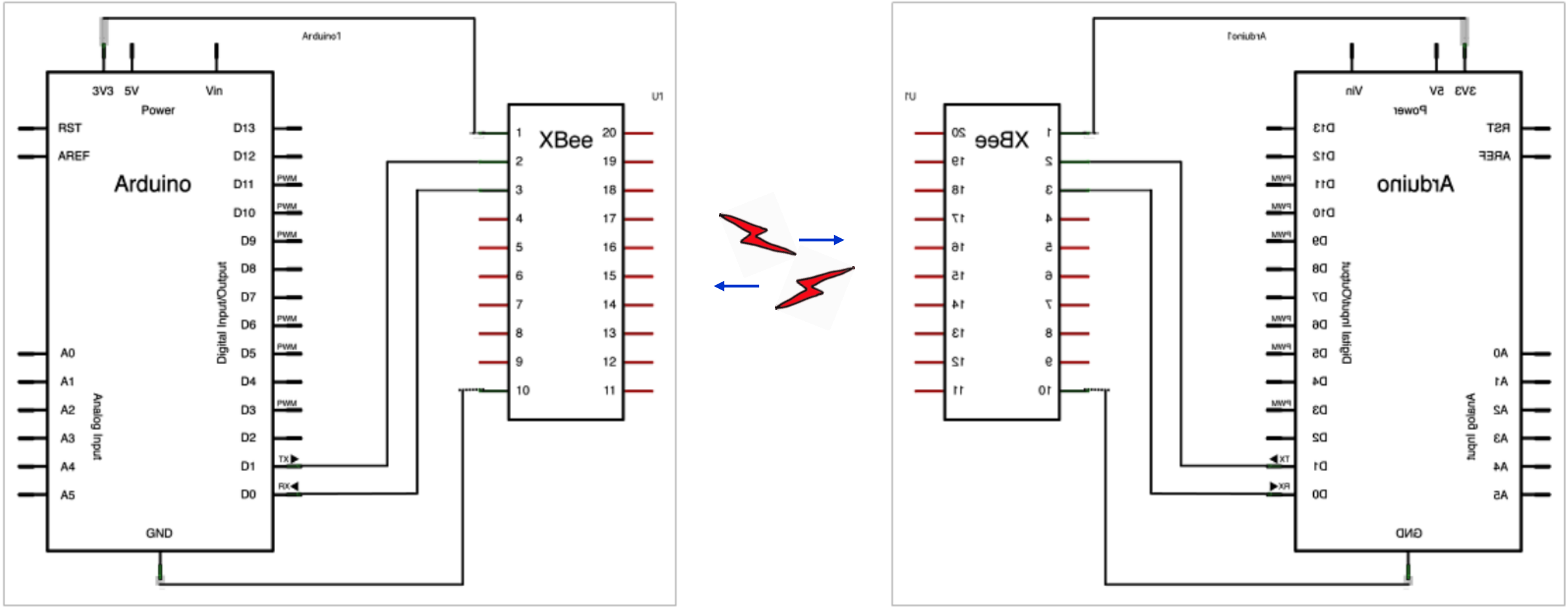

Arduino1
3V3
5V
Vin
Power
RST
AREF
Arduino
D13
D12
D11
D10
D9
D8
D7
D6
D5
D4
D3
D2
D1
D0
PWM
PWM
PWM
PWM
PWM
TX
RX
Digital Input/Output
A0
A1
A2
A3
A4
A5
Analog Input
GND
U1
XBee
1
2
3
4
5
6
7
8
9
10
20
19
18
17
16
15
14
13
12
11

Between Two Arduinos



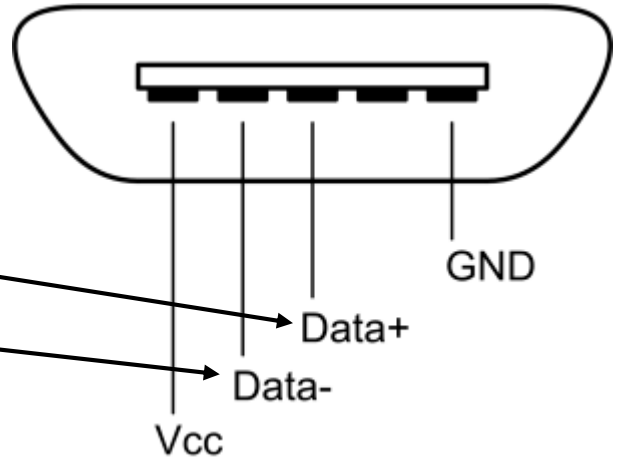


Between Two Arduinos



Connecting to a PC

1	GND		DIO0	1
2	3.3V (out)		DIO1	2
3	DOUT		DIO2	3
4	DIN		DIO3	4
5	DIO12	RTS	DIO6	5
6	/reset		DIO5	6
7	RSSI	RES	Vref	7
8	DIO11		DIO6	8
9	(reserved)	CTS	DIO7	9
10	/DTR		DIO4	10
11	GND		5.0 V	11



1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

Line Passing Mode

also called

Virtual Wires

	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

Line Passing Mode

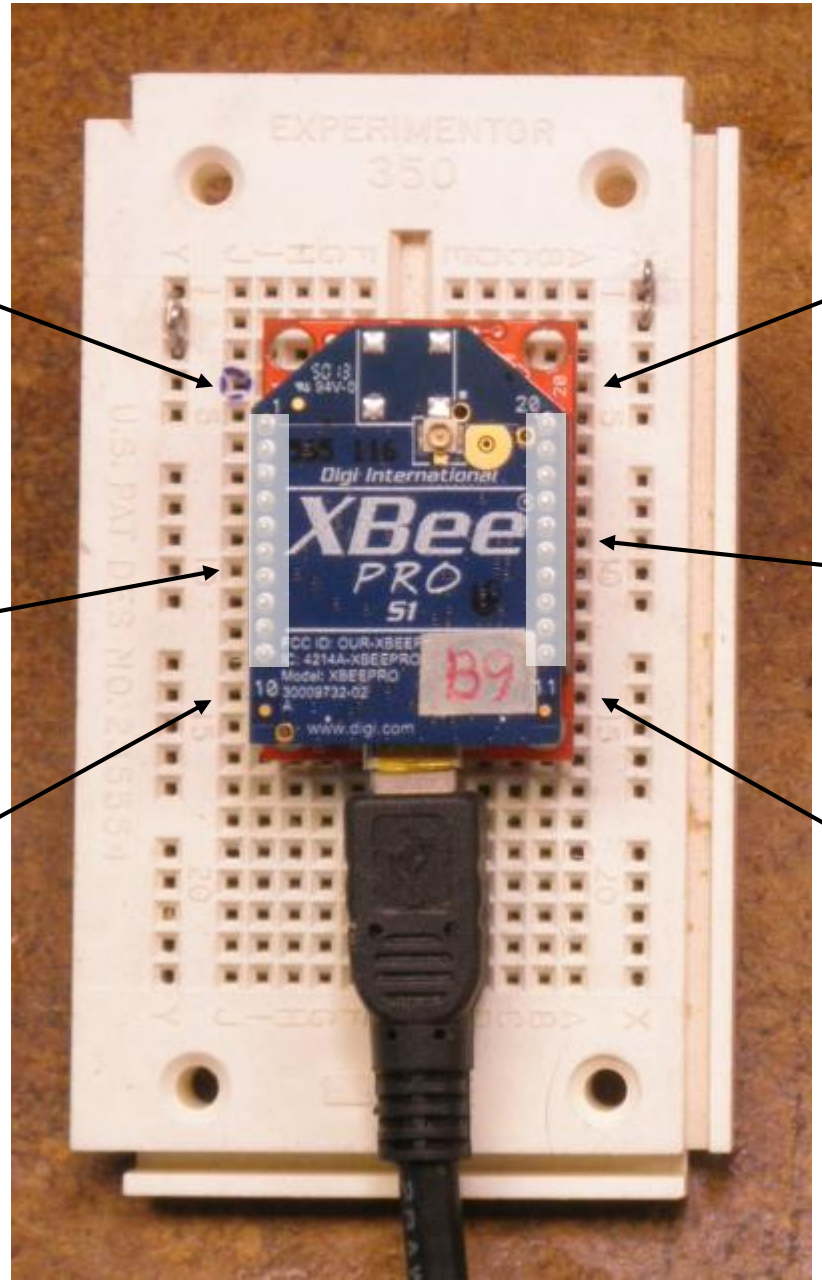
also called

Virtual Wires

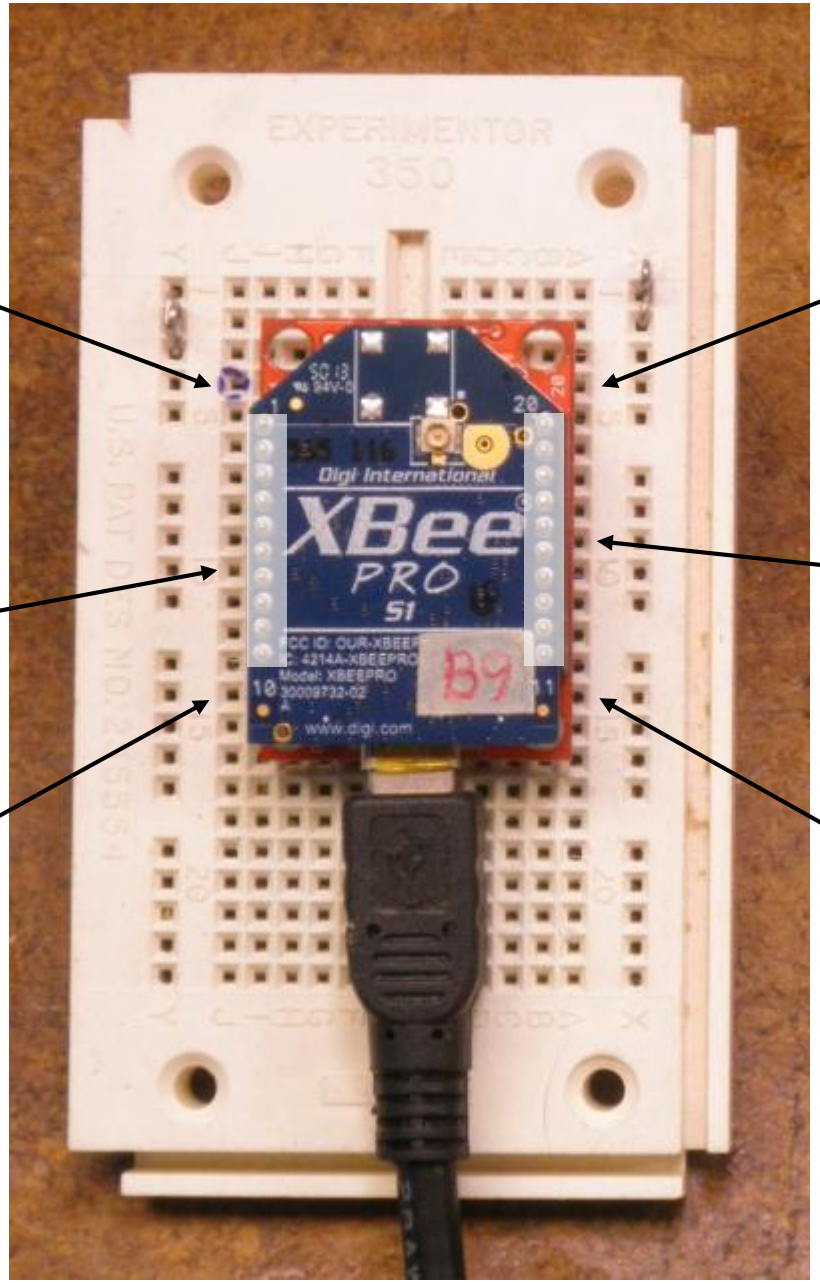
(the rest of the talk)

	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

1	GND			DIO0	1
2	3.3V (out)			DIO1	2
3	DOUT			DIO2	3
4	DIN			DIO3	4
5	DIO12		RTS	DIO6	5
6	/reset			DIO5	6
7	RSSI		RES	Vref	7
8	DIO11			DIO6	8
9	(reserved)		CTS	DIO7	9
10	/DTR			DIO4	10
11	GND			5.0 V	11



1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND



These can be hard wired digital inputs or outputs

	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

These can be hard wired digital inputs or outputs

DIO0 1
DIO1 2
DIO2 3
DIO3 4
DIO6 5
DIO5 6

DIO6 8
DIO7 9
DIO4 10

LEDs would be on those pins on one XBee and the same pins would have switches on them on other XBee.

These can be hard wired digital inputs or outputs

DIO0 1
DIO1 2
DIO2 3
DIO3 4
DIO6 5
DIO5 6

DIO6 8
DIO7 9
DIO4 10

LEDs would be on those pins on one XBee and the same pins would have switches on them on other XBee.

Can you see why it's called

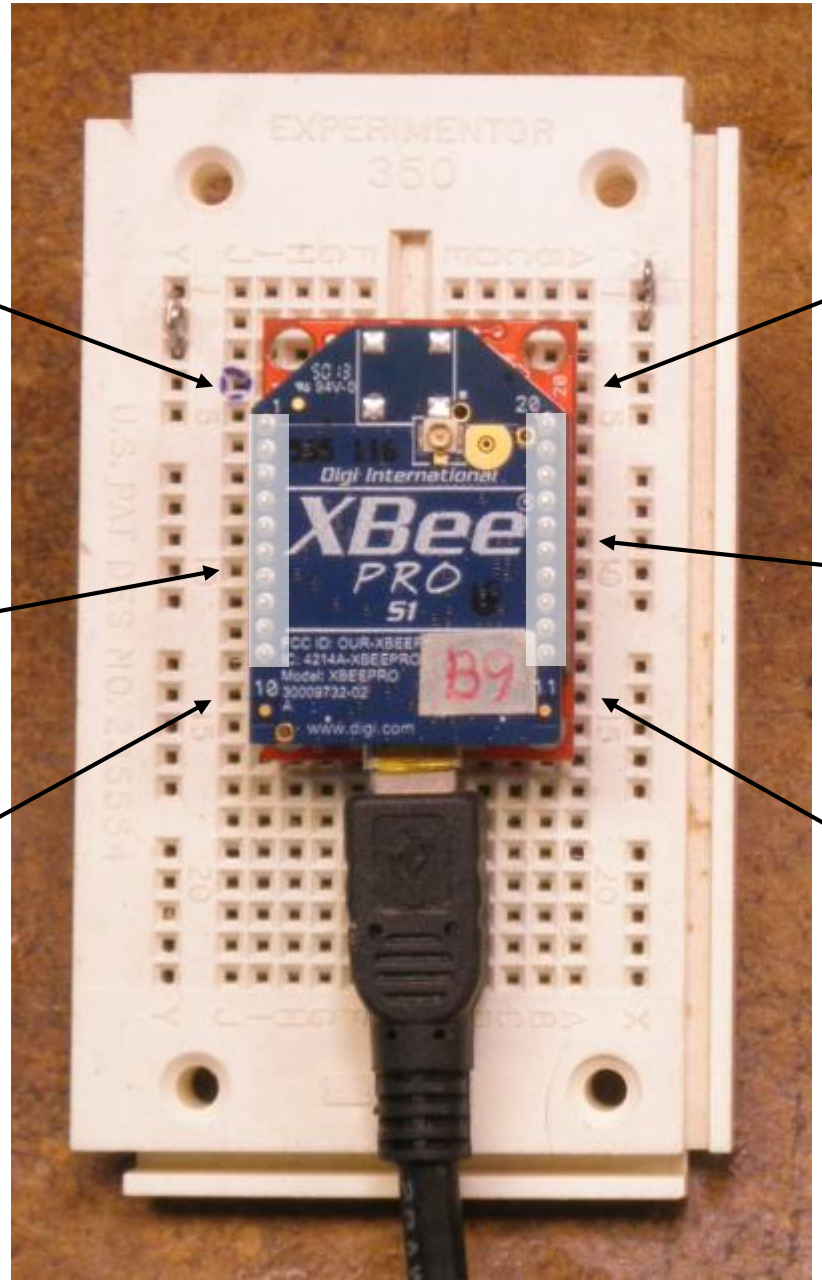
Line Passing?

These can be hard wired digital inputs or outputs

DIO0 1
DIO1 2
DIO2 3
DIO3 4
DIO6 5
DIO5 6

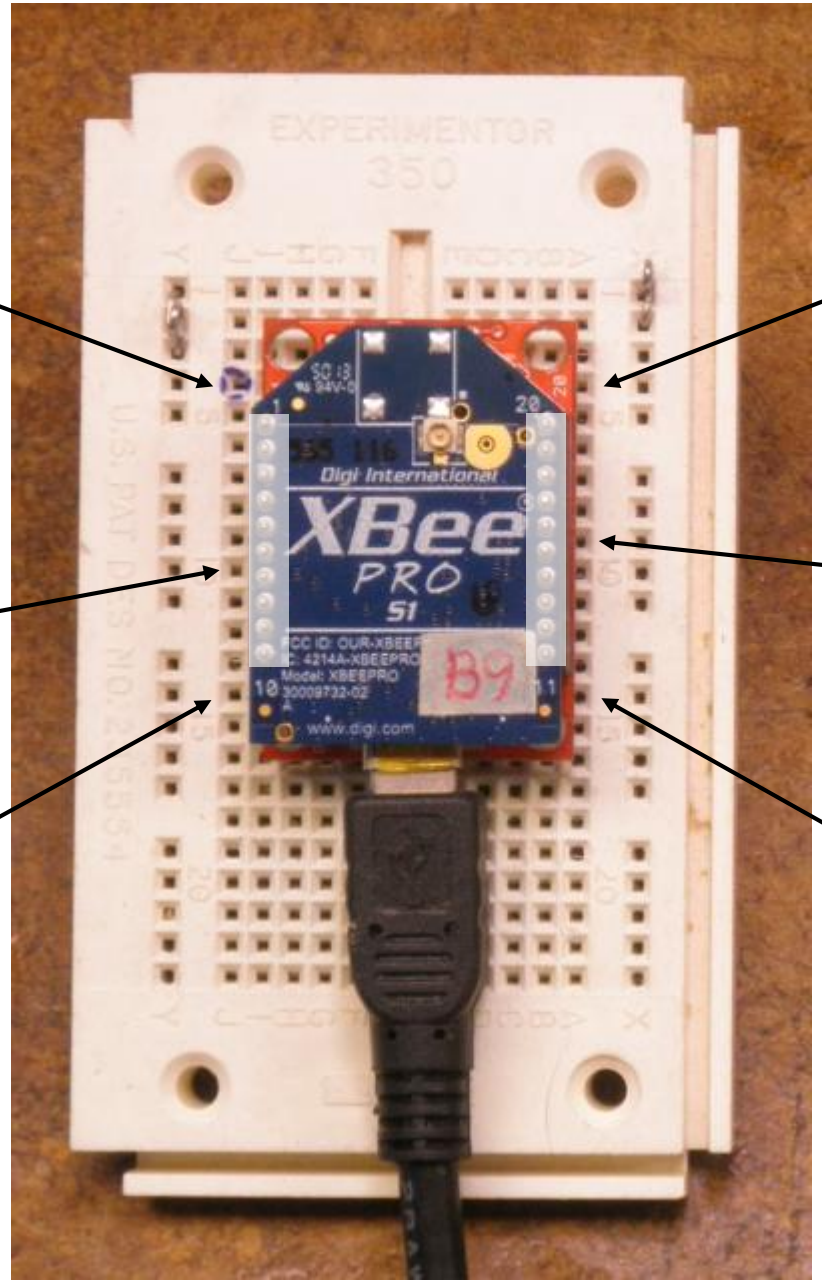
DIO6 8
DIO7 9
DIO4 10

1	GND			DIO0	1
2	3.3V (out)			DIO1	2
3	DOUT			DIO2	3
4	DIN			DIO3	4
5	DIO12		RTS	DIO6	5
6	/reset			DIO5	6
7	RSSI		RES	Vref	7
8	DIO11			DIO6	8
9	(reserved)		CTS	DIO7	9
10	/DTR			DIO4	10
11	GND			5.0 V	11



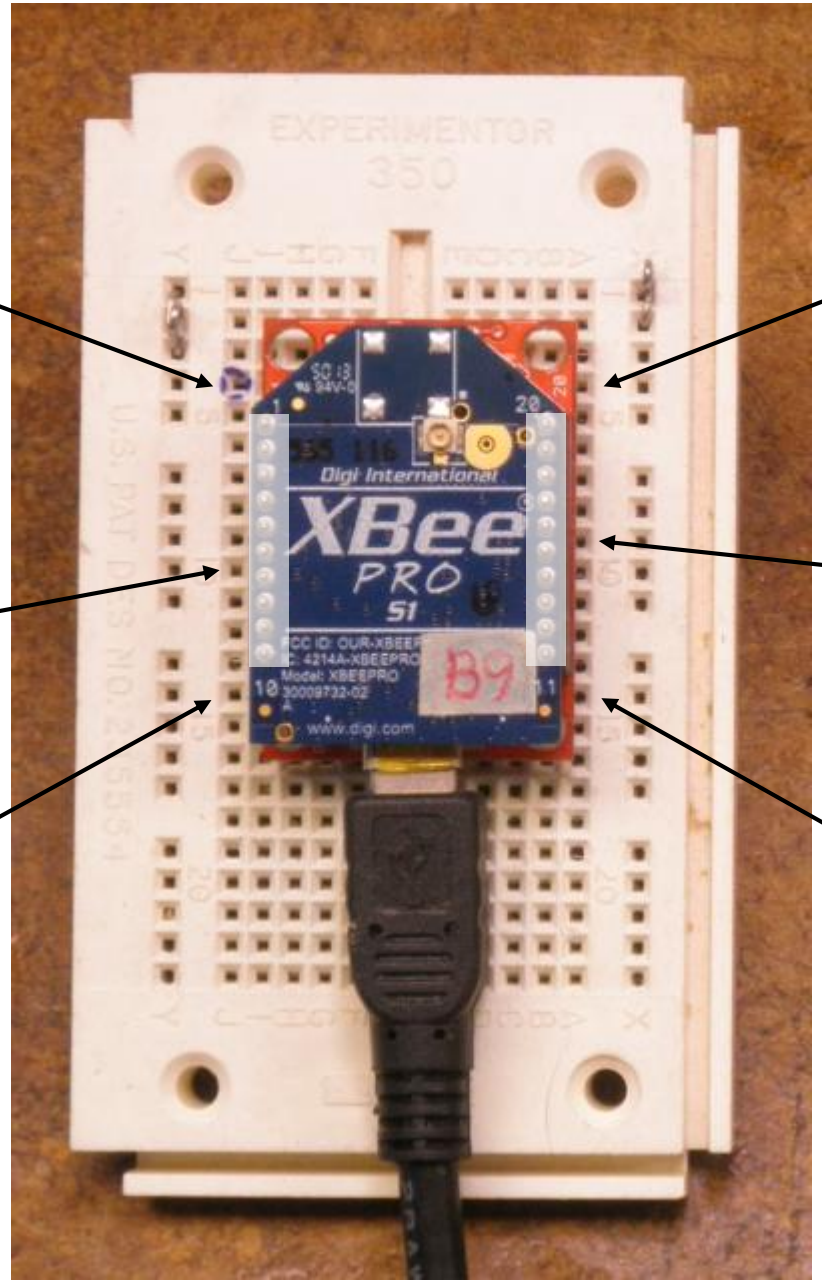
1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

These are the only hard wired “analog” outputs.



	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

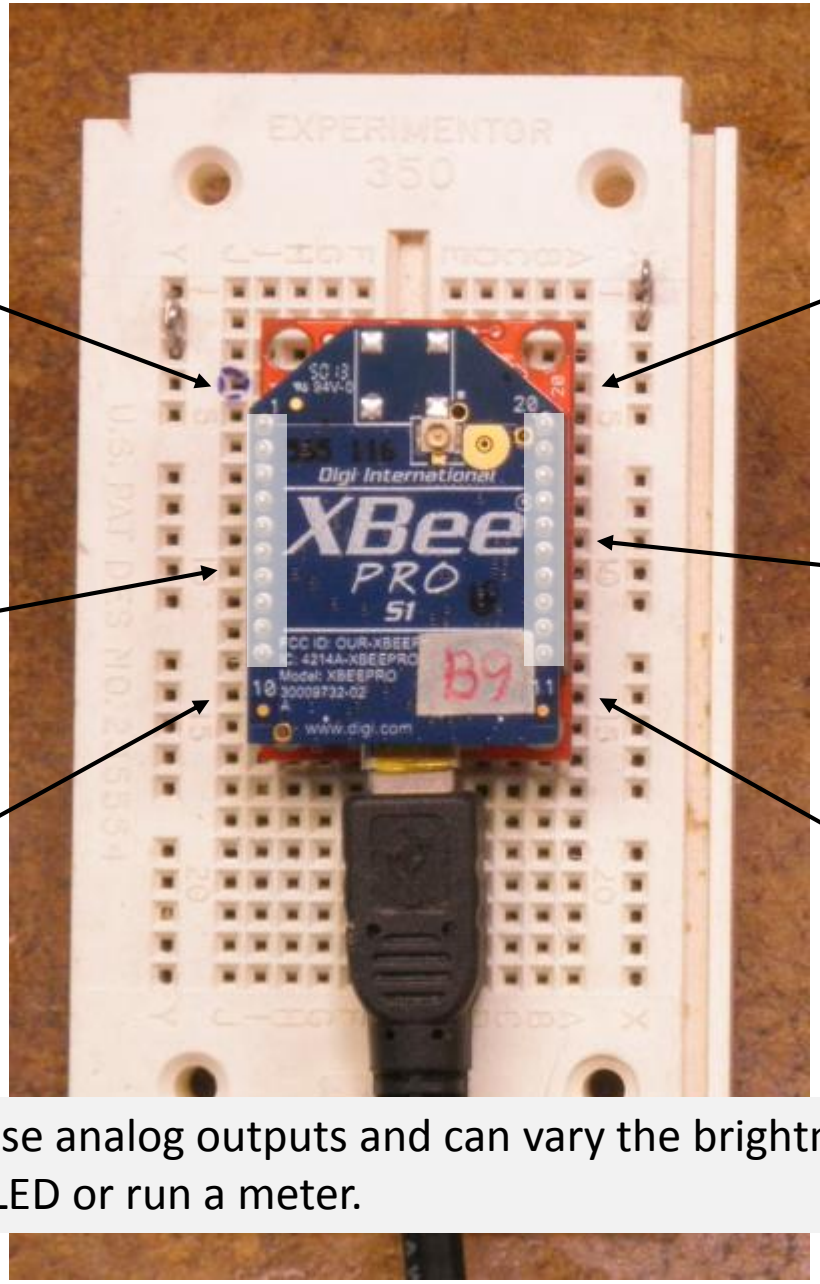


	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

Pins 7 and 8 can be either

- signal strength indication
- or an analog output

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI
8	DIO11
9	(reserved)
10	/DTR
11	GND

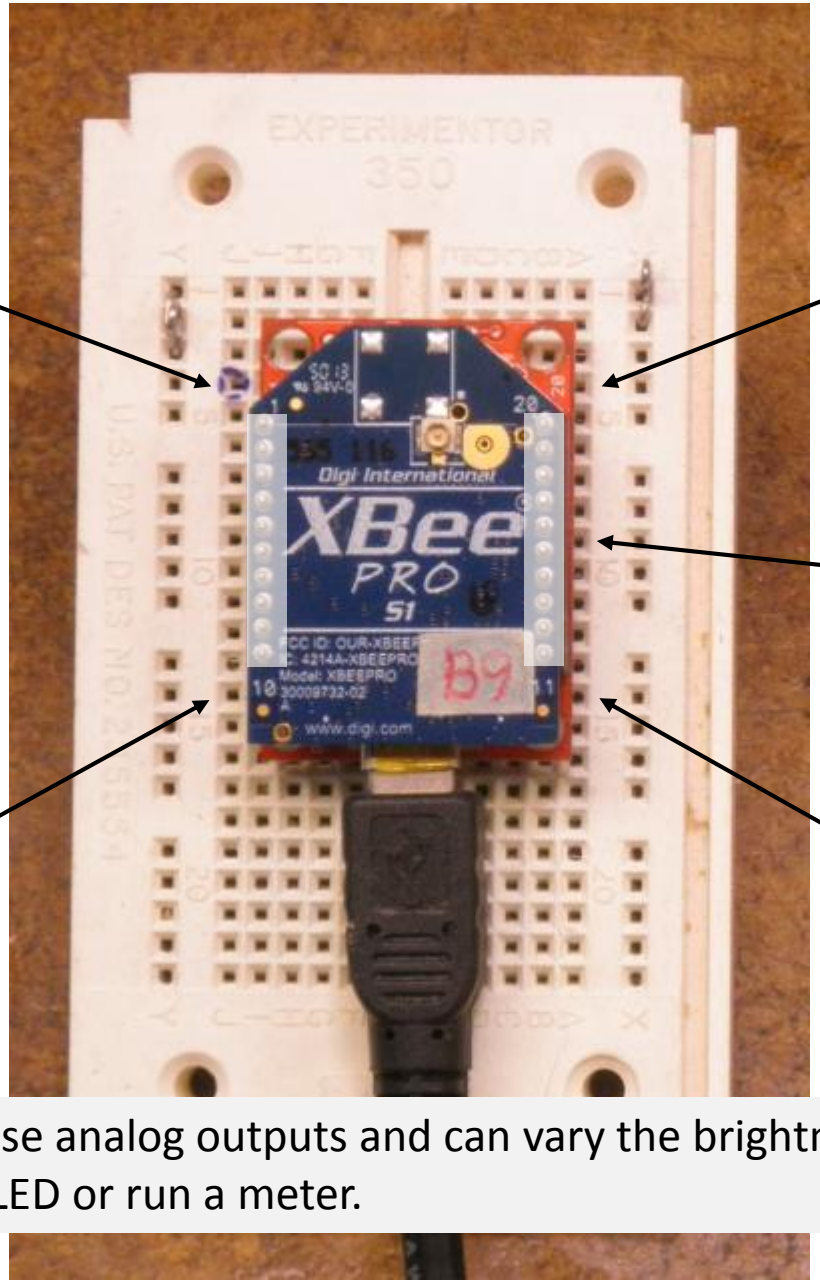


	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

Pins 7 and 8 can be either
- signal strength indication
- or an analog output

These analog outputs and can vary the brightness of an LED or run a meter.

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI or PWM0
8	DIO11 or PWM1
9	(reserved)
10	/DTR
11	GND

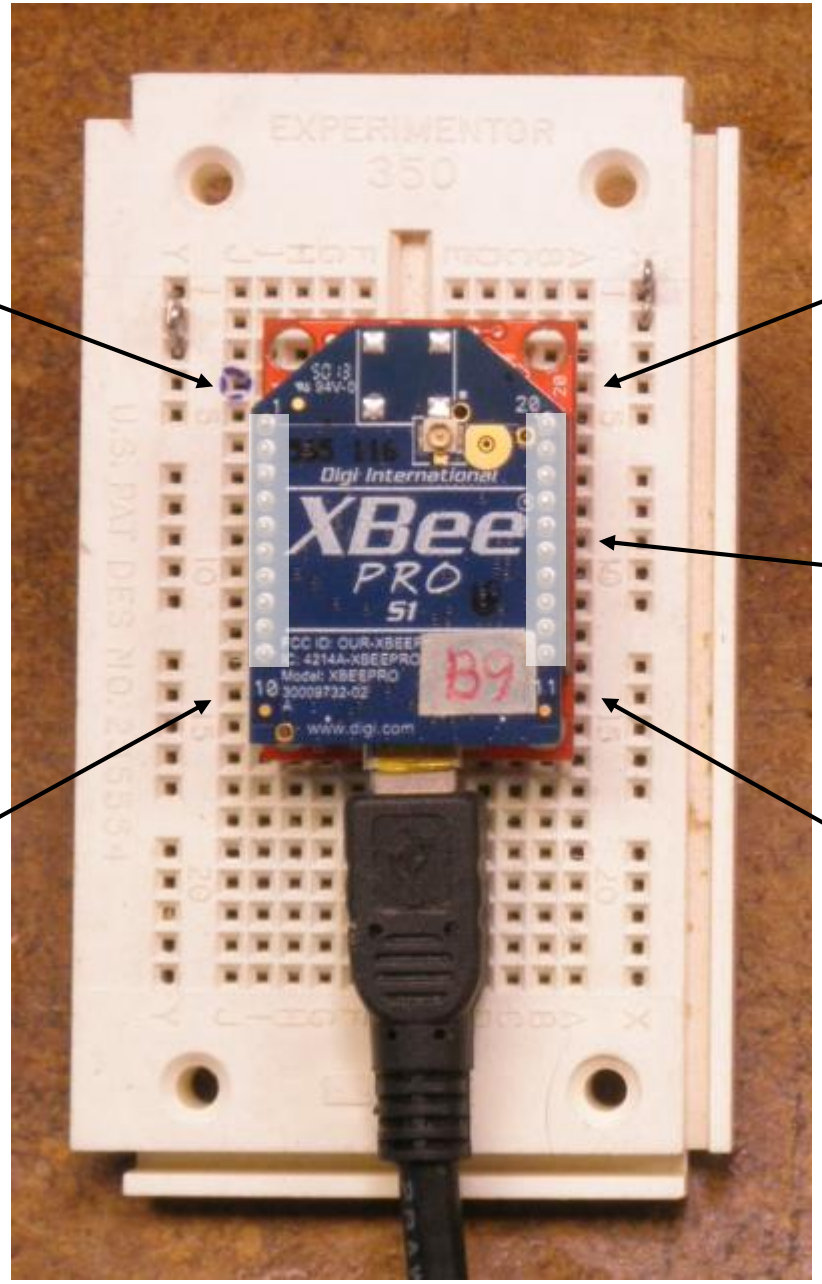


	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

Pins 7 and 8 can be either
- signal strength indication
- or an analog output

These analog outputs and can vary the brightness of an LED or run a meter.

1	GND
2	3.3V (out)
3	DOUT
4	DIN
5	DIO12
6	/reset
7	RSSI or PWM0
8	DIO11 or PWM1
9	(reserved)
10	/DTR
11	GND

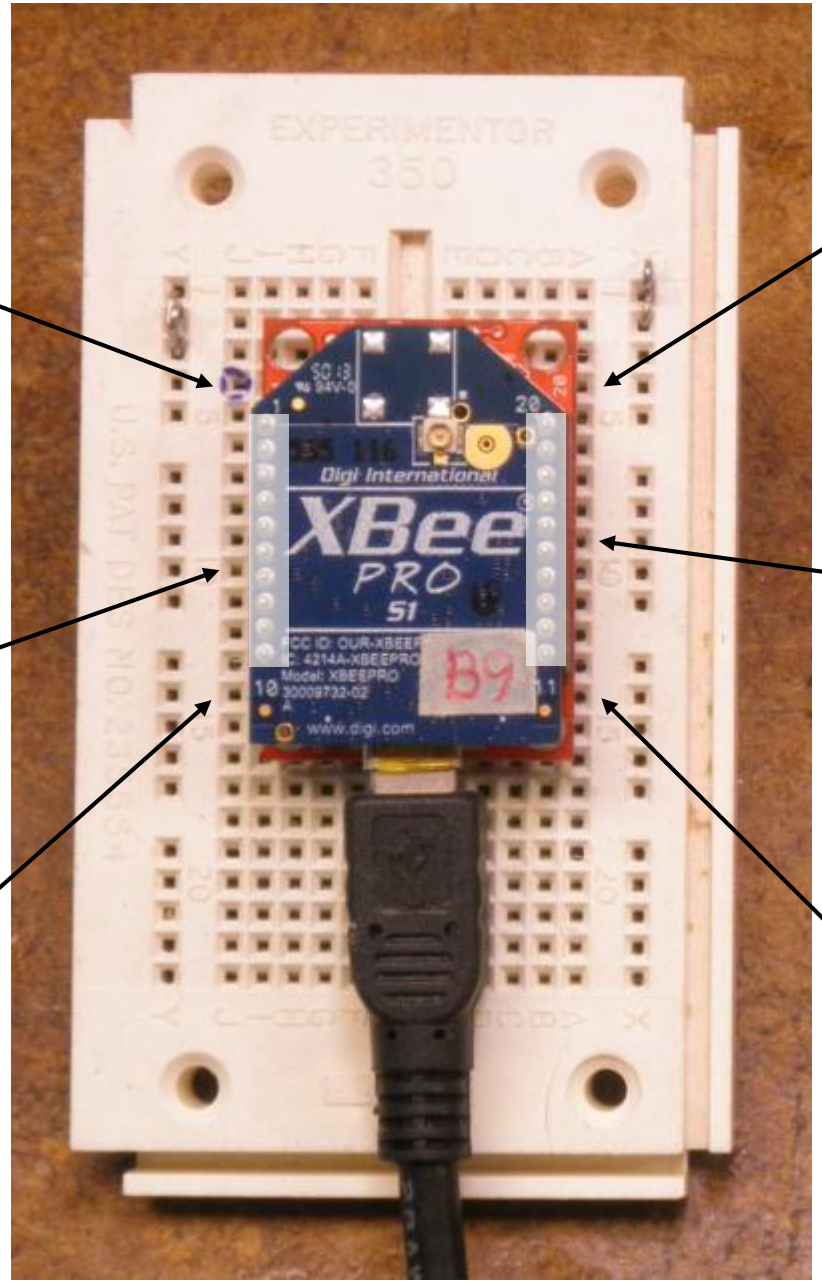


	DIO0	1
	DIO1	2
	DIO2	3
	DIO3	4
RTS	DIO6	5
	DIO5	6
RES	Vref	7
	DIO6	8
CTS	DIO7	9
	DIO4	10
	5.0 V	11

Pins 7 and 8 can be either

- signal strength indication
- or an analog output

1	GND
2	3.3V (out)
3	DOUT
4	DIN /config
5	DIO12
6	/reset
7	RSSI or PWM0
8	DIO11 or PWM1
9	(reserved)
10	/DTR or DI8
11	GND

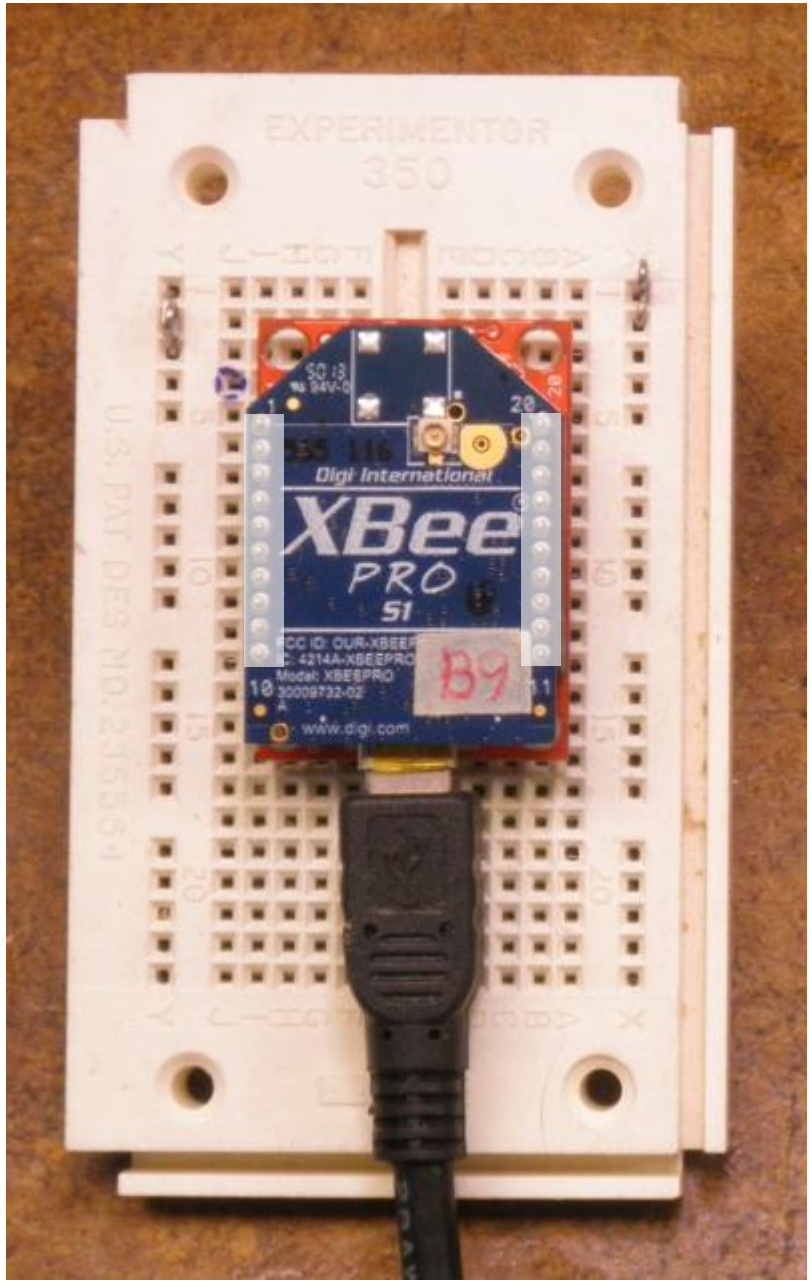


AD0 or DIO0	1
AD1 or DIO1	2
AD2 or DIO2	3
AD3 or DIO3	4
AD6 or DIO6	5
AD5 or DIO5	6
RES Vref	7
DIO6	8
CTS DIO7	9
AD4 or DIO4	10
5.0 V	11

other alternate pin functions

XBee	explorer		XBee	explorer	
	1	GND	AD0 or DIO0	1	20
1	2	3.3V (out)	AD1 or DIO1	2	19
2	3	DOUT	AD2 or DIO2	3	18
3	4	DIN /config	AD3 or DIO3	4	17
4	5	DIO12	AD6 or DIO6	5	16
5	6	/reset	AD5 or DIO5	6	15
6	7	RSSI or PWM0	AD5 or Vref	7	14
7	8	DIO11 or PWM1	AD5 or DIO6	8	13
8	9	(reserved)	AD5 or DIO7	9	12
9	10	/DTR or DI8	AD4 or DIO4	10	11
10	11	GND	AD5 or 5.0 V	11	

XBee	explorer	
	1	GND
1	2	3.3V (out)
2	3	DOUT
3	4	DIN /config
4	5	DIO12
5	6	/reset
6	7	RSSI or PWM0
7	8	DIO11 or PWM1
8	9	(reserved)
9	10	/DTR or DI8
10	11	GND

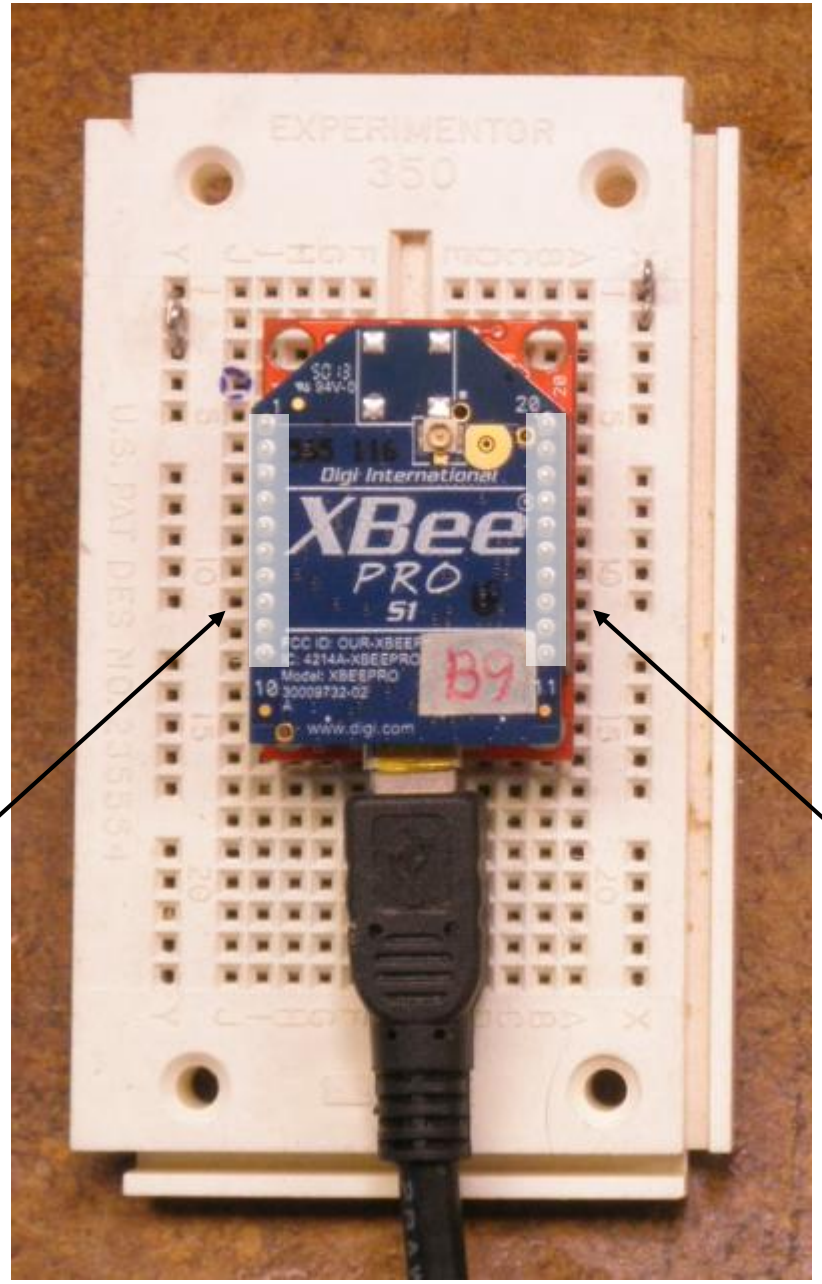


XBee	explorer	
AD0 or DIO0	1	20
AD1 or DIO1	2	19
AD2 or DIO2	3	18
AD3 or DIO3	4	17
AD6 or DIO6	5	16
AD5 or DIO5	6	15
Vref	7	14
DIO6	8	13
DIO7	9	12
AD4 or DIO4	10	11
5.0 V	11	

explorer

1	GND
2	3.3V (out)
3	DOUT
4	DIN /config
5	DIO12
6	/reset
7	RSSI or PWM0
8	DIO11 or PWM1
9	(reserved)
10	/DTR or DI8
11	GND

left side pin 8

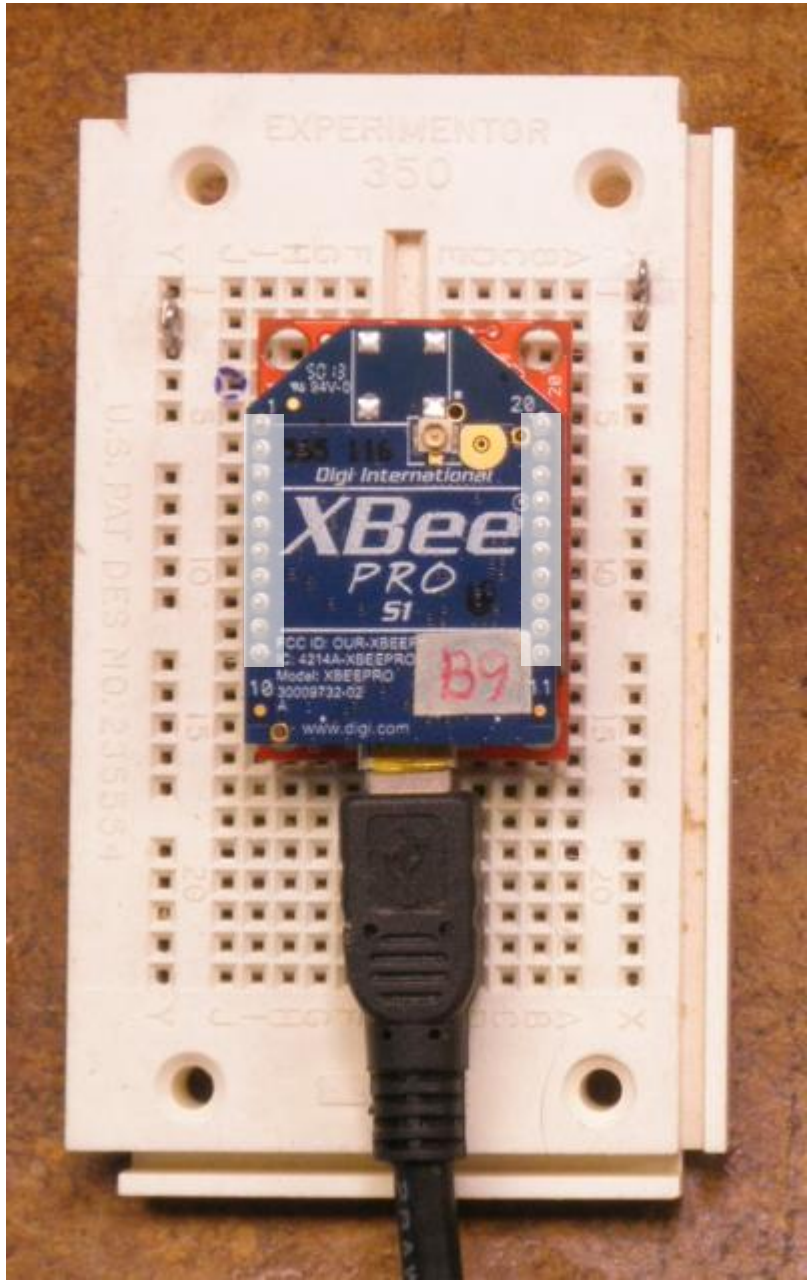


explorer

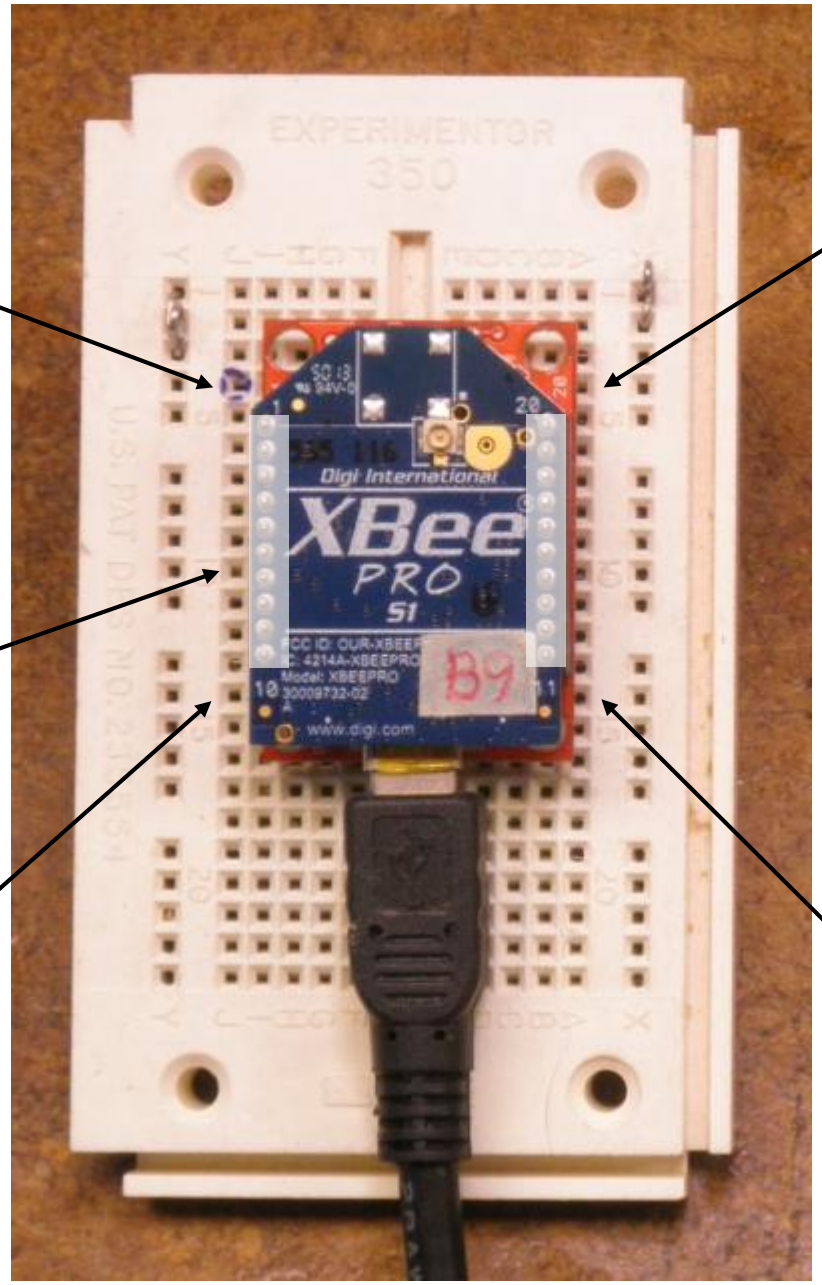
AD0 or DIO0	1
AD1 or DIO1	2
AD2 or DIO2	3
AD3 or DIO3	4
AD6 or DIO6	5
AD5 or DIO5	6
Vref	7
DIO6	8
DIO7	9
AD4 or DIO4	10
5.0 V	11

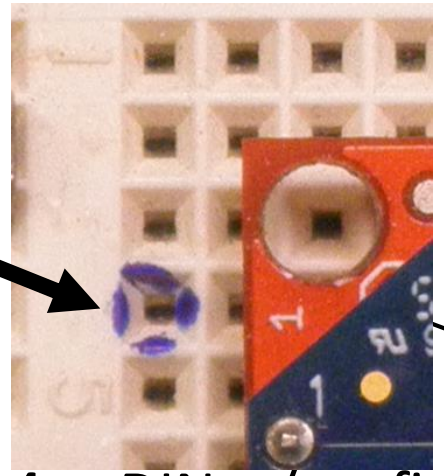
right side pin 8

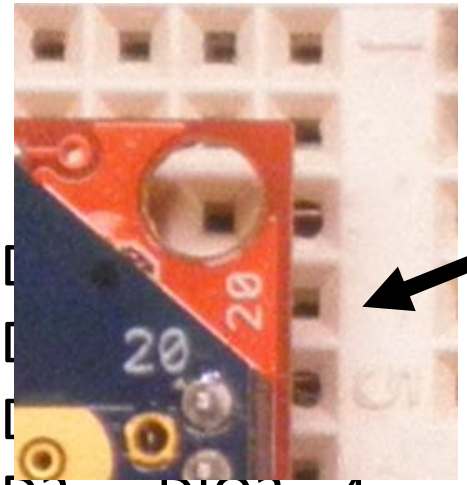
	explorer	
	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



explorer		
AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

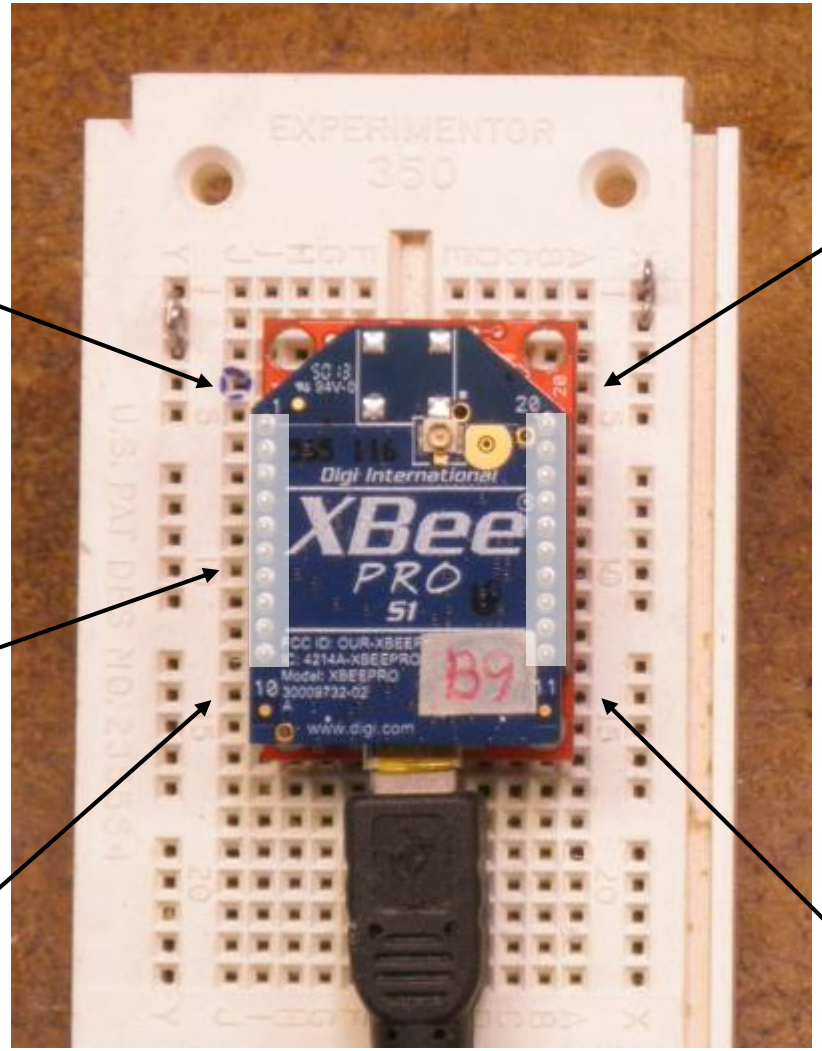


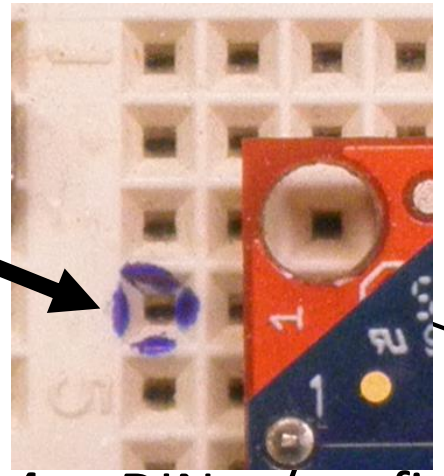


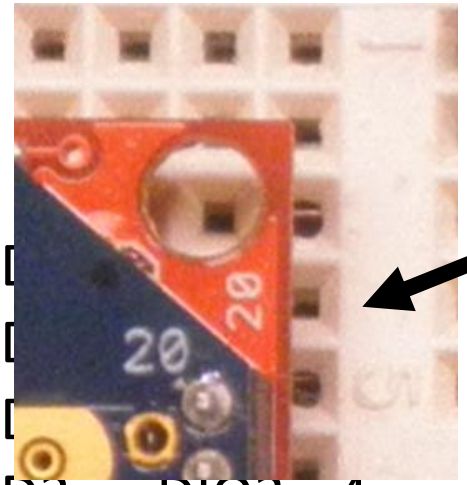


	4	DIN /config	
	5	DIO12	
	6	/reset	
	7	RSSI or PWM0	
	8	DIO11 or PWM1	
	9	(reserved)	
Sleep RQ	10	/DTR or DI8	
	11	GND	

		AD	
		AD	
		AD	
	4	AD3 or DIO3	
/RTS	5	AD6 or DIO6	
associate	6	AD5 or DIO5	
	7	Vref	
ON /sleep	8	DIO6	
CTS	9	DIO7	
	10	AD4 or DIO4	
	11	5.0 V	





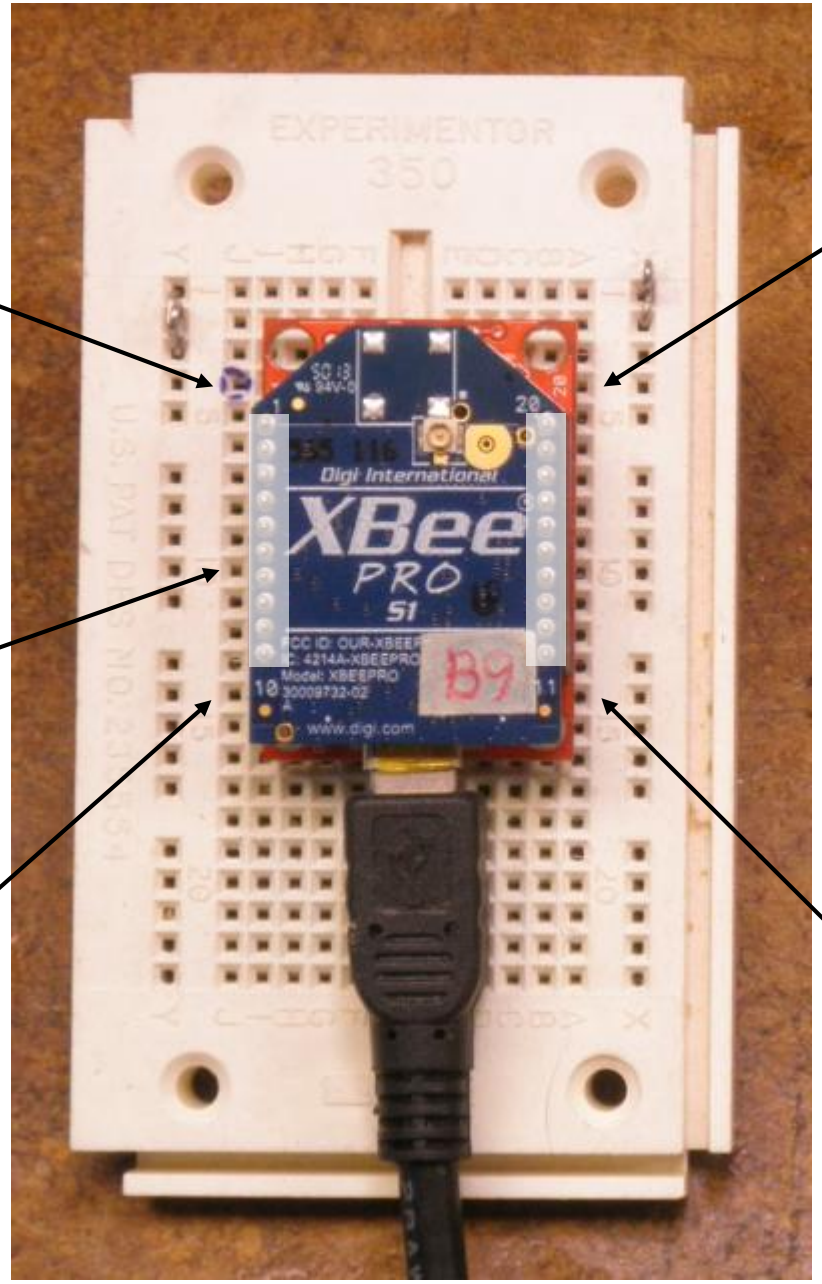


	4	DIN /config	
	5	DIO12	
	6	/reset	
	7	RSSI or PWM0	
	8	DIO11 or PWM1	
	9	(reserved)	
Sleep RQ	10	/DTR or DI8	
	11	GND	

AD			
AD			
AD			
AD3 or DIO3	4		
AD6 or DIO6	5	/RTS	
AD5 or DIO5	6	associate	
	Vref	7	
	DIO6	8	ON /sleep
	DIO7	9	CTS
AD4 or DIO4	10		
	5.0 V	11	

The only thing more confusing than pin numbers is X-CTU, coming up shortly.

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

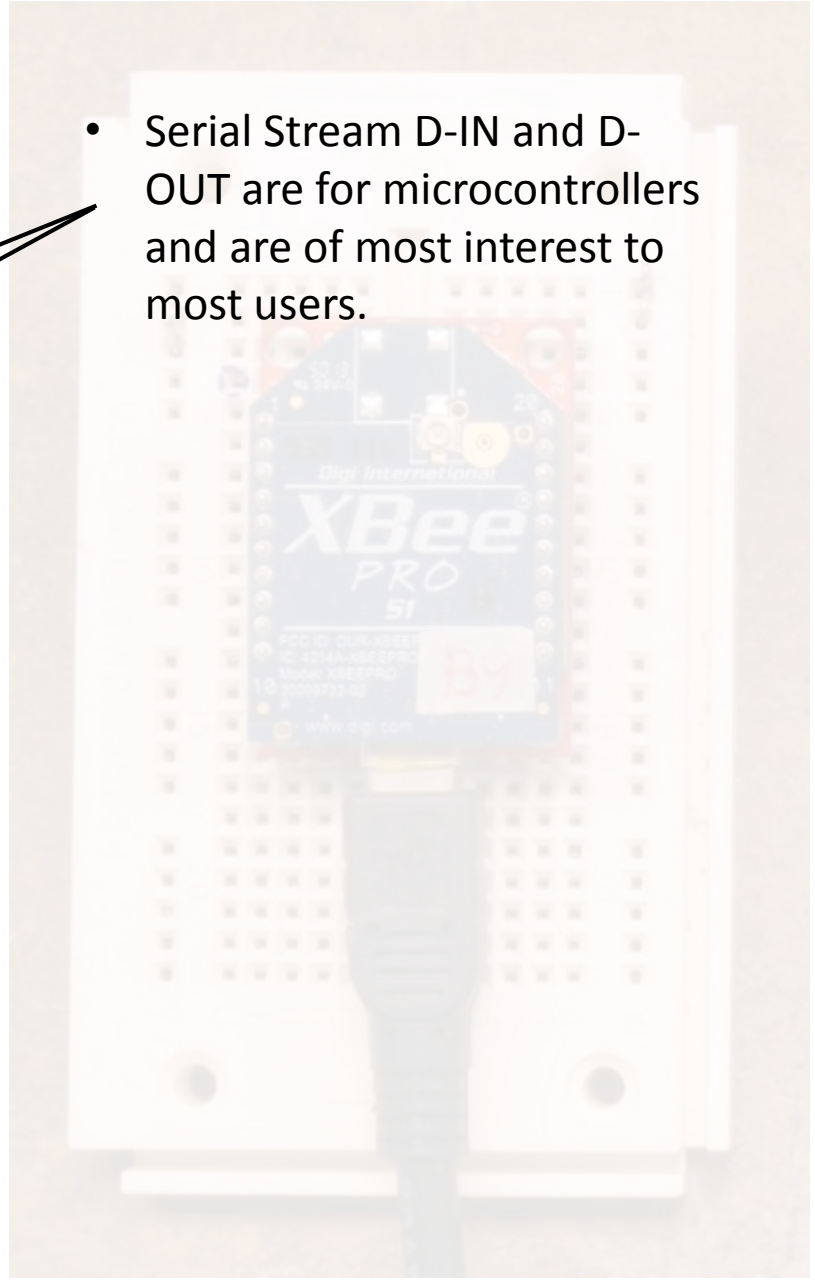
(print this out)

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

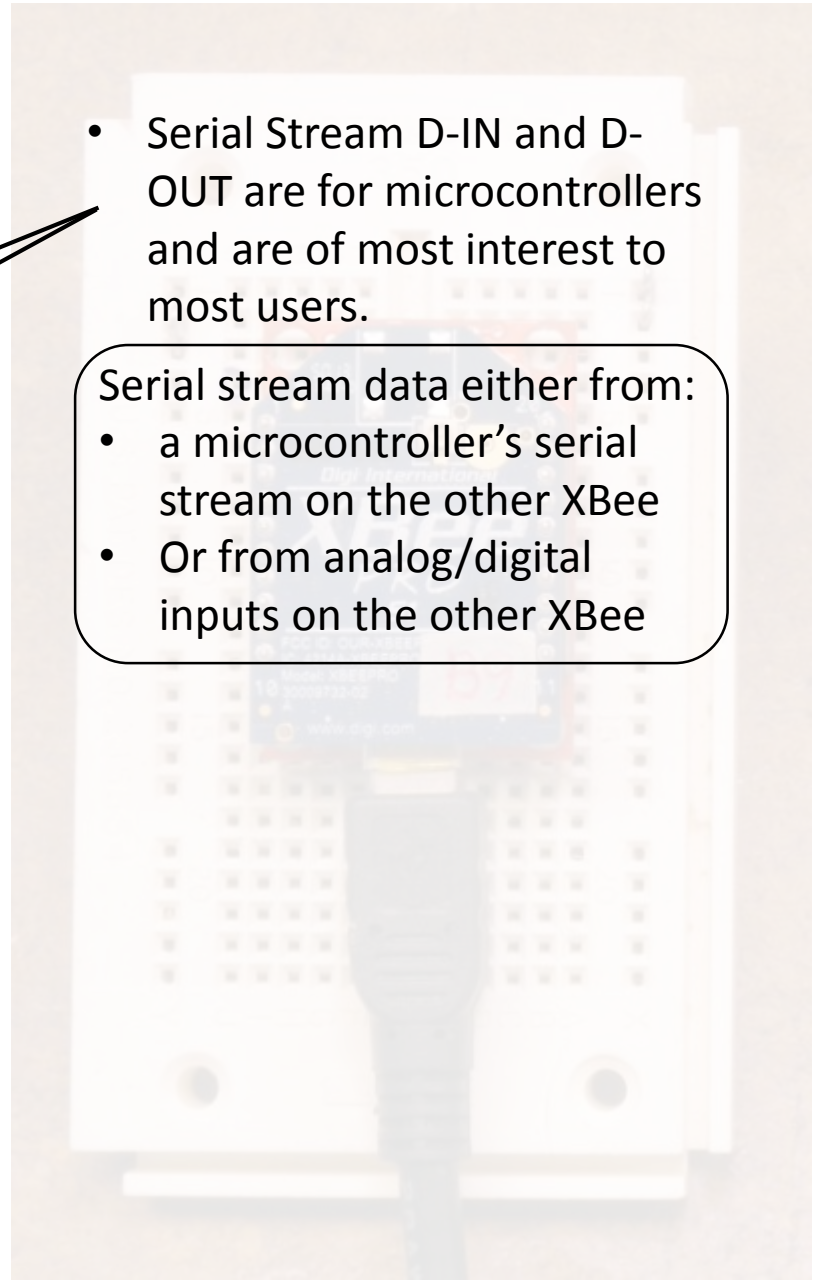
AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.



AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	



- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.

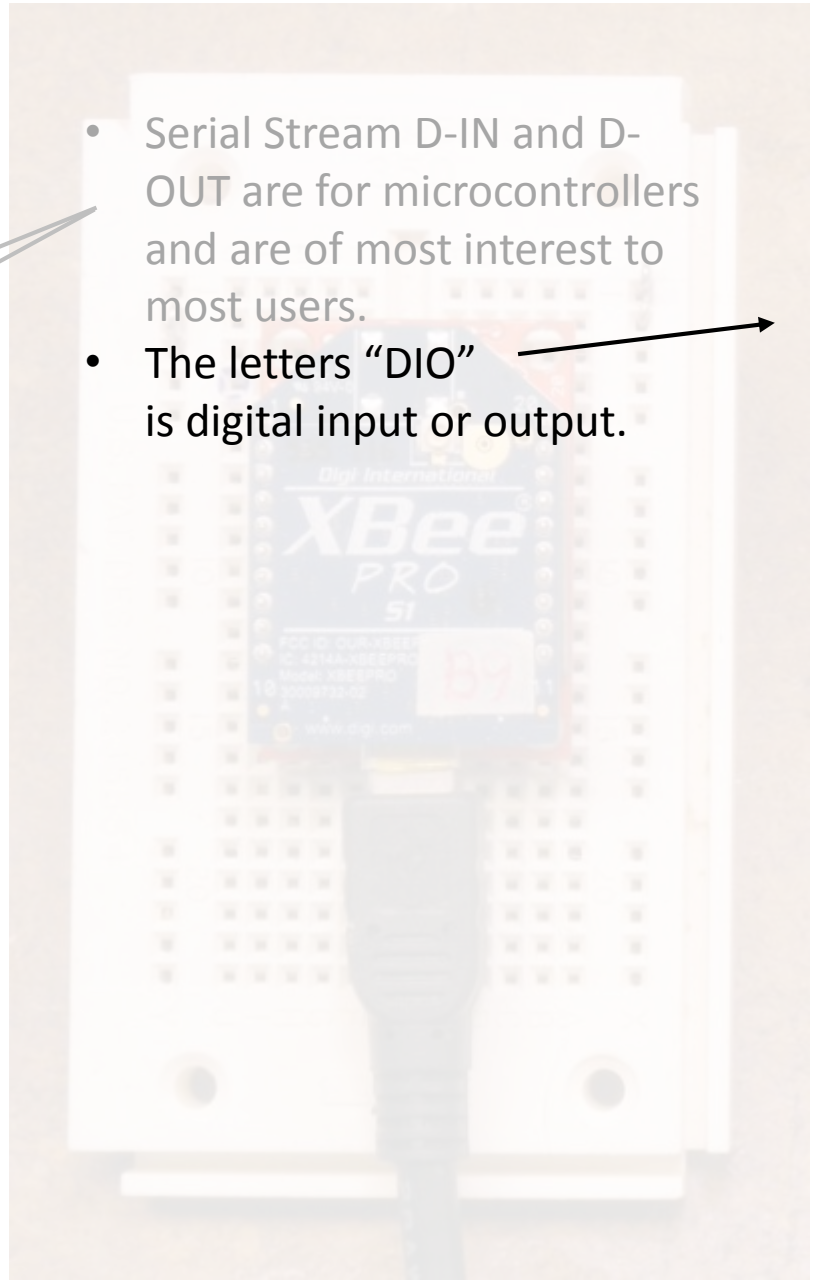
Serial stream data either from:

- a microcontroller's serial stream on the other XBee
- Or from analog/digital inputs on the other XBee

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V **(out)**
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

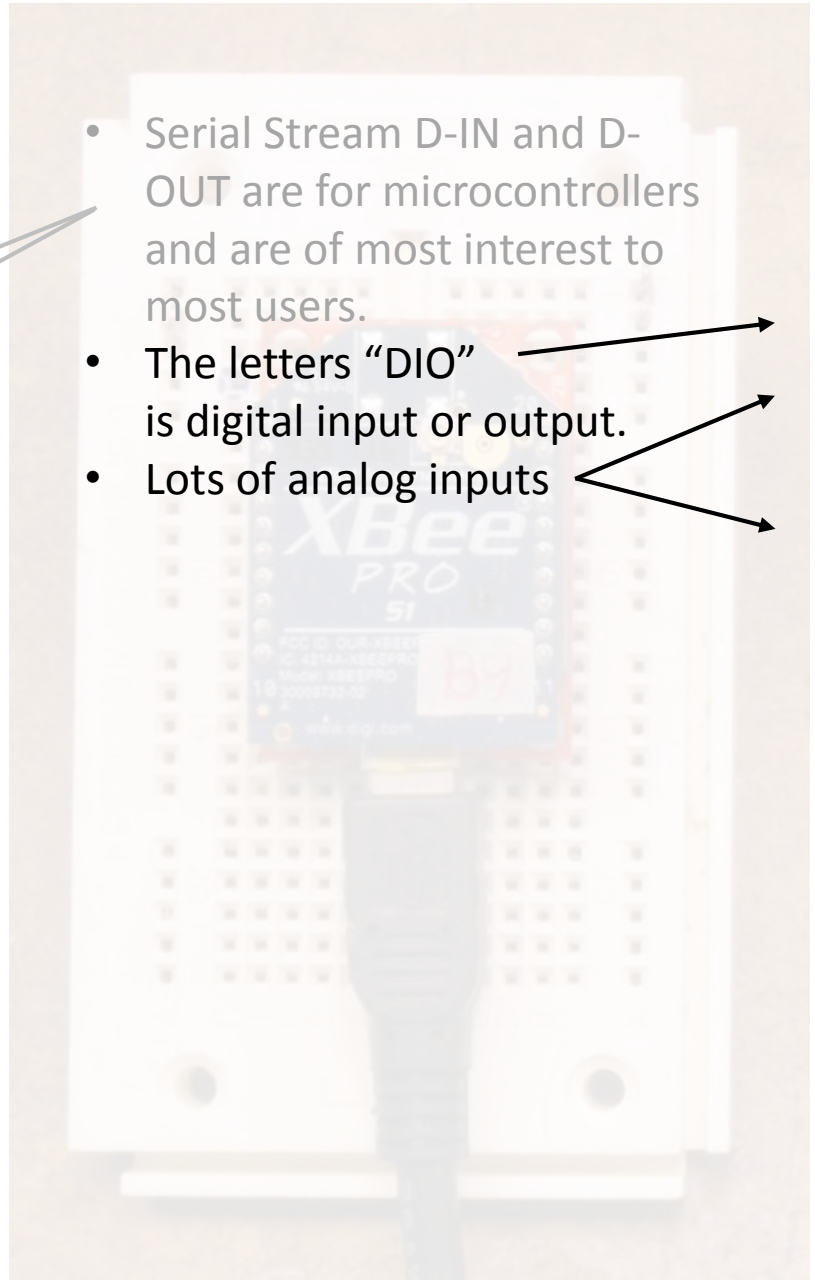
	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.

Sending and Receiving XBees are identical.
When you “configure” an XBee, you determine whether a particular pin is input or output.

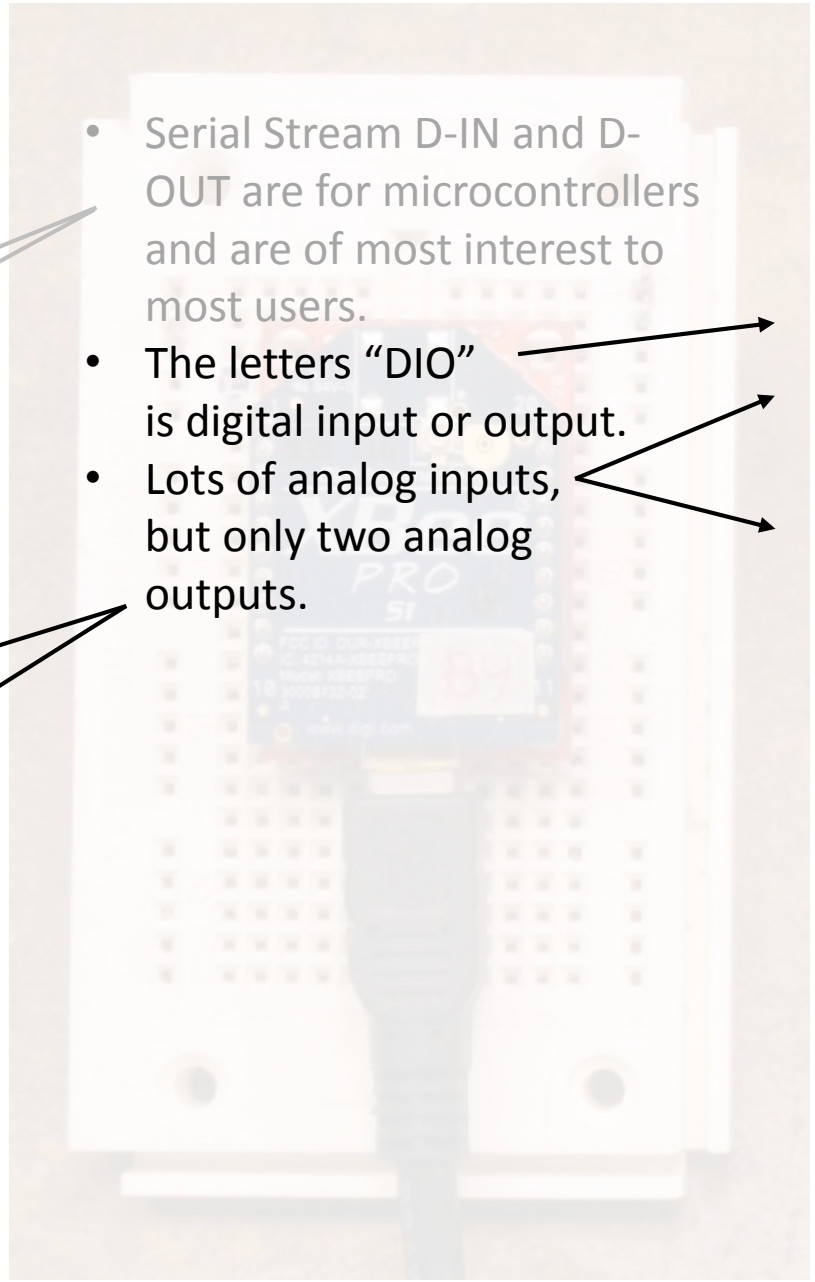
AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.
- Lots of analog inputs

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

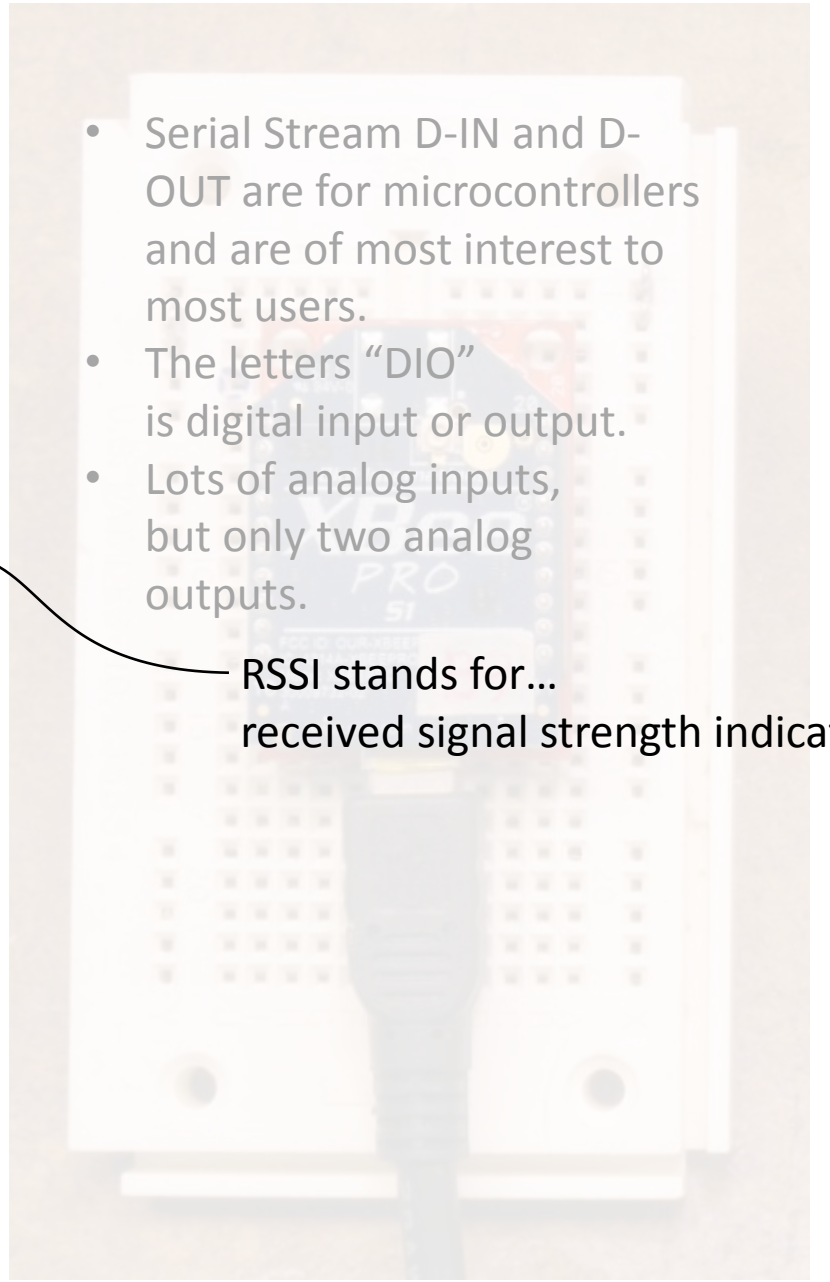


- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.
- Lots of analog inputs, but only two analog outputs.

	1	GND
	2	3.3V **(out)**
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

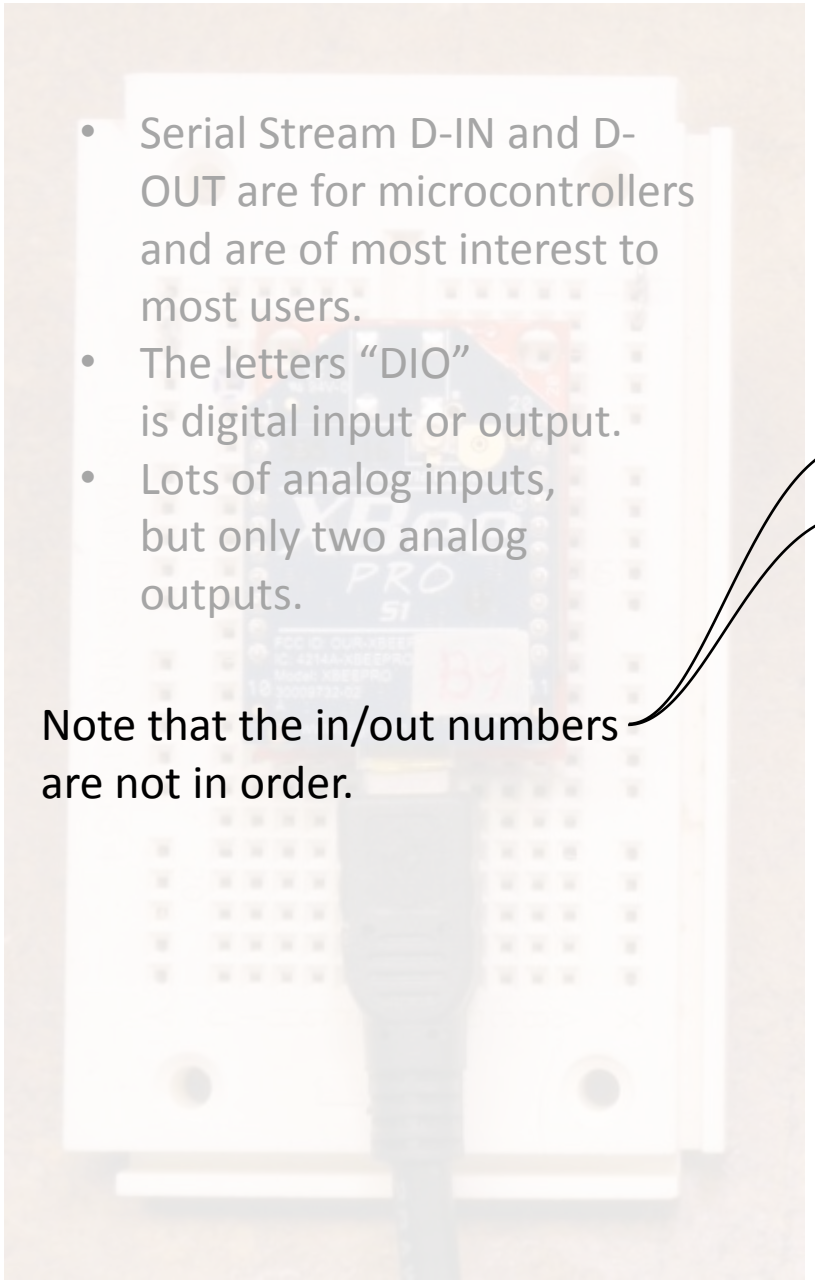


- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.
- Lots of analog inputs, but only two analog outputs.

RSSI stands for…
received signal strength indication

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

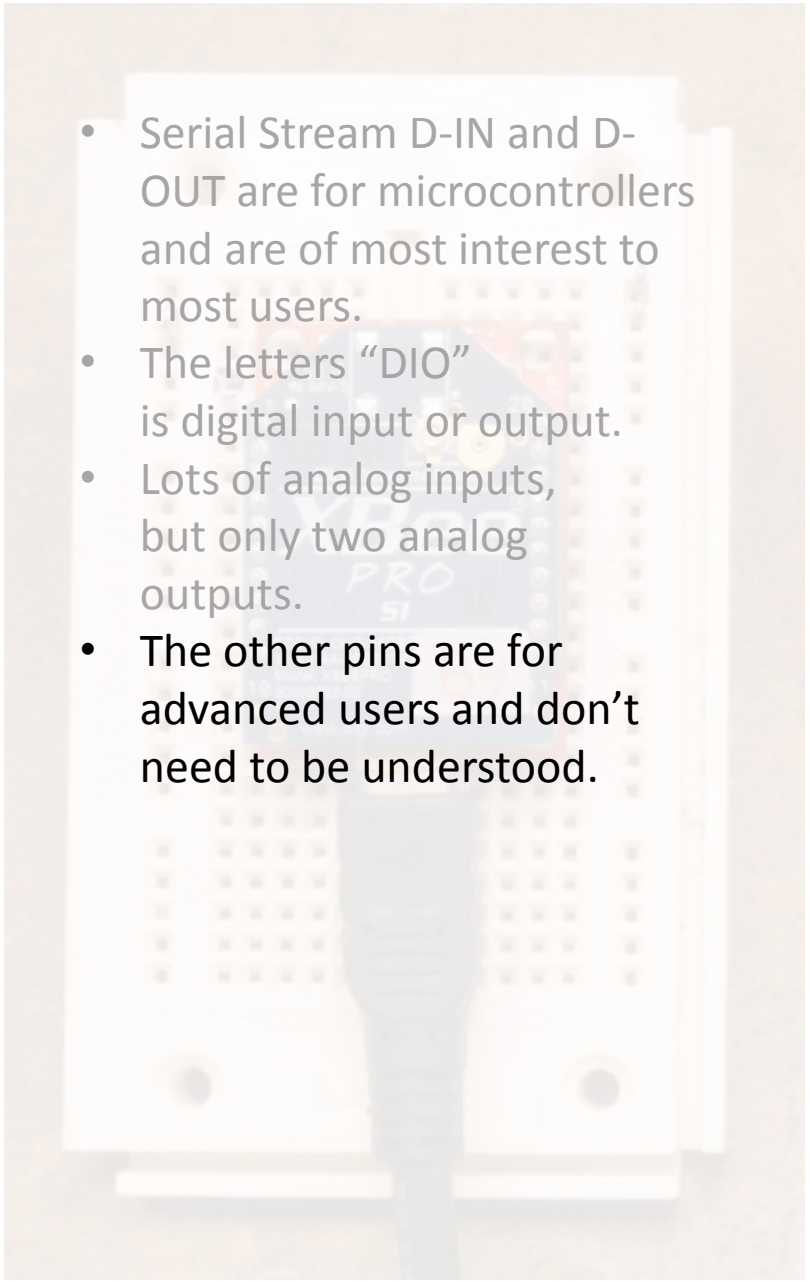


- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.
- Lots of analog inputs, but only two analog outputs.

Note that the in/out numbers are not in order.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



- Serial Stream D-IN and D-OUT are for microcontrollers and are of most interest to most users.
- The letters “DIO” is digital input or output.
- Lots of analog inputs, but only two analog outputs.
- The other pins are for advanced users and don’t need to be understood.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND	AD0 or DIO0	1	
	2	3.3V (out)	AD1 or DIO1	2	
	3	DOUT	AD2 or DIO2	3	
	4	DIN /config	AD3 or DIO3	4	
	5	DIO12	AD6 or DIO6	5	/RTS
	6	/reset	AD5 or DIO5	6	associate
	7	RSSI or PWM0	Vref	7	
	8	DIO11 or PWM1	DIO6	8	ON /sleep
	9	(reserved)	DIO7	9	CTS
Sleep RQ	10	/DTR or DI8	AD4 or DIO4	10	
	11	GND	5.0 V	11	

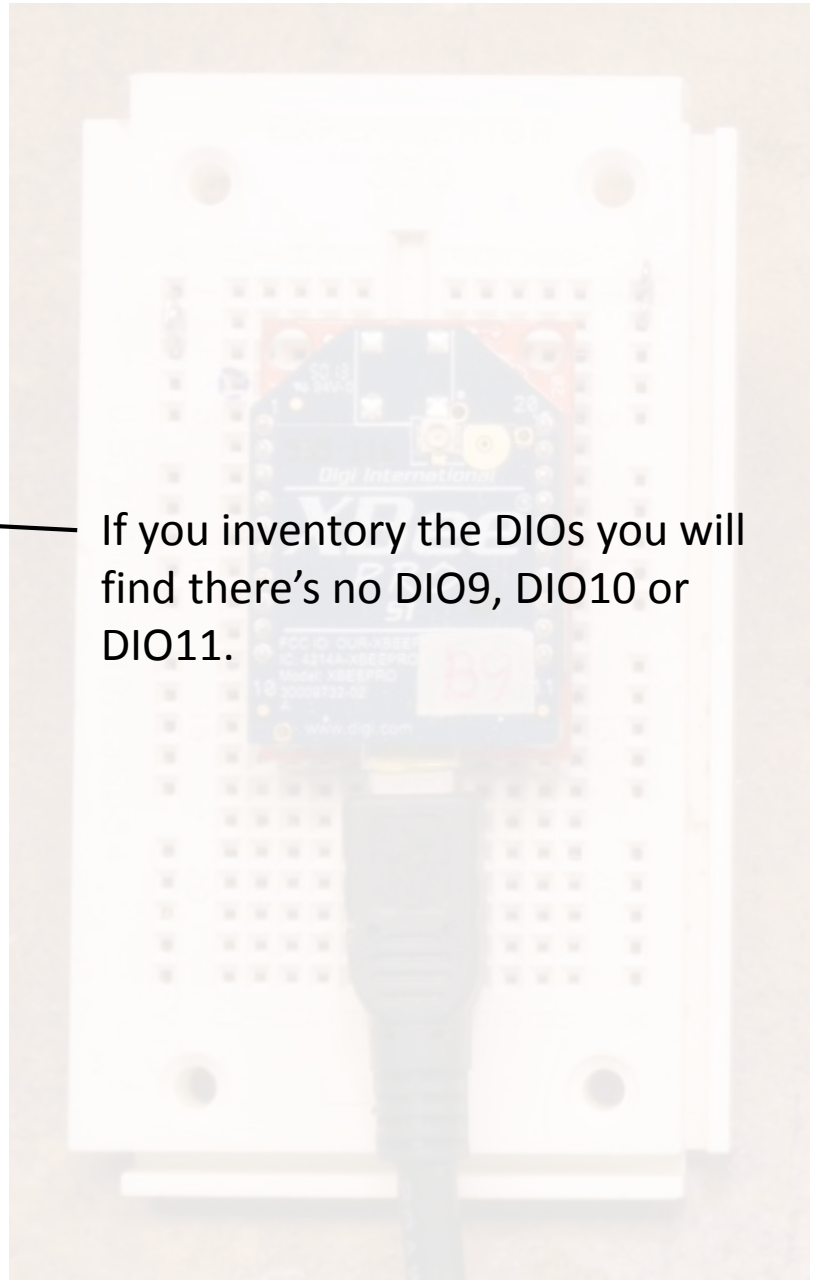
Just a reminder… These are Explorer pin numbers.

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

Note that this is DI 8, and not DIO8. This is the only digital input that can't be used as a digital output.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

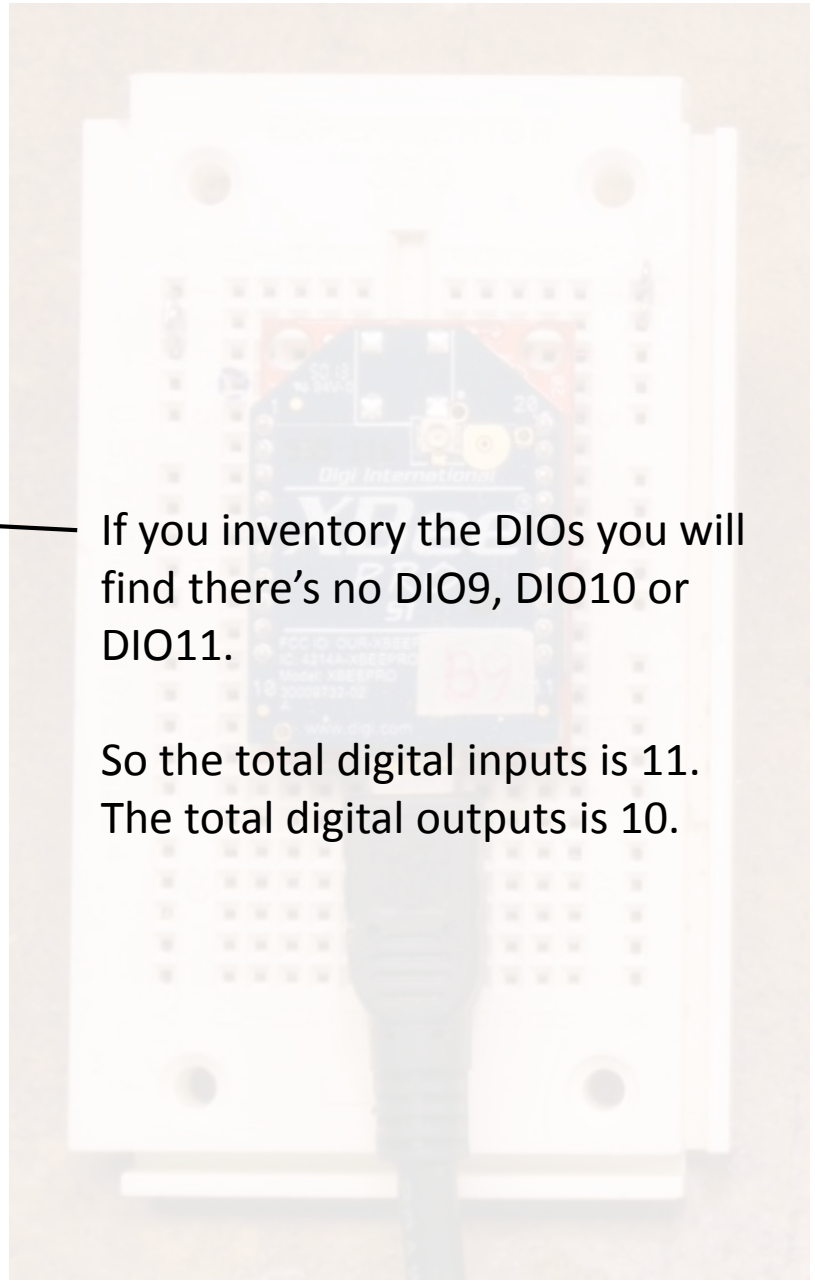
	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



If you inventory the DIOs you will find there's no DIO9, DIO10 or DIO11.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

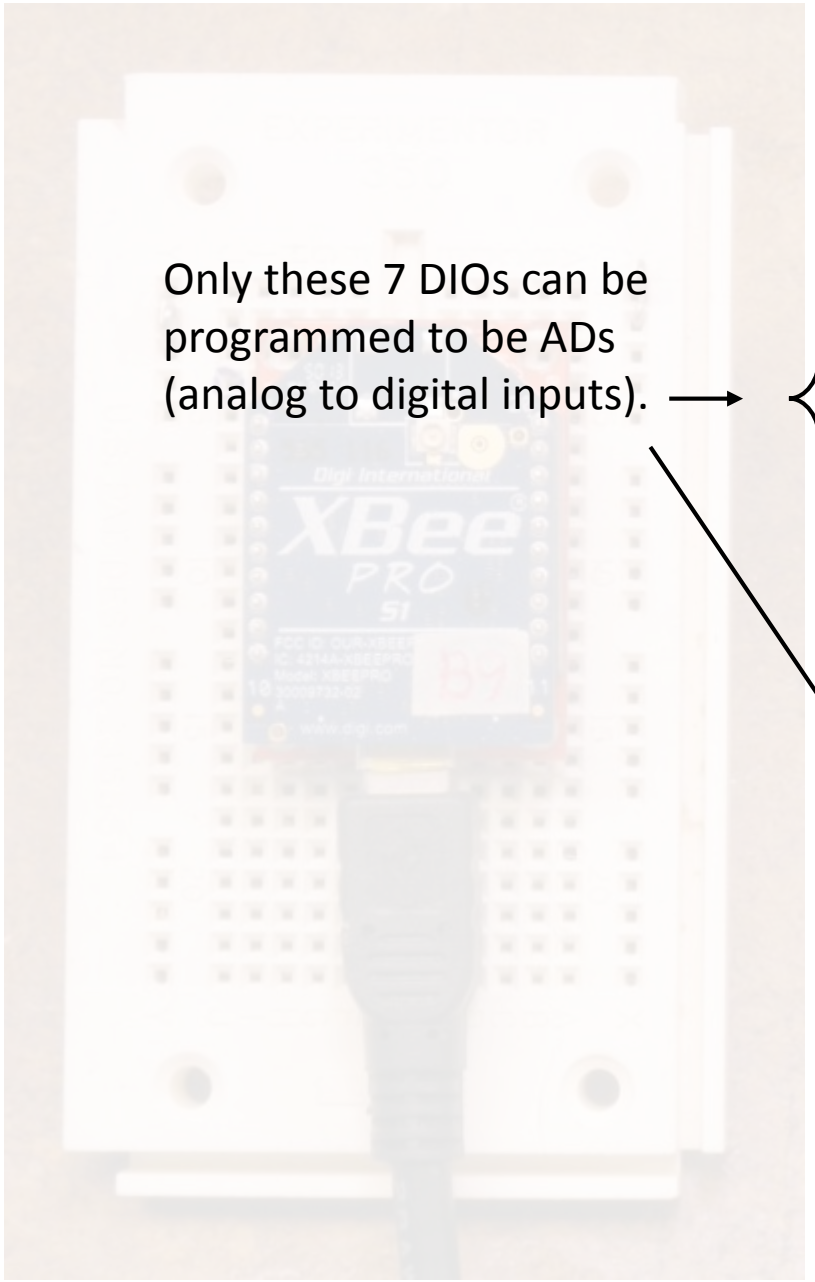


If you inventory the DIOs you will find there's no DIO9, DIO10 or DIO11.

So the total digital inputs is 11.
The total digital outputs is 10.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
DIO6	8	ON /sleep
DIO7	9	CTS
AD4 or DIO4	10	
5.0 V	11	

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND



Only these 7 DIOs can be programmed to be ADs (analog to digital inputs).

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
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	9	(reserved)
Sleep RQ	10	/DTR or DI8
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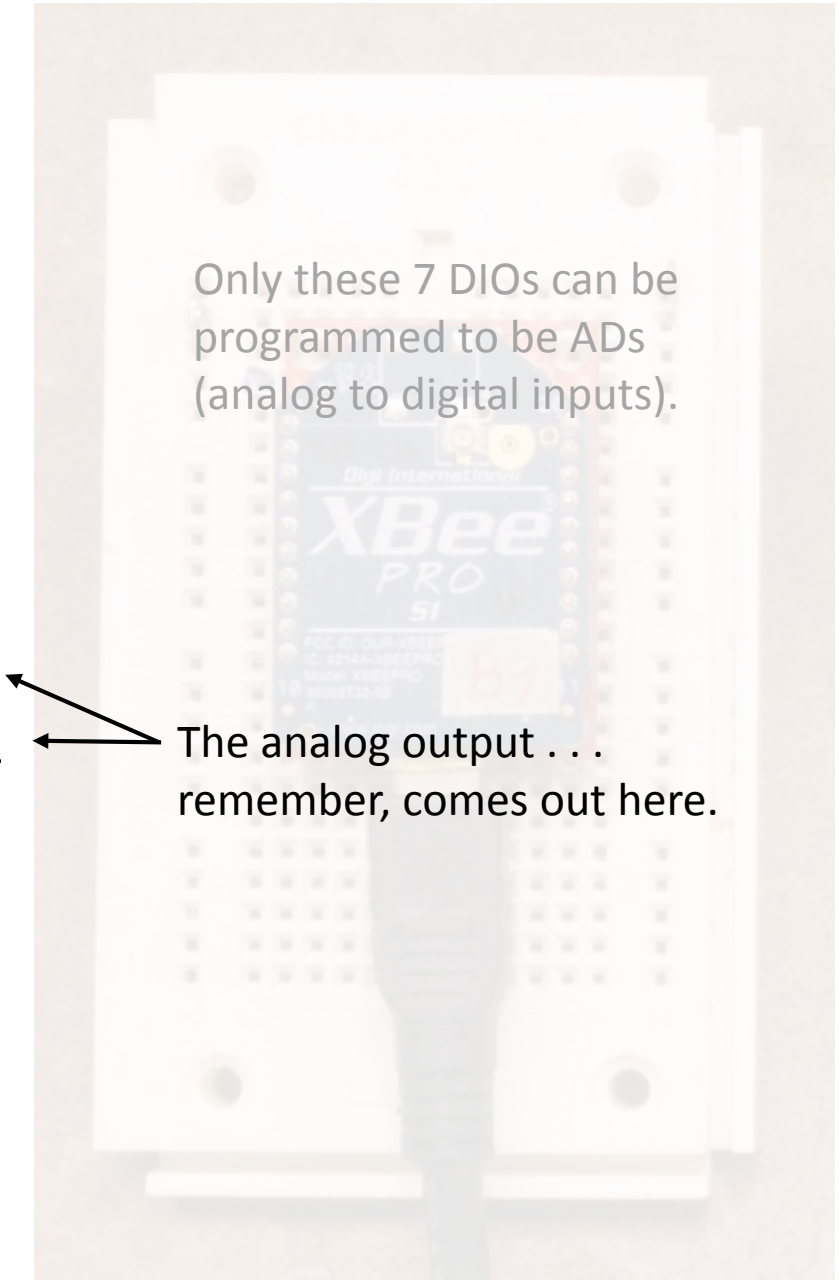

AD0 or DIO0	1	
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DIO7	9	CTS
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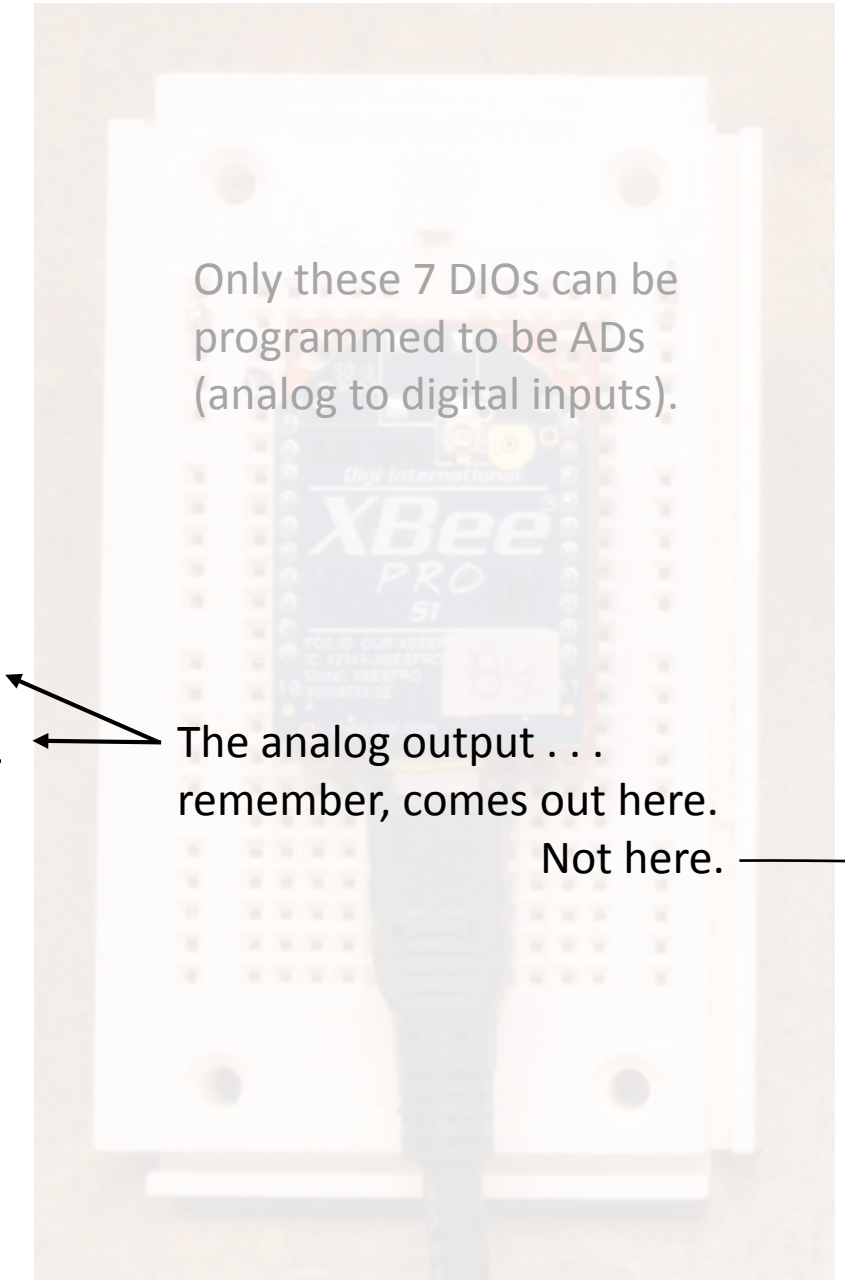
5.0 V	11	



	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

The analog output . . .
remember, comes out here.
Not here.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
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Vref	7	
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Sleep RQ	10	/DTR or DI8
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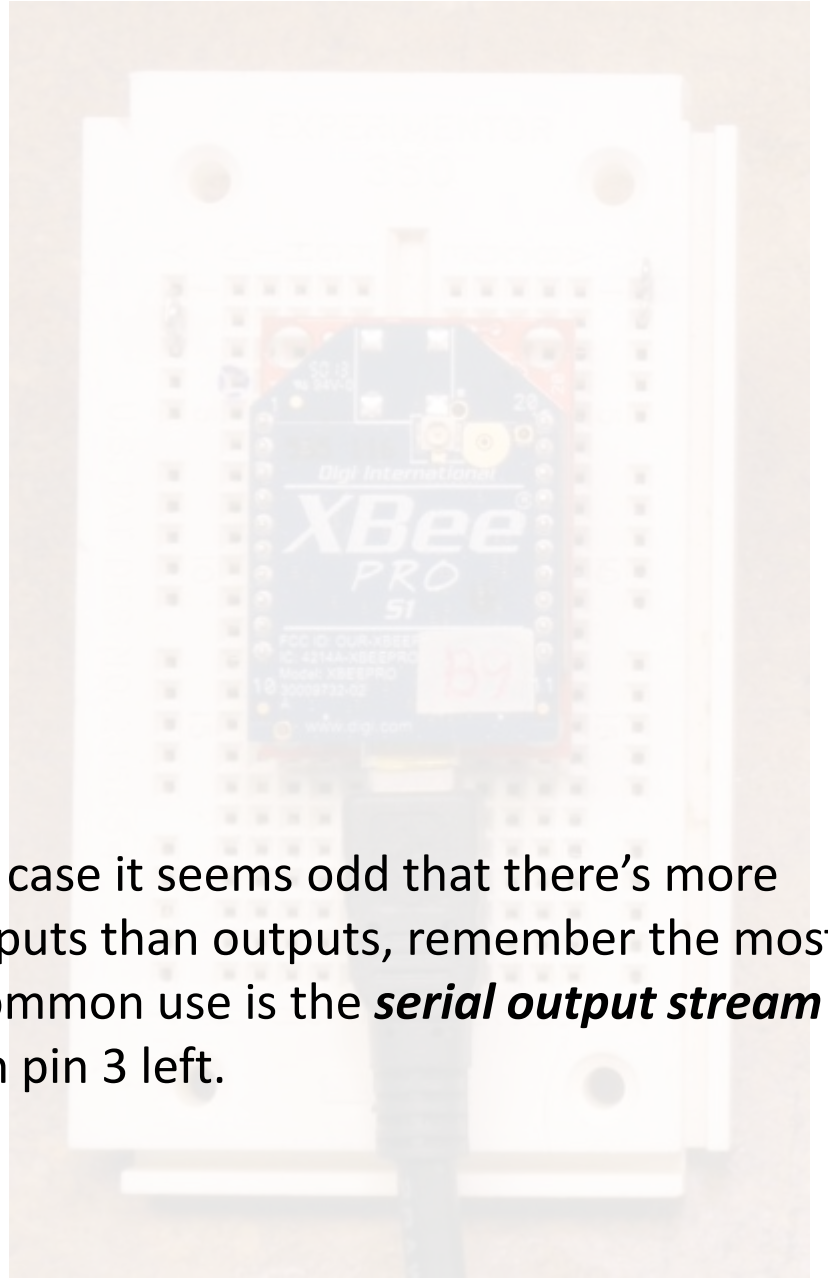

In case it seems odd that there's more inputs than outputs, remember the most common use is the ***serial output stream*** on pin 3 left.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
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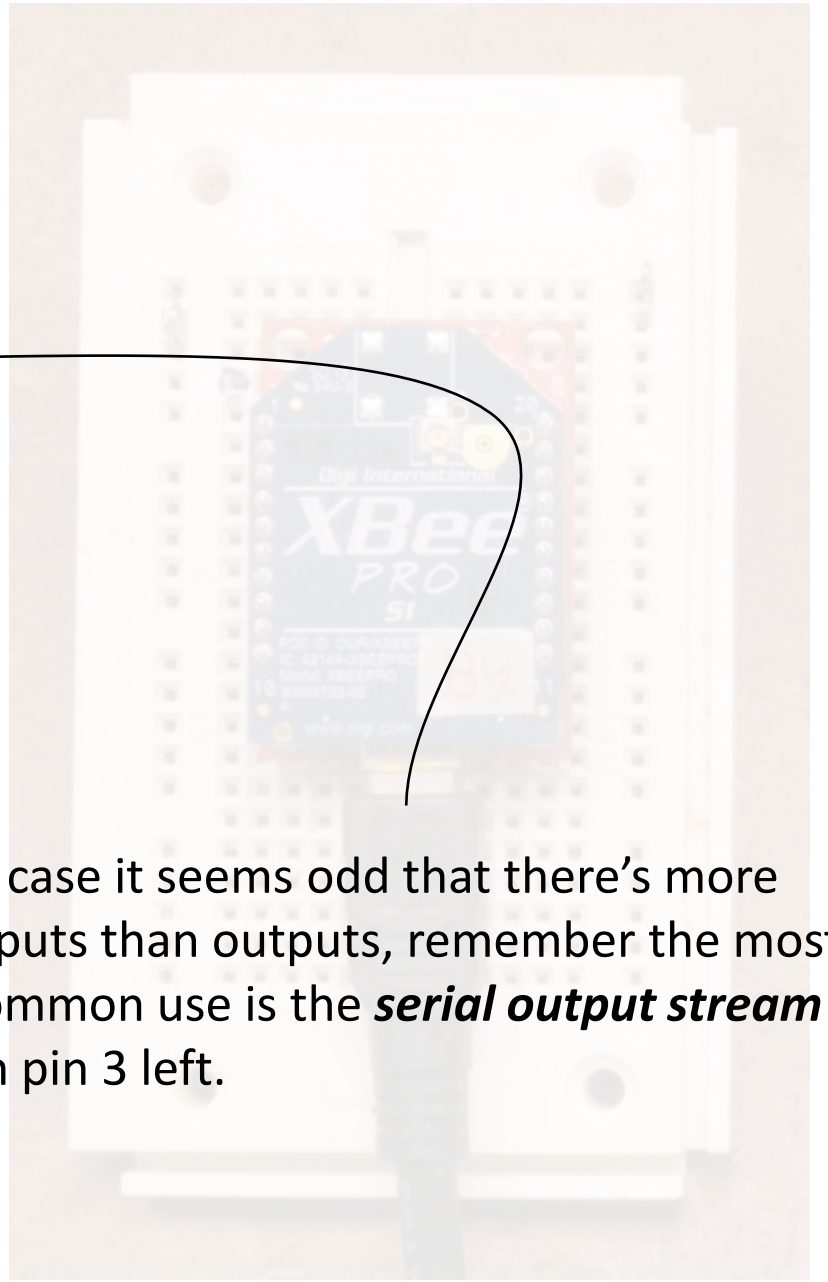

	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
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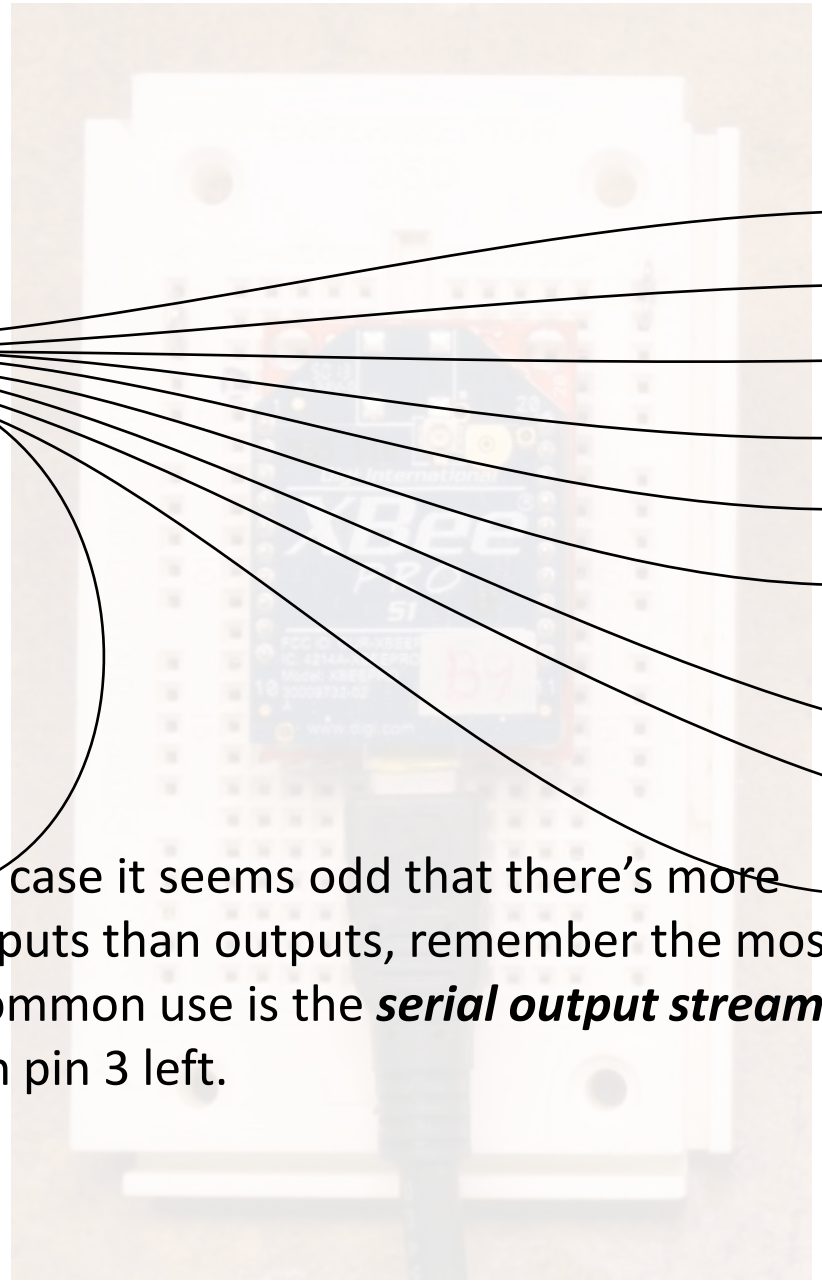
5.0 V	11	



	1	GND	AD0 or DIO0	1	
	2	3.3V (out)	AD1 or DIO1	2	
	3	DOUT	AD2 or DIO2	3	
	4	DIN /config	AD3 or DIO3	4	
	5	DIO12	AD6 or DIO6	5	/RTS
	6	/reset	AD5 or DIO5	6	associate
	7	RSSI or PWM0	Vref	7	
	8	DIO11 or PWM1	DIO6	8	ON /sleep
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Sleep RQ	10	/DTR or DI8	AD4 or DIO4	10	
	11	GND	5.0 V	11	

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	1	GND
	2	3.3V (out)
	3	DOUT
	4	DIN /config
	5	DIO12
	6	/reset
	7	RSSI or PWM0
	8	DIO11 or PWM1
	9	(reserved)
Sleep RQ	10	/DTR or DI8
	11	GND

3.3V is created by the Explorer for the XBee. But it is available here to be used by you if your sensors need power.

AD0 or DIO0	1	
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Sleep RQ	10	/DTR or DI8
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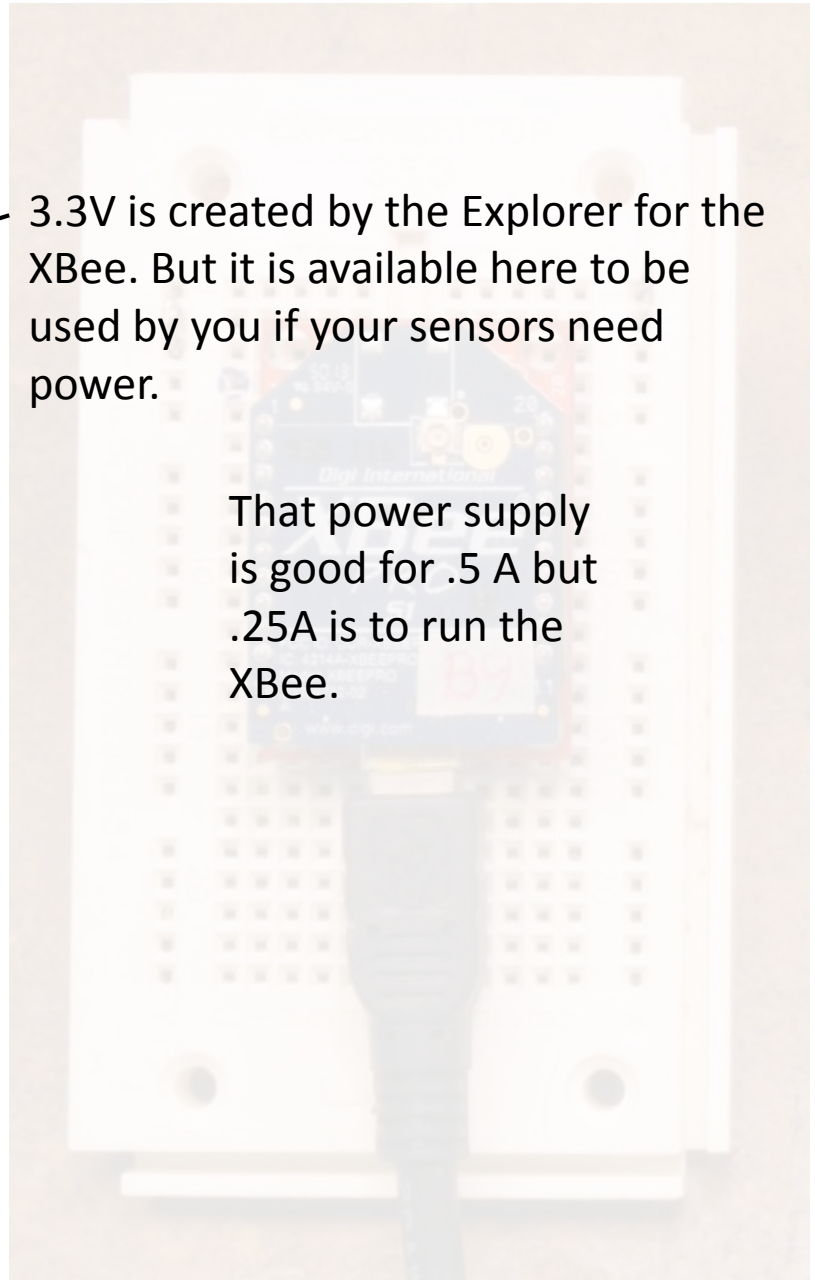
That power supply is good for .5 A but .25A is to run the XBee.



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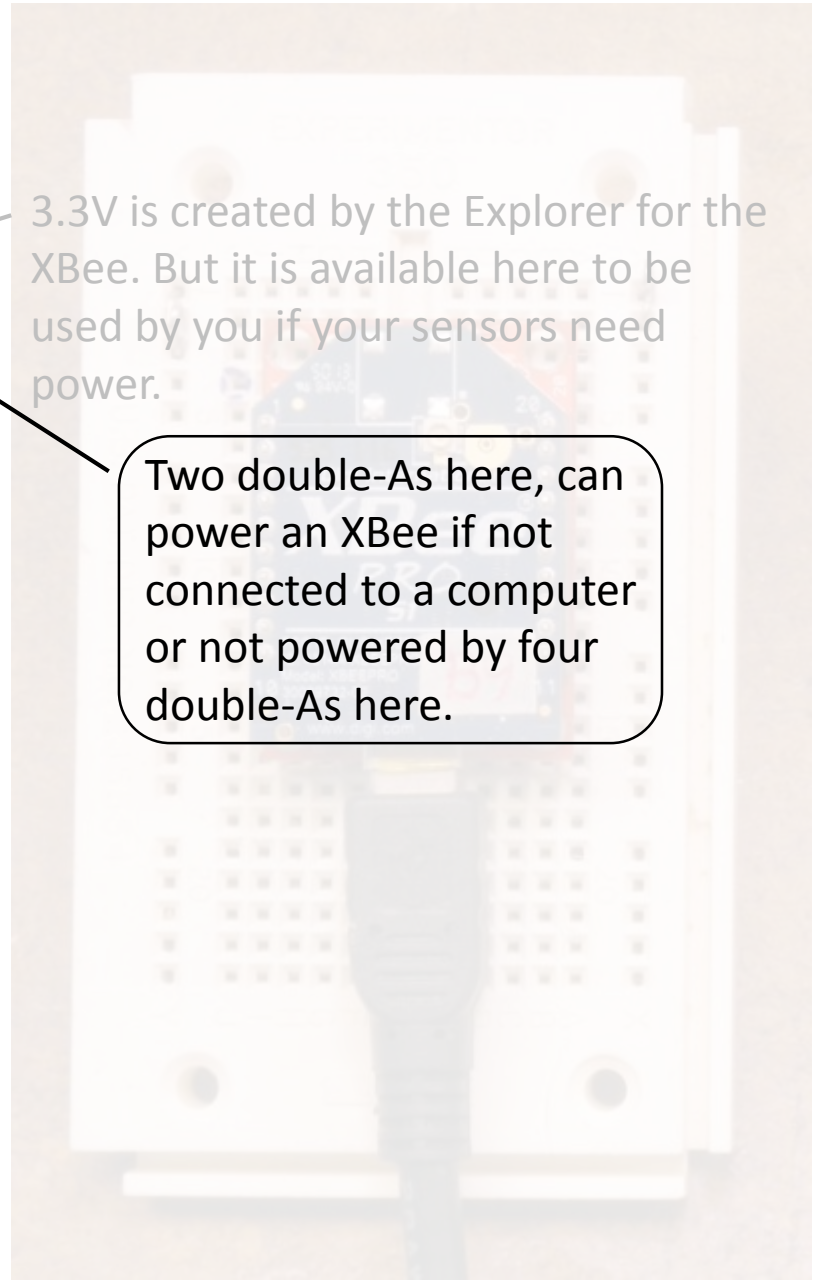

	1	GND
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Sleep RQ	10	/DTR or DI8
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Two double-As here, can power an XBee if not connected to a computer or not powered by four double-As here.

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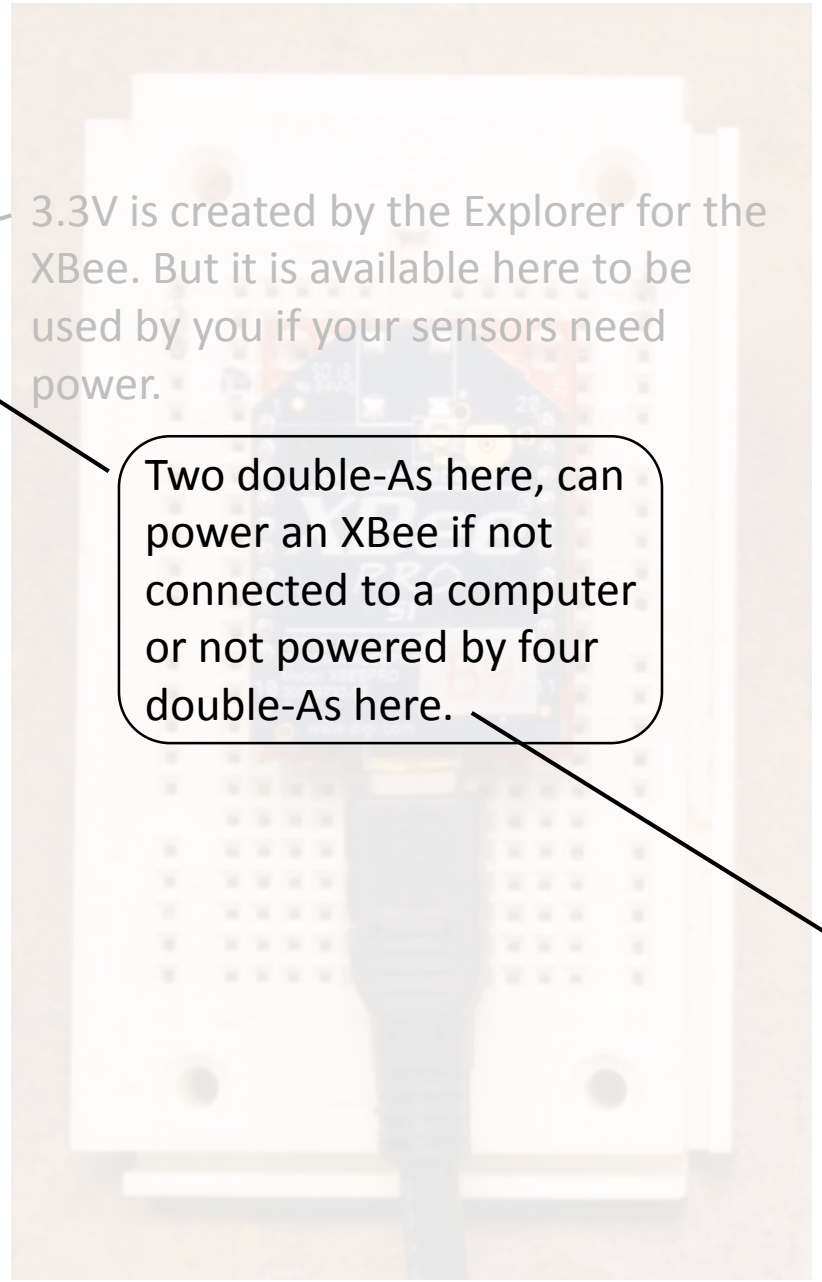
5.0 V	11	



	1	GND
	2	3.3V (out)
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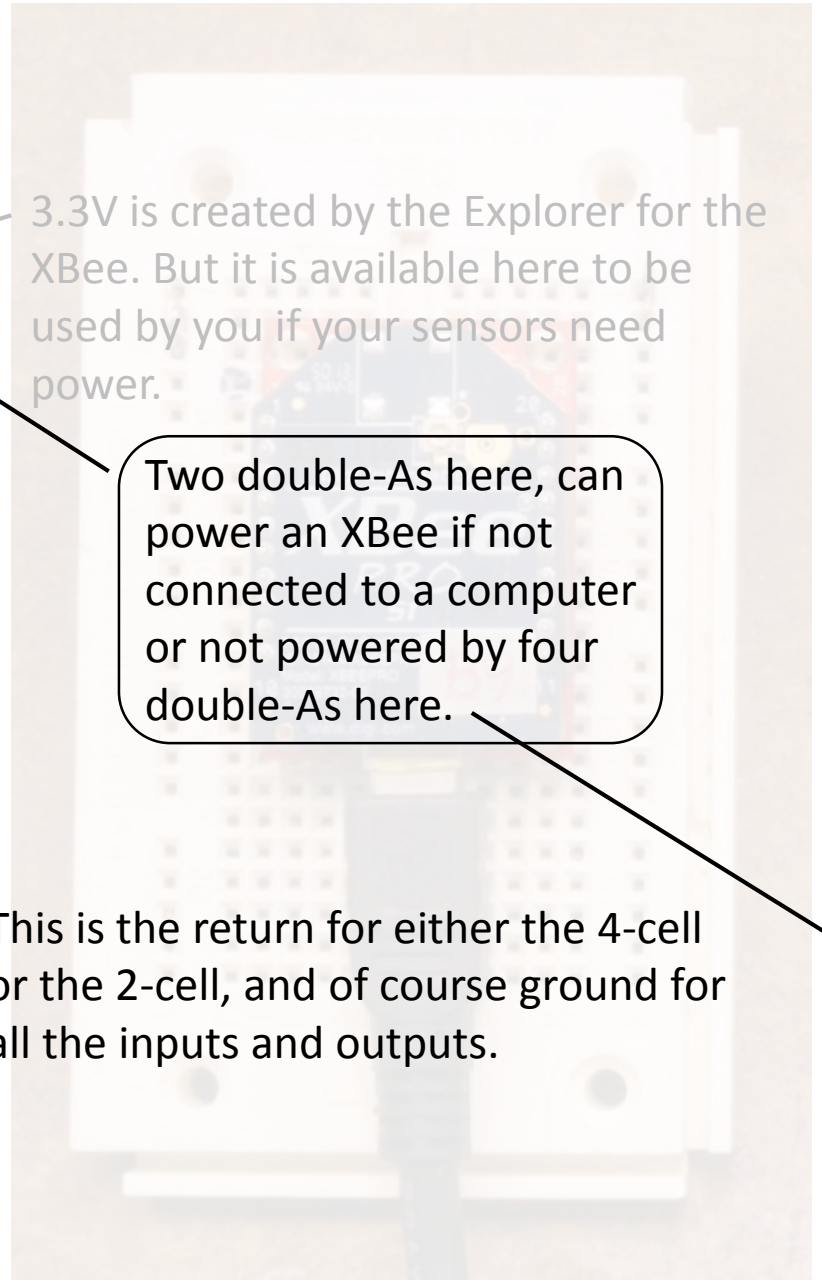

	1	GND		
	2	3.3V (out)		
	3	DOUT		
	4	DIN /config		
	5	DIO12		
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	7	RSSI or PWM0		
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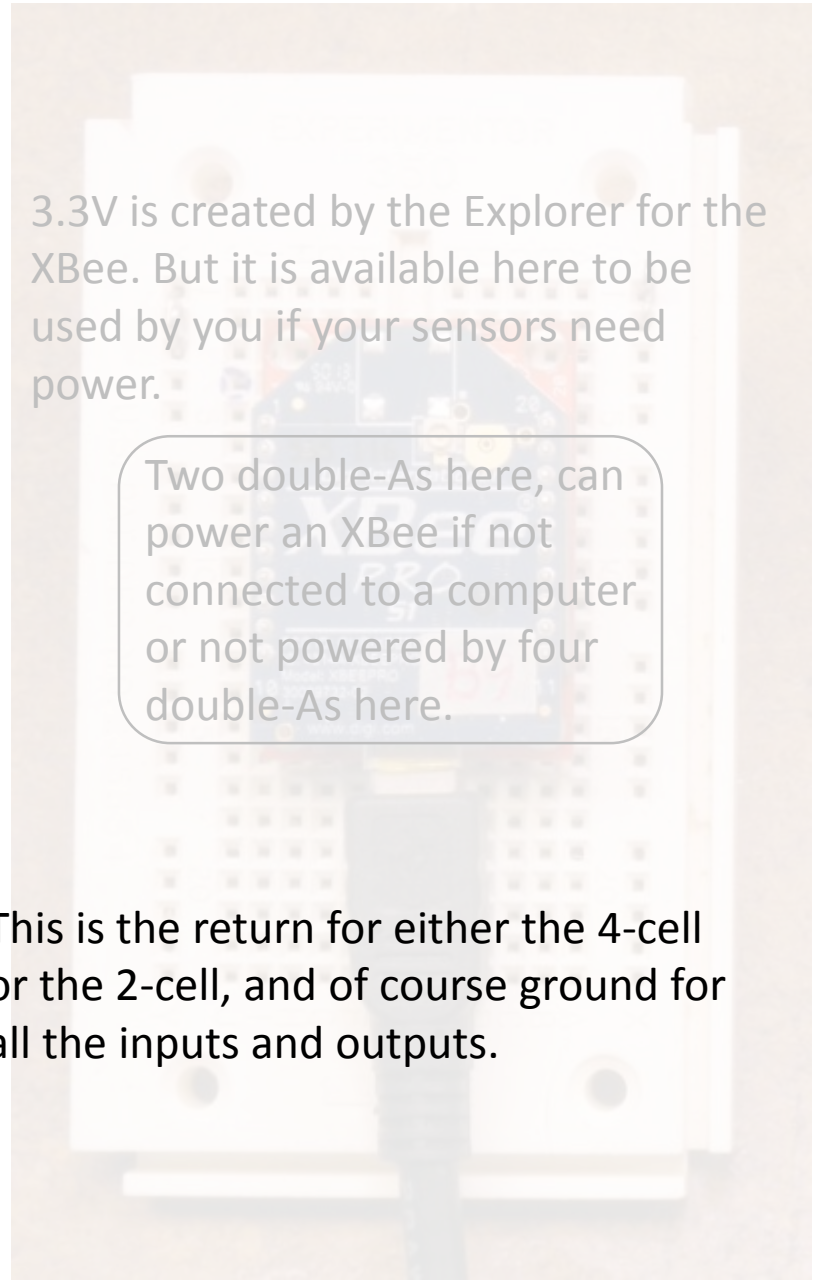
This is the return for either the 4-cell or the 2-cell, and of course ground for all the inputs and outputs.



	1	GND	AD0 or DIO0	1	
	2	3.3V (out)	AD1 or DIO1	2	
	3	DOUT	AD2 or DIO2	3	
	4	DIN /config	AD3 or DIO3	4	
	5	DIO12	AD6 or DIO6	5	/RTS
	6	/reset	AD5 or DIO5	6	associate
	7	RSSI or PWM0	Vref	7	
	8	DIO11 or PWM1	DIO6	8	ON /sleep
	9	(reserved)	DIO7	9	CTS
Sleep RQ	10	/DTR or DI8	AD4 or DIO4	10	
	11	GND	5.0 V	11	

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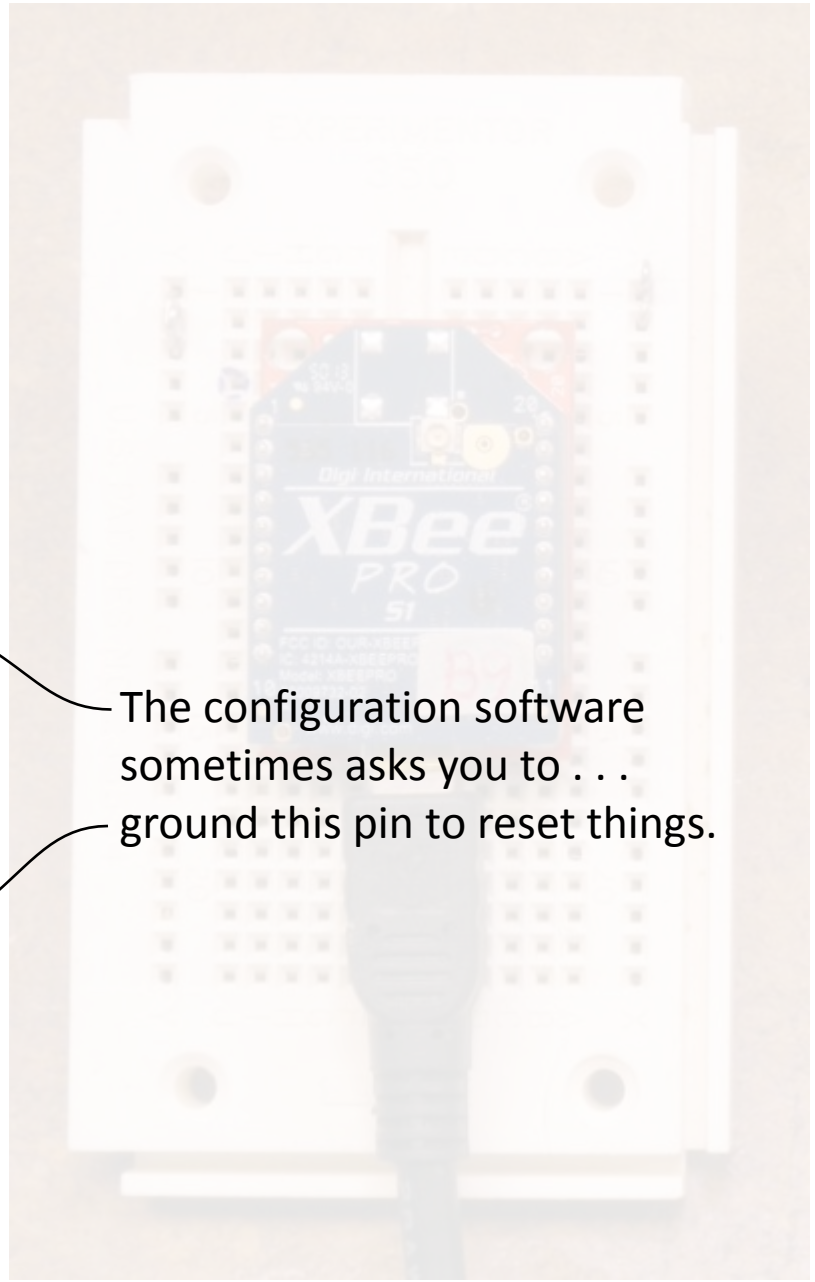

The configuration software sometimes asks you to . . . ground this pin to reset things.

AD0 or DIO0	1	
AD1 or DIO1	2	
AD2 or DIO2	3	
AD3 or DIO3	4	
AD6 or DIO6	5	/RTS
AD5 or DIO5	6	associate
Vref	7	
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USB cable connected to the Explorer allows a remote USB with sensor/microcontroller to communicate with your PC.

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The USB also allows you to configure the XBee using . . . ***X-CTU***

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XBee Configuration Program

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Configuration change is not necessary when the XBees are on microcontrollers.

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X-CTU is essential for line passing.

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Configuration change is not necessary when the XBees are on microcontrollers.

X-CTU is essential for line passing.

The X-CTU Configuration Program will be discussed extensively later.

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XBee Configuration Program

Configuration change is not necessary when the XBees are on microcontrollers.

X-CTU is essential for line passing.

After X-CTU programming . . .

- The USB cable can be removed. Or . . .
- The XBee can be removed from that Explorer and put on another one without a USB.
- The XBee can even run alone on a customized 2 mm spacing PCB which has a 3 volt supply.

The following 50 slides or so is about setting up and wiring a pair of XBees to exchange . . .

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- several channels of digital information
- and 2 separate channels of analog

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without microcontroller

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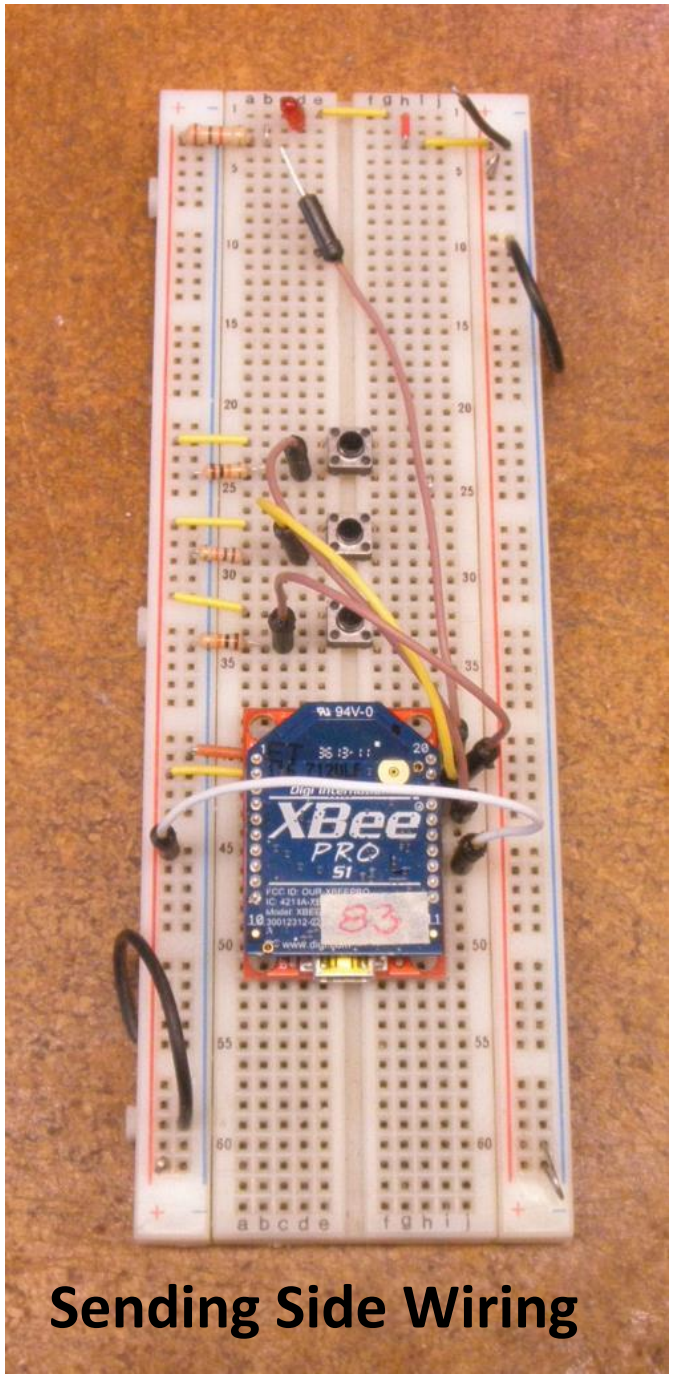
In XBee terminology, this is called

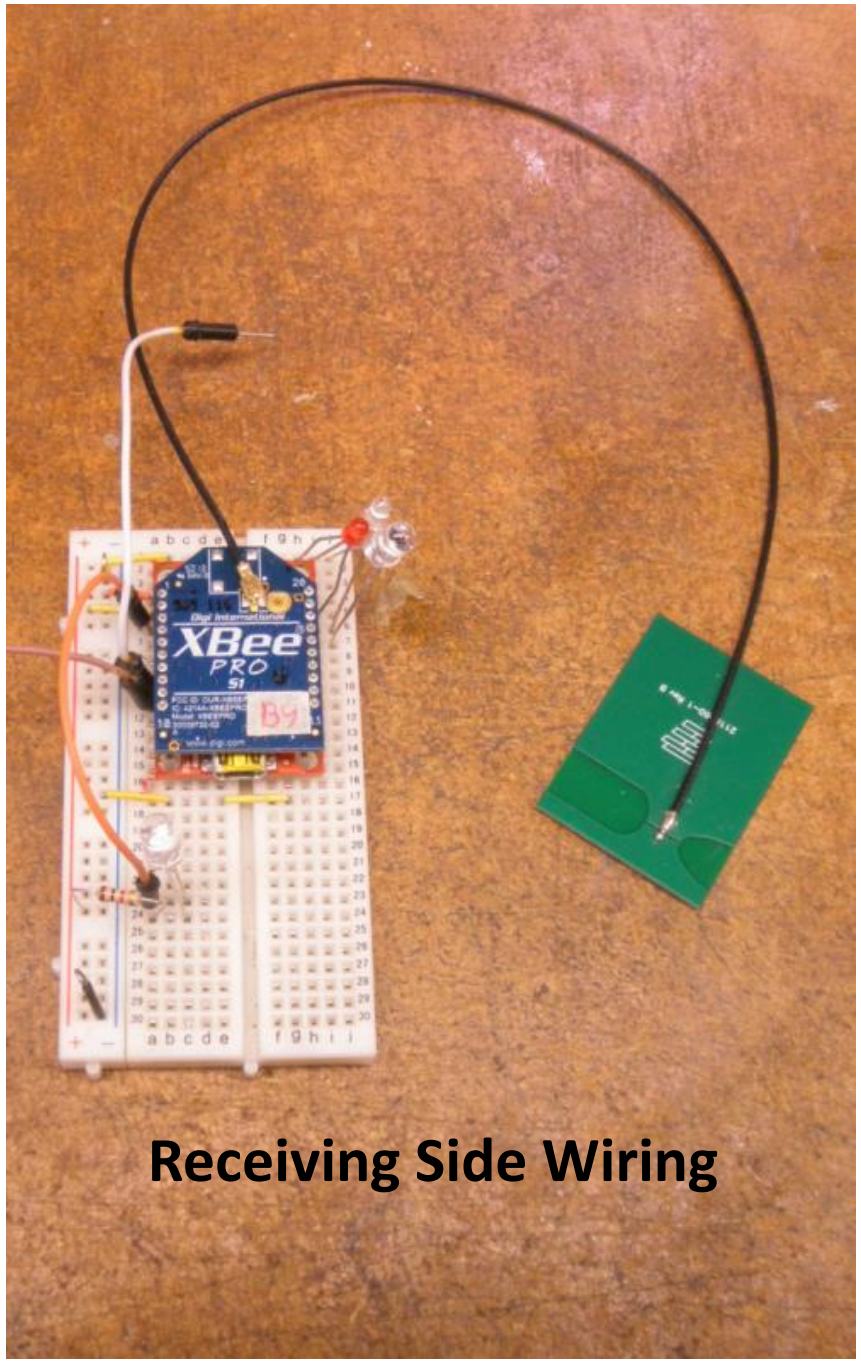
line passing



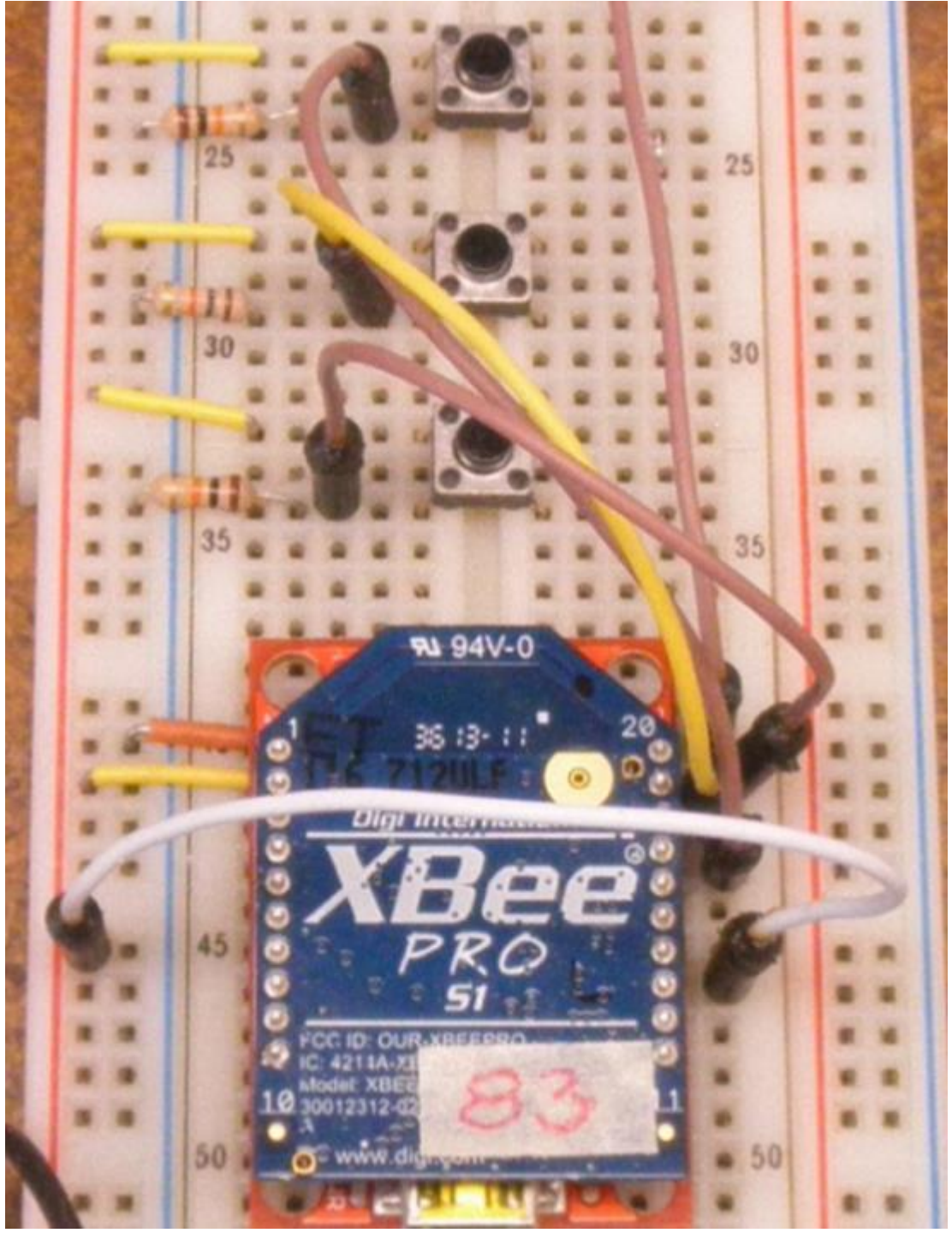
Sending Side Wiring

without microcontroller

line passing

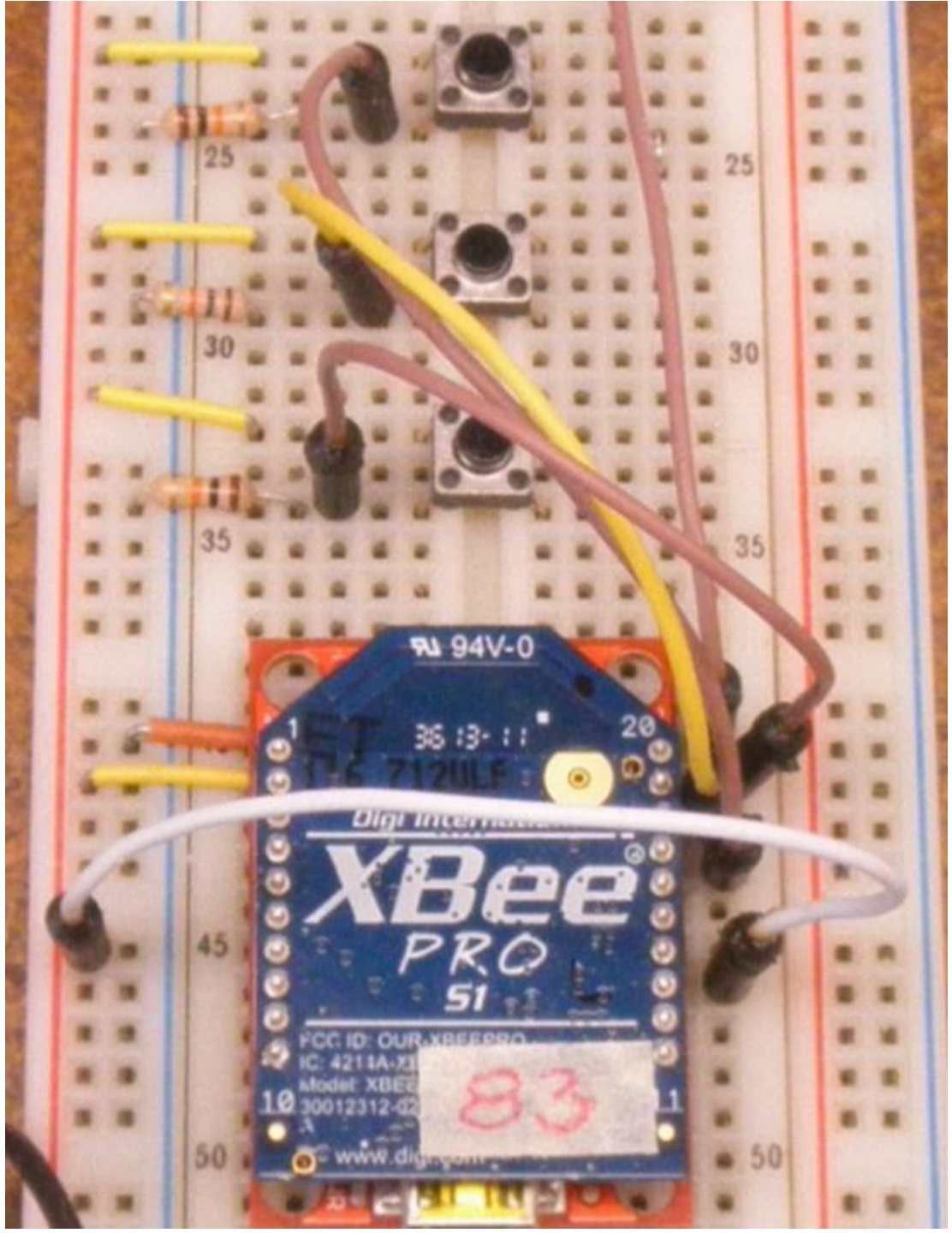


Receiving Side Wiring



Sending Side Wiring

- left side pin number 1 to protoboard ground
- left side pin number 2 is 3.3V (out of explorer) goes to protoboard Vcc
- right side pin number 7 to 3.3V (Vcc)
- three **Switched Sources** of 3.3V to: right side pin numbers 2, 3,and 4
- right side pin number 1 is analog voltage input



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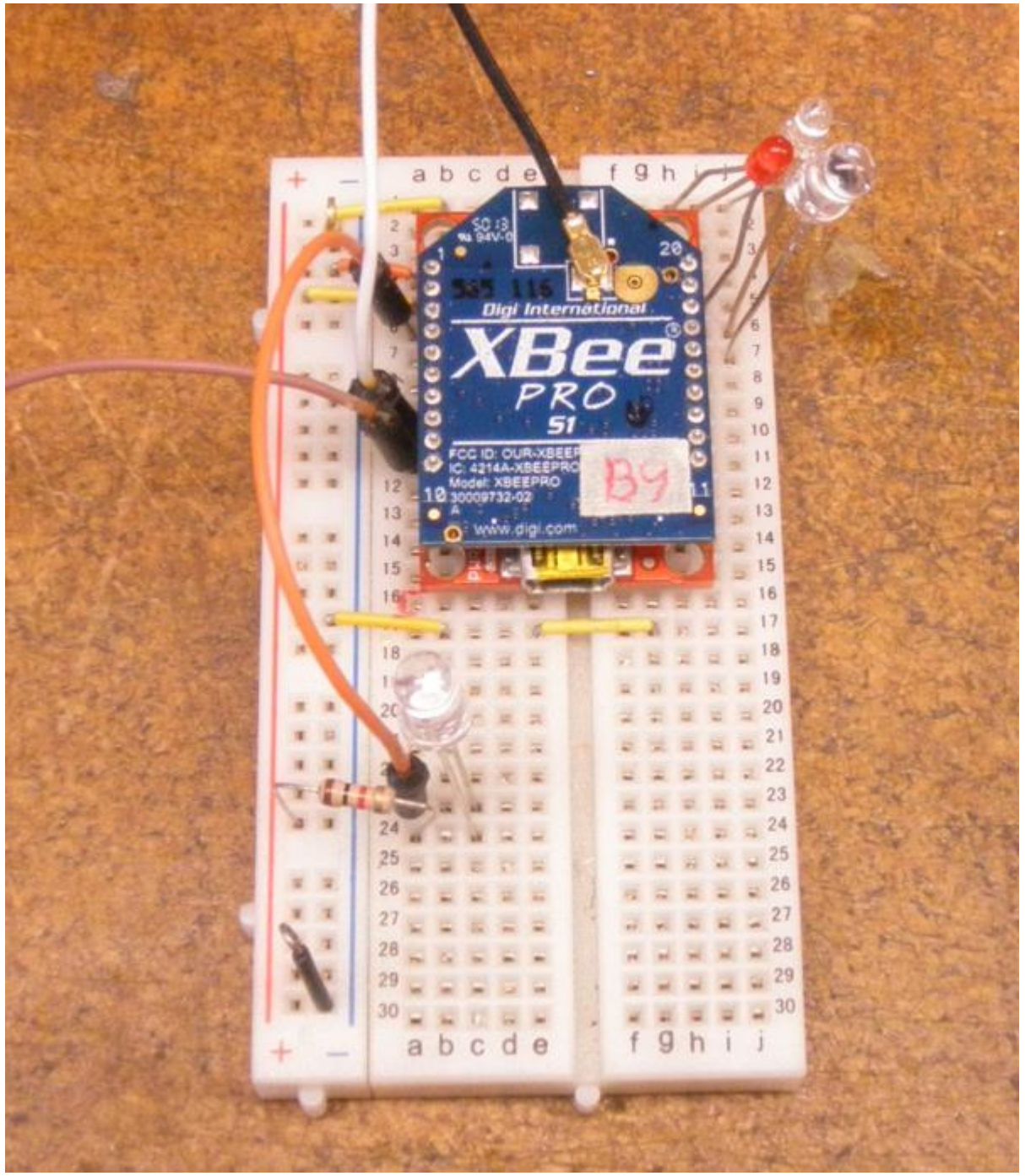
Switched Source is:

- **3.3V to switch**
- **from other side of switch to 10K**
- **from other side of 10K to ground**
- **A wire goes from between 10K and switch to the above input pins**

Receiving Side Wiring

- left side pin number 1 to protoboard ground
- left side pin number 2 is 3.3V (out of explorer) and it goes to protoboard Vcc
- right side pin numbers 2,3,4 to LEDs
- the other LED leads go to ground
- left side pin number 7 is analog output



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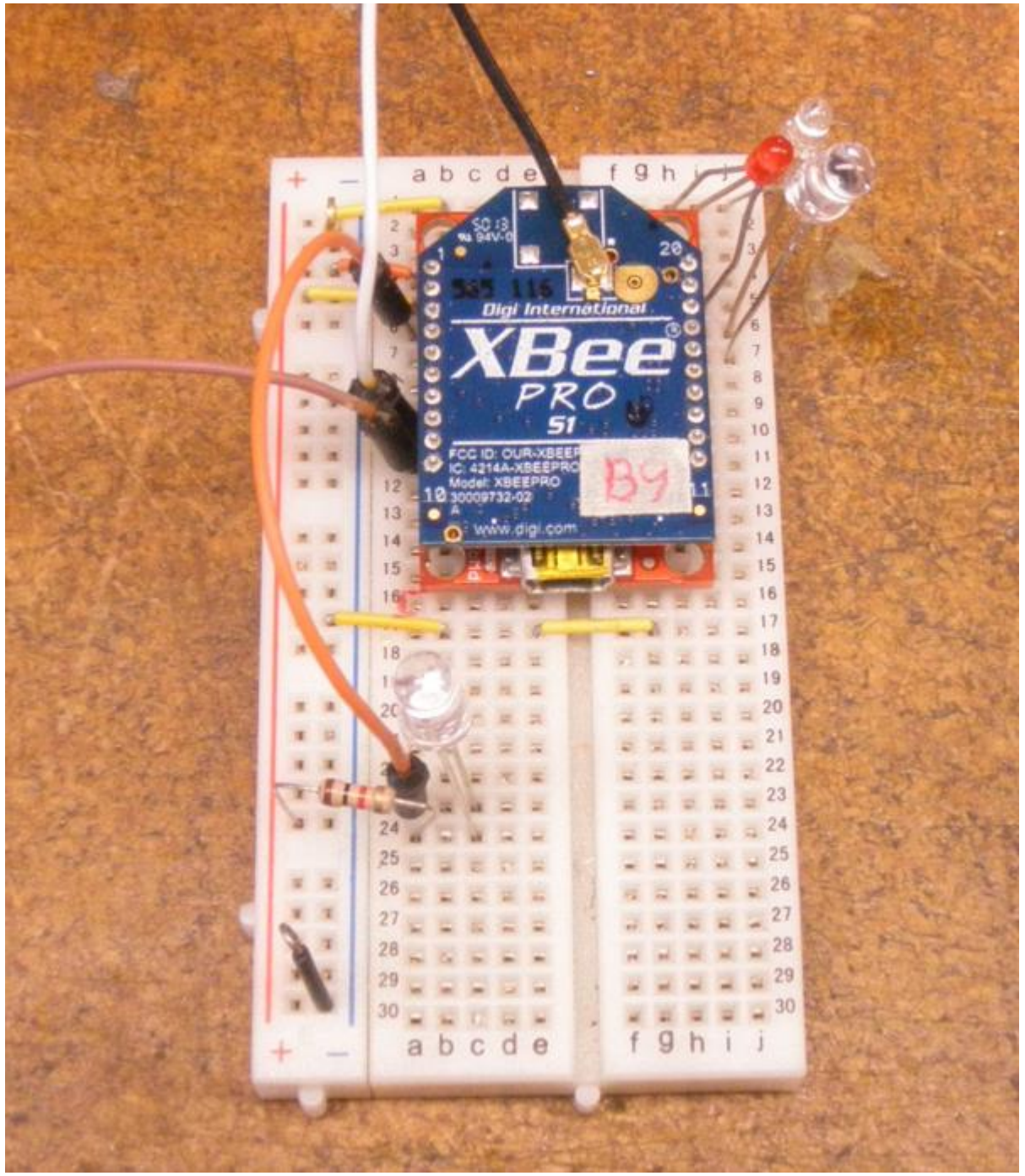
- left side pin 3 is a serial stream output. This normally goes to a microcontroller but here it is going to an LED and 10 K resistor to 3.3V just to show activity on the line.



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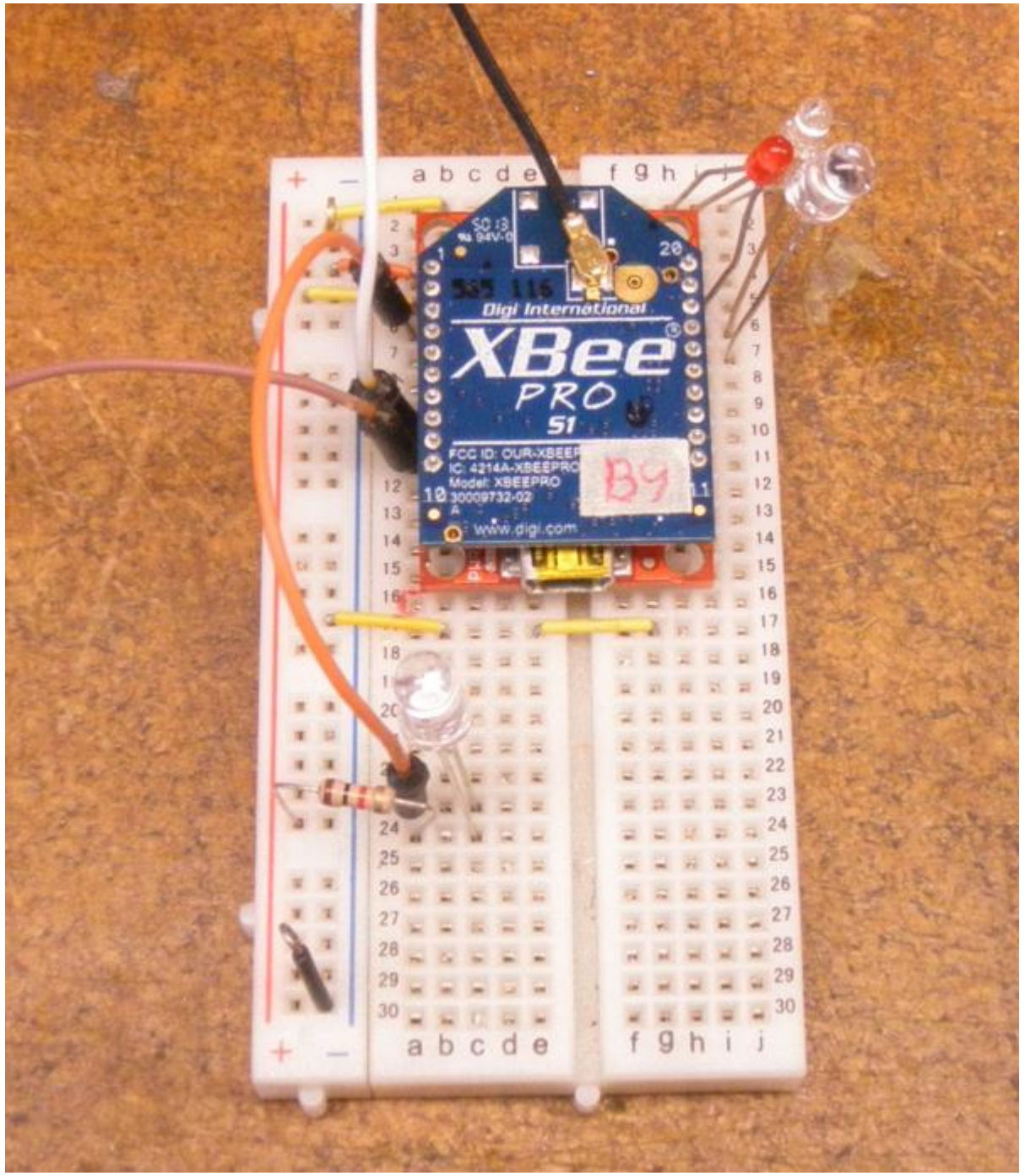
When “analog” is not being used, this LED only lights if any of the switches are touched. With the analog data enabled, this LED is continuously on, indicating a constant updating of information. This LED goes out when there’s insufficient RF signal strength.



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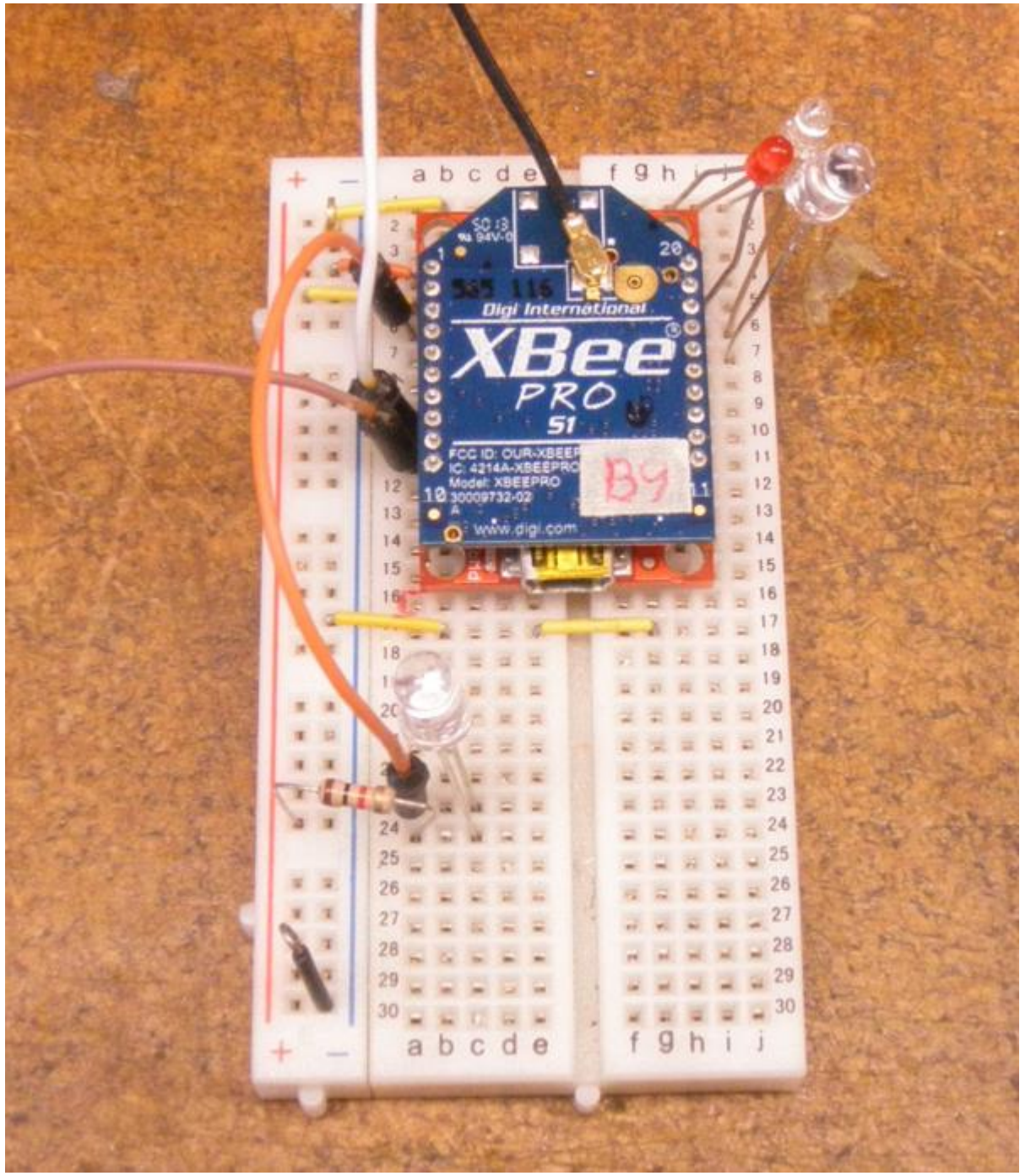
Left side pin 7 can be programmed to show signal strength, but that ties up one of the two analog outputs.



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It also allows you to configure the XBee using X-CTU.

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What's configurable are these pins.
- either inputs or outputs.

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X-CTU also allows you to optimize the modem parameters for efficient transfer of data.

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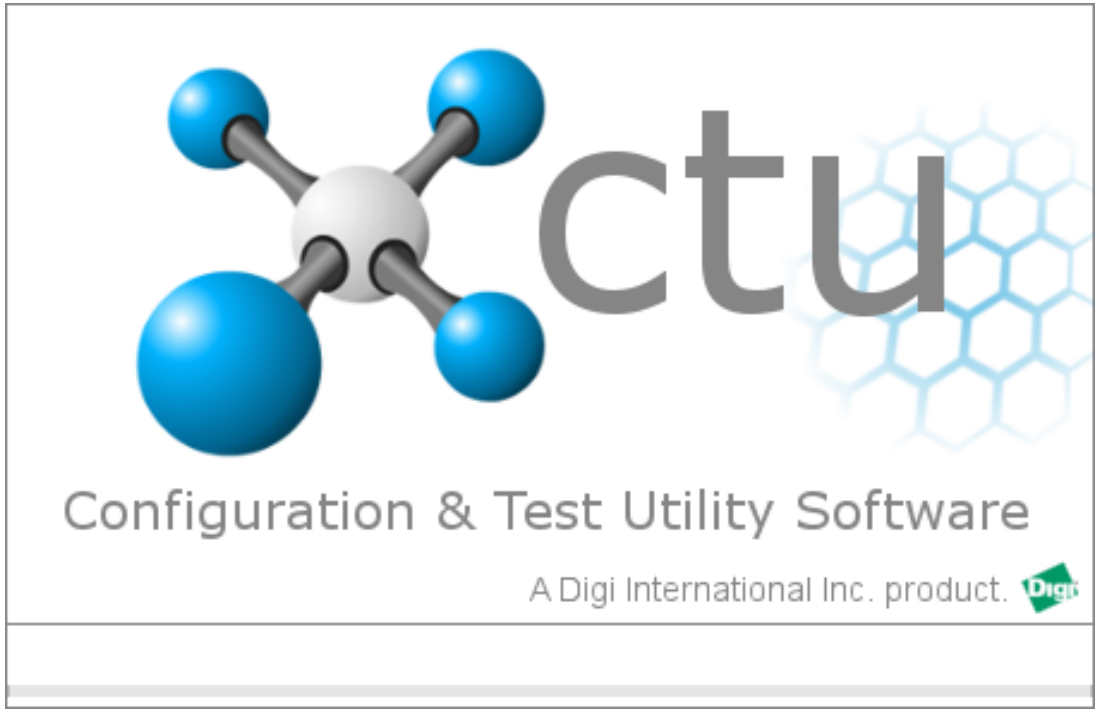
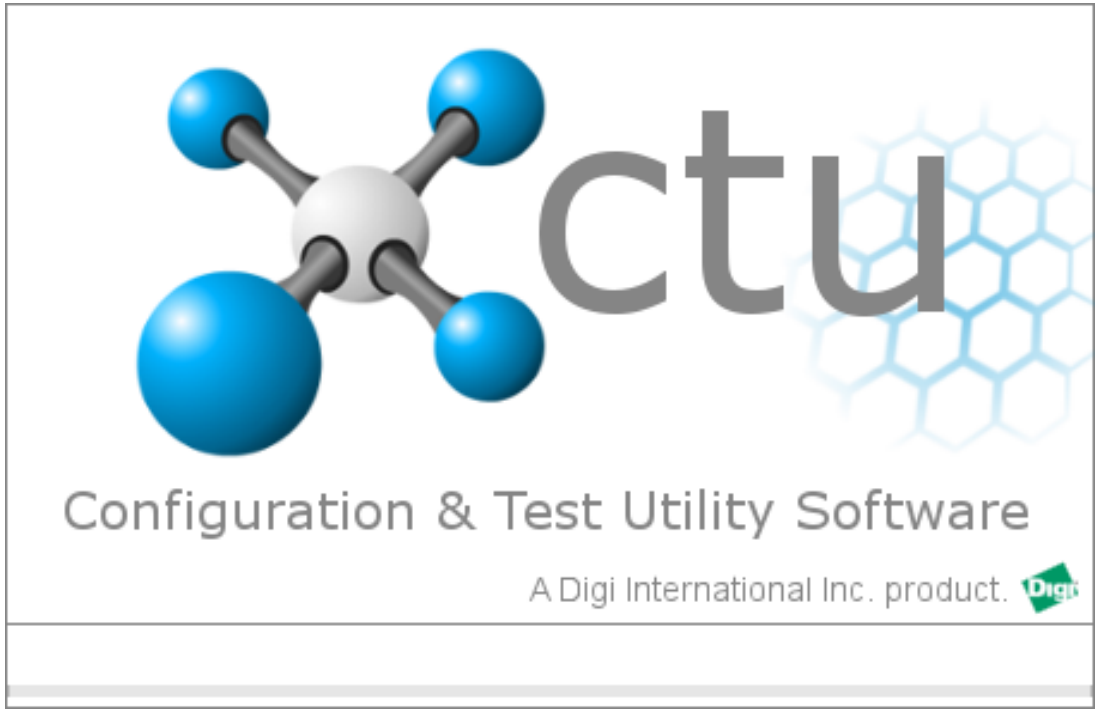
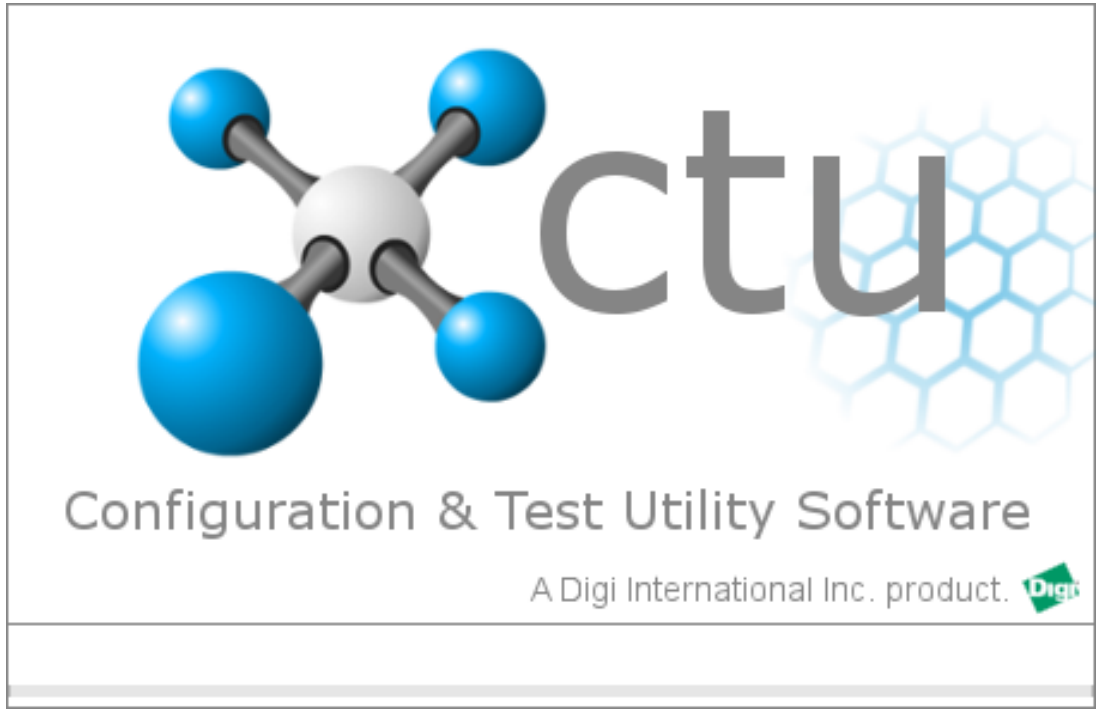


Download it from this webpage: http://www.digi.com/products/wireless-wired-embedded-solutions/zigbee-rf-modules/xctu



Download it from this webpage: http://www.digi.com/products/wireless-wired-embedded-solutions/zigbee-rf-modules/xctu

Note: To use the XBee Explorer, with the USB, you will need to install the FTDI driver onto your computer. Click here to download the drivers for your operating system.



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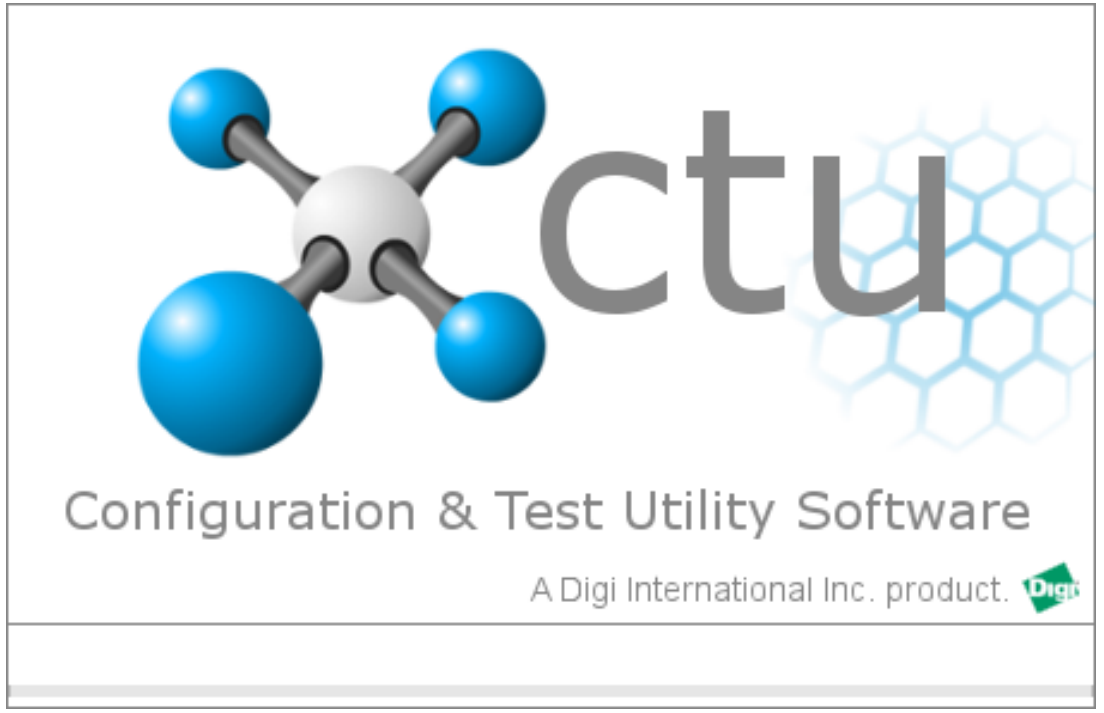
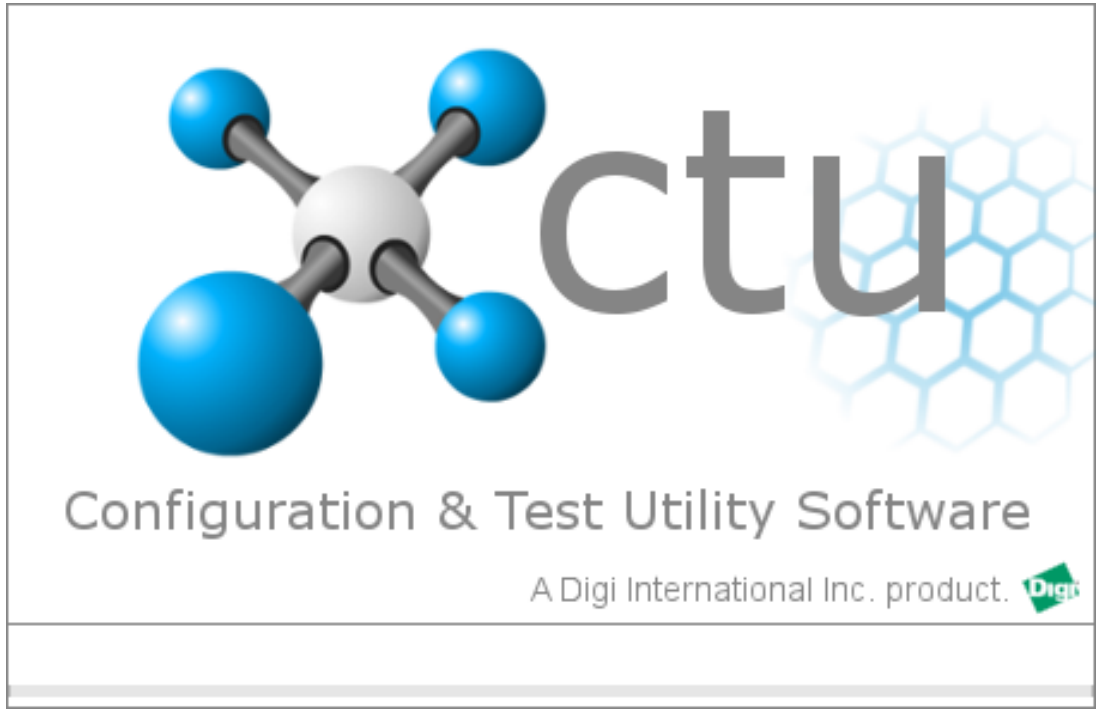
Connect Explorer to PC with USB cable.



Download it from this webpage: http://www.digi.com/products/wireless-wired-embedded-solutions/zigbee-rf-modules/xctu

Connect Explorer to PC with USB cable.

Run X-CTU after connecting Explorer.



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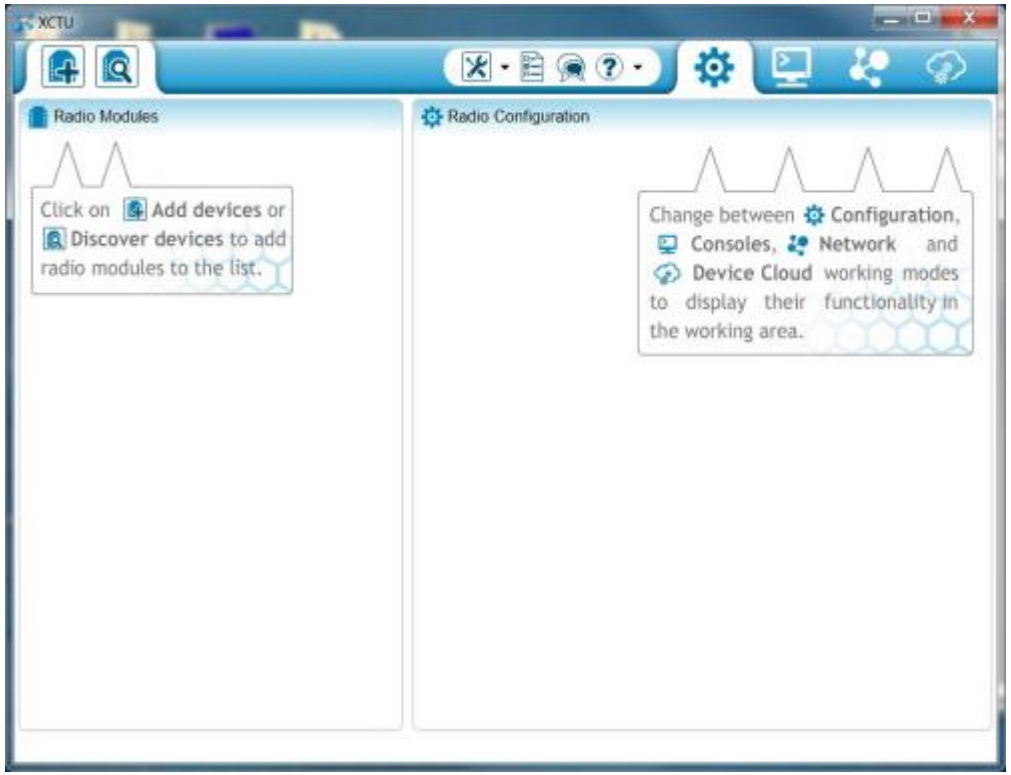
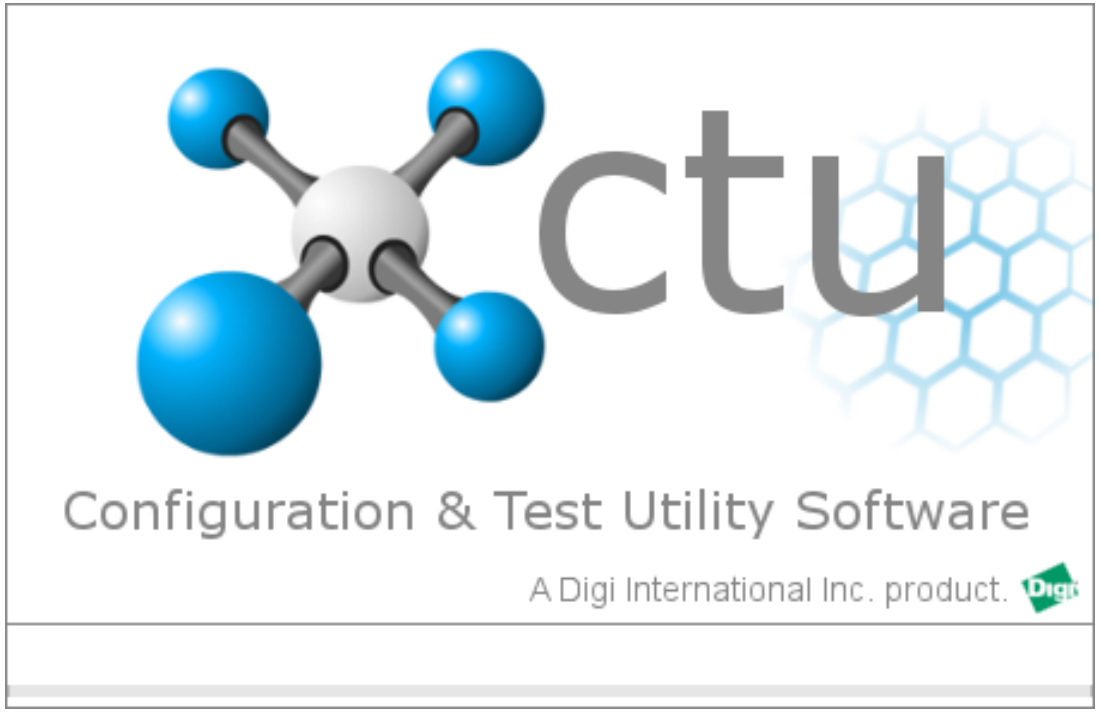


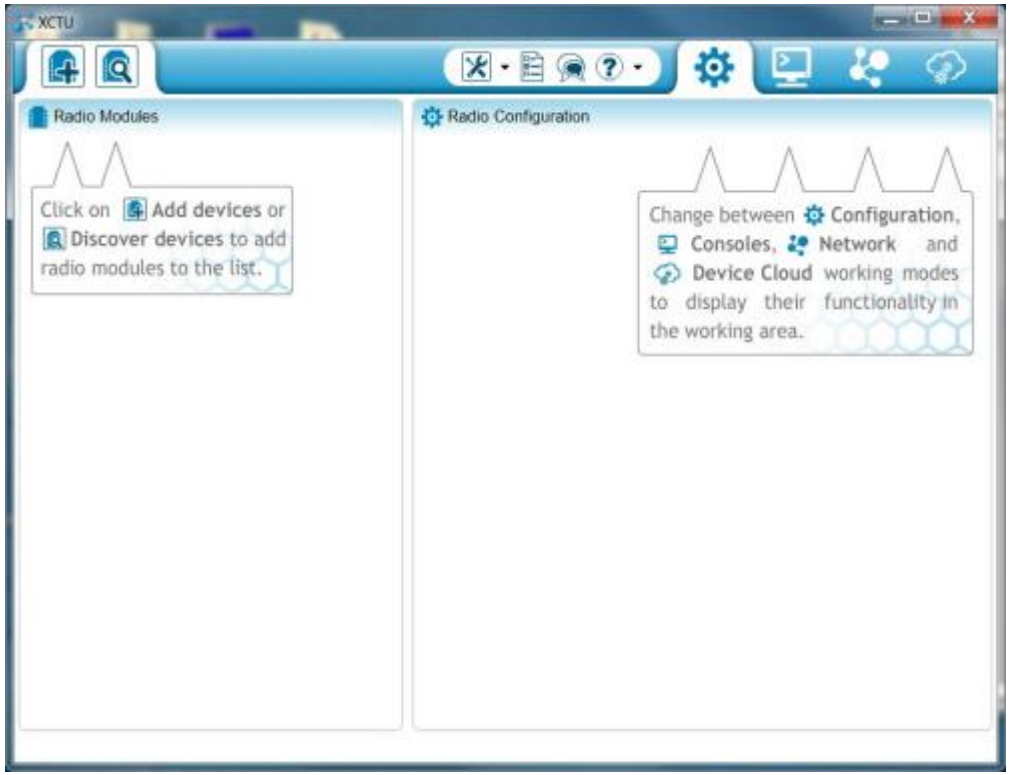


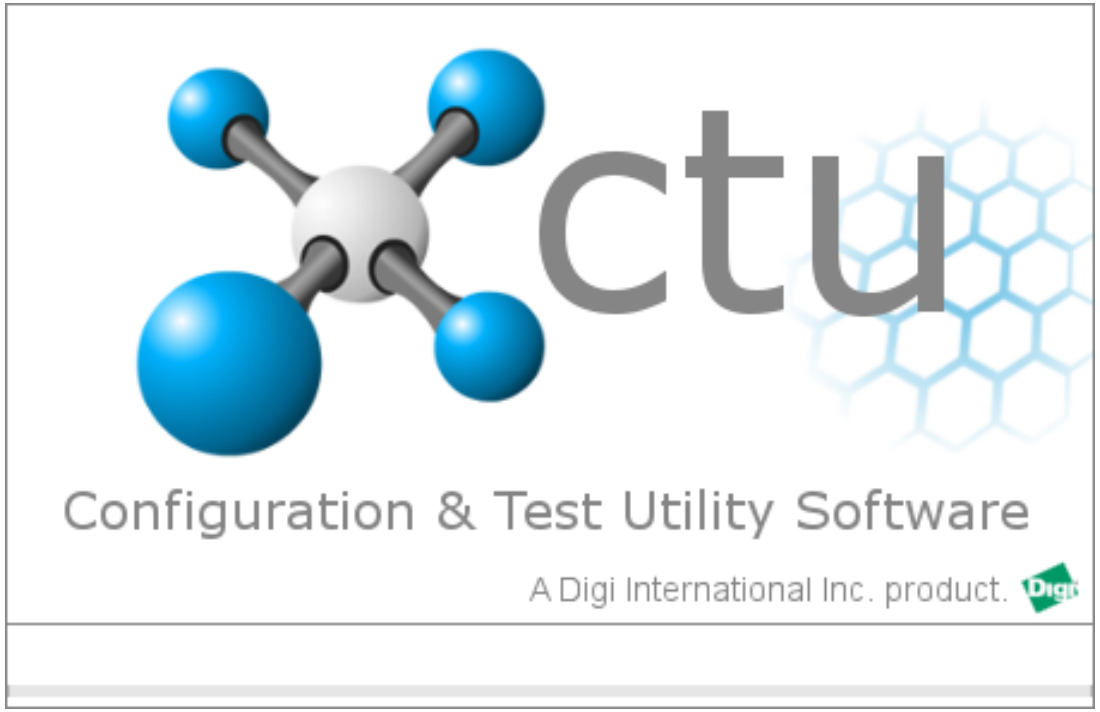
Download it from this webpage: http://www.digi.com/products/wireless-wired-embedded-solutions/zigbee-rf-modules/xctu

Connect Explorer to PC with USB cable.

Run X-CTU after connecting Explorer.

This order is not essential, but if connection is made after running, you may get error messages that don't make sense, from to time.





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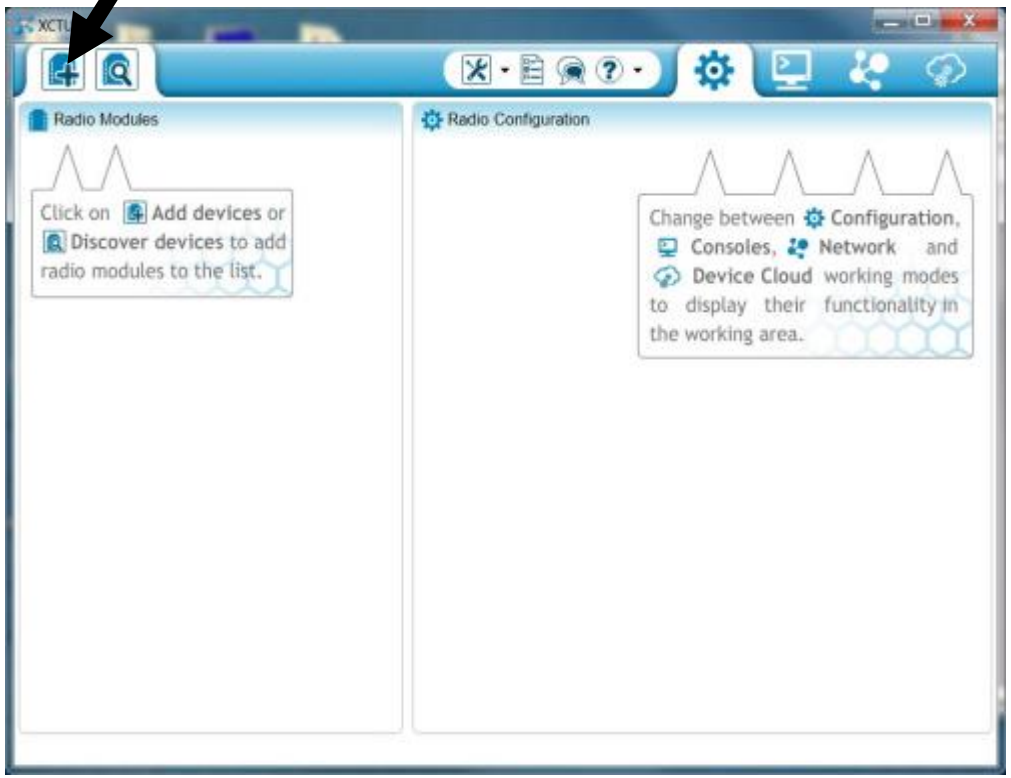
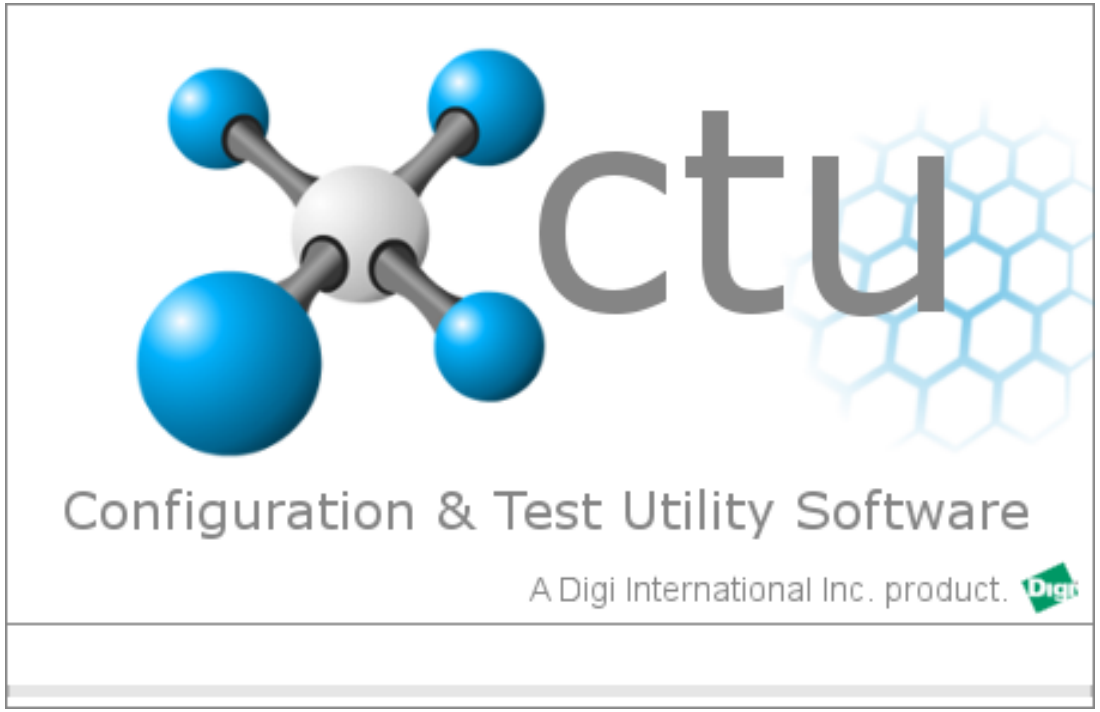
Click here to connect XBee





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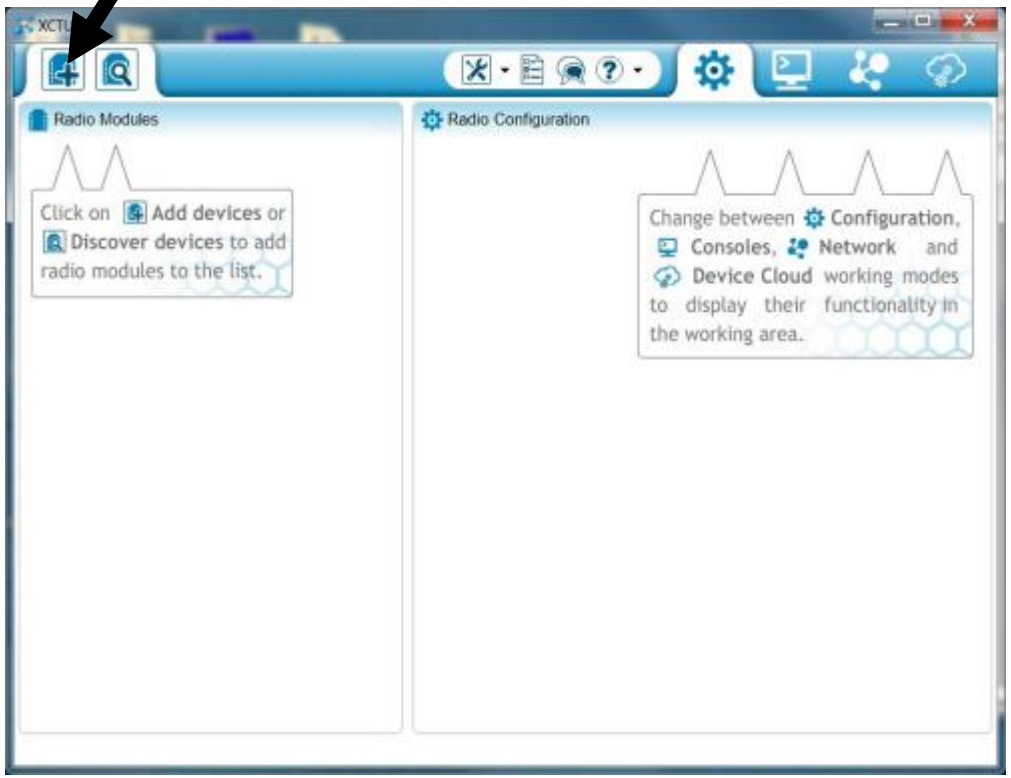
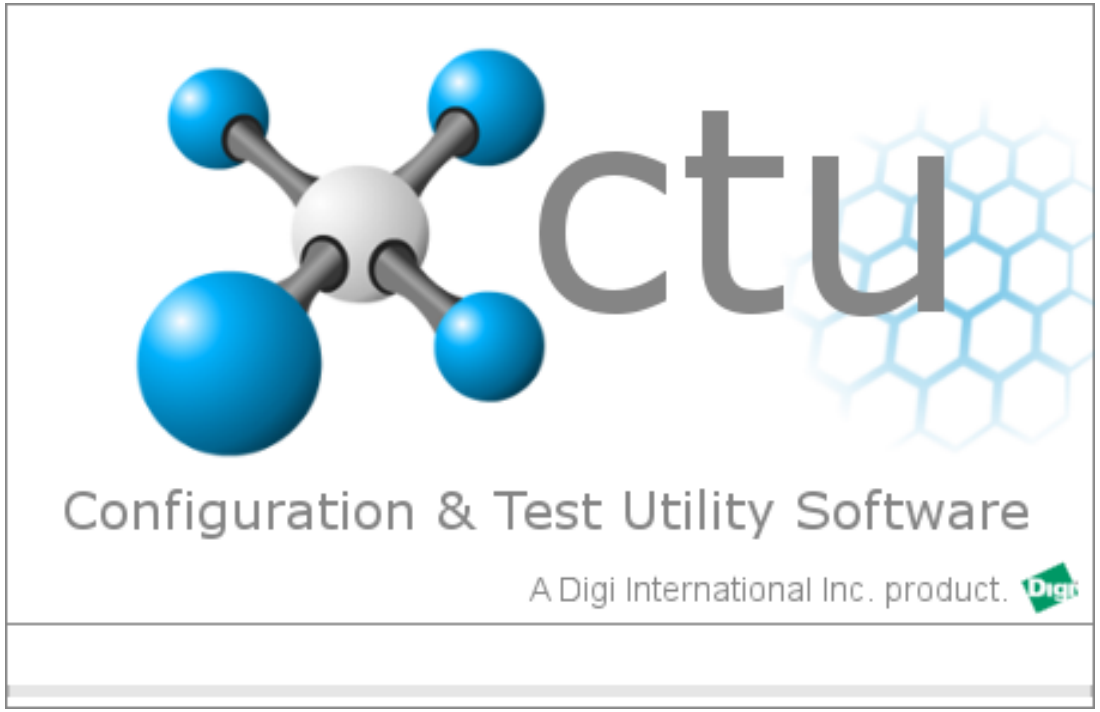
Click here to connect XBee

hint: X-CTU is more stable if the other XBee is off





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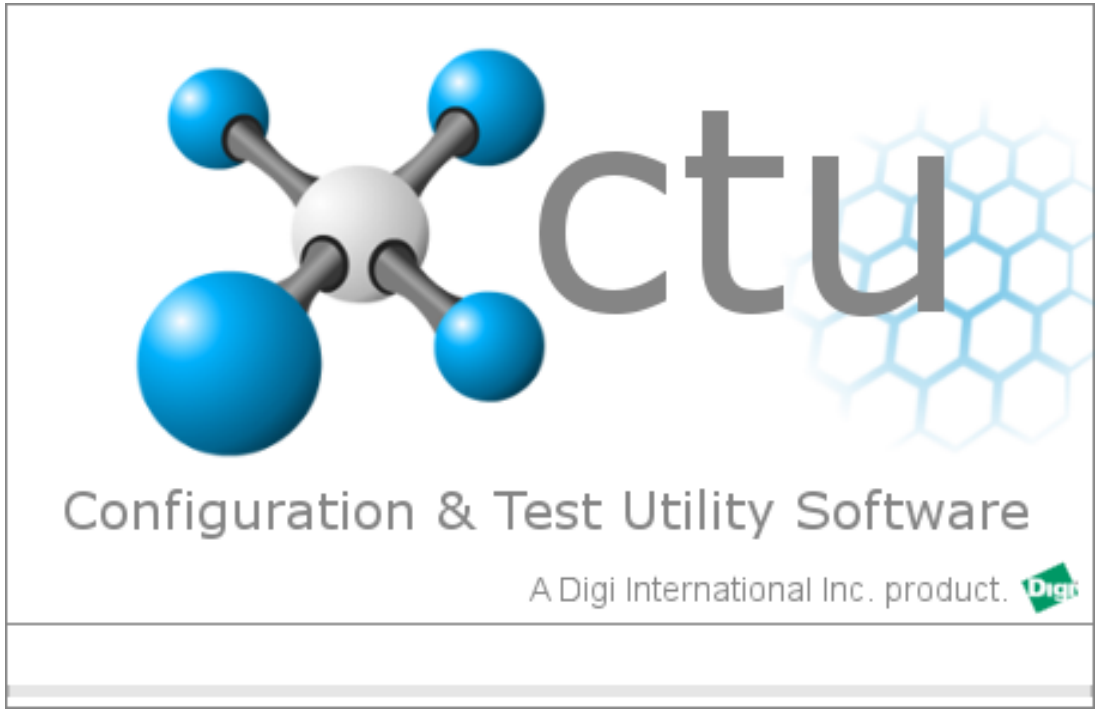
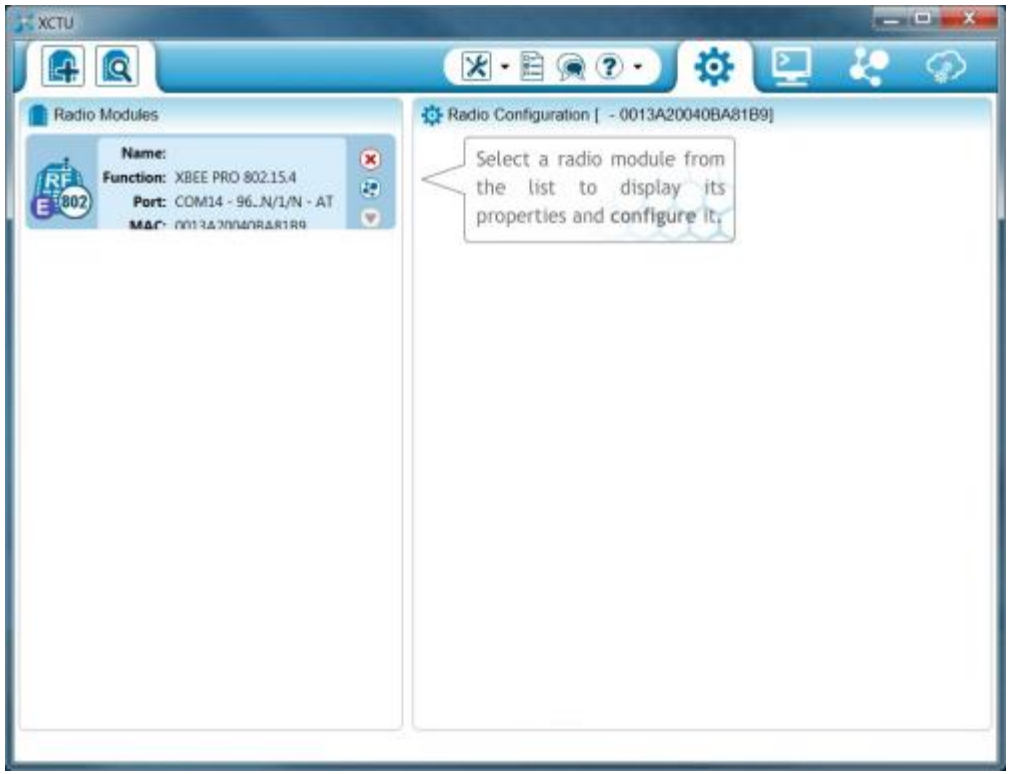
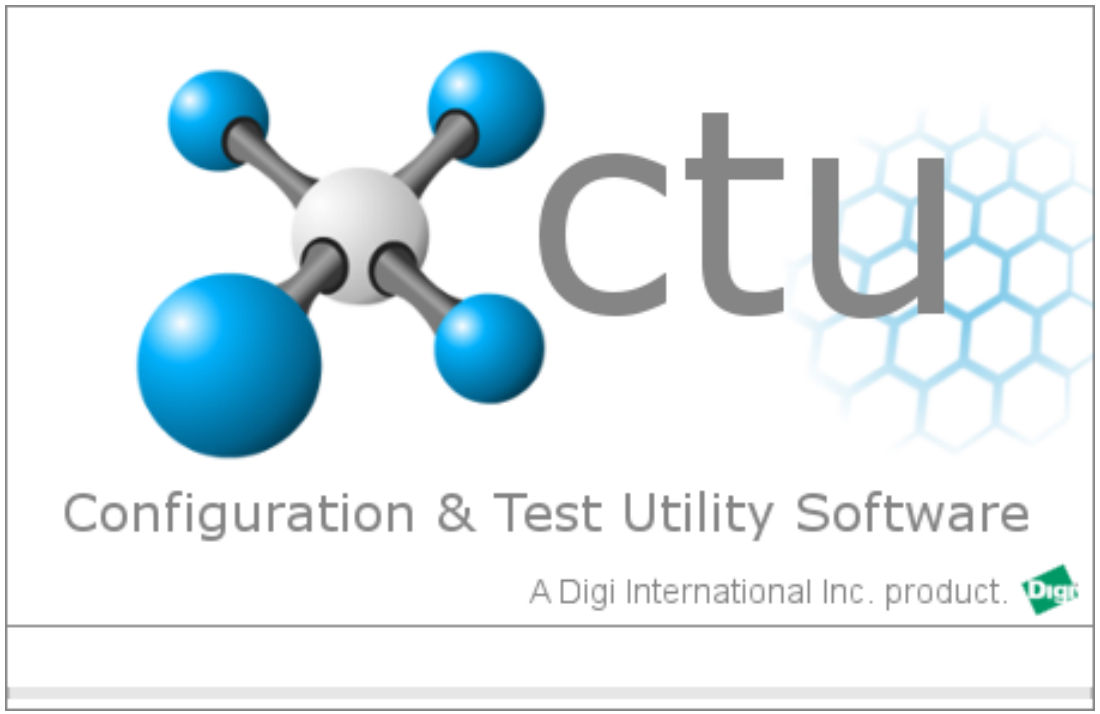
Yes you can load two XBees if you have two free USB slots.



or one at a time is OK too





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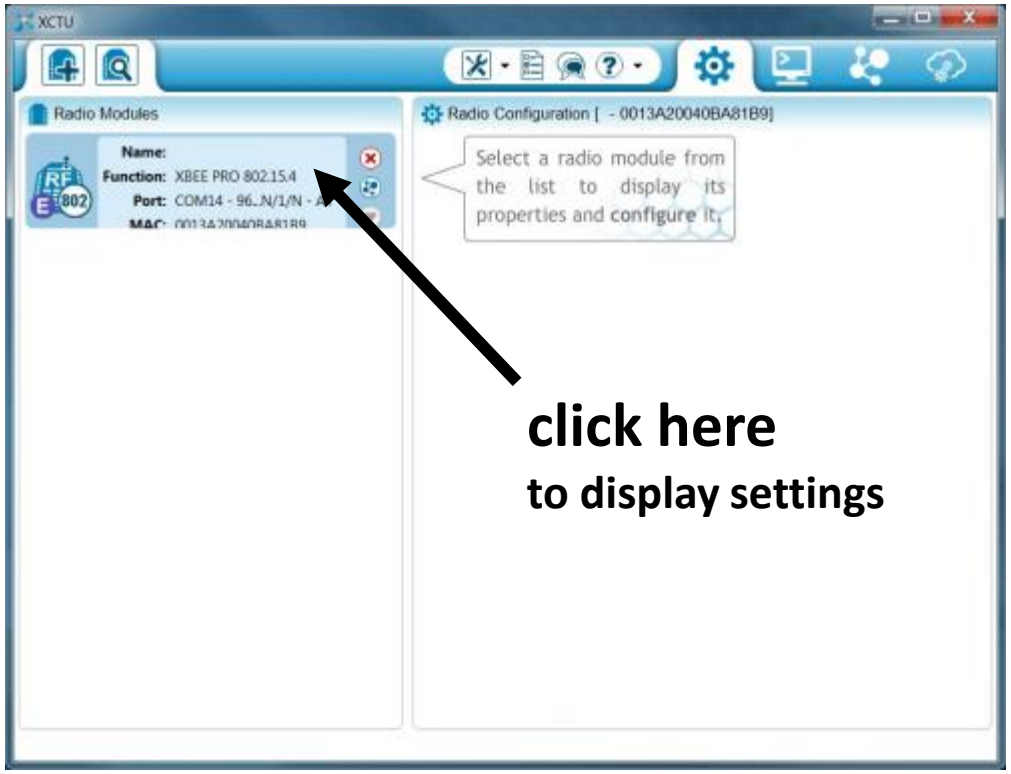
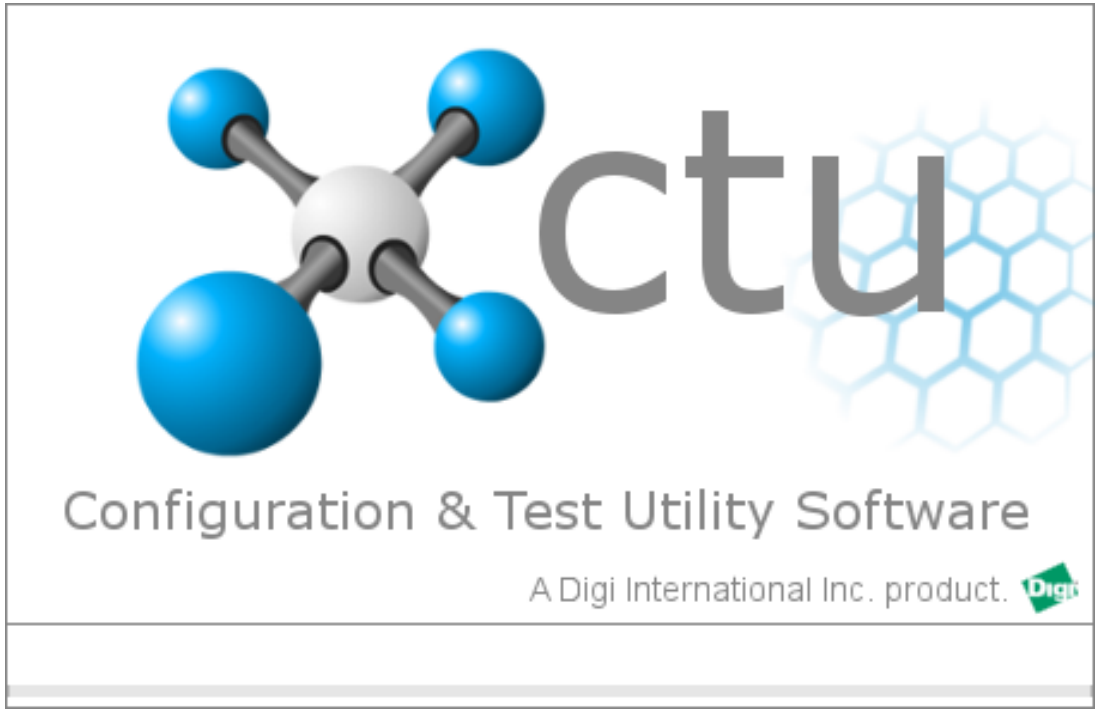
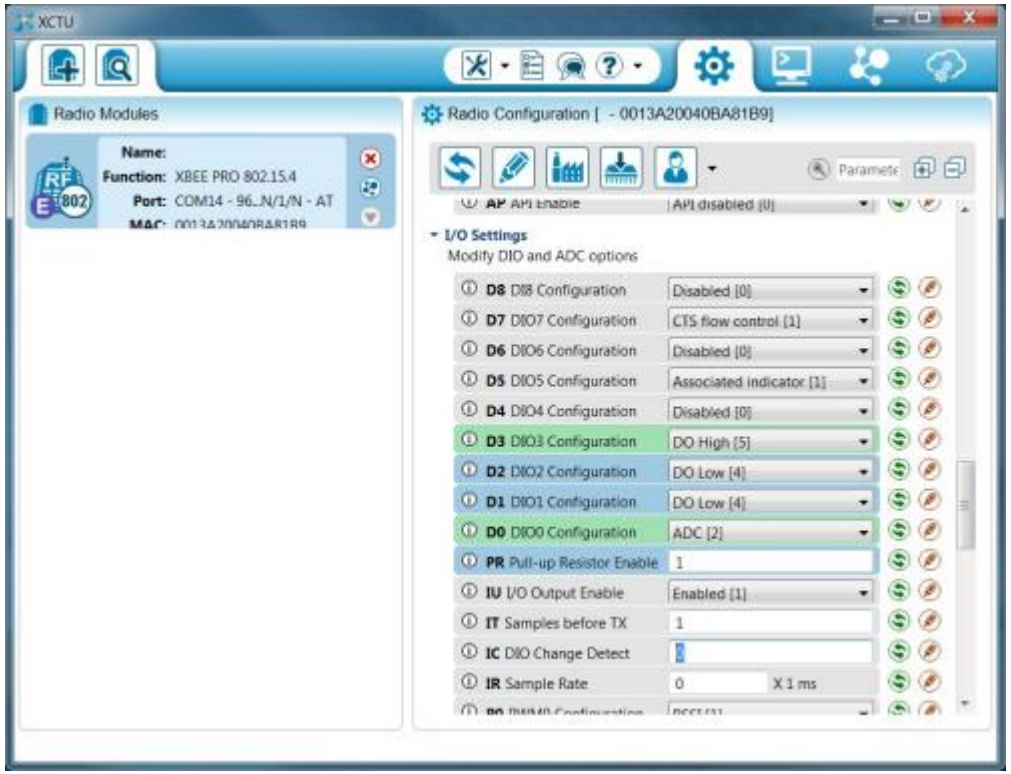
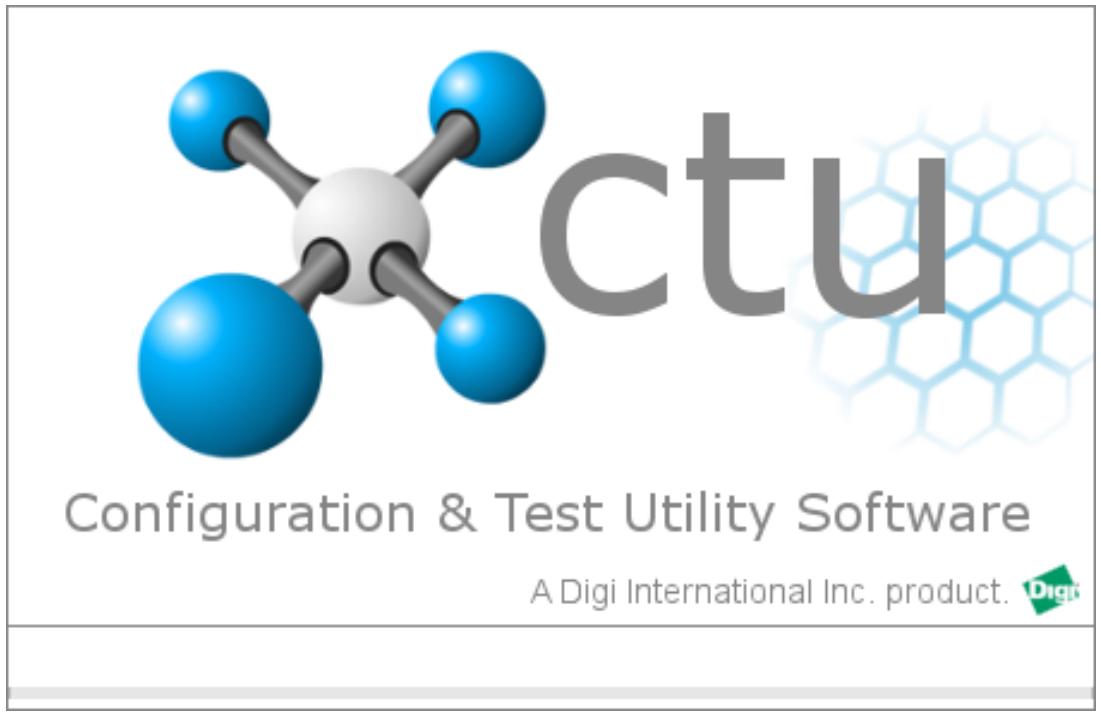
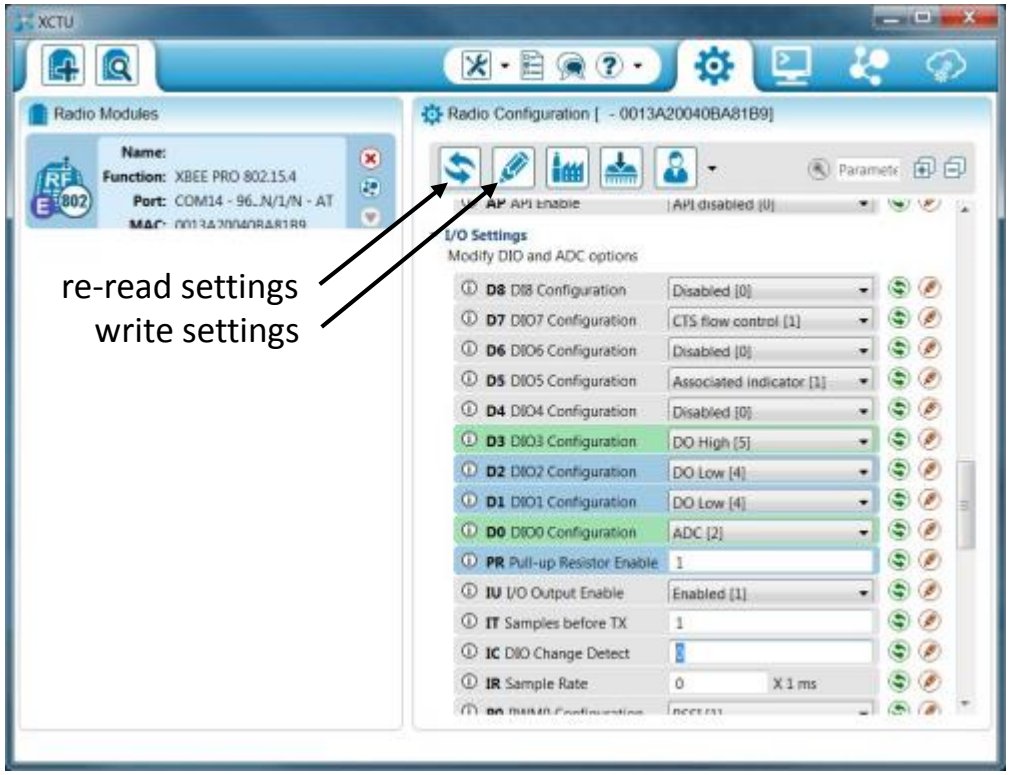





XCTU
Radio Modules
Name:
Function: XBEE PRO 802.15.4
Port: COM14 - 96..N/1/N - AT
Radio Configuration [- 0013A20040BA81B9]
I/O Settings
Modify DIO and ADC options
D8 DIO8 Configuration
Disabled [0]
D7 DIO7 Configuration
CTS flow control [1]
D6 DIO6 Configuration
Disabled [0]
D5 DIO5 Configuration
Associated indicator [1]
D4 DIO4 Configuration
Disabled [0]
D3 DIO3 Configuration
DO High [5]
D2 DIO2 Configuration
DO Low [4]
D1 DIO1 Configuration
DO Low [4]
D0 DIO0 Configuration
ADC [2]
PR Pull-up Resistor Enable
IU I/O Output Enable
Enabled [1]
IT Samples before TX
IC DIO Change Detect
IR Sample Rate
X 1 ms


xctu
Configuration & Test Utility Software
A Digi International Inc. product.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PR Pull-up Resistor Enable
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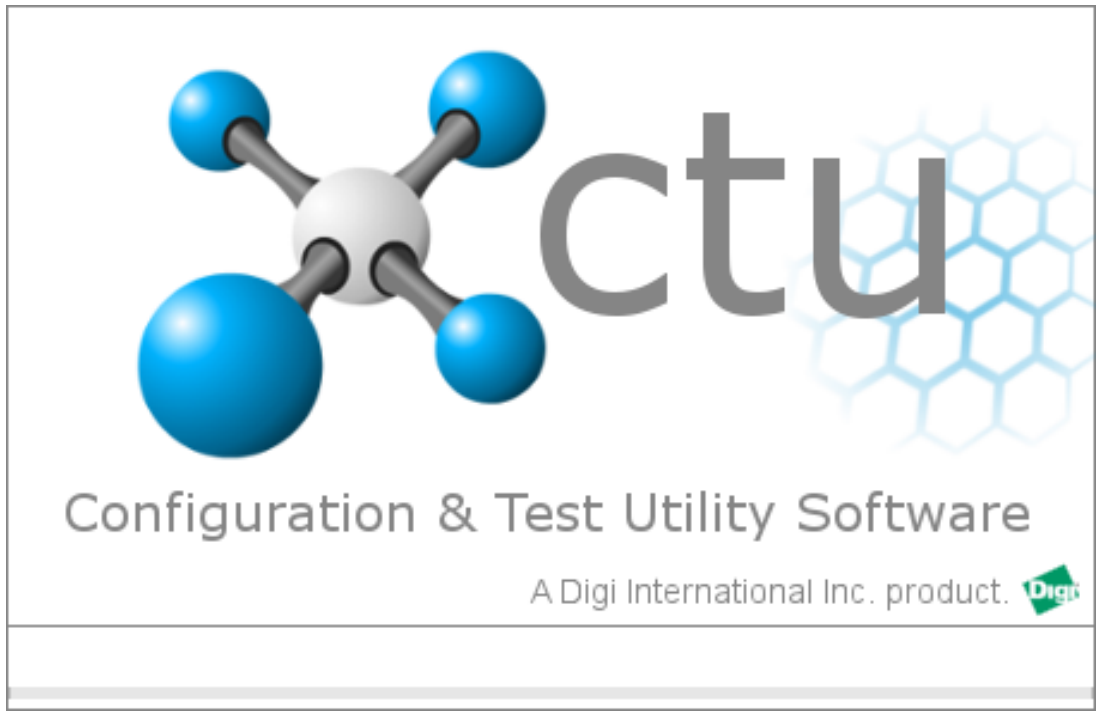
IT Samples before TX
IC DIO Change Detect
IR Sample Rate
X 1 ms
re-read settings
write settings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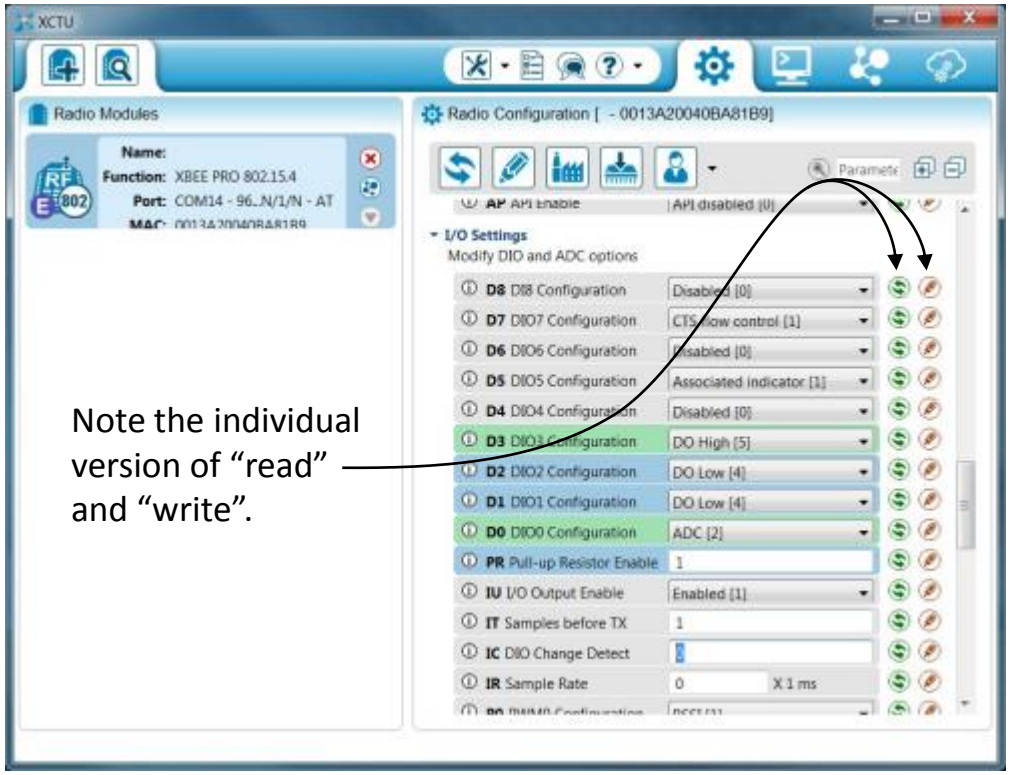
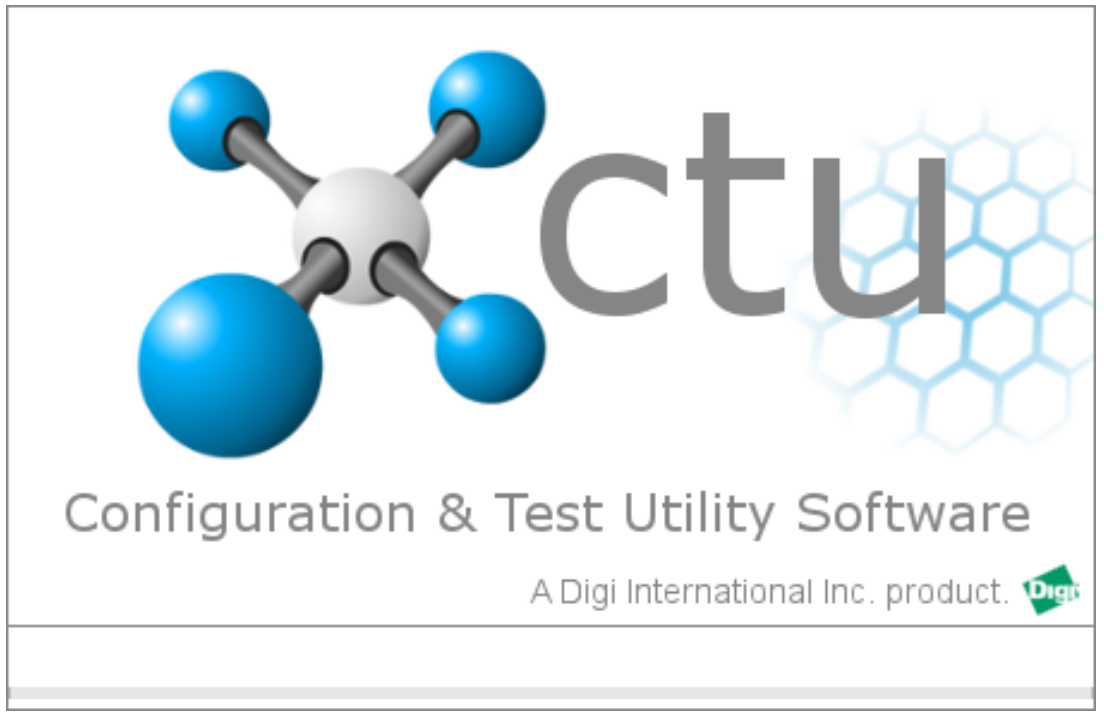
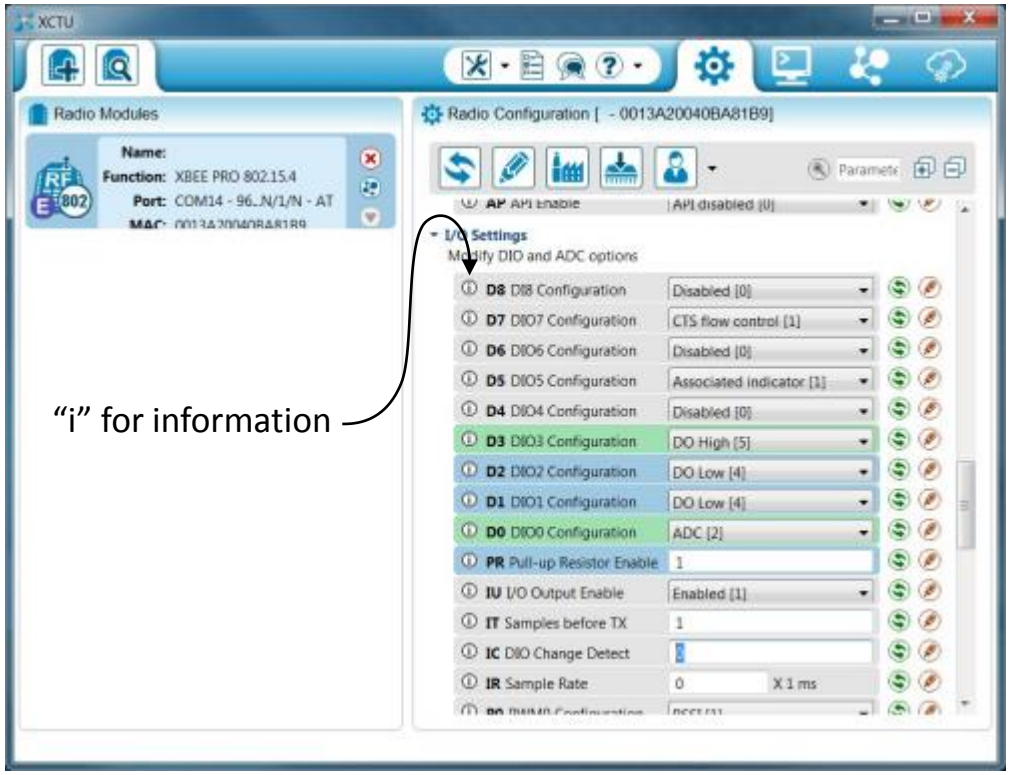


Note the individual version of “read” and “write”.

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IU I/O Output Enable
Enabled [1]
IT Samples before TX
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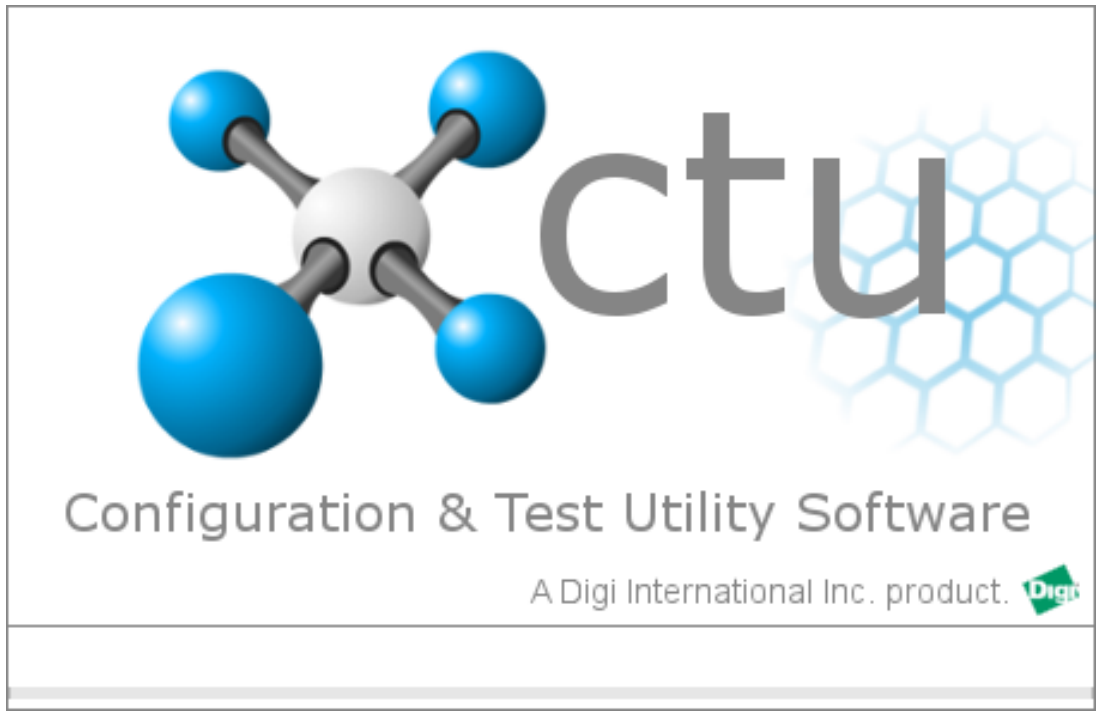
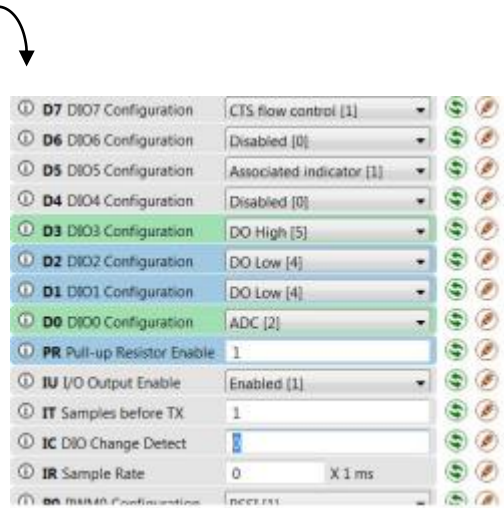
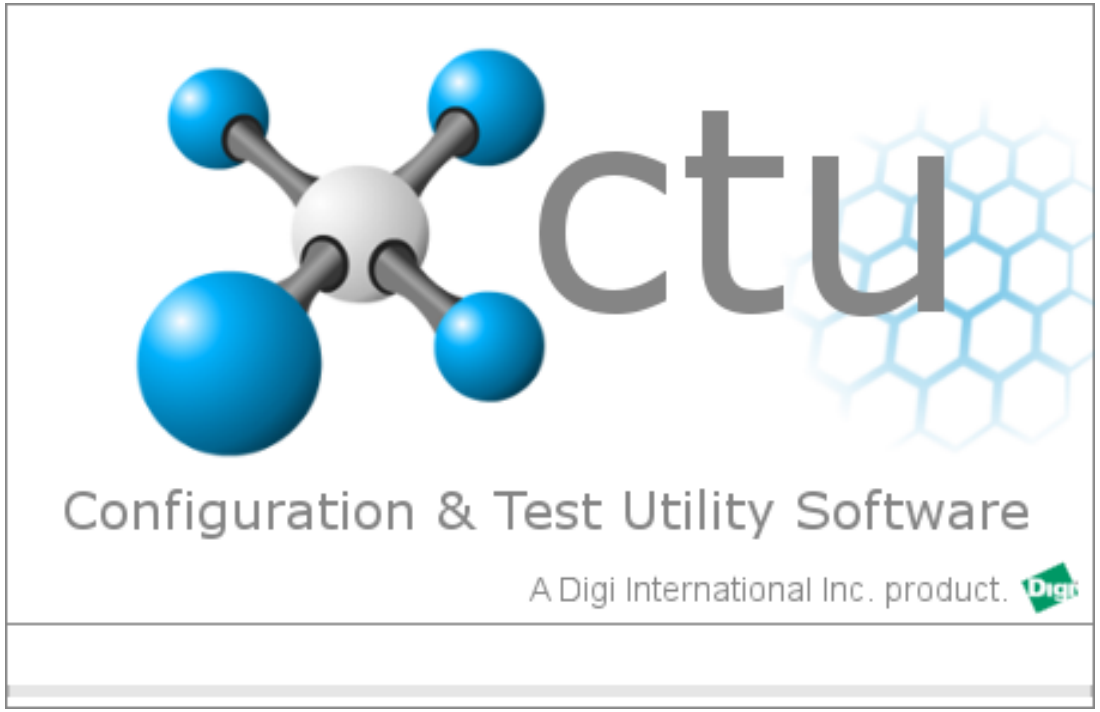
IR Sample Rate
X 1 ms
"i" for information


xctu
Configuration & Test Utility Software
A Digi International Inc. product.

- The X-CTU program is a list of commands and pin descriptions

“i” for information





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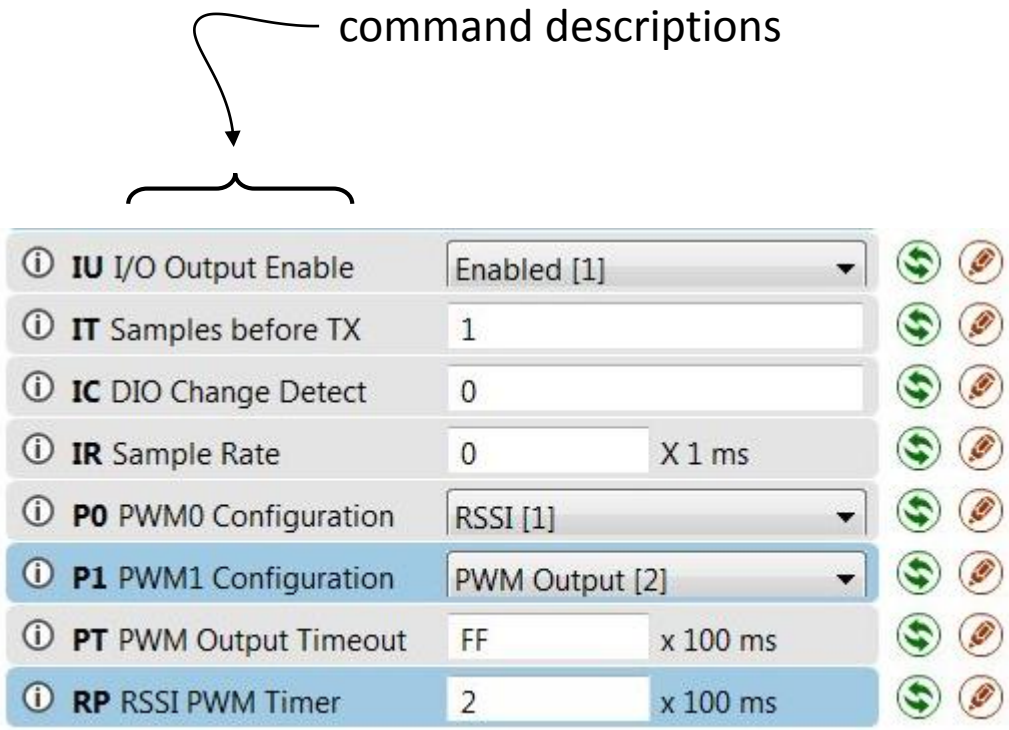

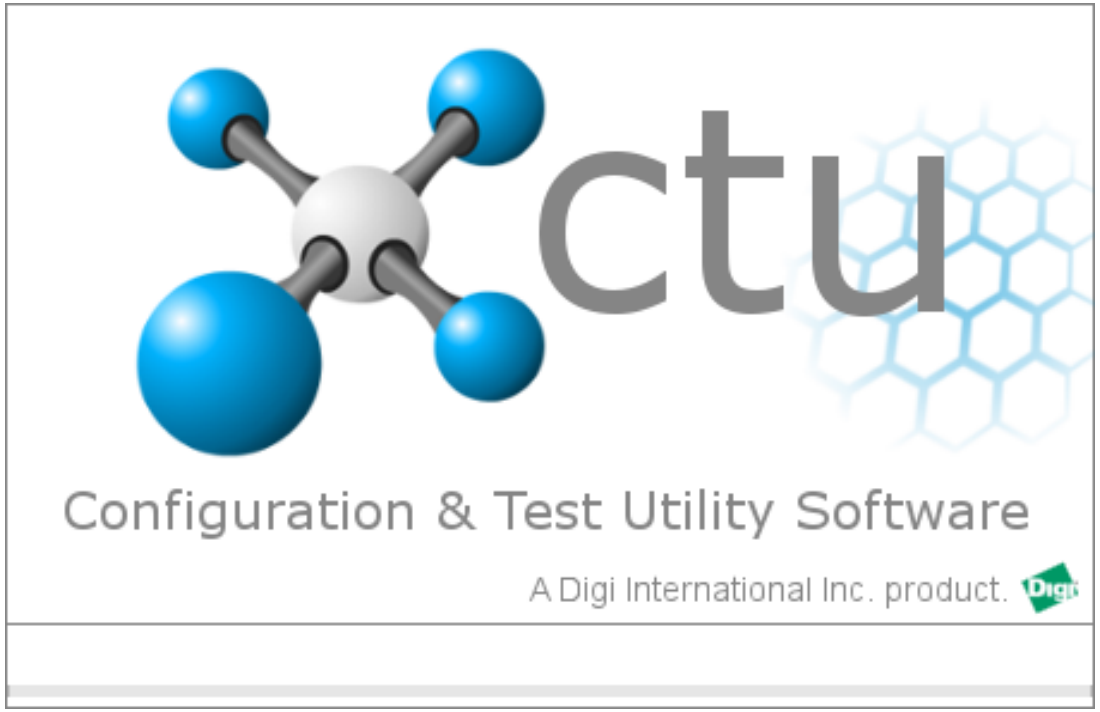

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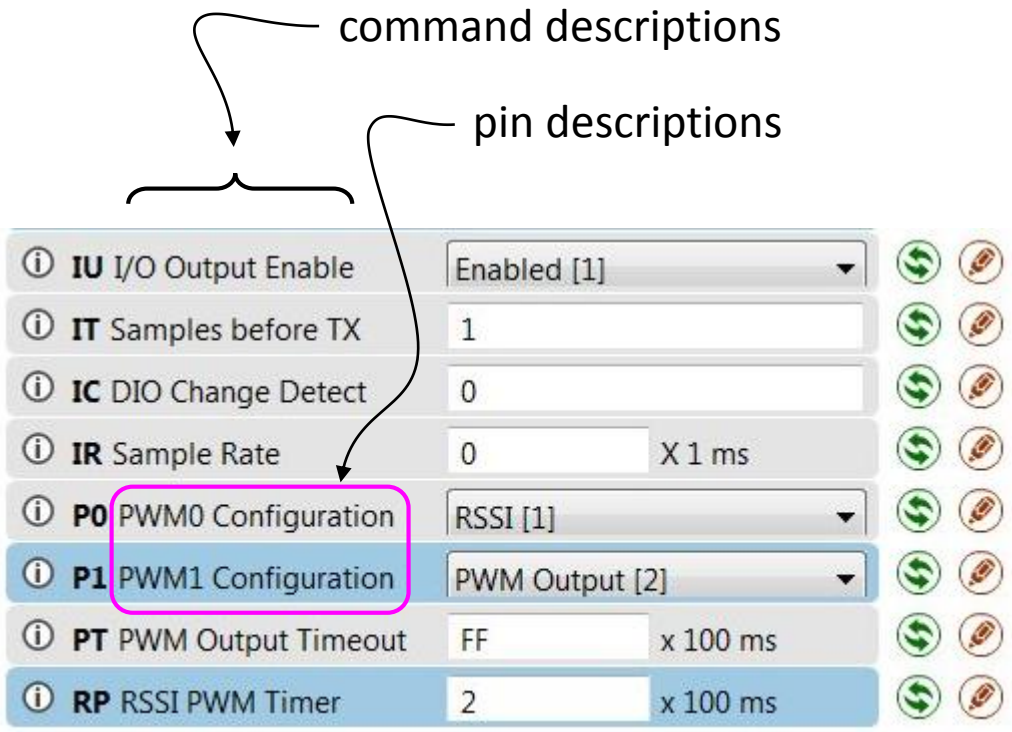
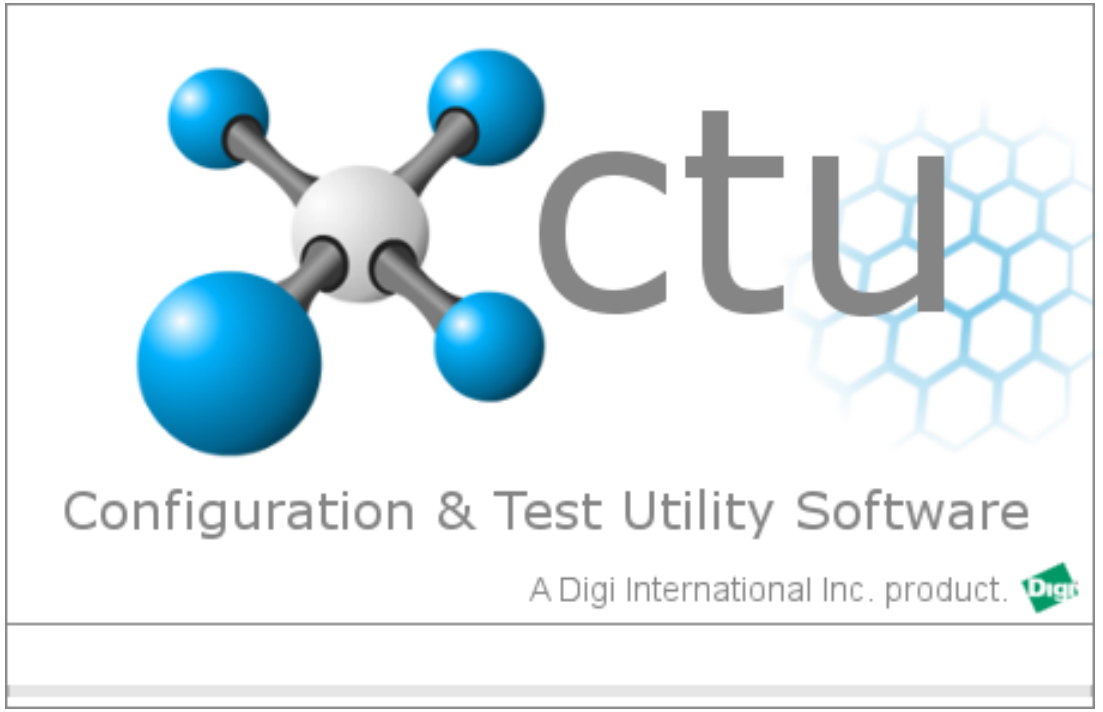
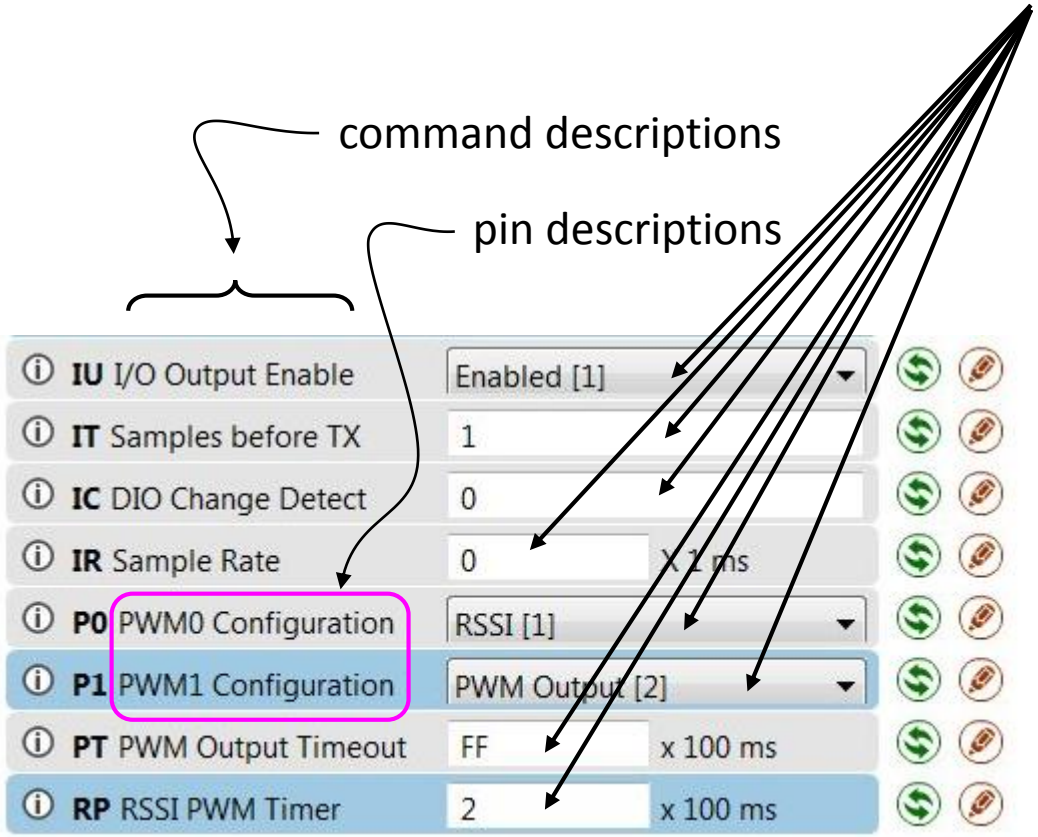
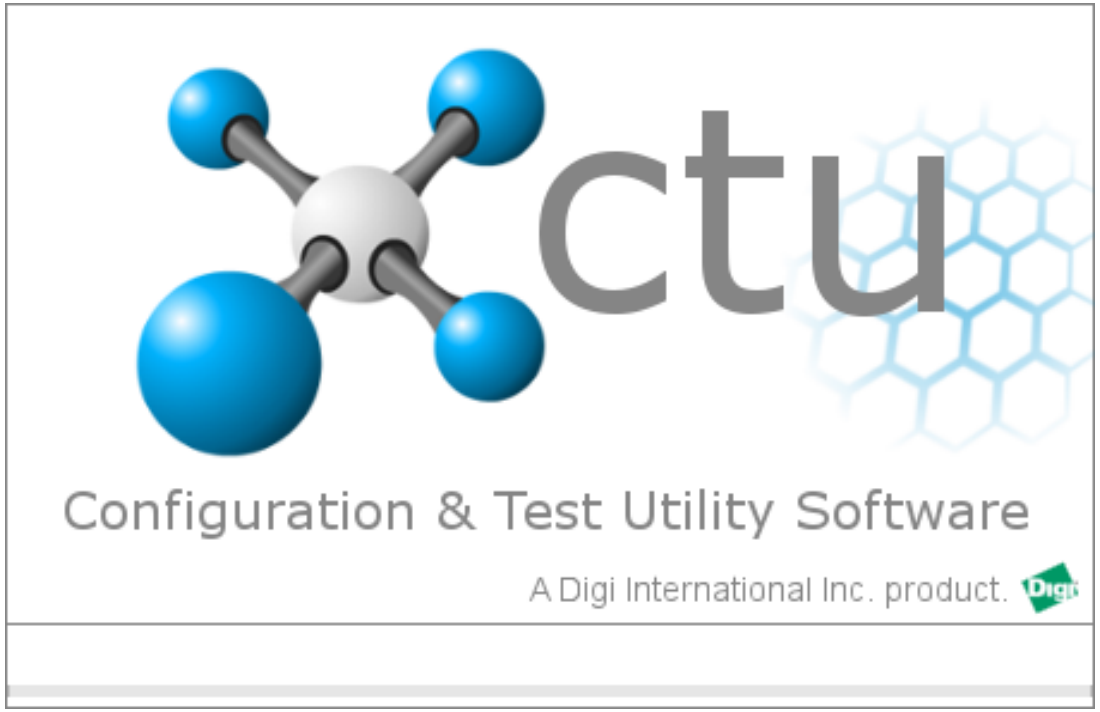




- The X-CTU program is a list of commands and pin descriptions

You change these fields.





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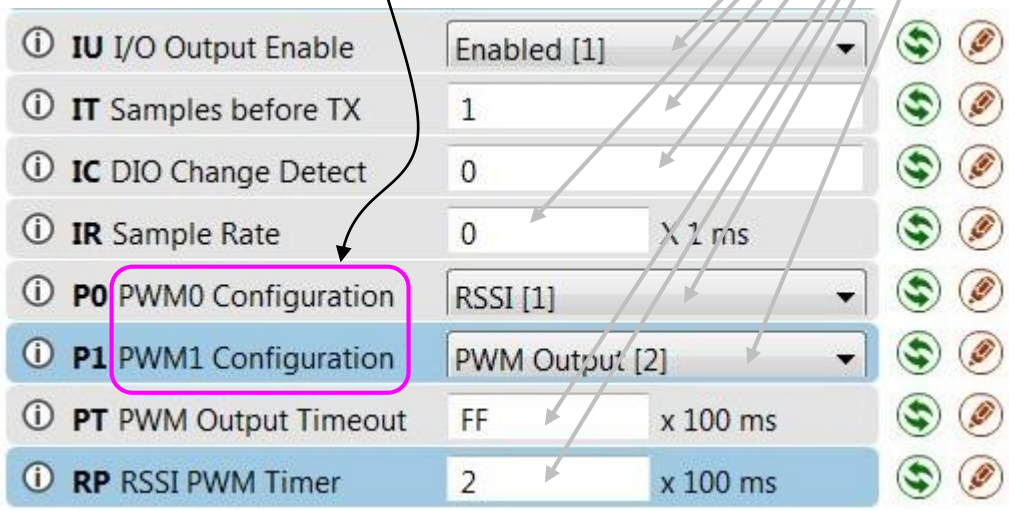
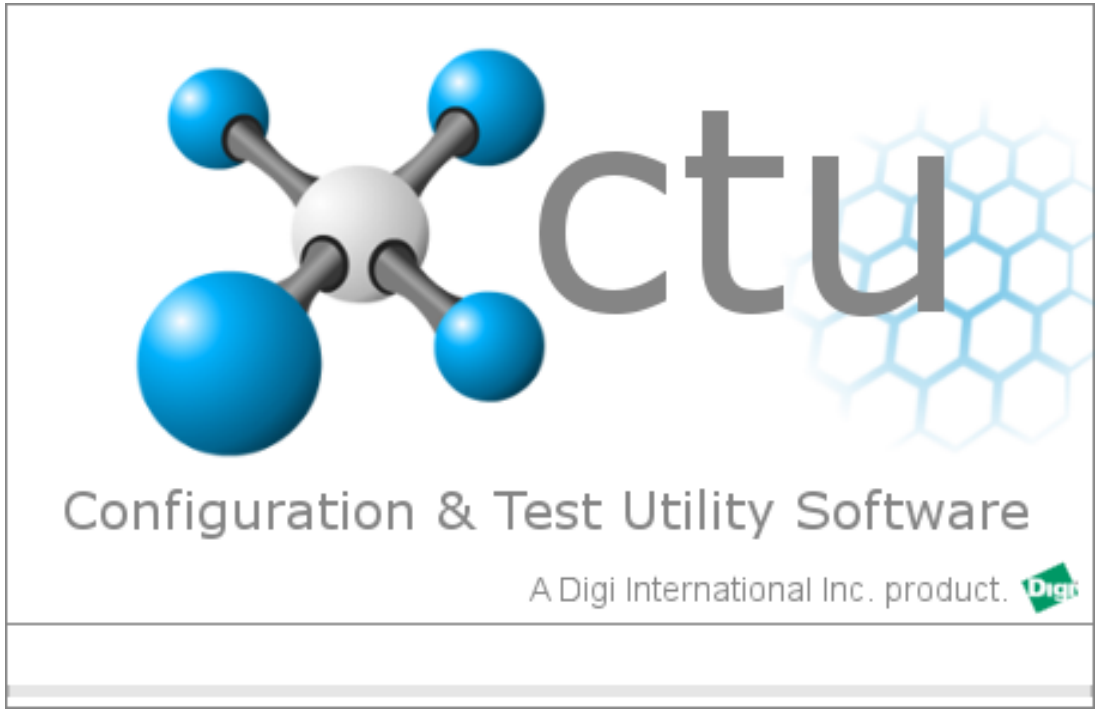
You change these fields.

command descriptions

pin descriptions





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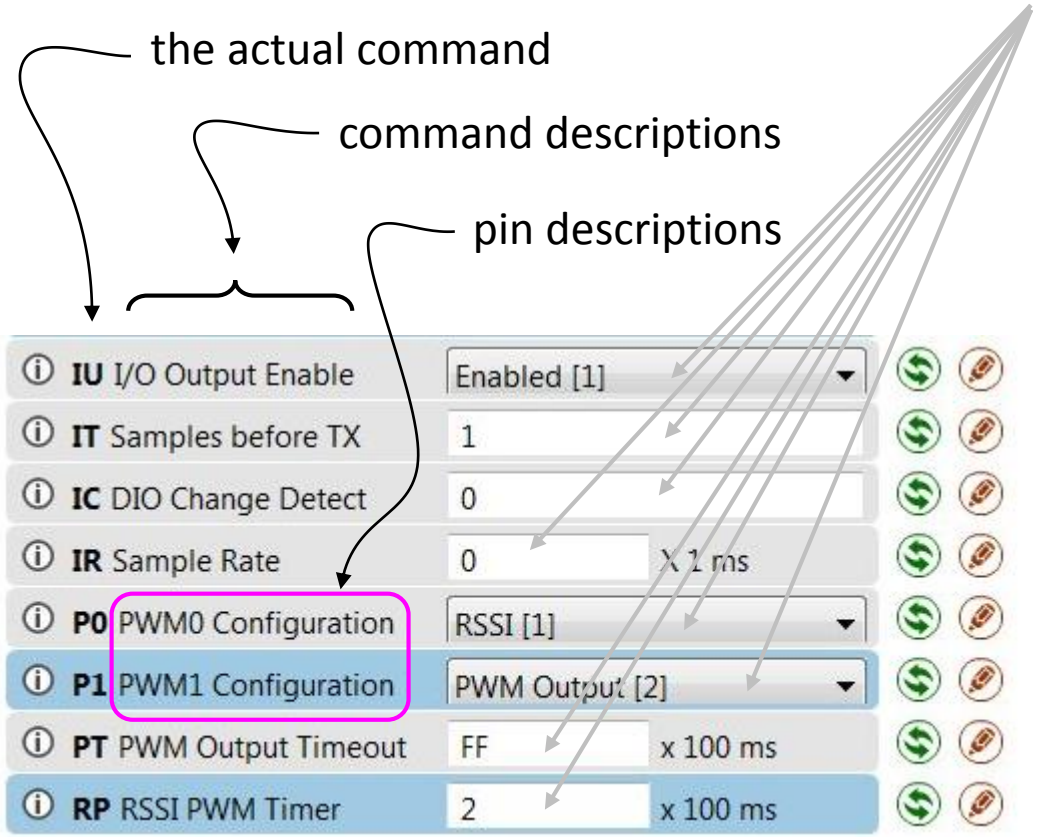
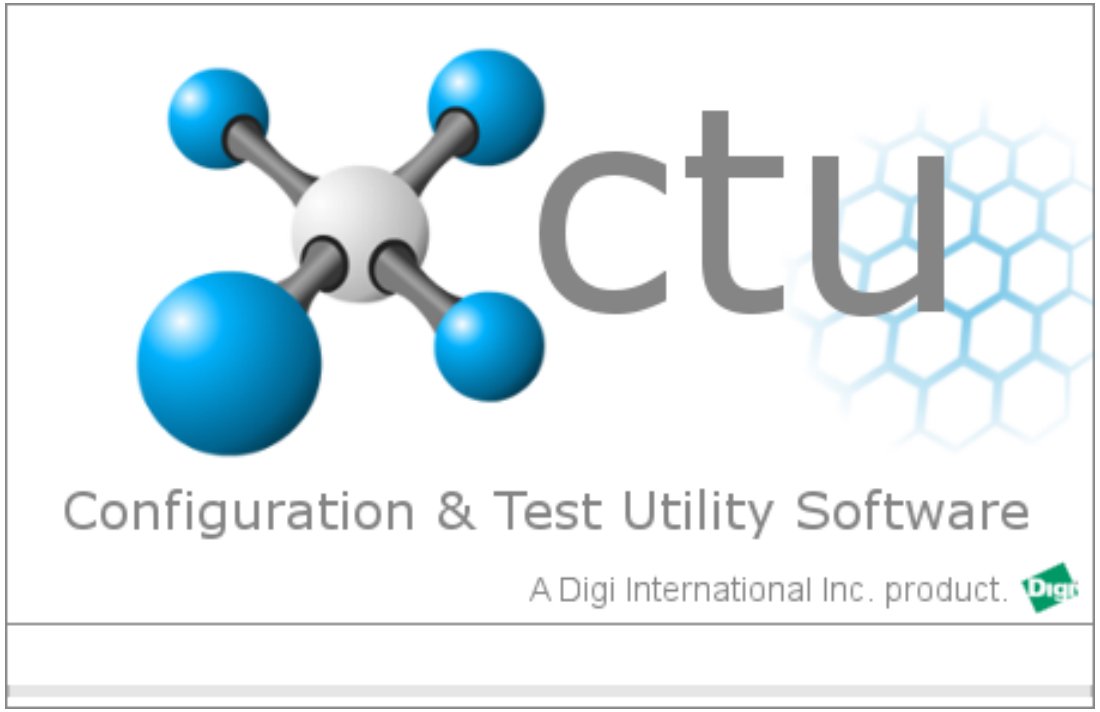
the actual command

command descriptions

pin descriptions





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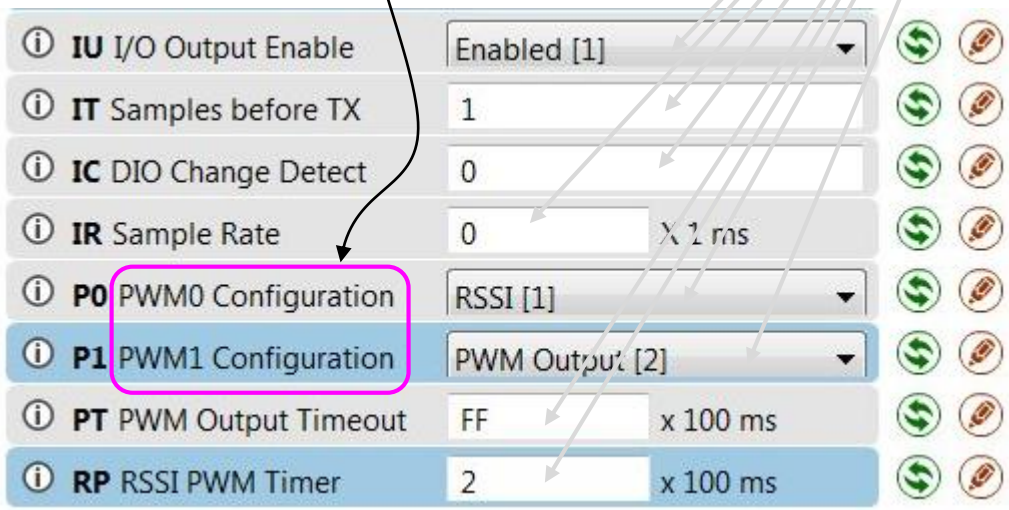
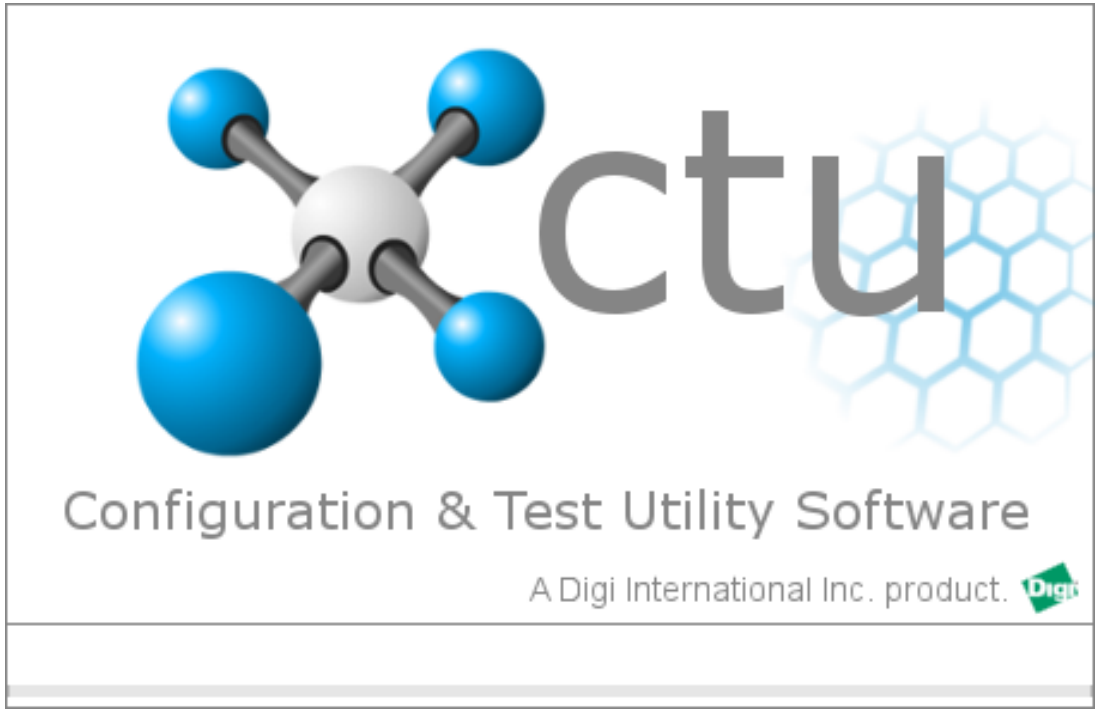
These are AT commands; as in **ATIU 1**

the actual command

command descriptions

pin descriptions





- The X-CTU program is a list of commands and pin descriptions

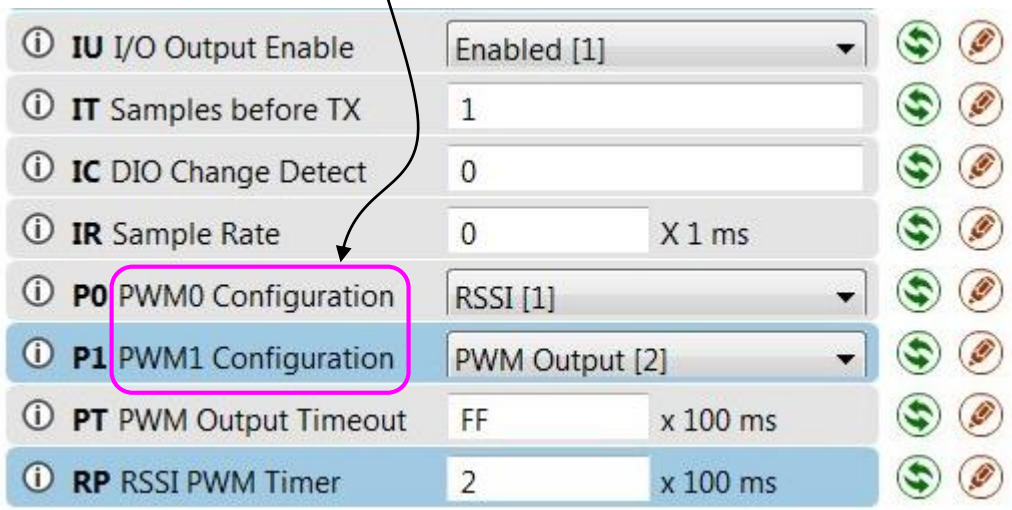
AT commands go in through the serial-input pin and can even be done remotely. X-CTU menu clicking are only for the most commonly used ones. There are many more AT commands for advanced users.

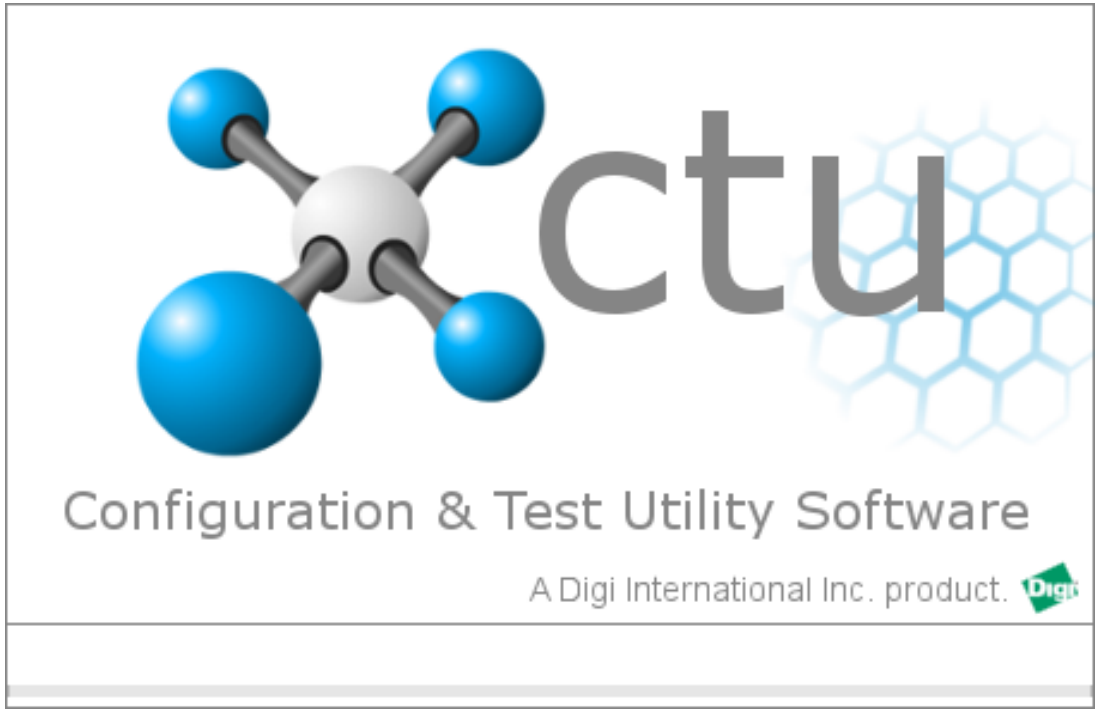
These are AT commands; as in **`ATIU 1`**

the actual command

command descriptions

pin descriptions





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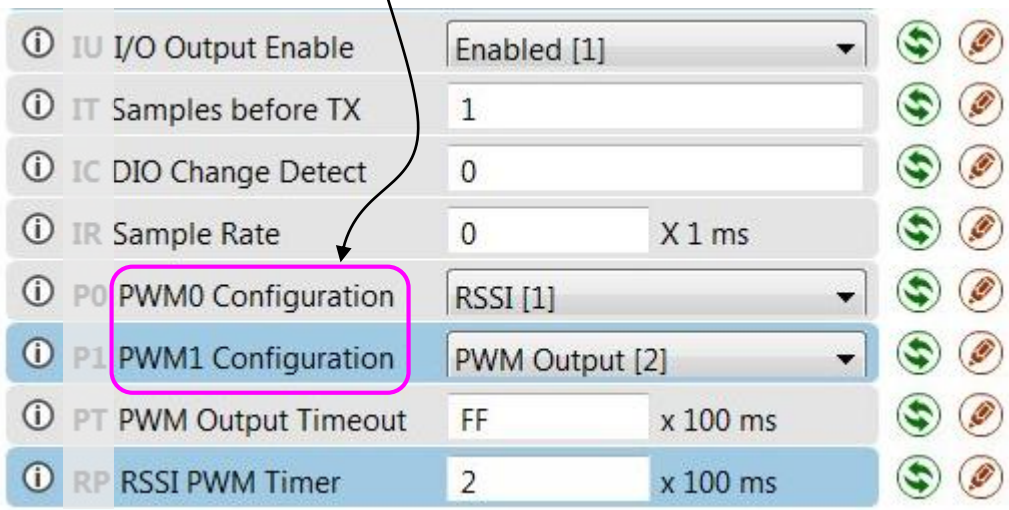
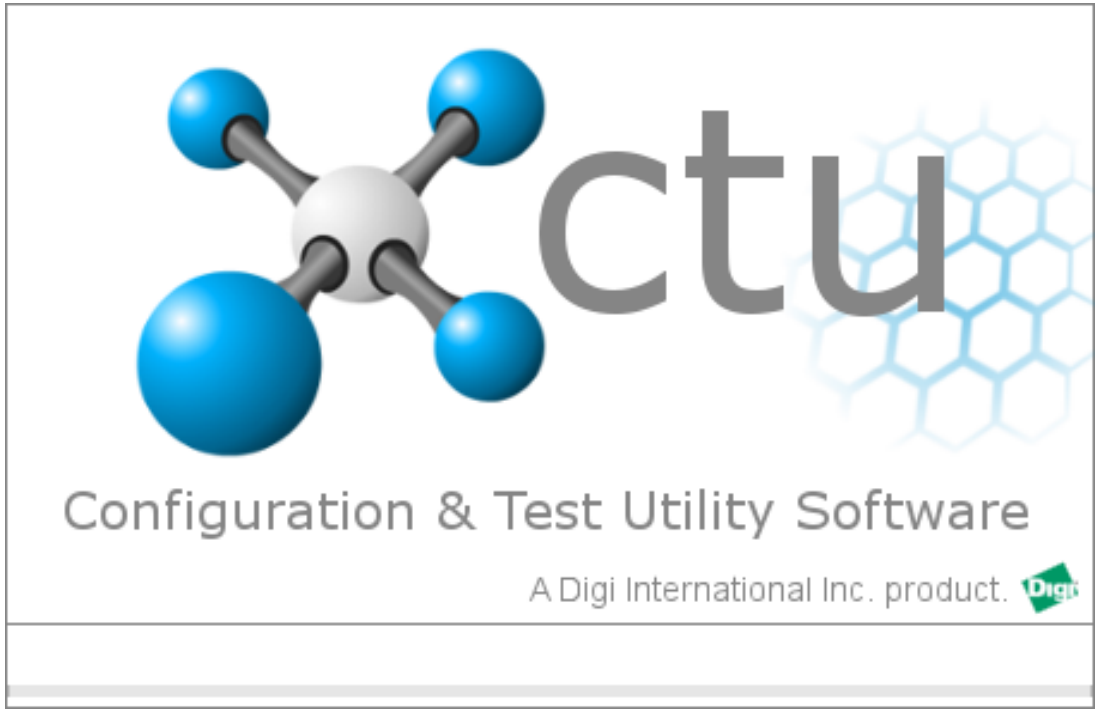




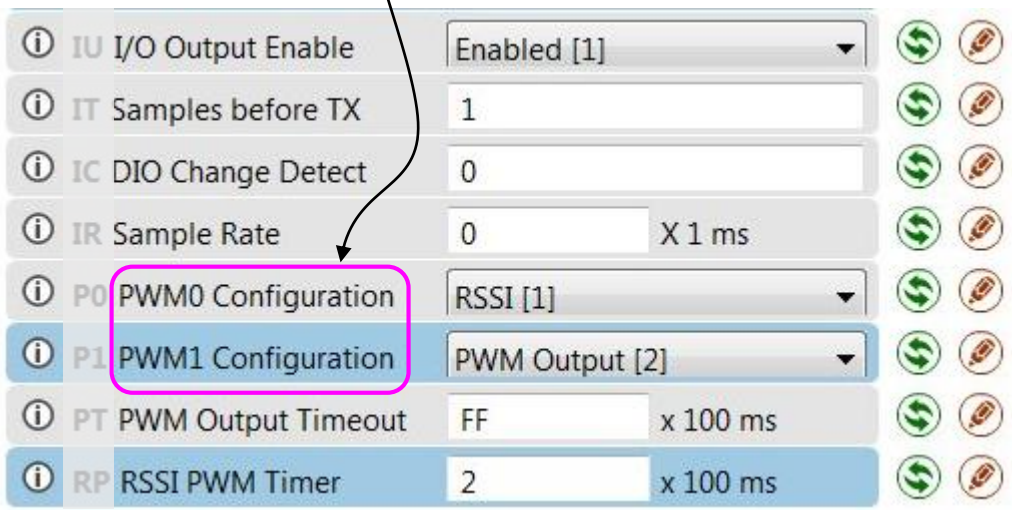
disregard these two letter AT commands; they are for advanced users.

- The X-CTU program is a list of commands and pin descriptions

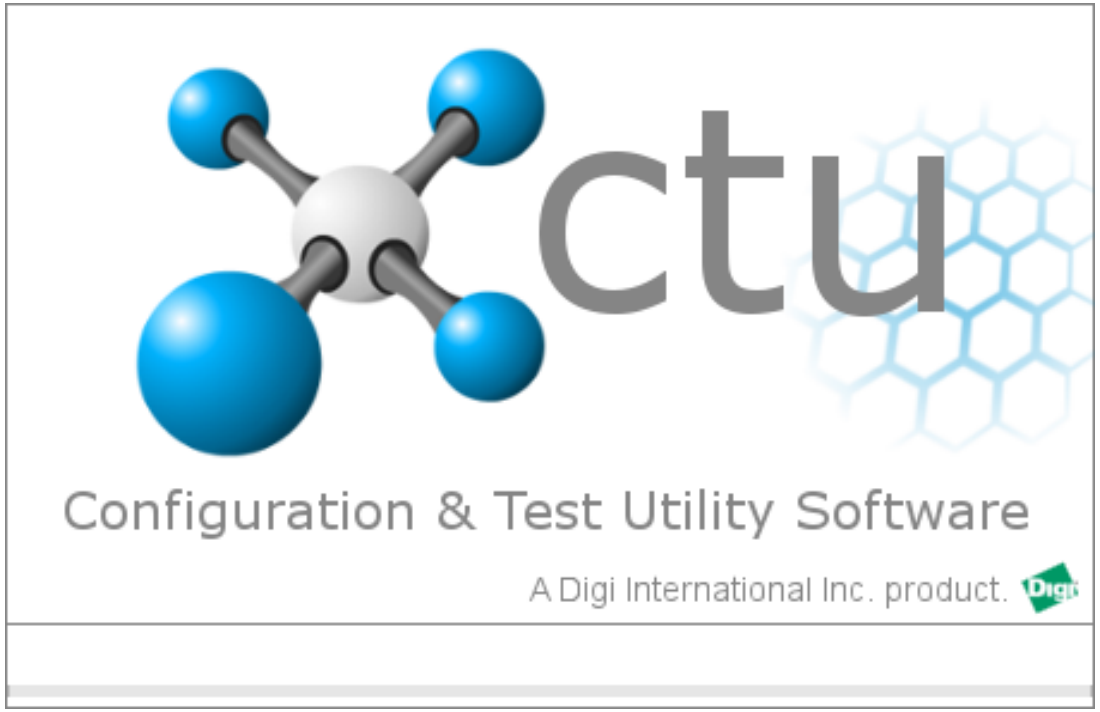
The descriptions sound the same and this, you will find very confusing.

command descriptions

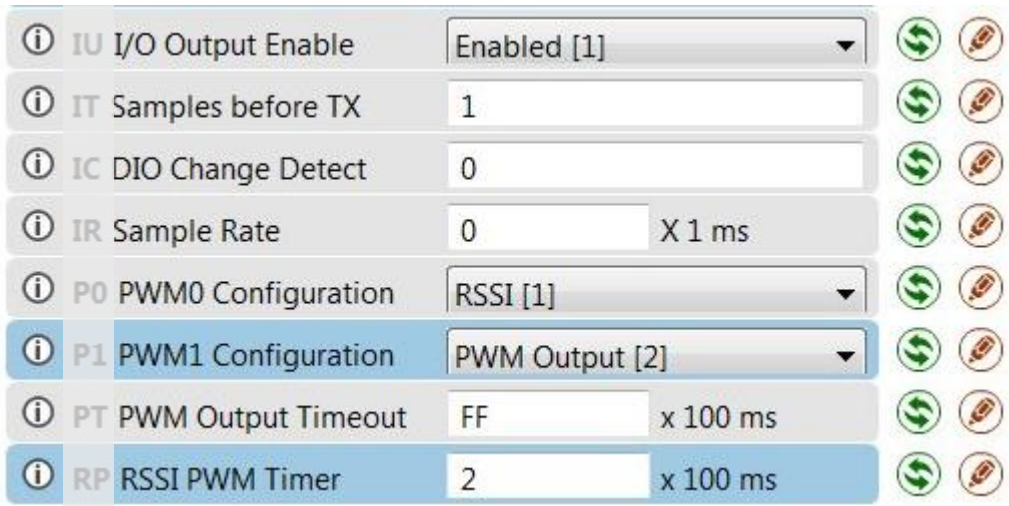
pin descriptions



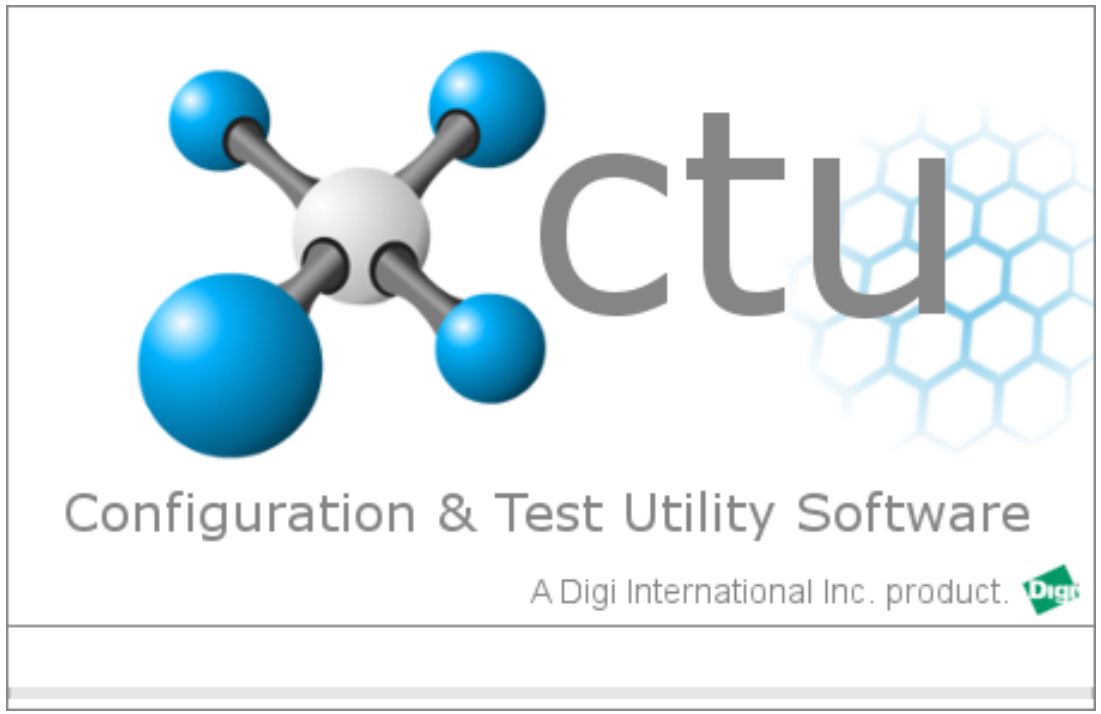
disregard these two letter AT commands



- The X-CTU program is a list of commands and pin descriptions
- Next to each you either choose some subcommand or enter a number into a field



disregard these two letter AT commands



- The X-CTU program is a list of commands and pin descriptions
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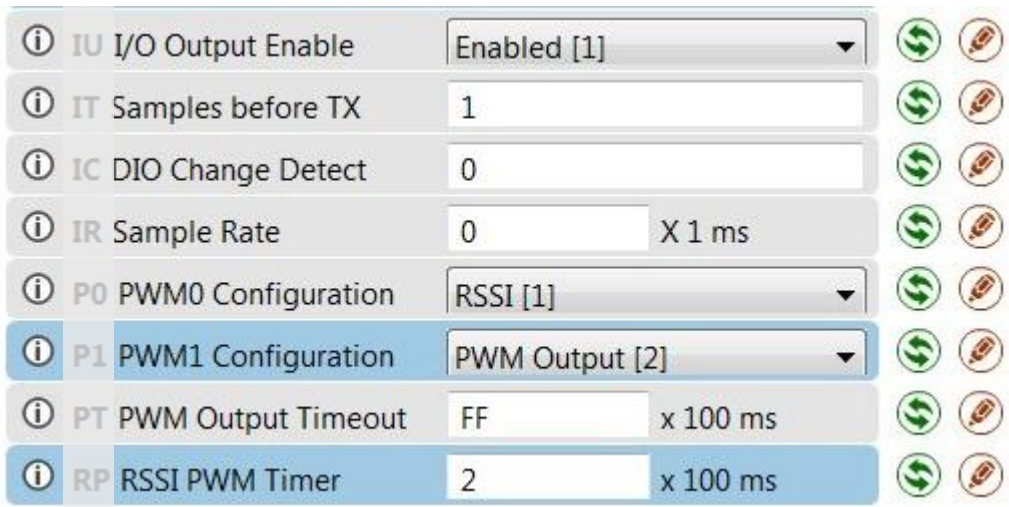

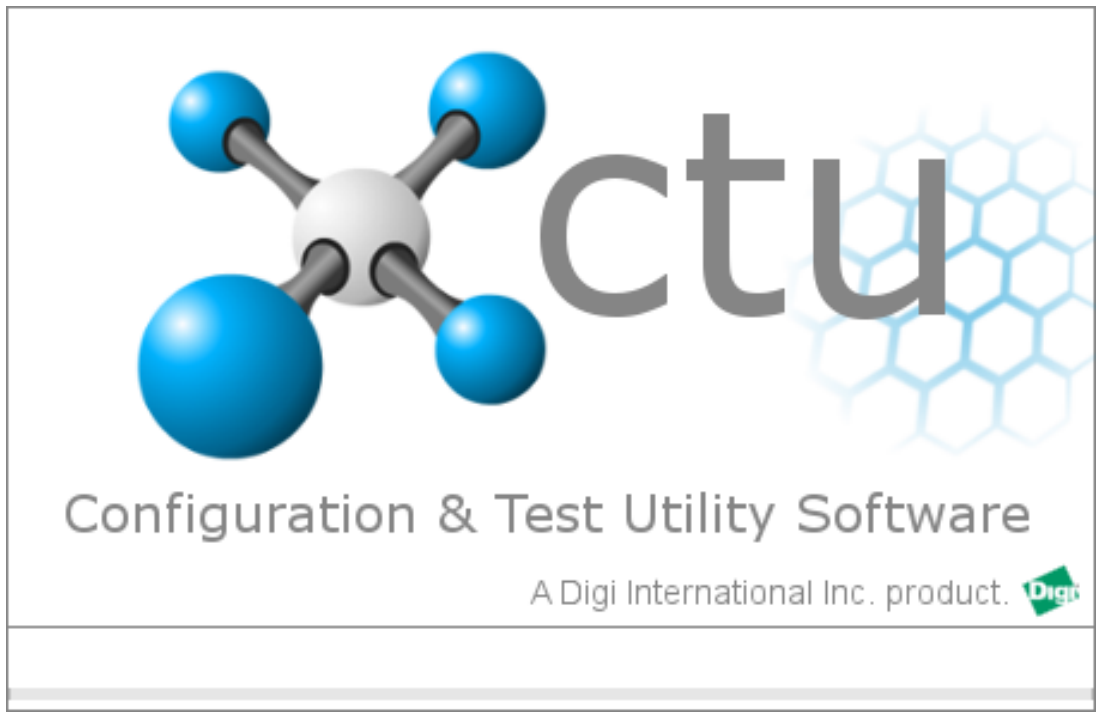

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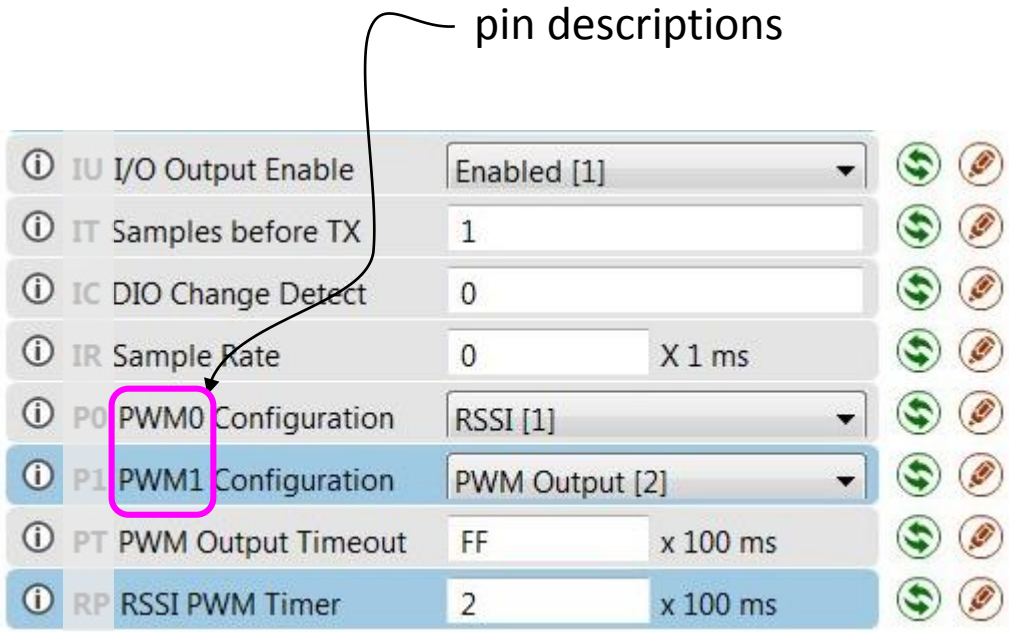

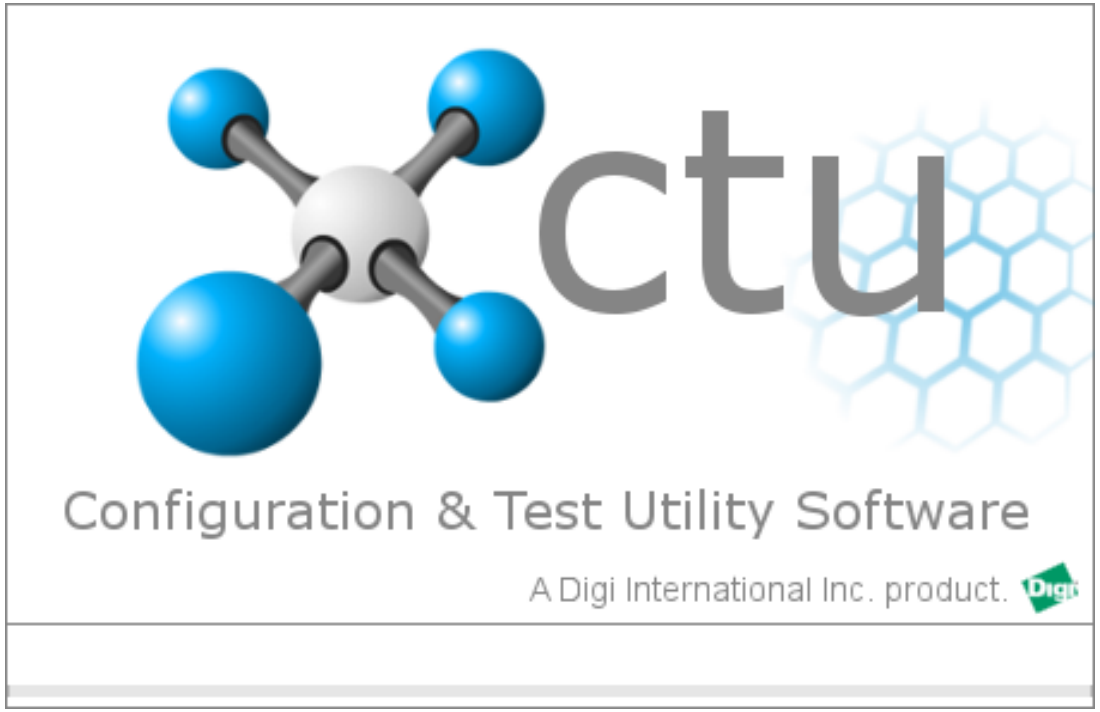

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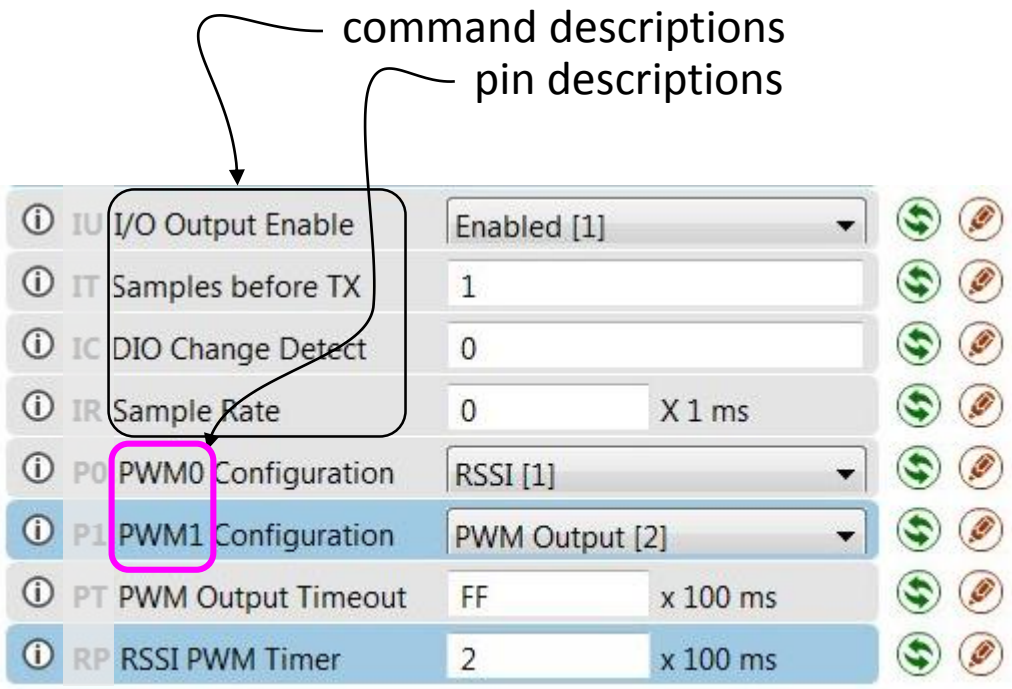

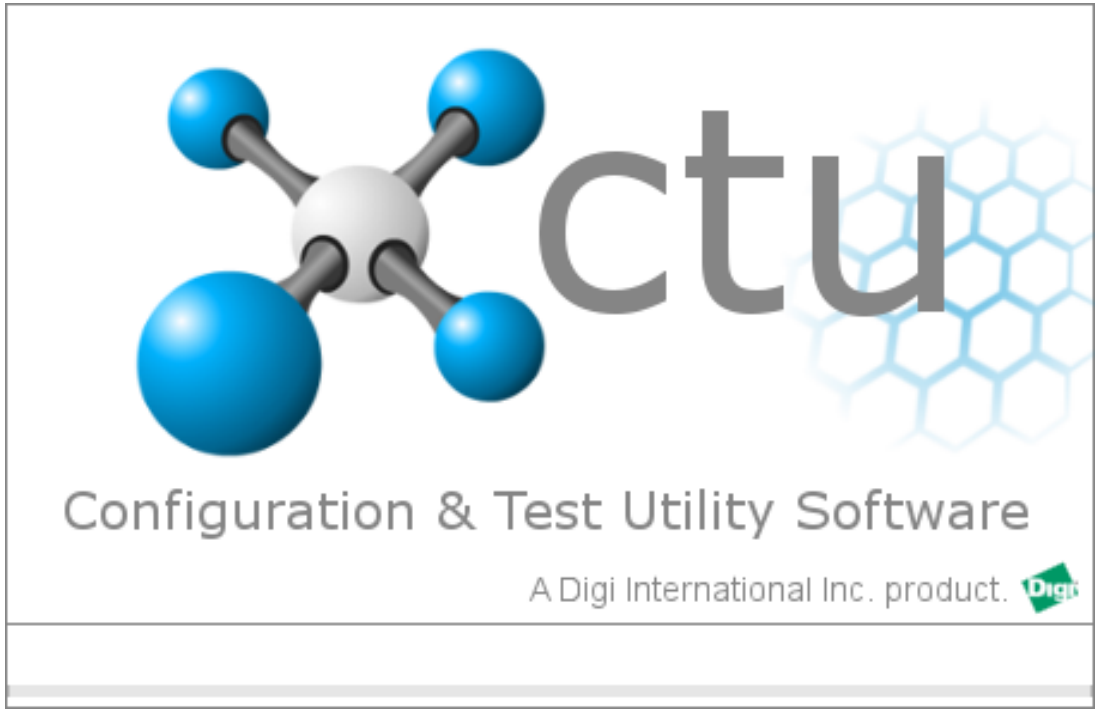

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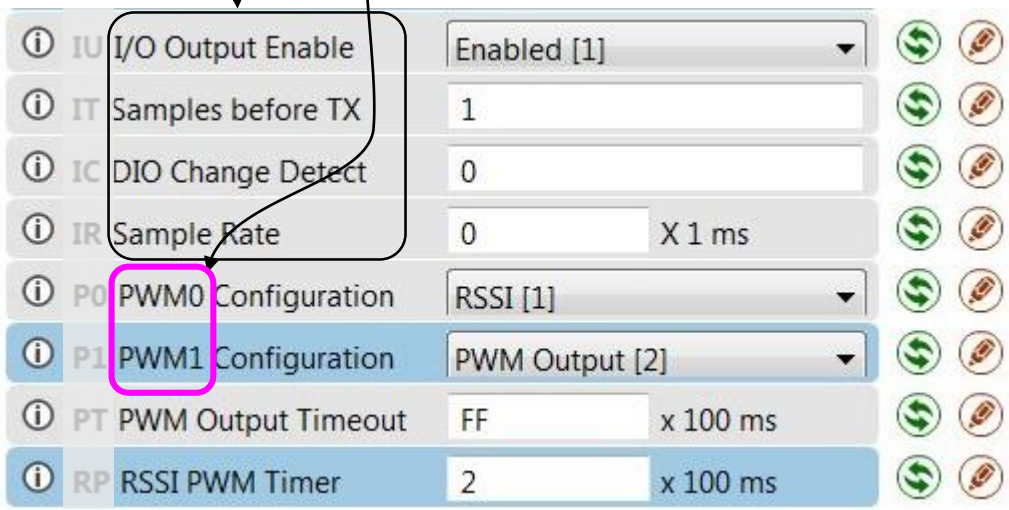
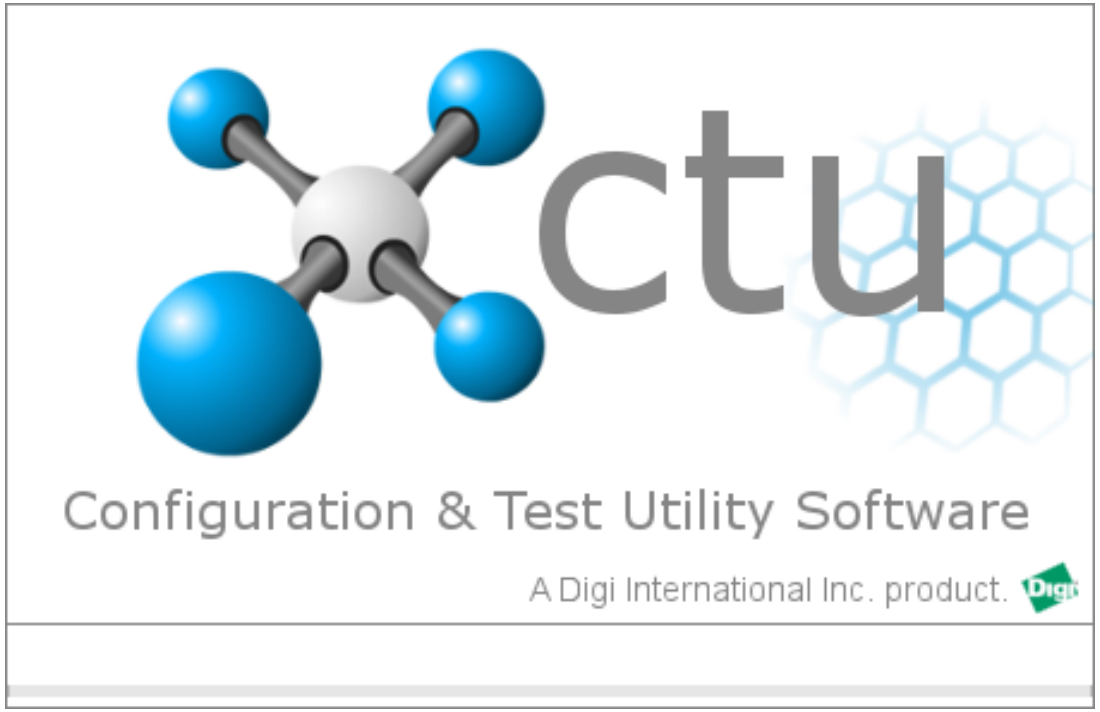
command descriptions

pin descriptions



It is a fault in X-CTU, that it doesn't help us distinguish between pins and commands.

We just have to put up with it.



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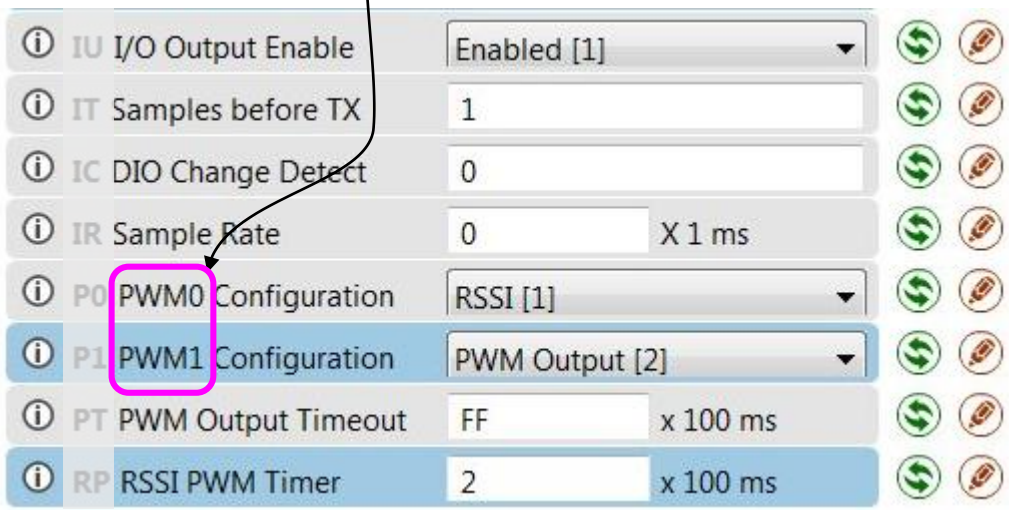
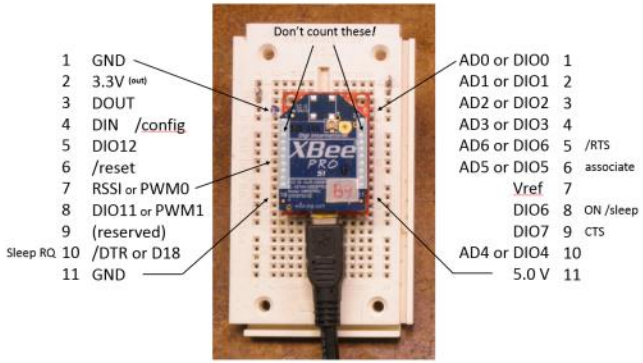
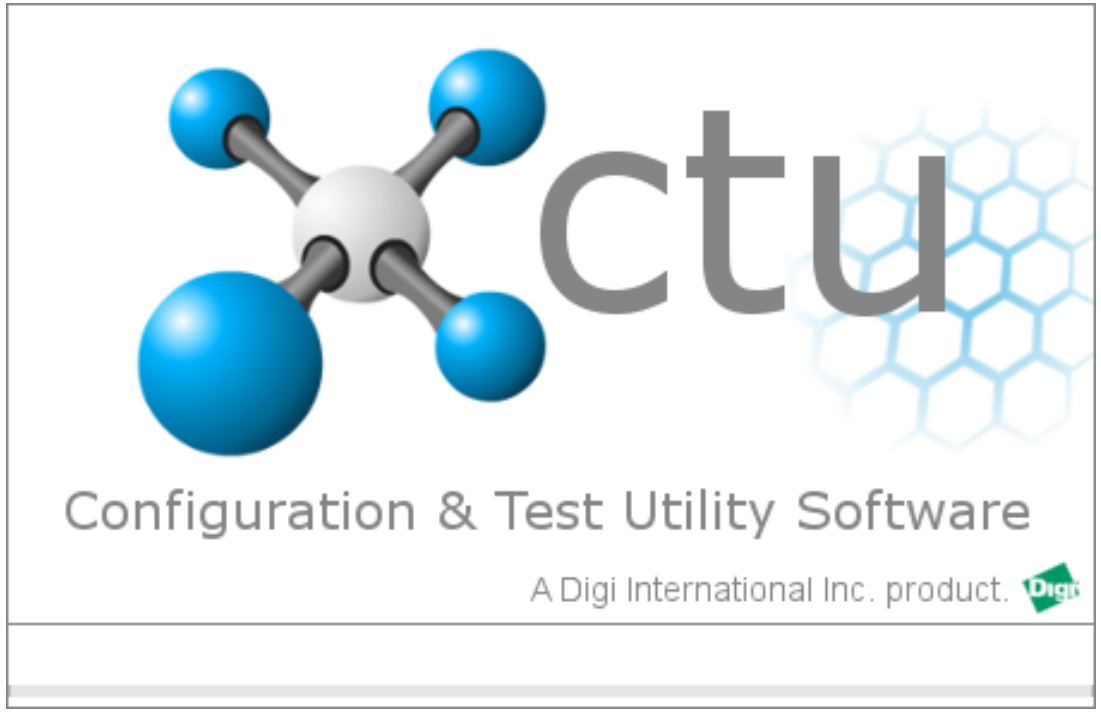
use this

pin descriptions







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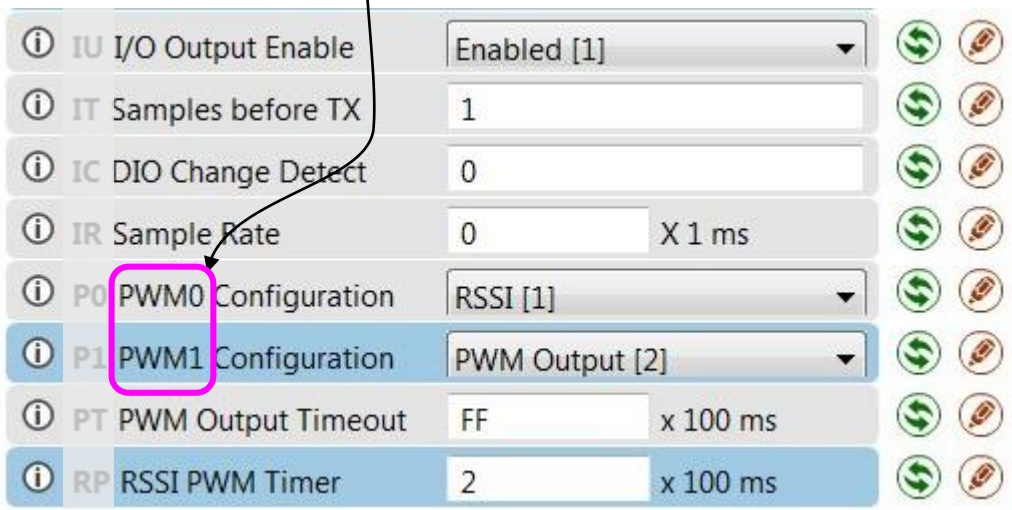
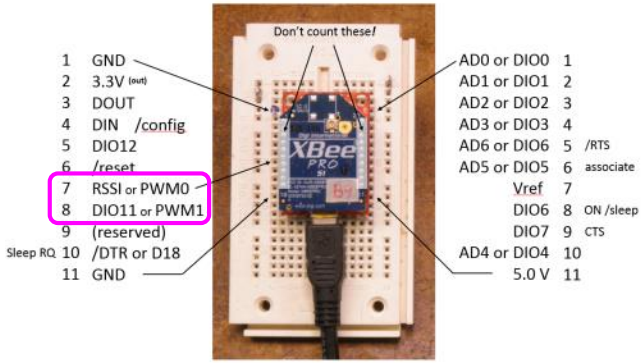
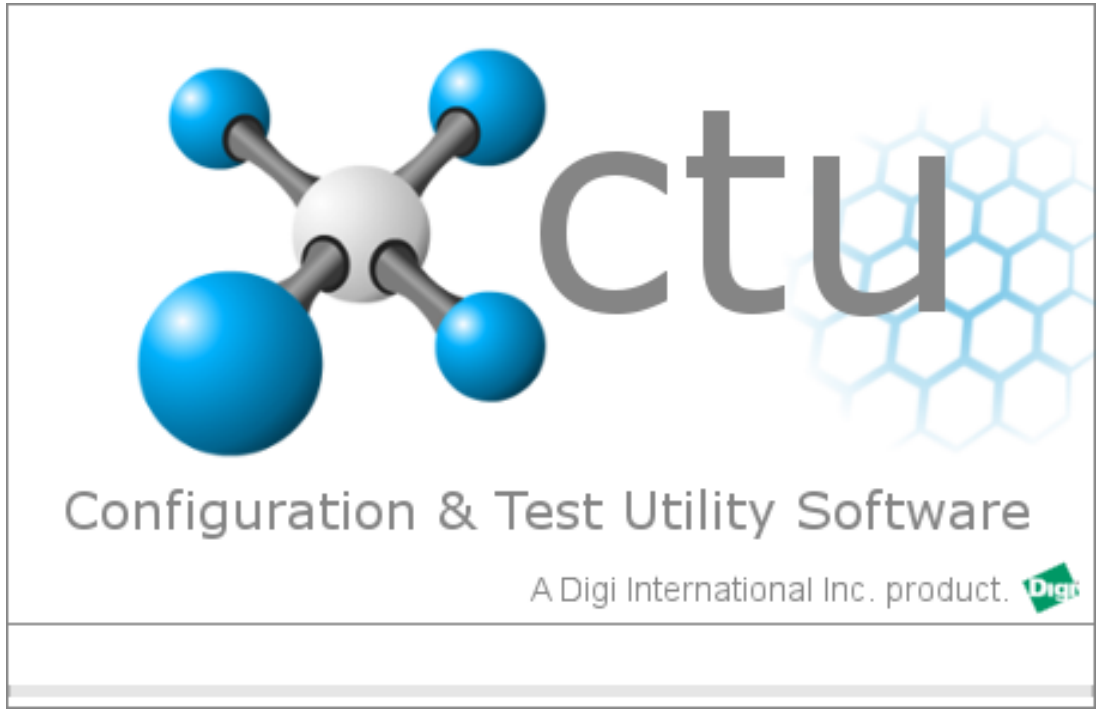
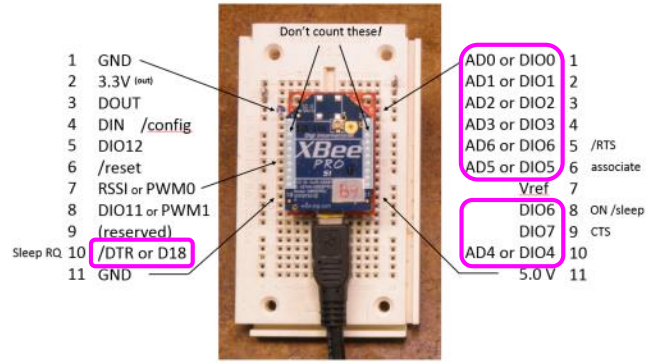
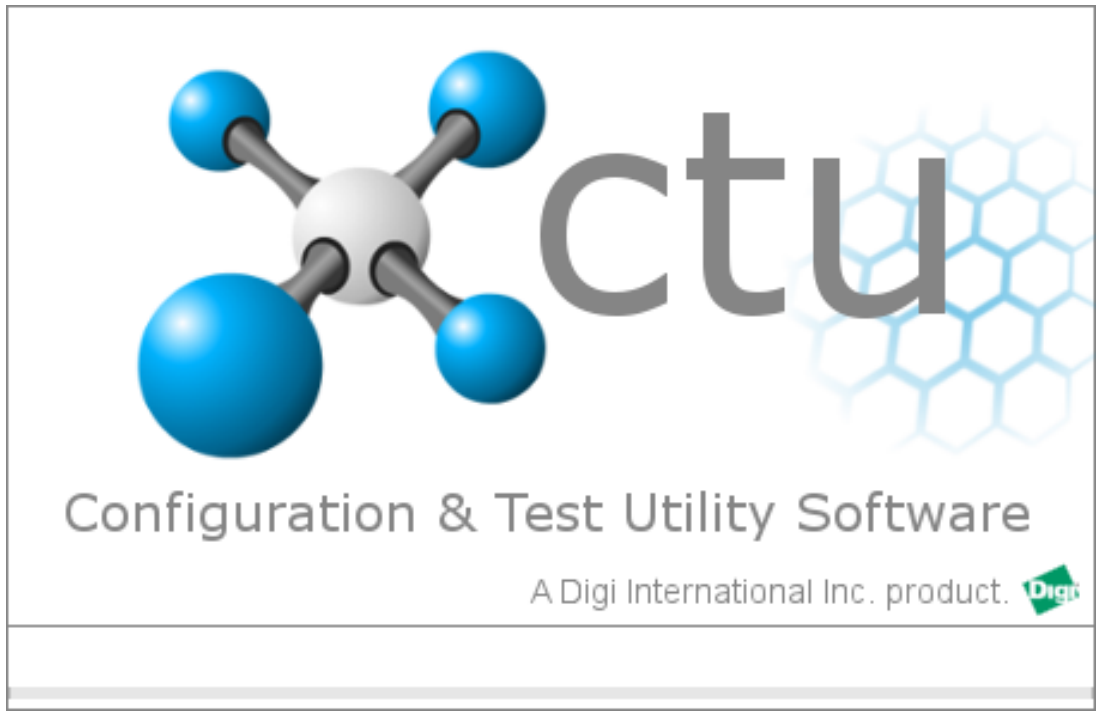








D8 DI8 Configuration	Disabled [0]	
D7 DIO7 Configuration	CTS flow control [1]	
D6 DIO6 Configuration	Disabled [0]	
D5 DIO5 Configuration	Associated indicator [1]	
D4 DIO4 Configuration	Disabled [0]	
D3 DIO3 Configuration	DO High [5]	
D2 DIO2 Configuration	DO Low [4]	
D1 DIO1 Configuration	DO Low [4]	
D0 DIO0 Configuration	ADC [2]	
PR Pull-up Resistor Enable	1	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	0	
IR Sample Rate	0	X 1 ms
P0 PWM0 Configuration	RSSI [1]	



TRANSMIT XBee

TRANSMIT XBee's X-CTU

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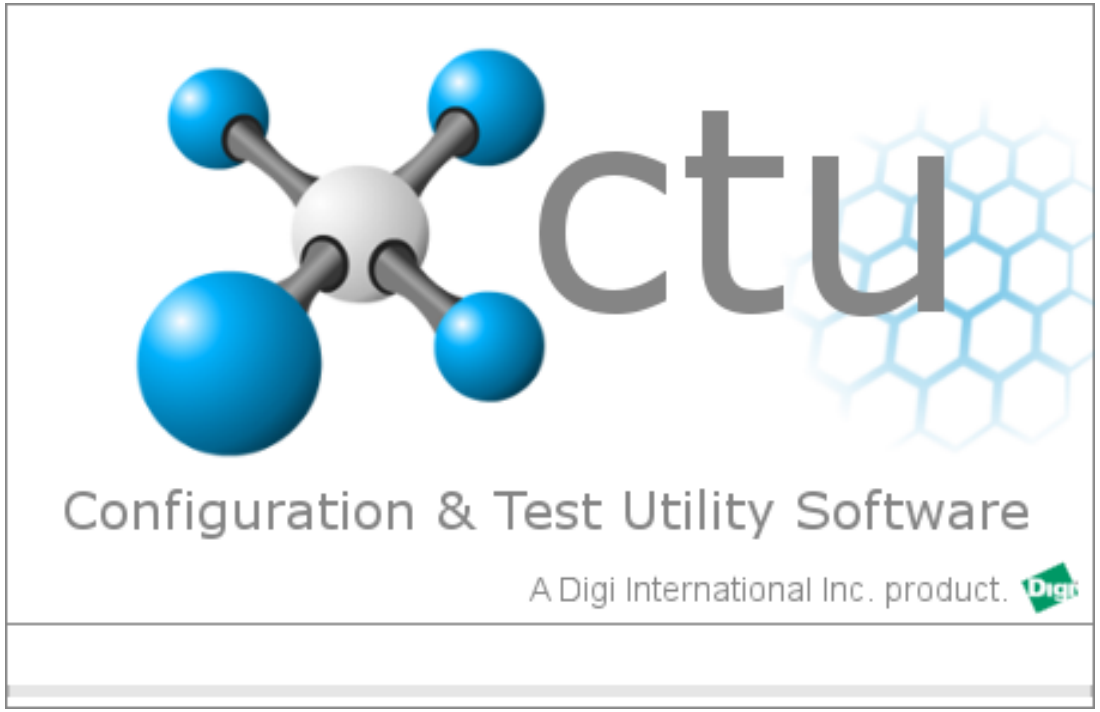
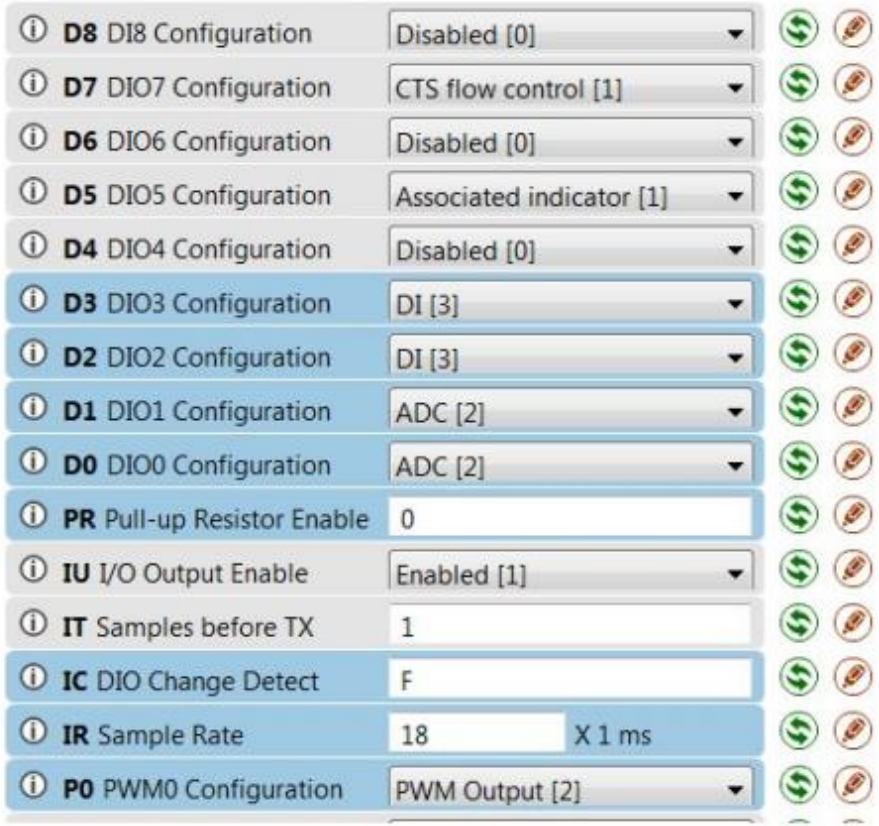
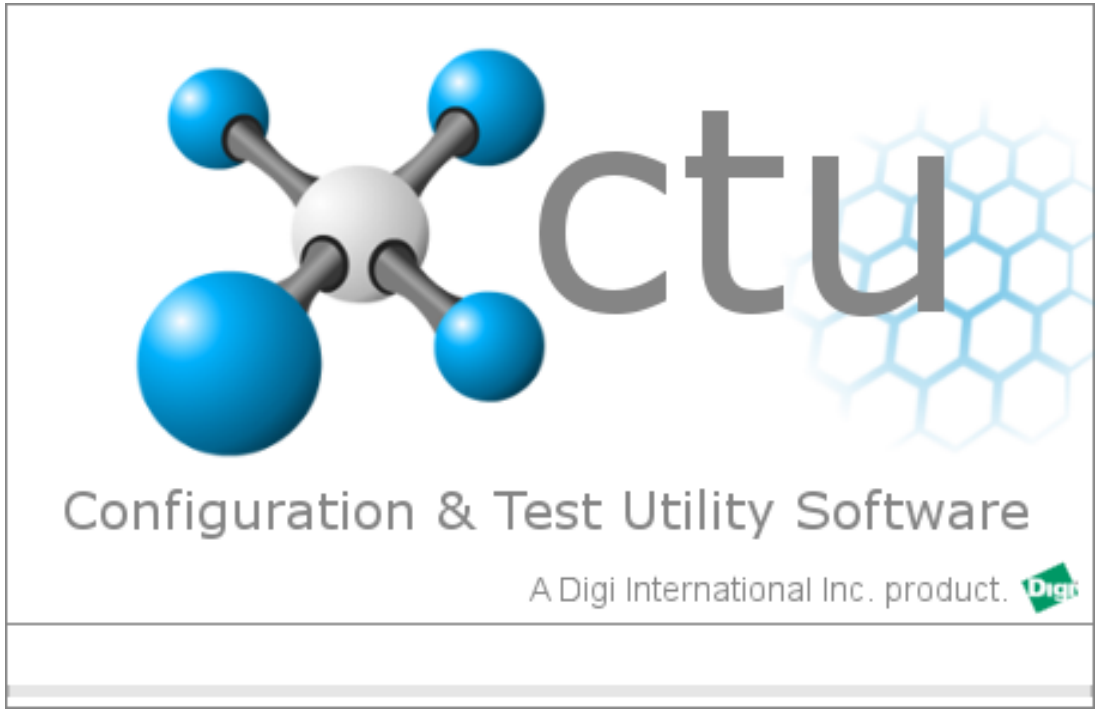
D3 DIO3 Configuration	DI [3]	
D2 DIO2 Configuration	DI [3]	
D1 DIO1 Configuration	ADC [2]	
D0 DIO0 Configuration	ADC [2]	
PR Pull-up Resistor Enable	0	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	F	
IR Sample Rate	18	X 1 ms
P0 PWM0 Configuration	PWM Output [2]	



Note how difficult it is to tell the difference between transmitting and receiving.

TRANSMIT XBee's X-CTU





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receive XBee's X-CTU

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IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
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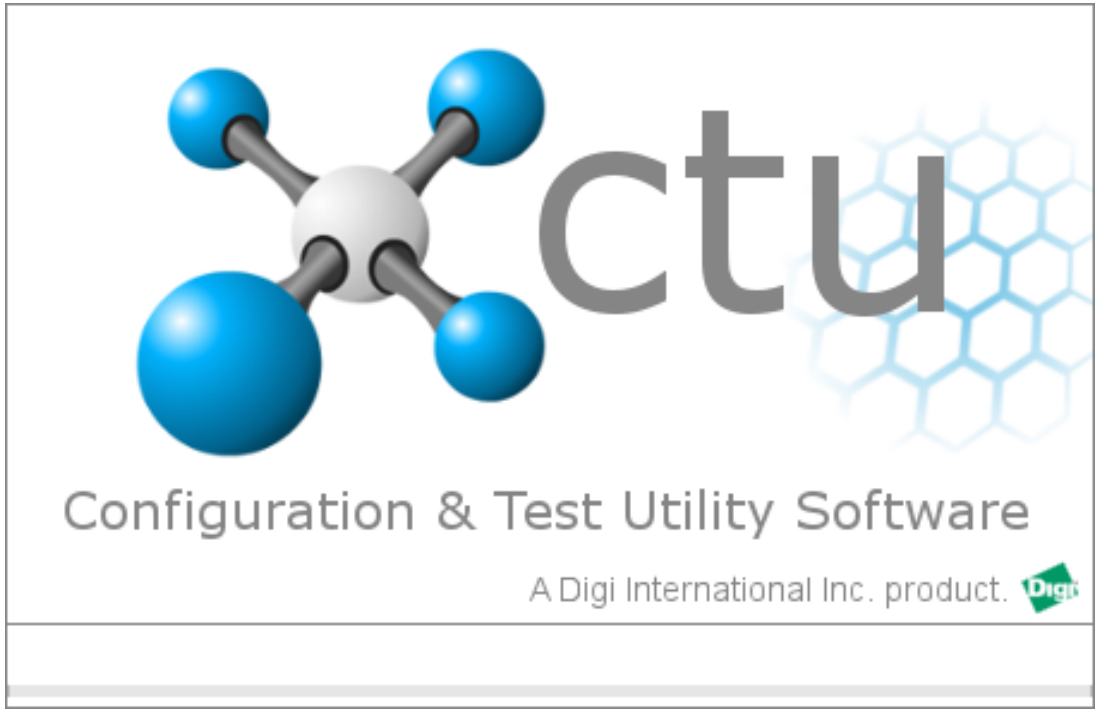

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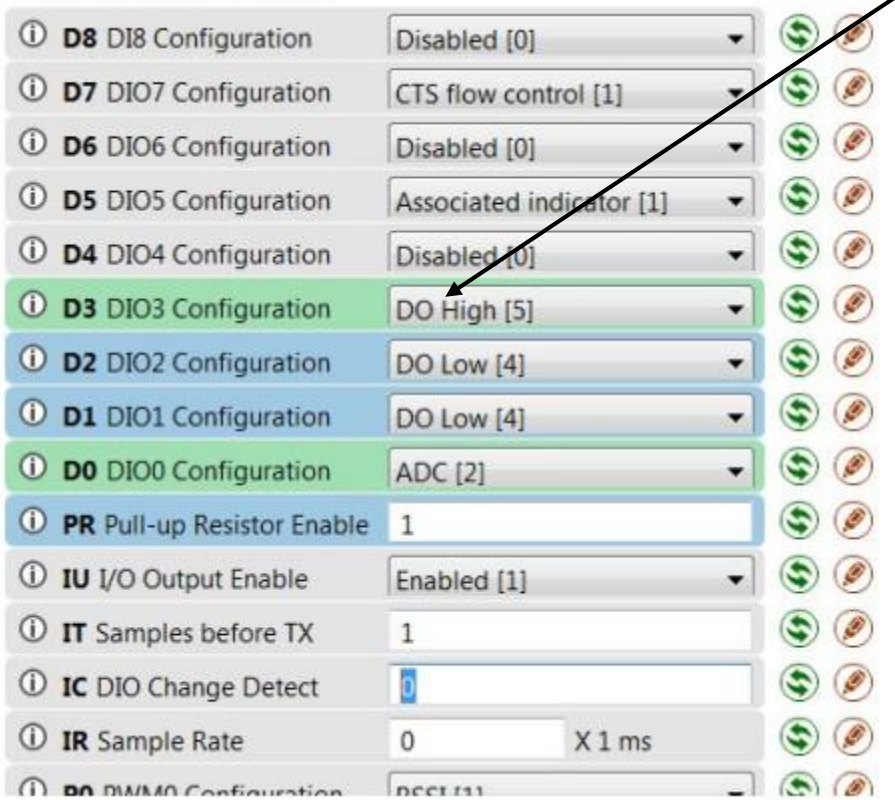
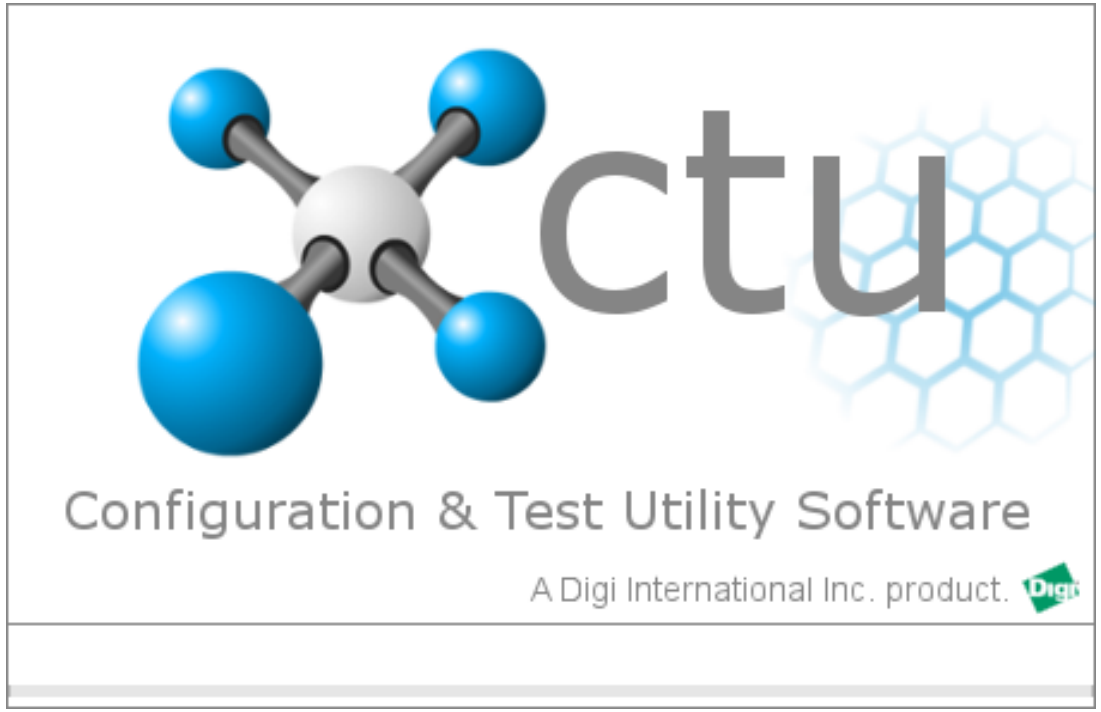
DO stands for ***digital out***

receive XBee's X-CTU





Note how difficult it is to tell the difference between transmitting and receiving.

DO stands for ***digital out***

DI stands for ***digital in***

back

TRANSMIT XBee's X-CTU

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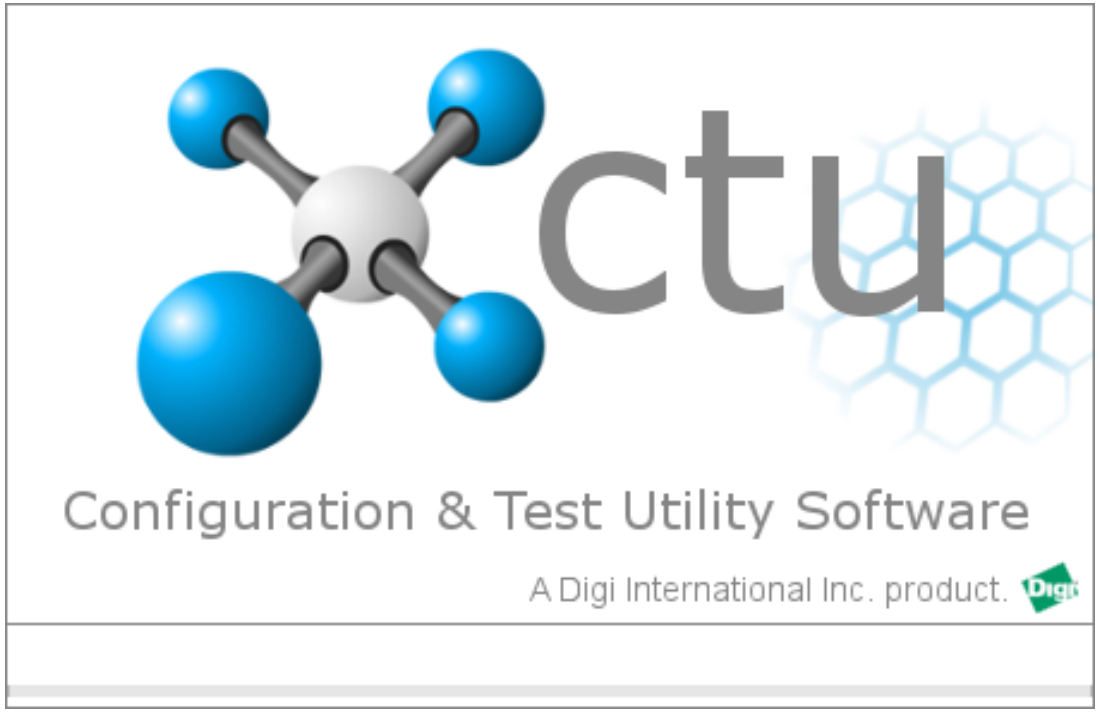
D3 DIO3 Configuration	DI [3]
D2 DIO2 Configuration	DI [3]
D1 DIO1 Configuration	ADC [2]
D0 DIO0 Configuration	ADC [2]
PR Pull-up Resistor Enable	0
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	F
IR Sample Rate	18 X 1 ms
P0 PWM0 Configuration	PWM Output [2]



Note how difficult it is to tell the difference between transmitting and receiving.

XBee works both ways.
The DIO3 Configuration can be DI [3] (input) and the next line, the DIO2 can be DO Low [4] (output)

TRANSMIT XBee's X-CTU

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D1 DIO1 Configuration	ADC [2]
D0 DIO0 Configuration	ADC [2]
PR Pull-up Resistor Enable	0
IU I/O Output Enable	Enabled [1]
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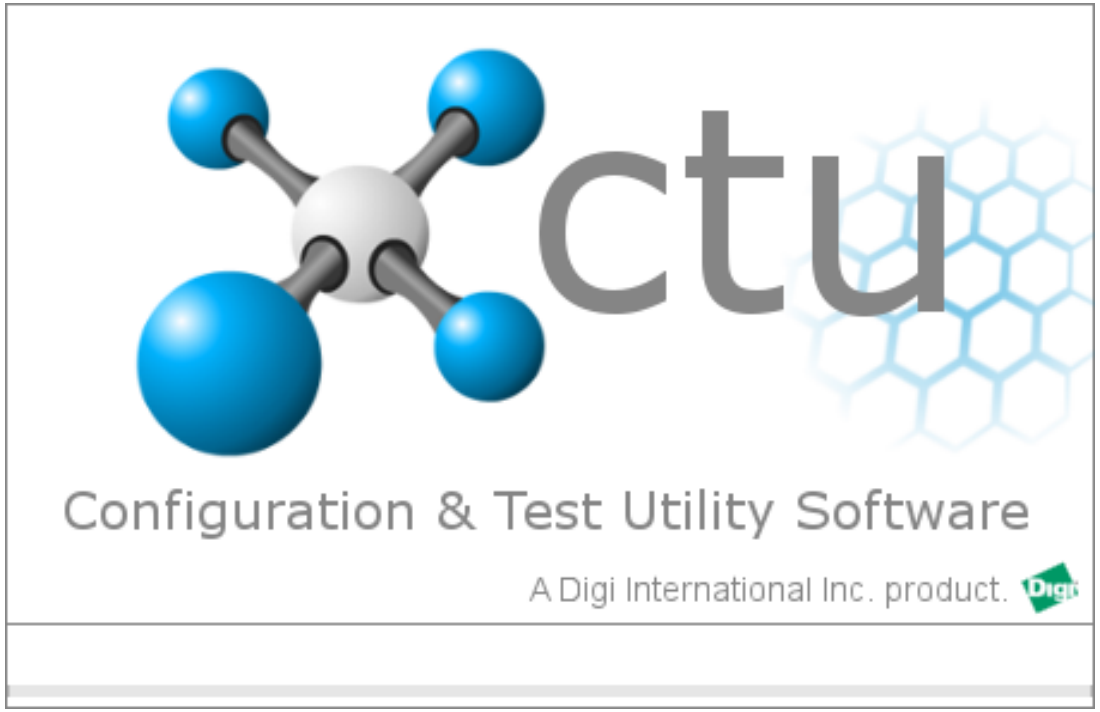
IR Sample Rate	18 X 1 ms
P0 PWM0 Configuration	PWM Output [2]



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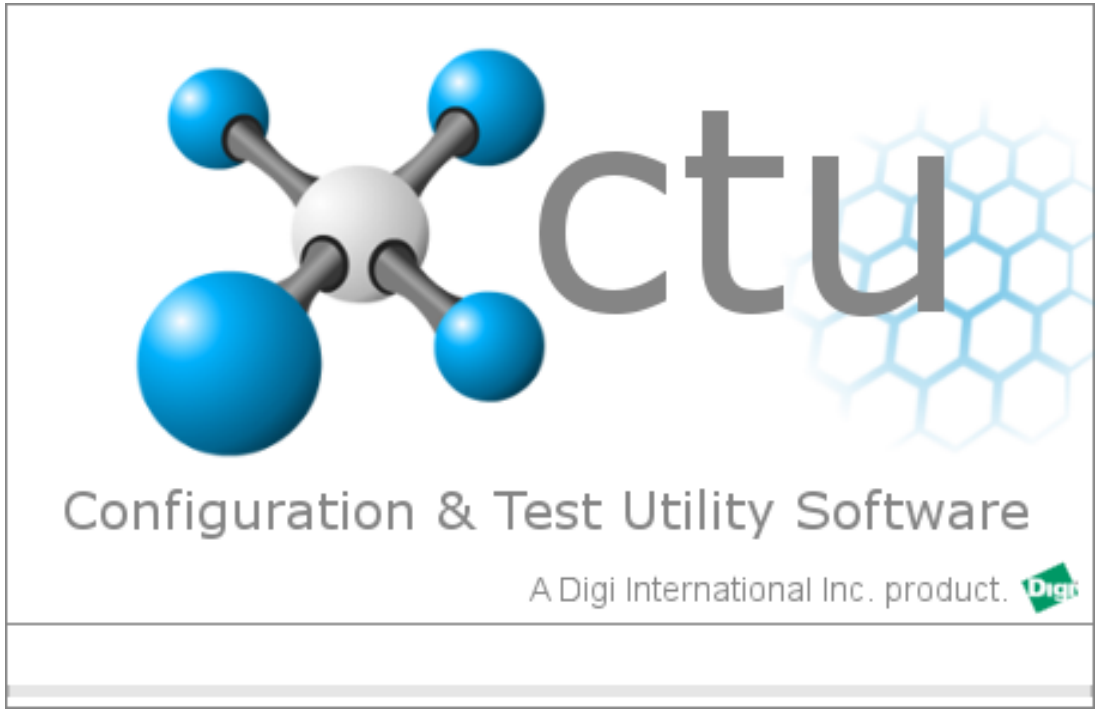
D3 DIO3 Configuration	DI [3]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	ADC [2]
D0 DIO0 Configuration	ADC [2]
PR Pull-up Resistor Enable	0
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	F
IR Sample Rate	18 X 1 ms
P0 PWM0 Configuration	PWM Output [2]



In XBee manuals, they use the terms . . .
Base XBee and ***Remote*** XBee.

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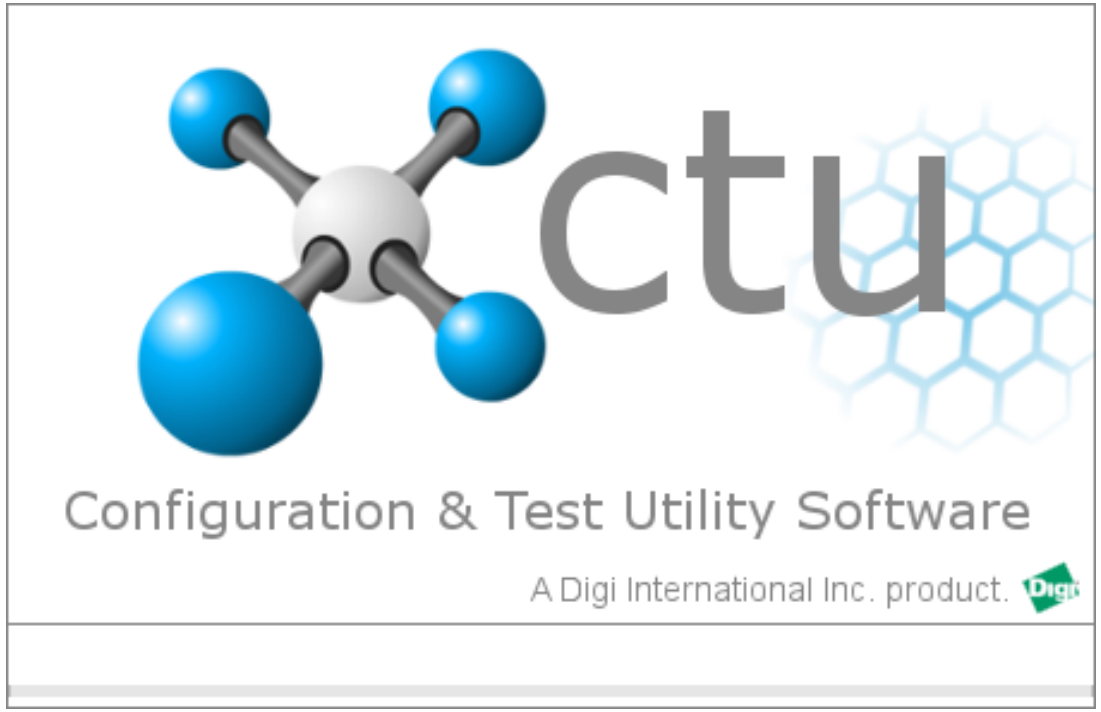

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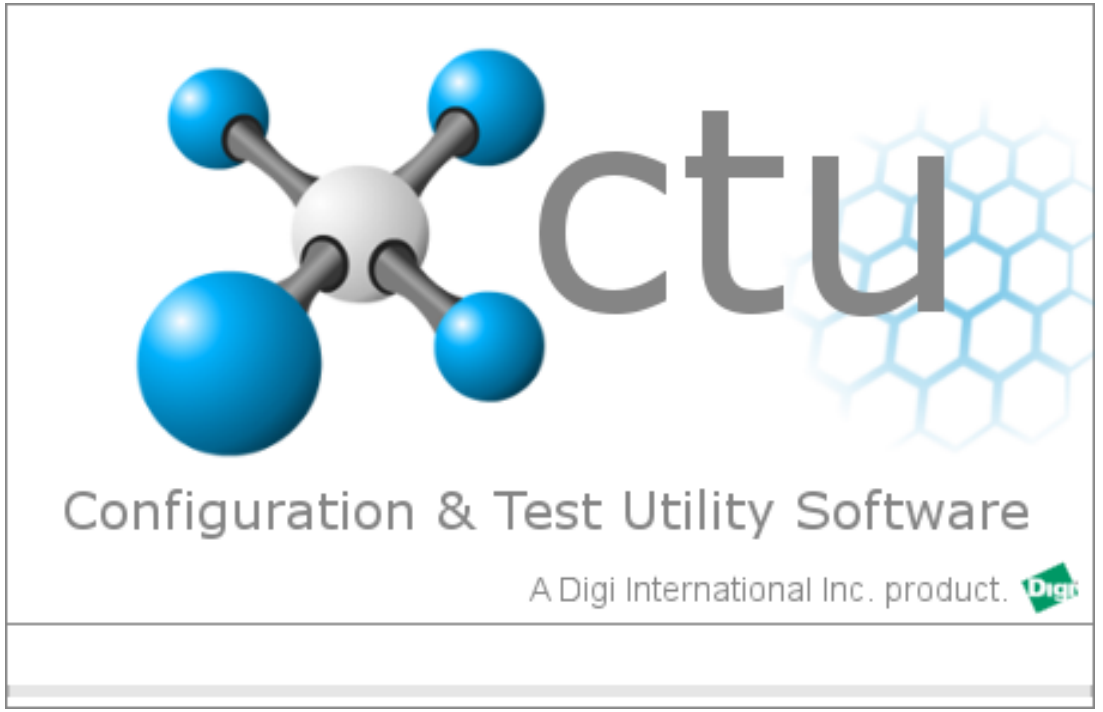
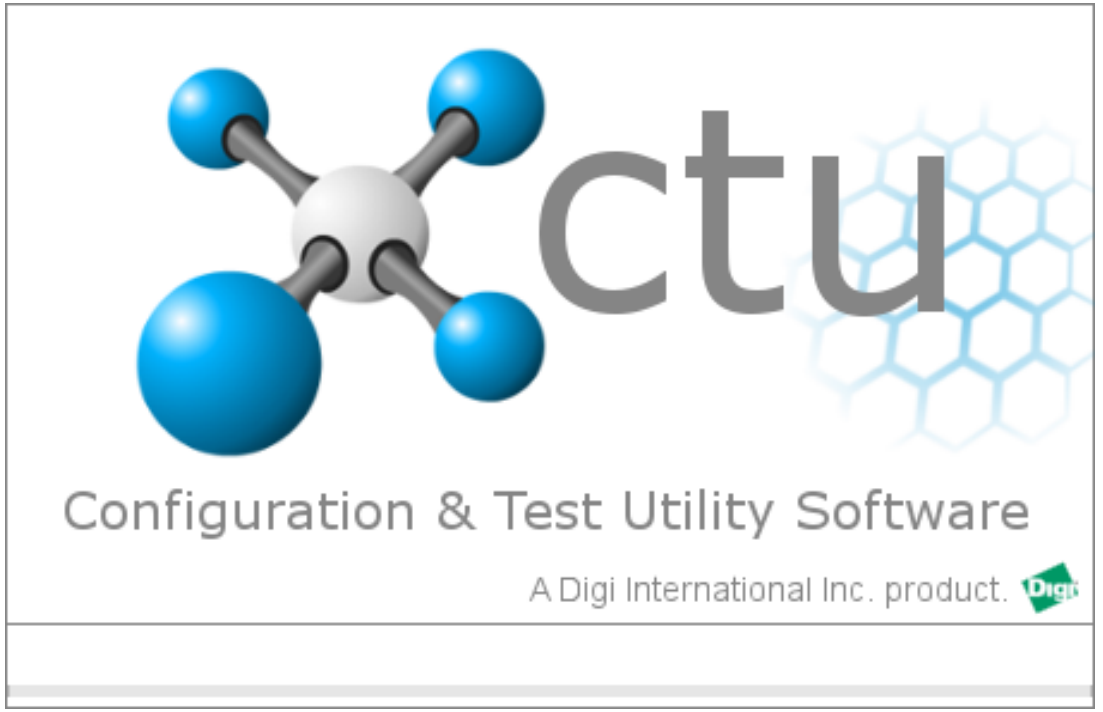


In XBee manuals, they use the terms . . .
Base XBee and ***Remote*** XBee.

The ***Remote XBee*** usually sends data from a sensor, but conceivably this transmitting unit could receive a command to change some parameter in the sensor.

Programming the Receive XBee

So the word **“Receive”** here is actually to keep it straight which XBee we are talking about ***during this lesson***.



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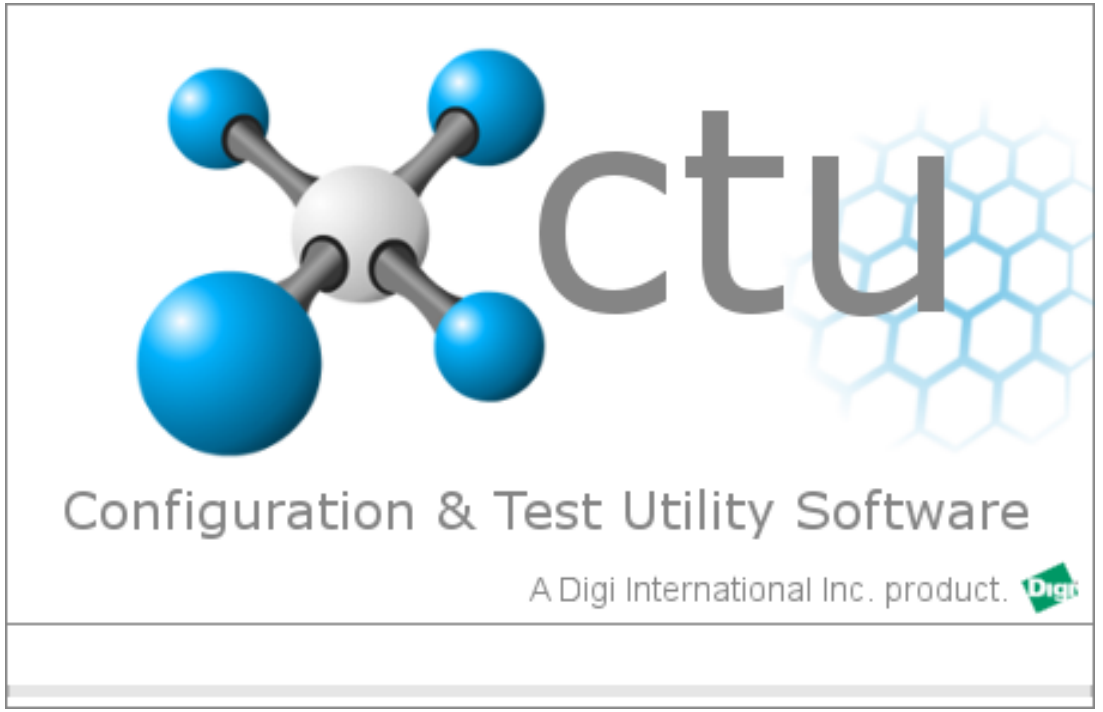
Receive Unit: the XBee with LEDs and meter display



Programming the Receive XBee

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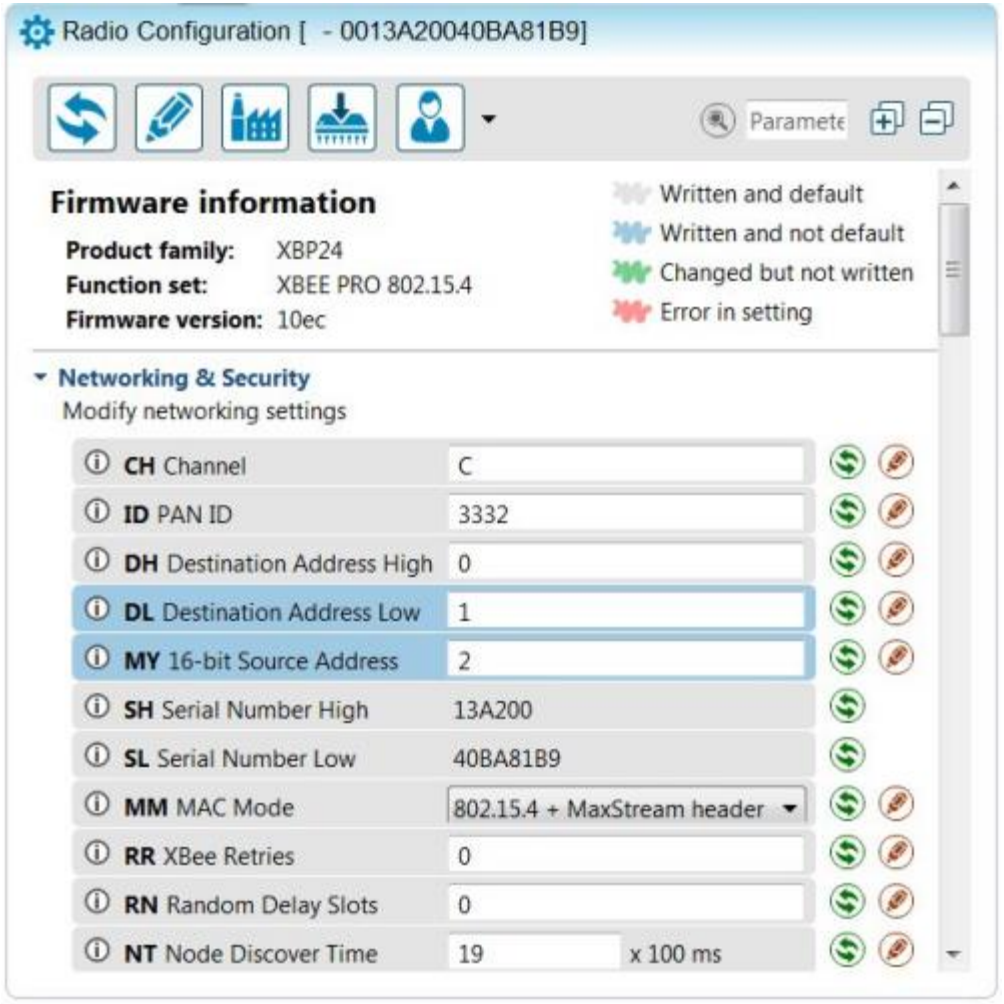
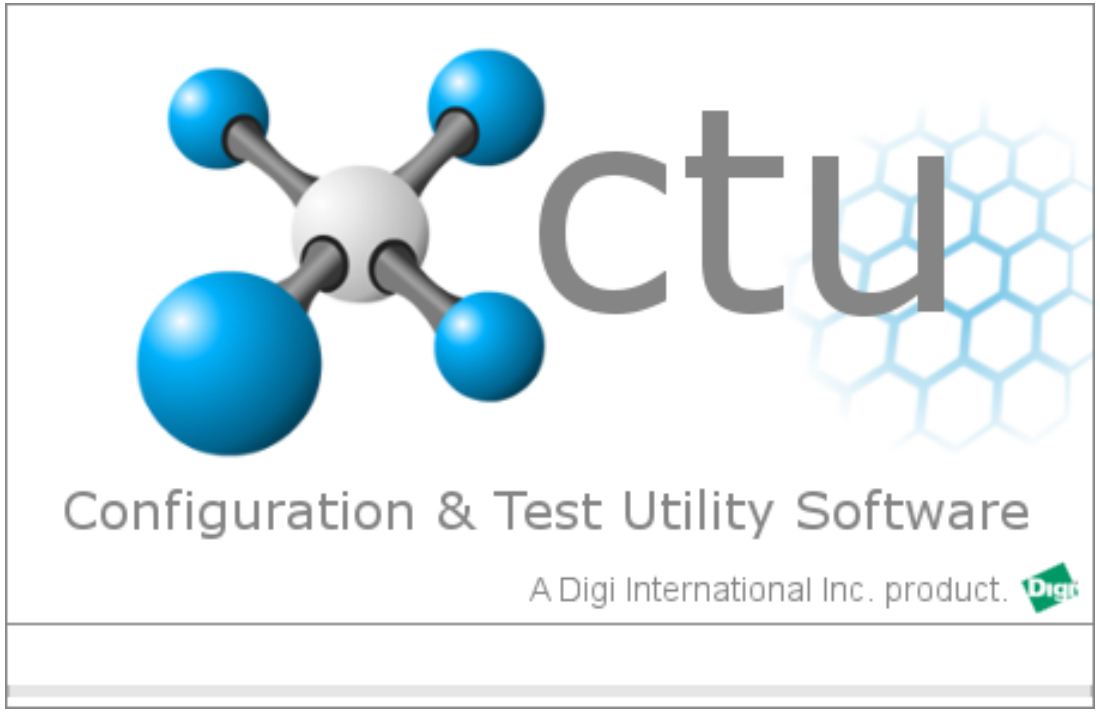
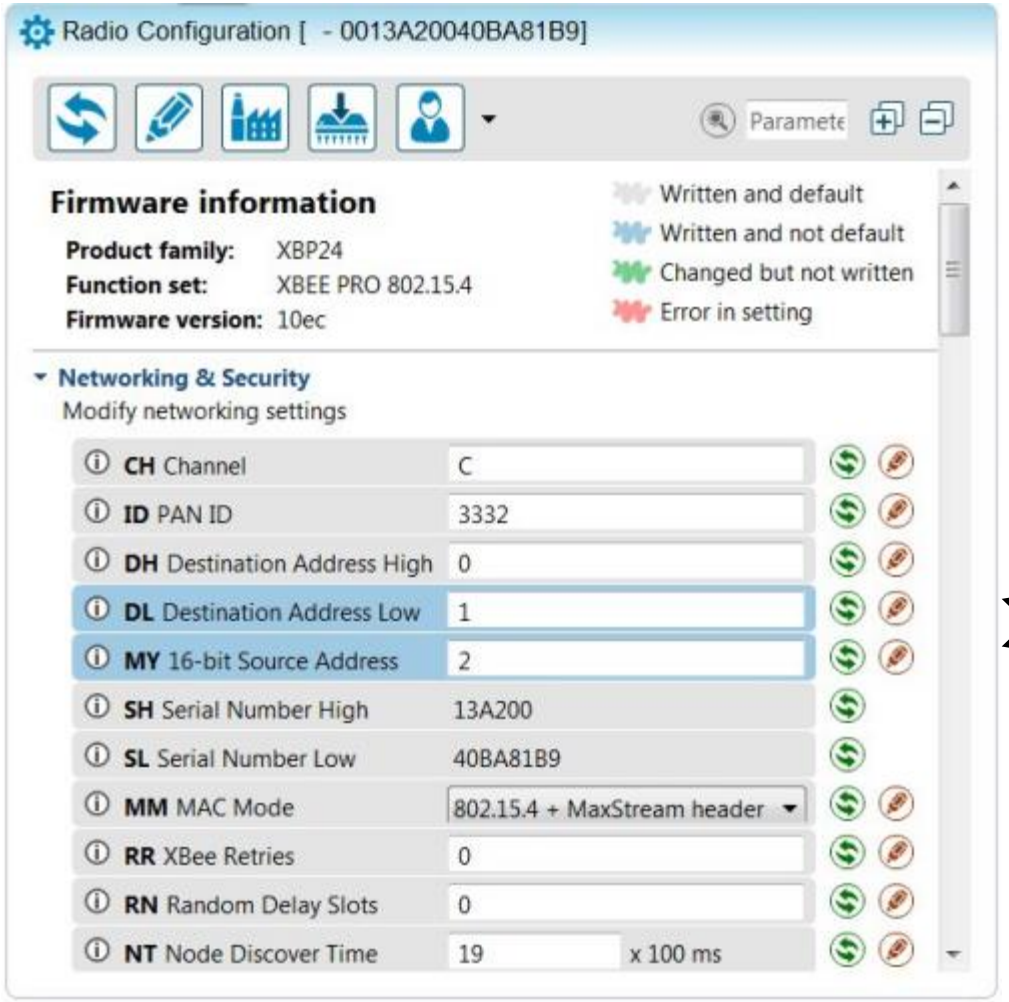
Receive Unit: the XBee with LEDs and meter display

top of **receive** XBee’s X-CTU

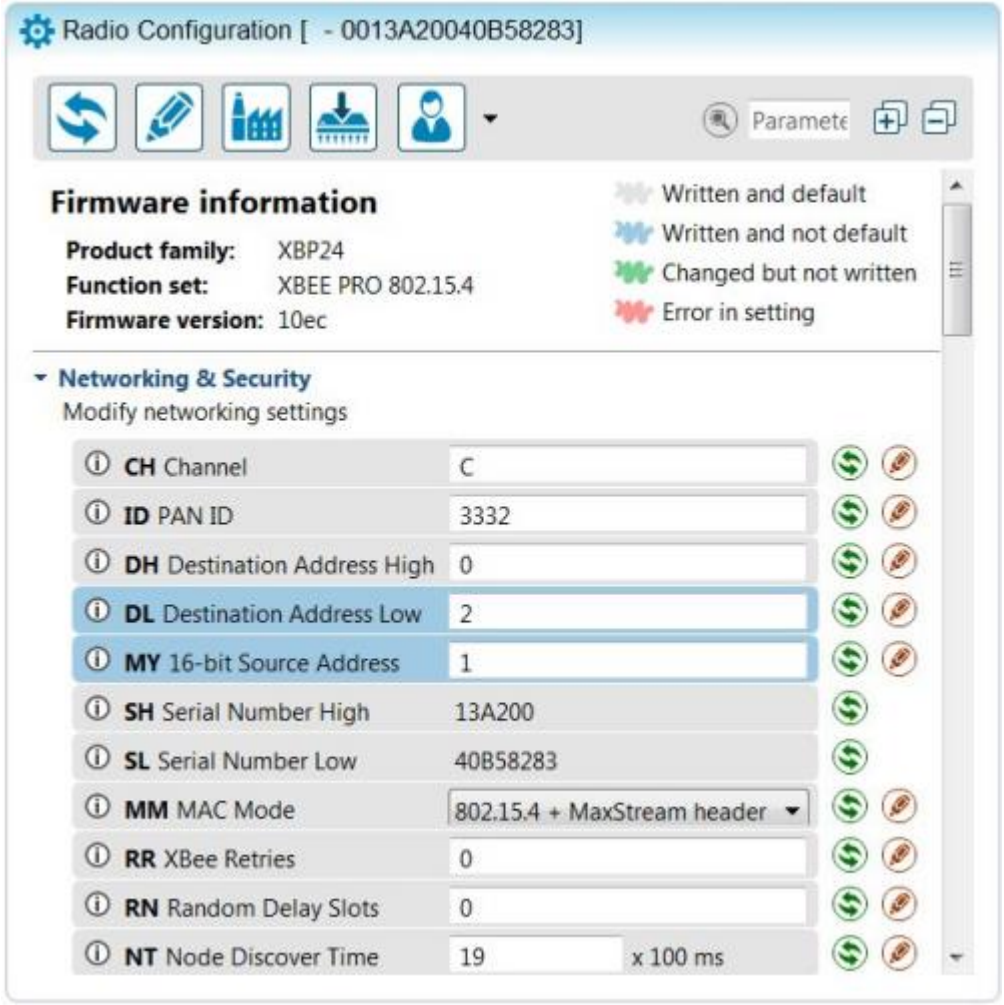




top of **receive** XBee's X-CTU

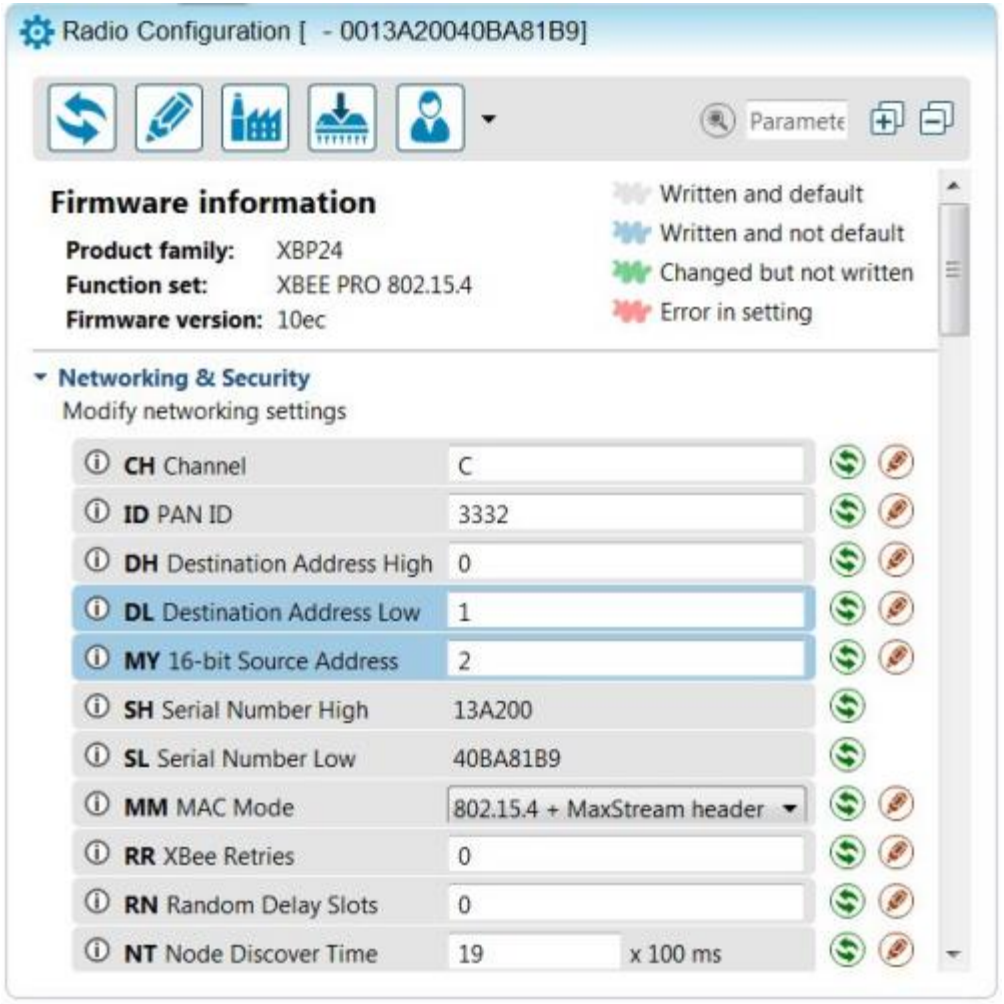


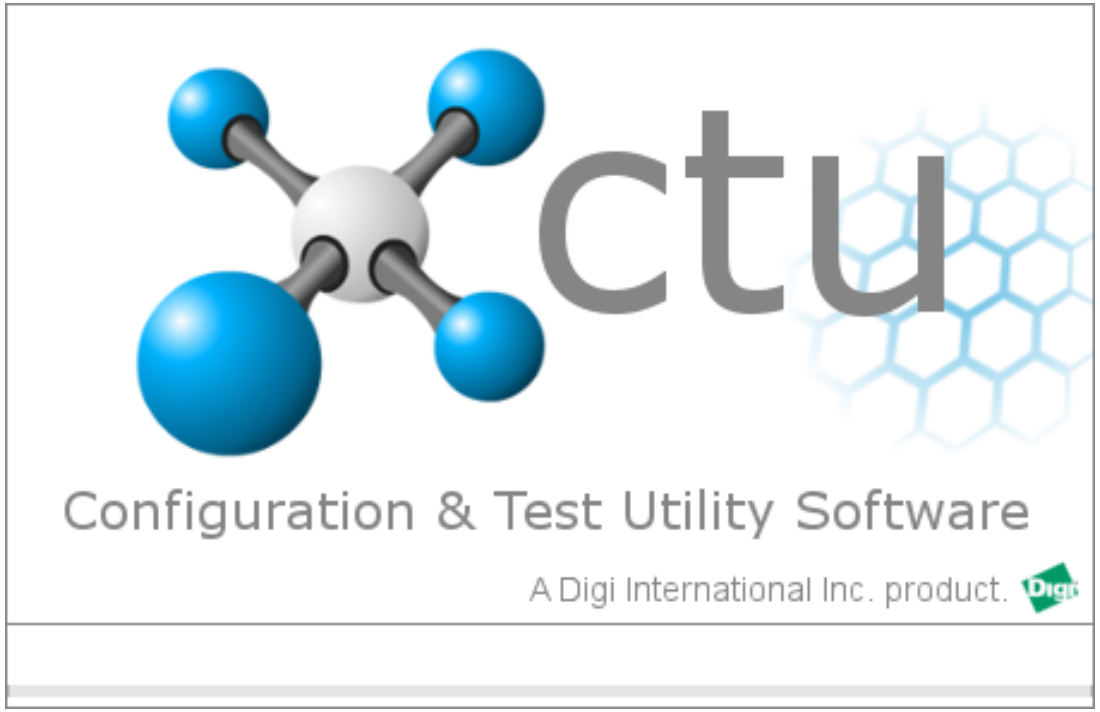
top of **transmit** XBee's X-CTU



Programming the Receive XBee

top of **receive** XBee's X-CTU

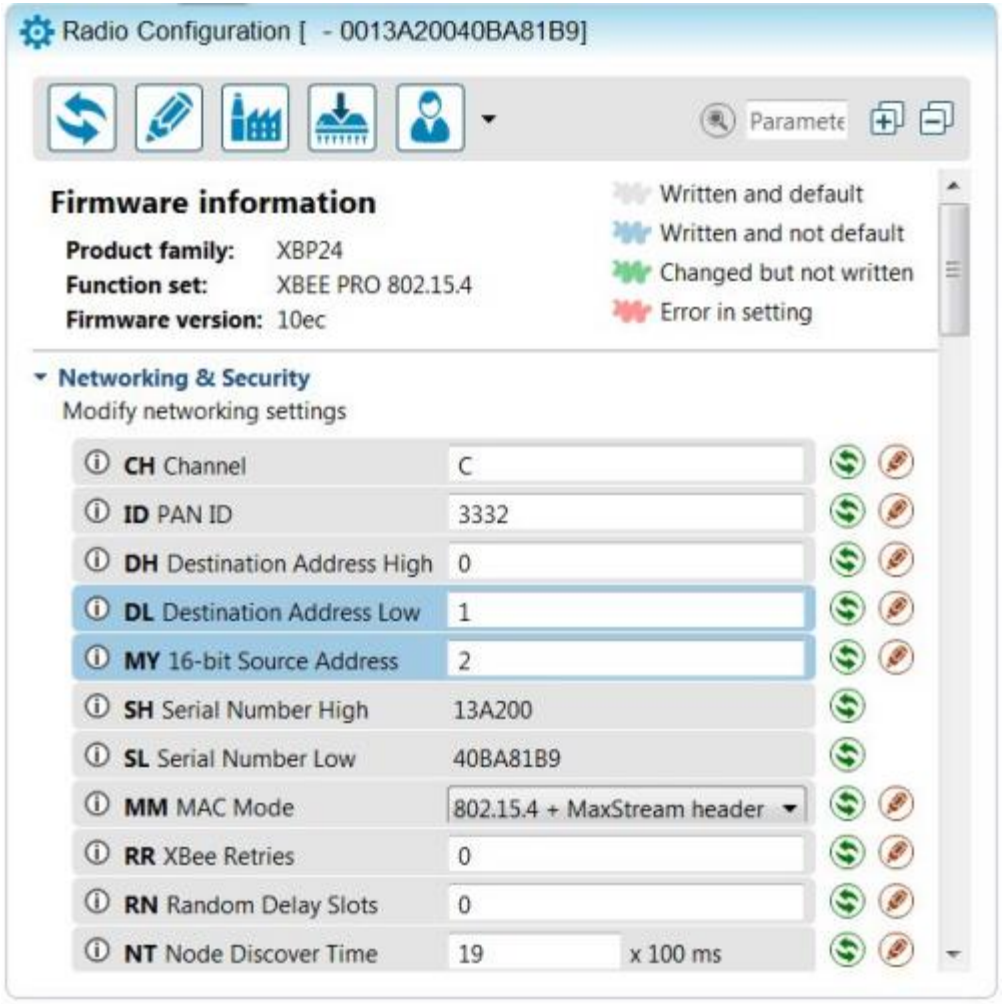


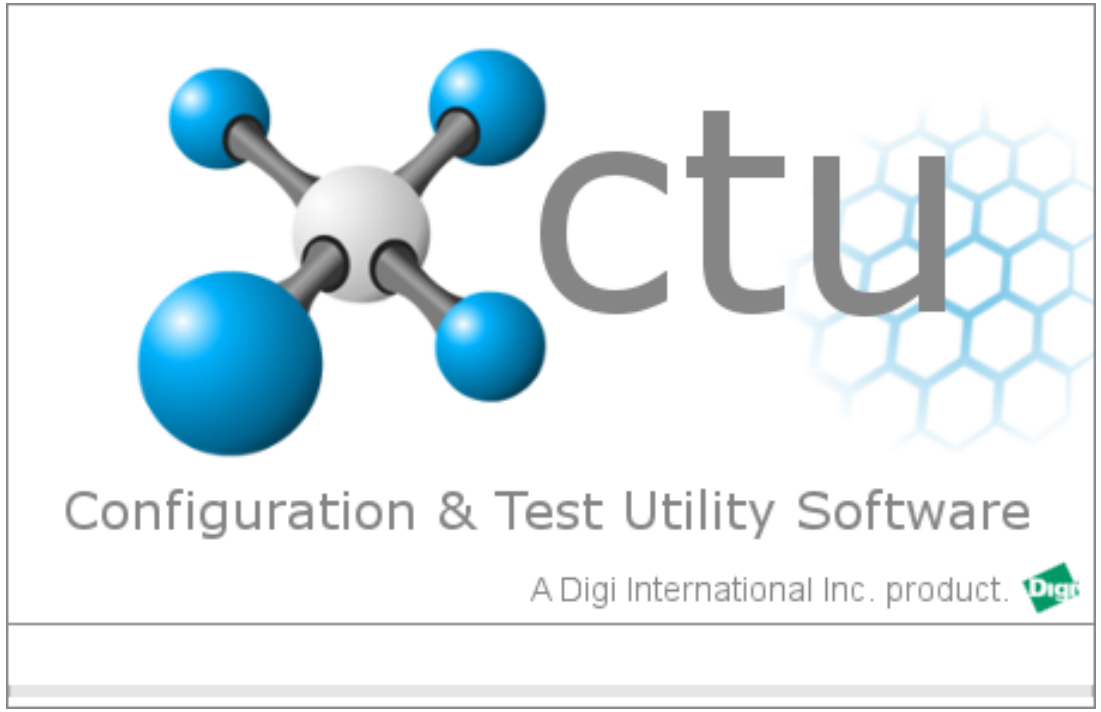


Programming the Receive XBee

Receive Unit: the XBee with LEDs and meter display

top of **receive** XBee's X-CTU



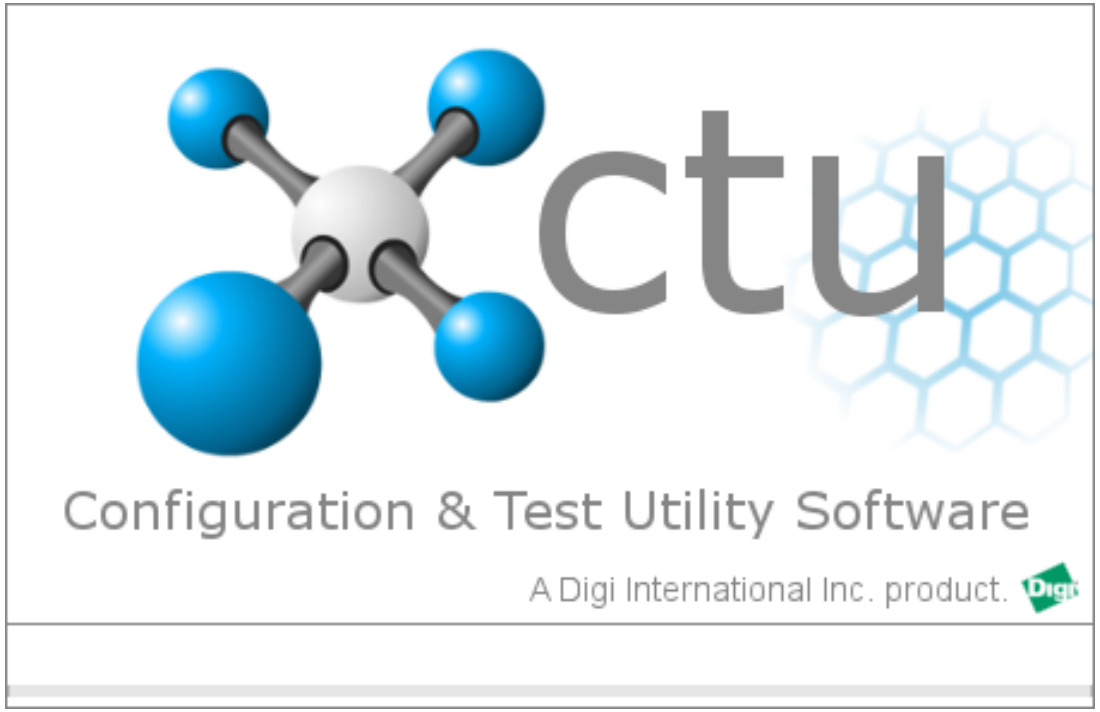


Programming the Receive XBee

Receive Unit: the XBee with LEDs and meter display

further down receive XBee's X-CTU

D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]



Programming the Receive XBee

Receive Unit: the XBee with LEDs and meter display

pin descriptions for receive unit's "digital" outputs

further down receive XBee's X-CTU

D4	DIO4 Configuration	DO Low [4]
D3	DIO3 Configuration	DO Low [4]
D2	DIO2 Configuration	DO Low [4]
D1	DIO1 Configuration	Disabled [0]
D0	DIO0 Configuration	Disabled [0]
PR	Pull-up Resistor Enable	1
IU	I/O Output Enable	Enabled [1]
IT	Samples before TX	1
IC	DIO Change Detect	0
IR	Sample Rate	0 X 1 ms
P0	PWM0 Configuration	PWM Output [2]
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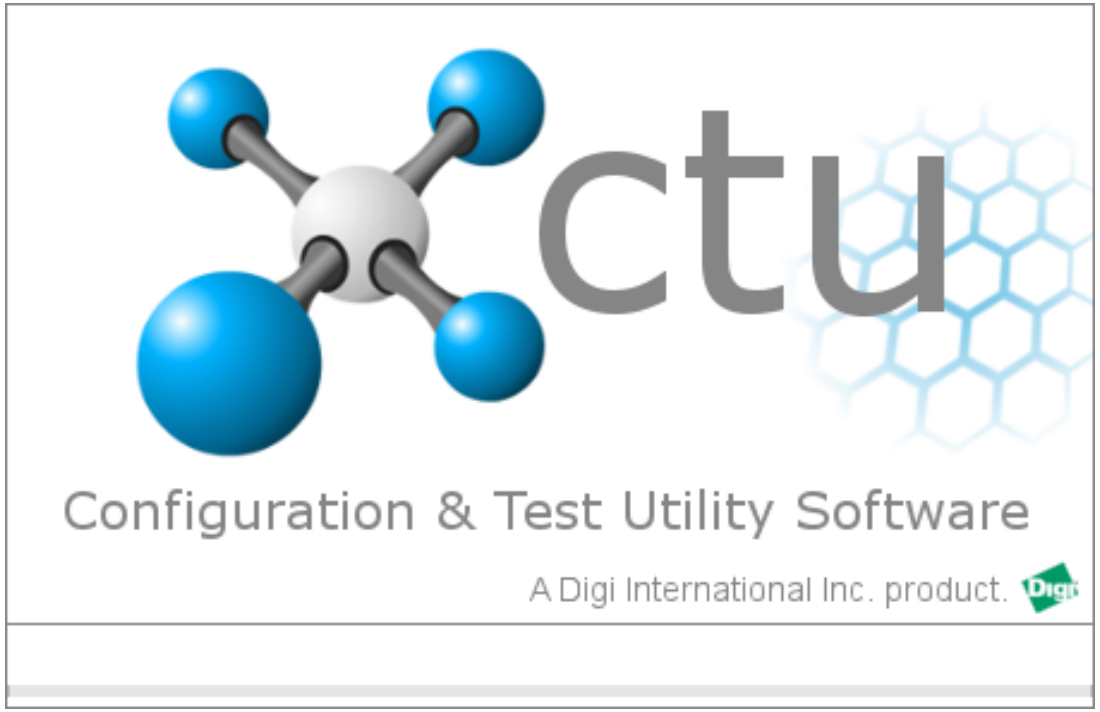


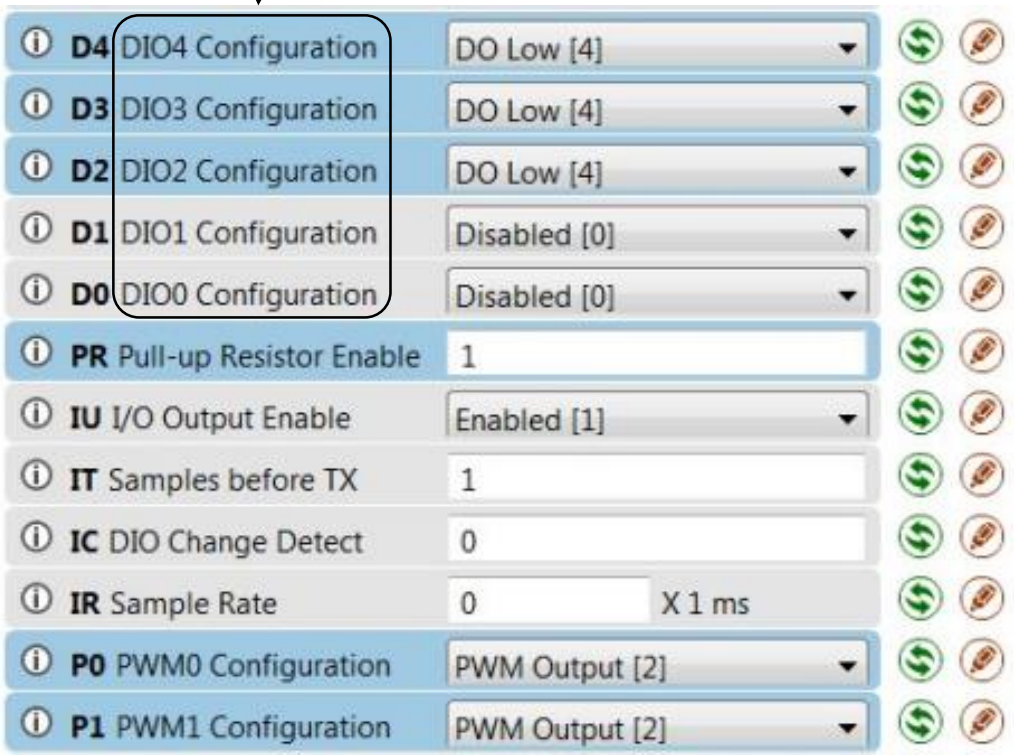
Programming the Receive XBee

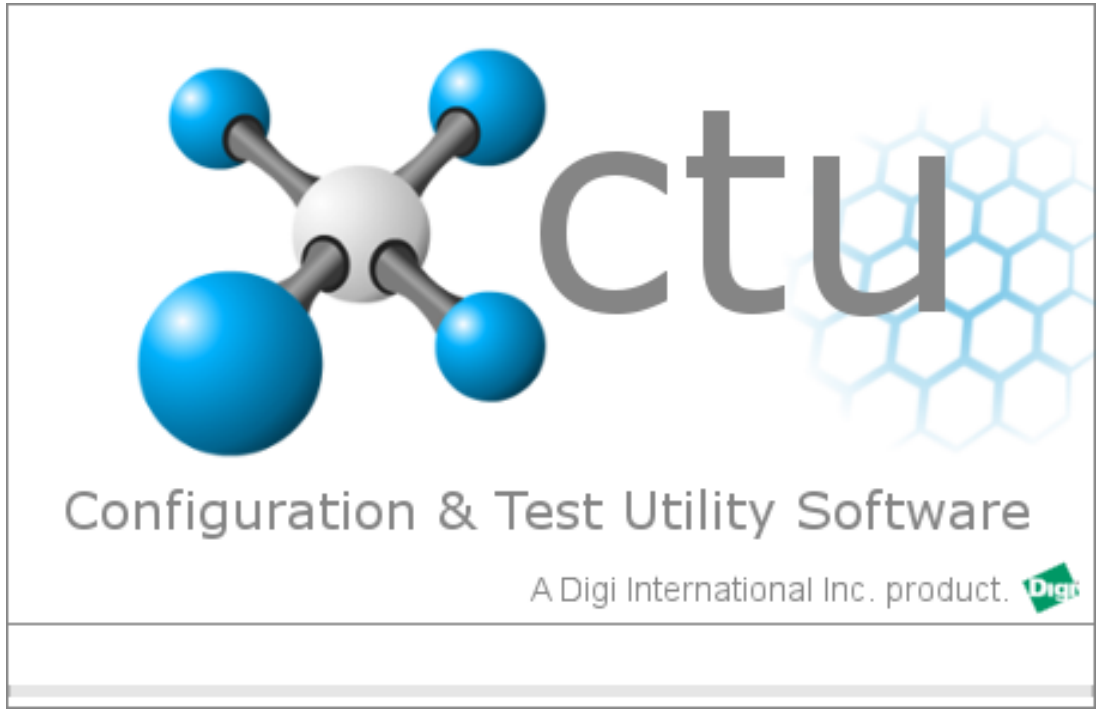
Receive Unit: the XBee with LEDs and meter display

pin descriptions for receive unit's "digital" outputs

confusing isn't it ***!***

further down receive XBee's X-CTU



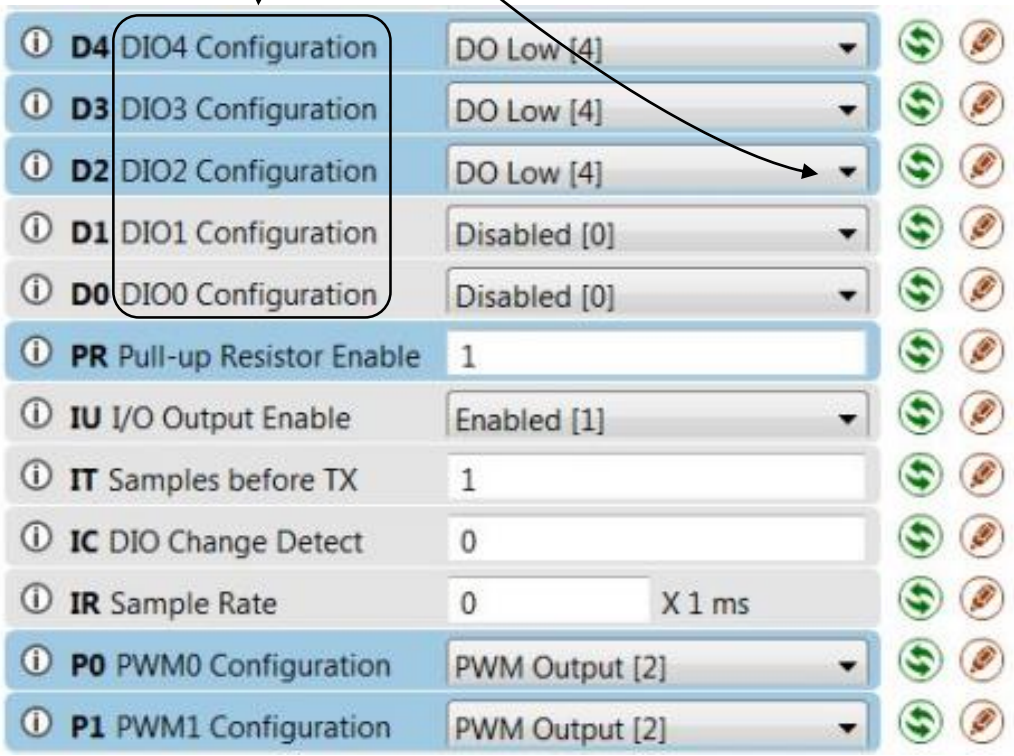


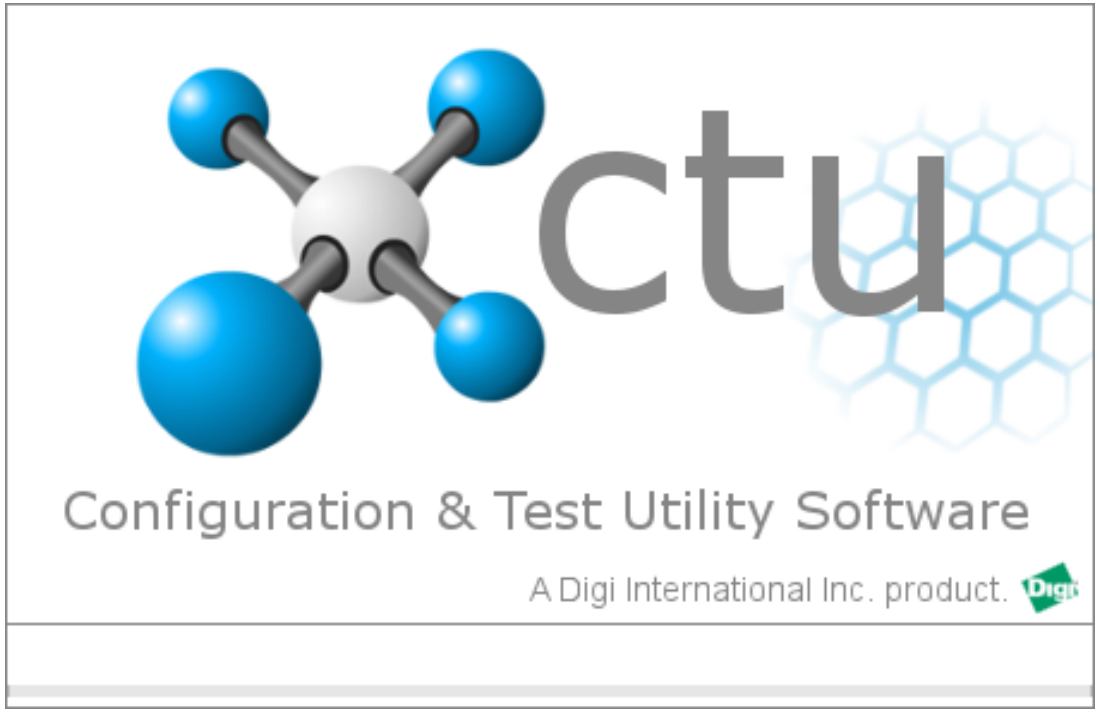
Programming the Receive XBee

Receive Unit: the XBee with LEDs and meter display

pin descriptions for receive unit's "digital" outputs

click here

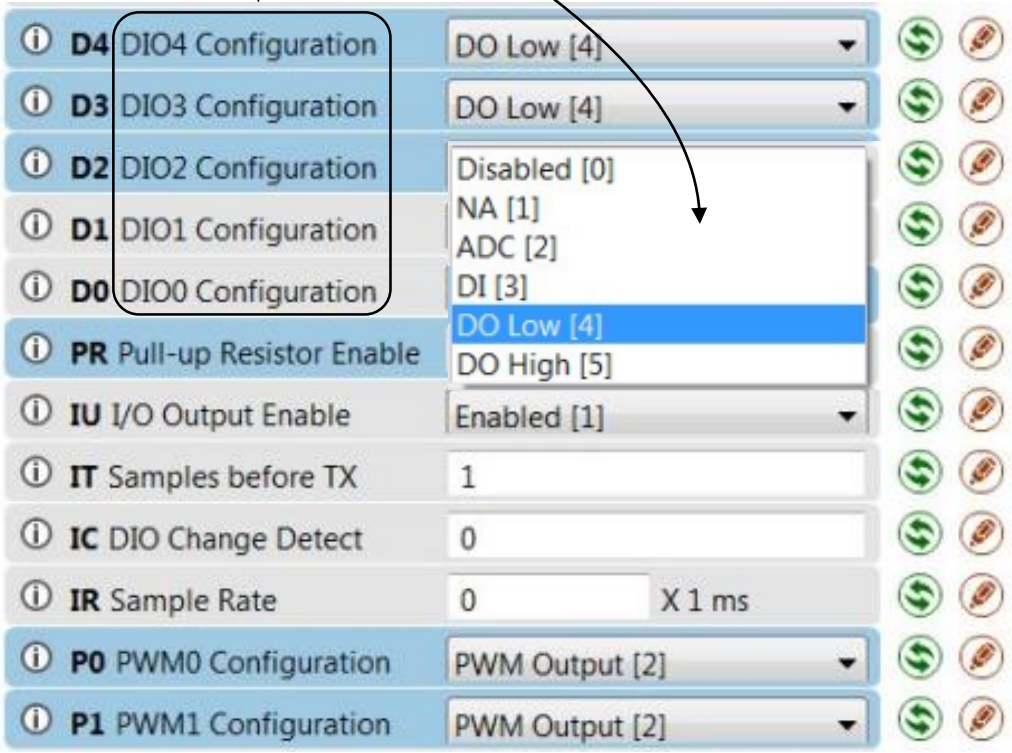


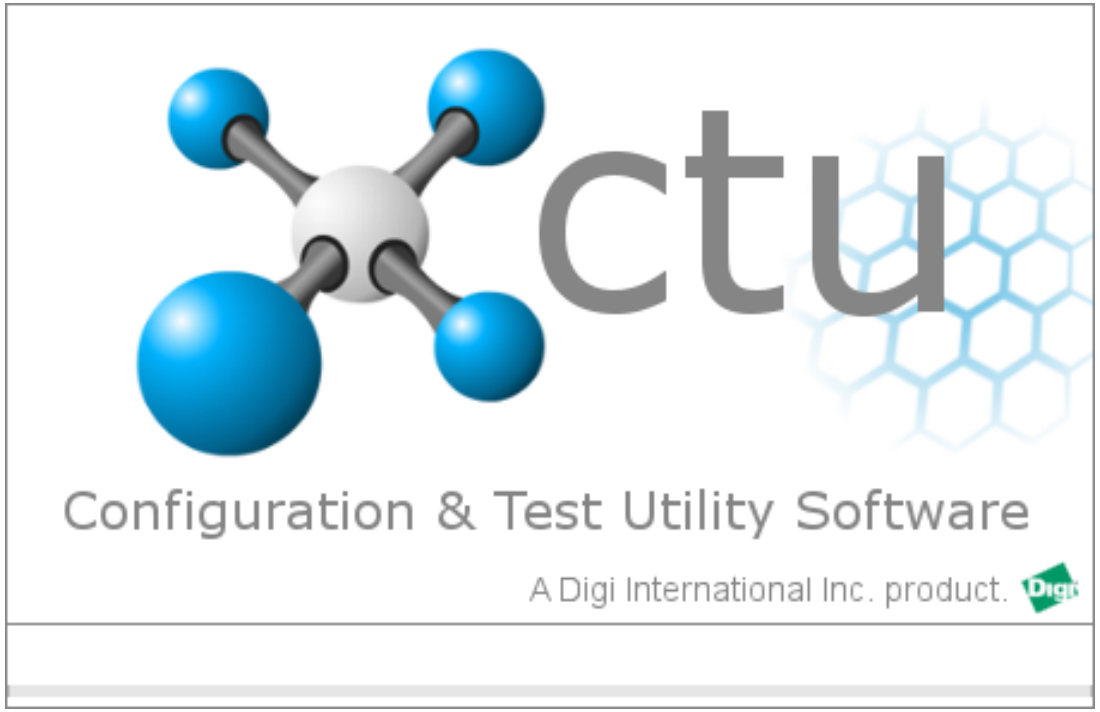


Programming the Receive XBee

pin descriptions for receive unit's "digital" outputs

then click on a subcommand



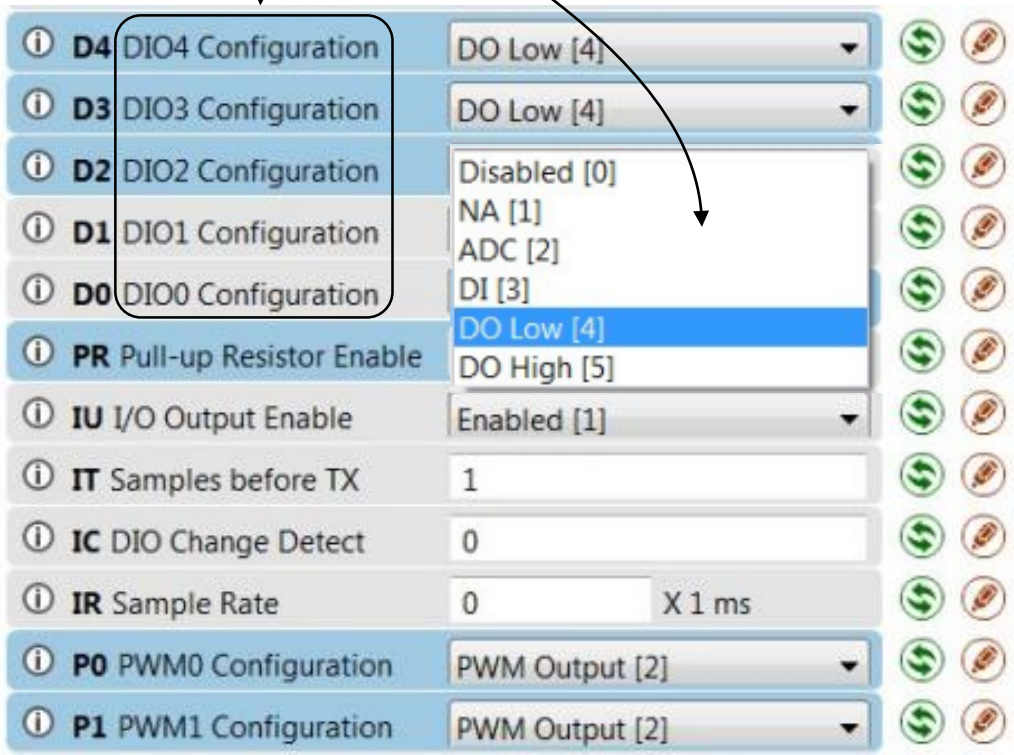


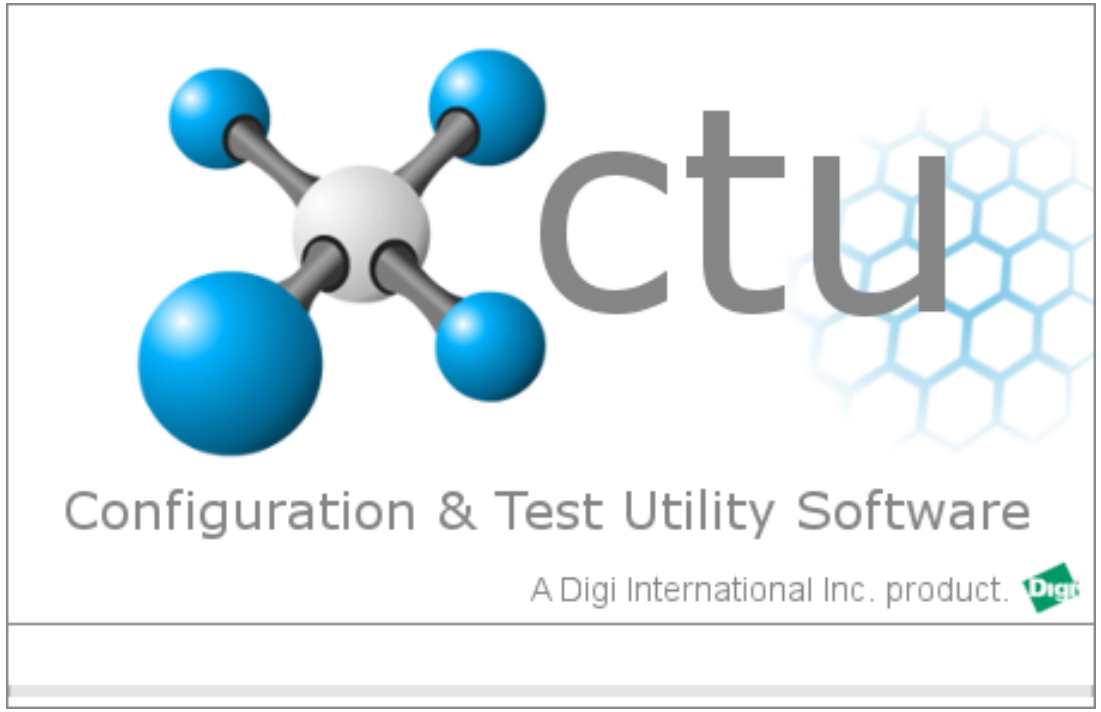
Programming the Receive XBee

Specific configuration examples will follow. Right now you are just getting acquainted a very nerd-like configuration protocol.

pin descriptions for receive unit's "digital" outputs

then click on a subcommand

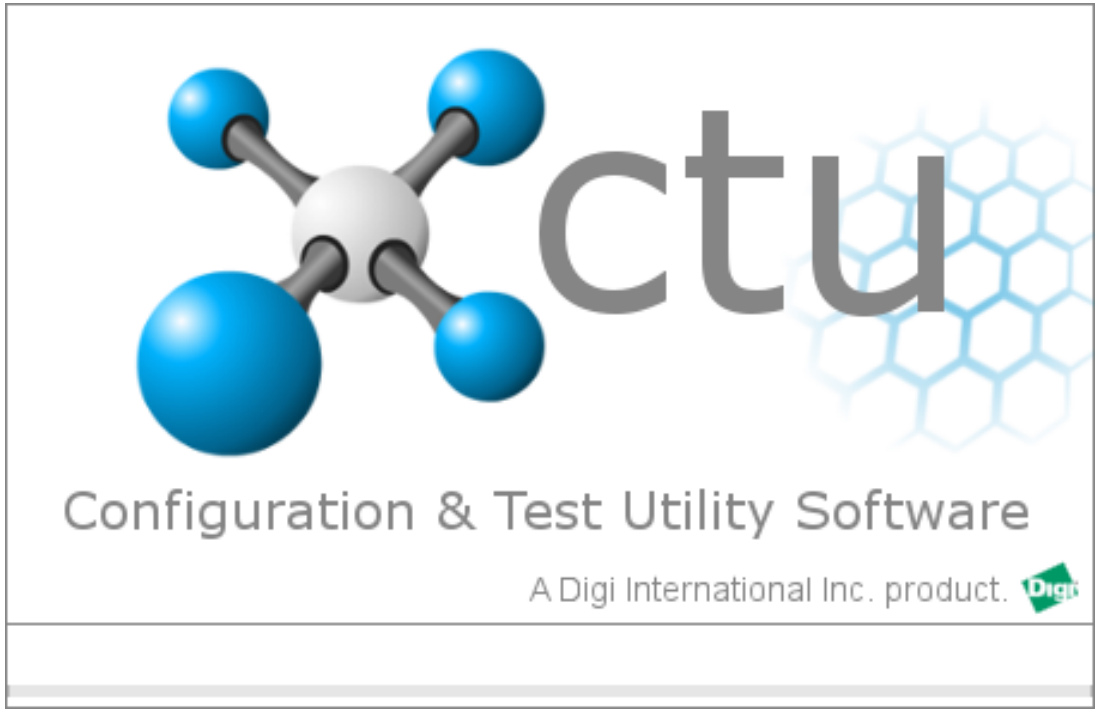




Programming the Receive XBee

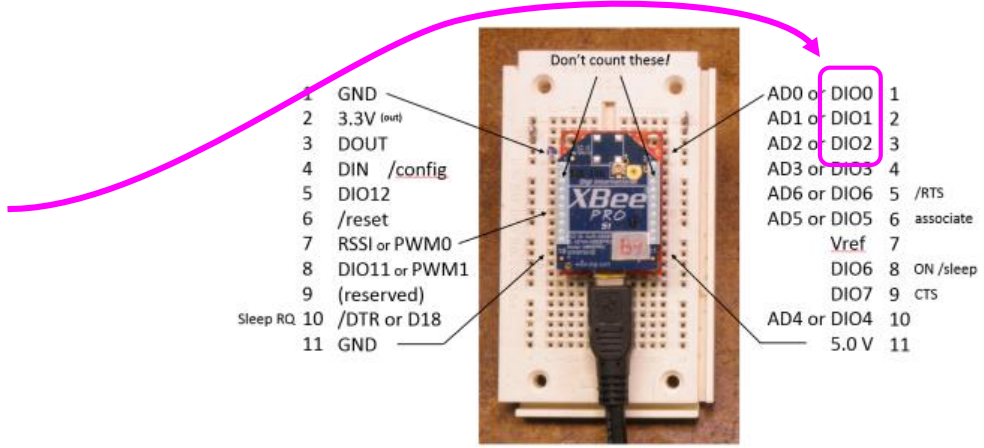
receive XBee's X-CTU continued

D4 DIO4 Configuration	DO Low [4]	
D3 DIO3 Configuration	DO Low [4]	
D2 DIO2 Configuration	DO Low [4]	
D1 DIO1 Configuration	Disabled [0]	
D0 DIO0 Configuration	Disabled [0]	
PR Pull-up Resistor Enable	1	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	0	
IR Sample Rate	0	X 1 ms
P0 PWM0 Configuration	PWM Output [2]	
P1 PWM1 Configuration	PWM Output [2]	



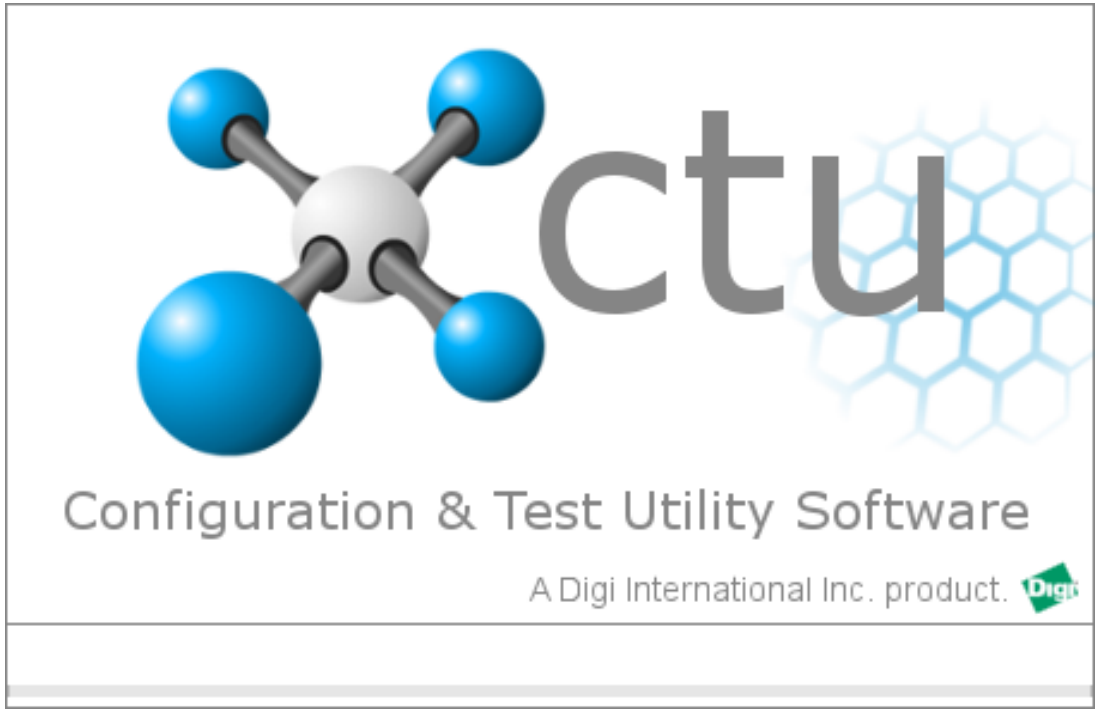
Programming the Receive XBee

Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.



receive XBee's X-CTU continued

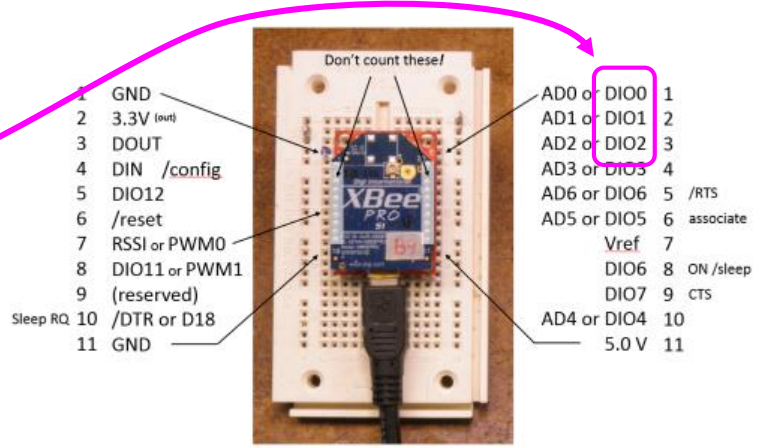
D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]



Programming the Receive XBee

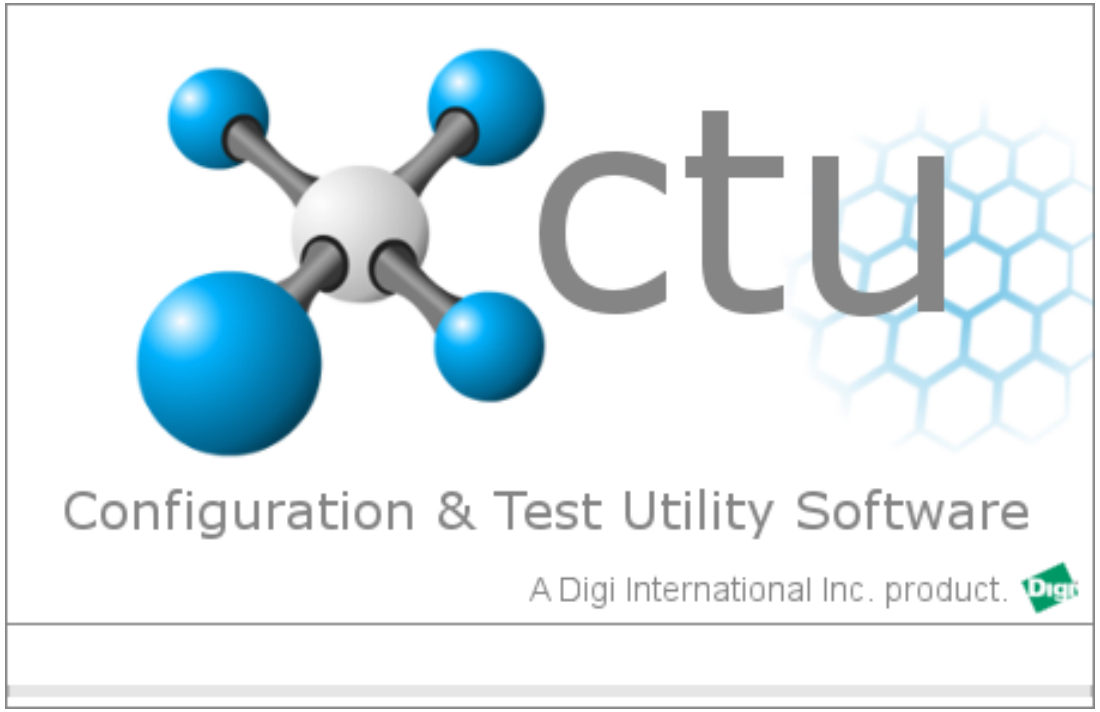
Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.

Explorer pin numbers



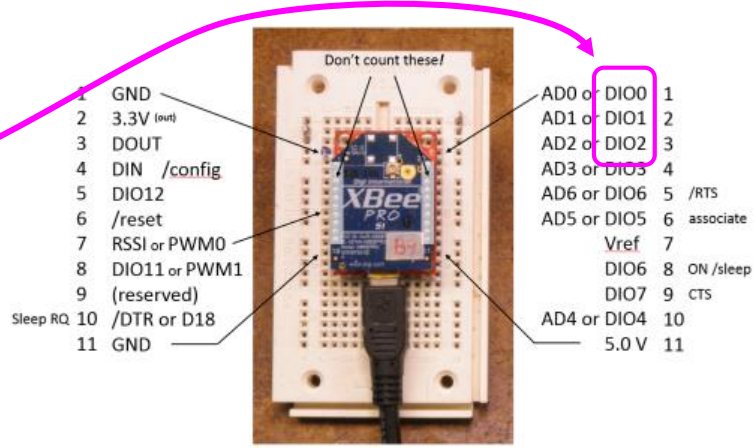
receive XBee's X-CTU continued

D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]

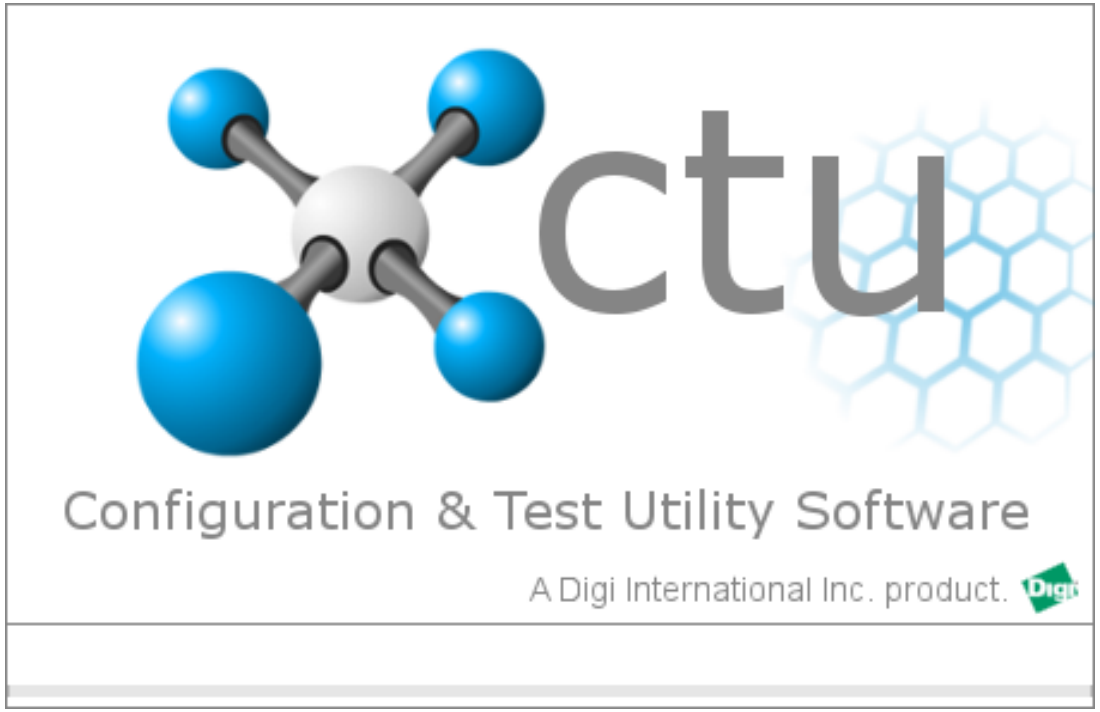


Programming the Receive XBee

Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.

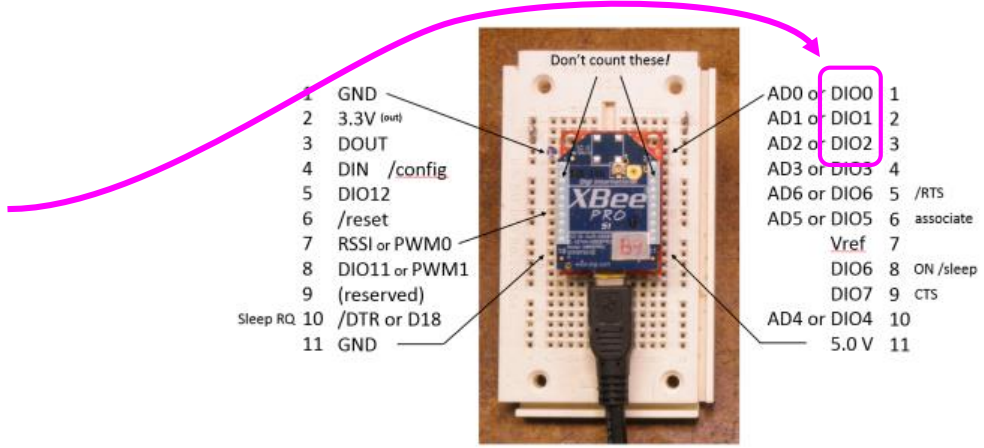


D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]

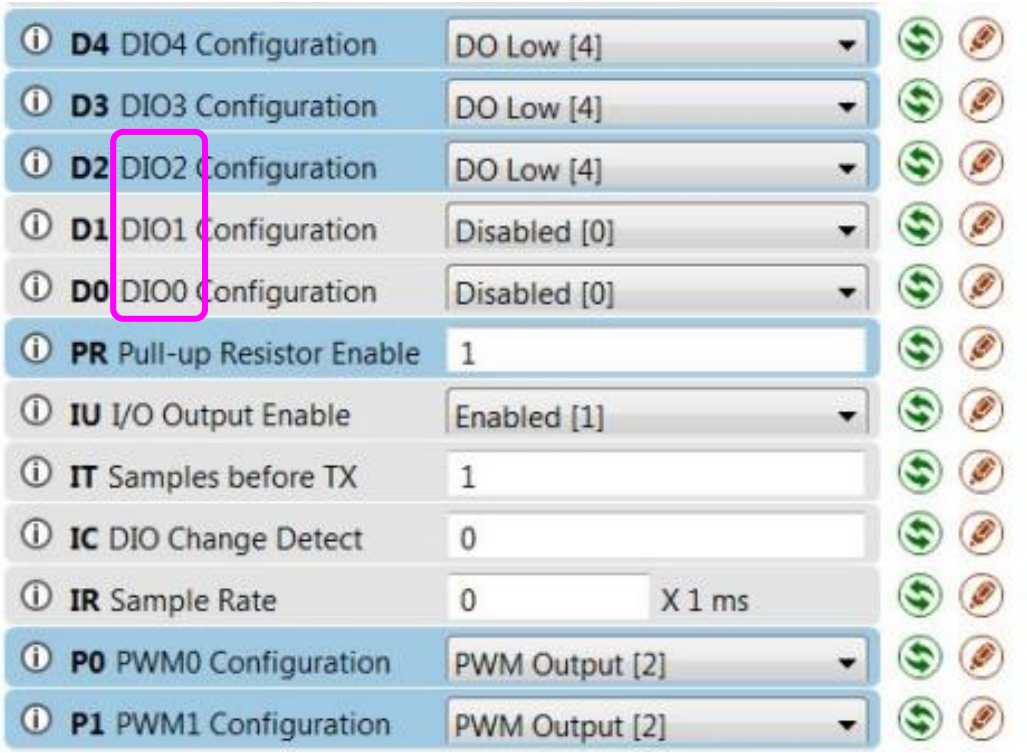


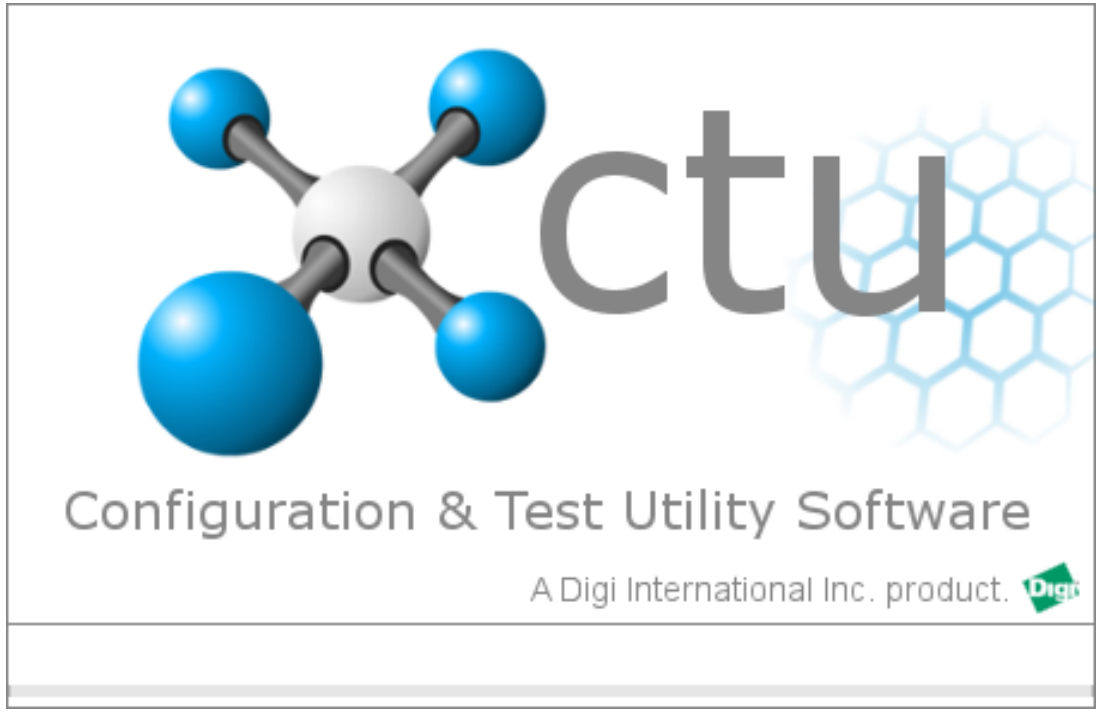
Programming the Receive XBee

Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.
You attach LEDs, or whatever to those pins.



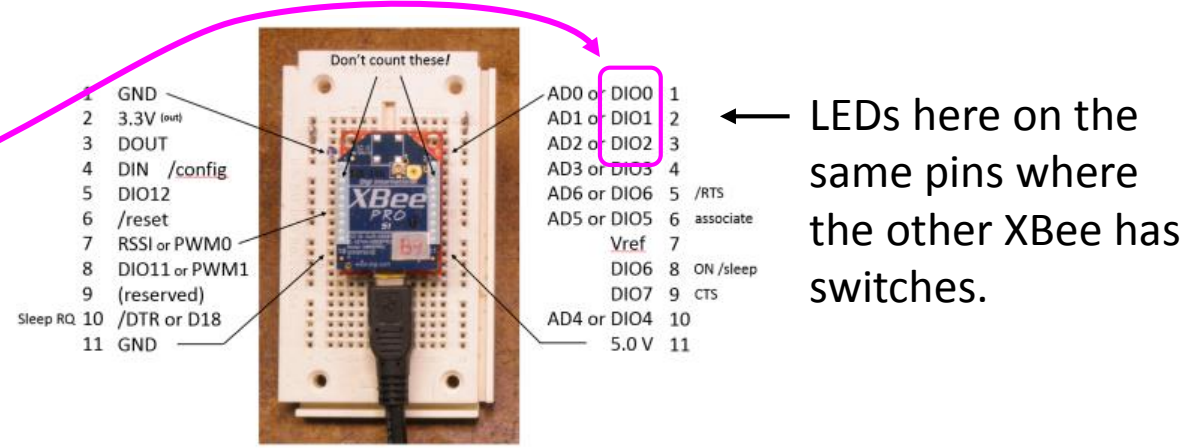
receive XBee's X-CTU





Programming the Receive XBee

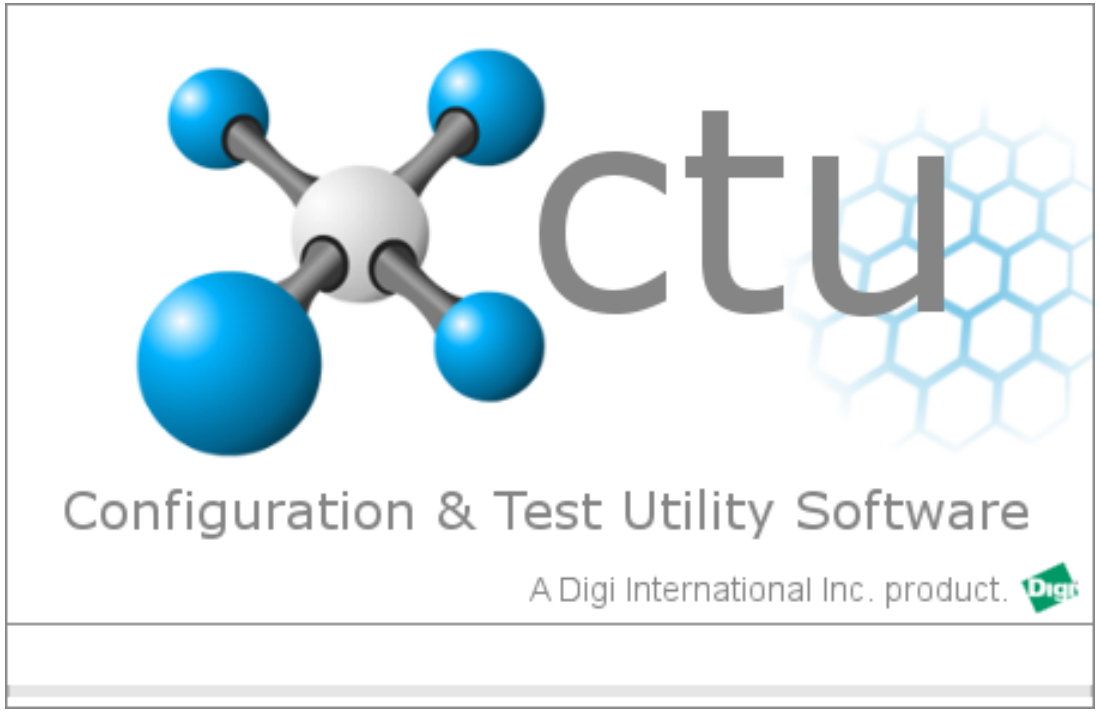
Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.
You attach LEDs, or whatever to those pins.



← LEDs here on the same pins where the other XBee has switches.

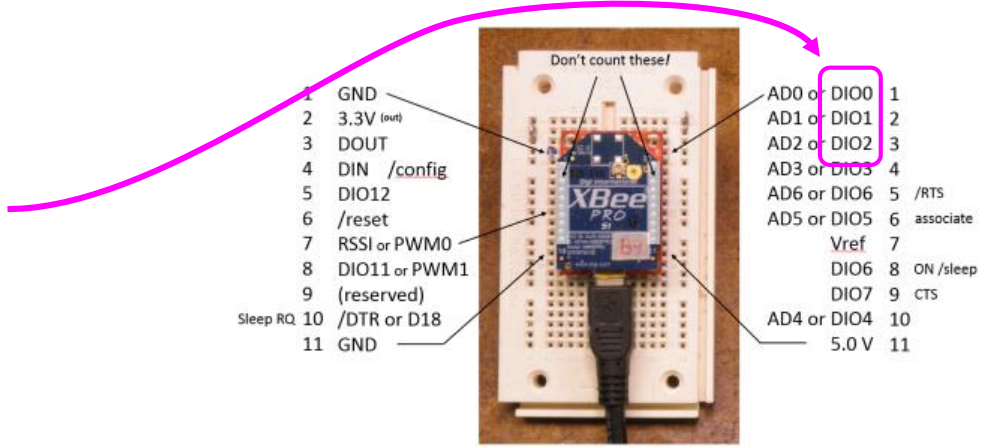
receive XBee's X-CTU

D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]



Programming the Receive XBee

Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.
You attach LEDs, or whatever to those pins.

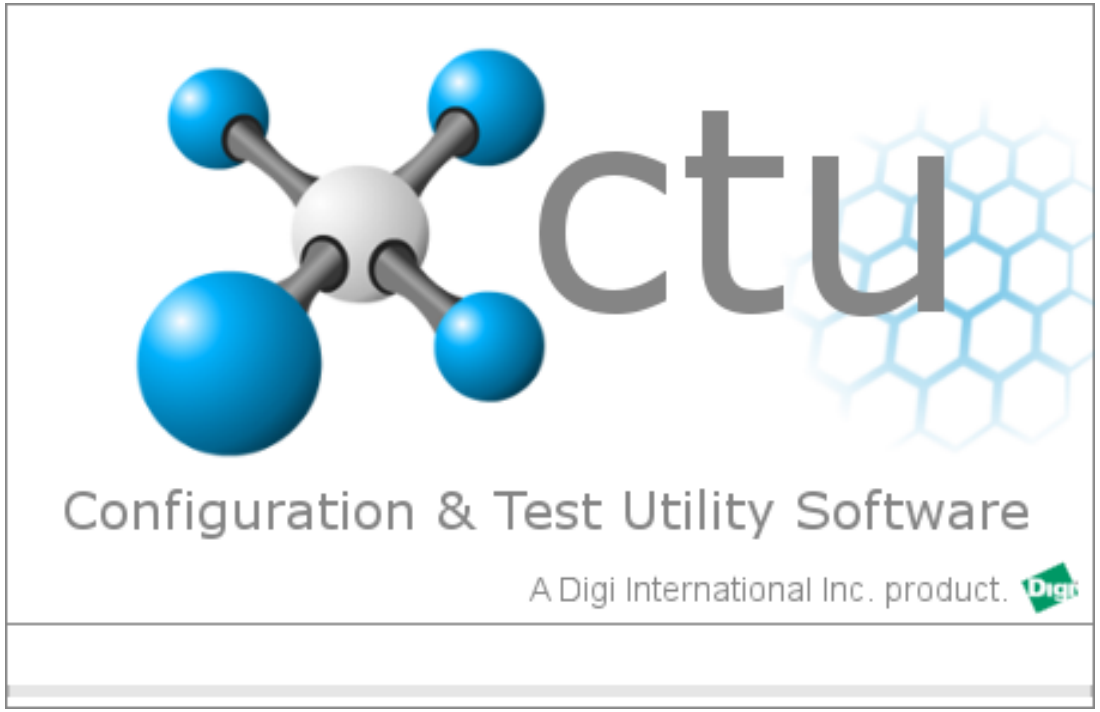


LEDs here on the same pins where the other XBee has switches.

DO means digital out (lighting an LED)

receive XBee's X-CTU

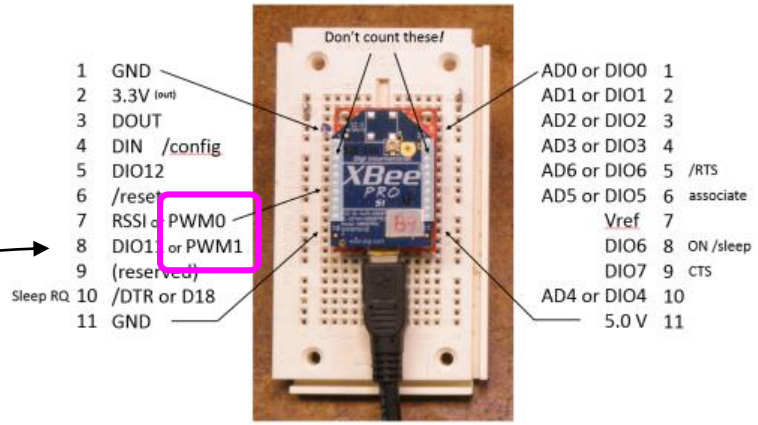
D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]

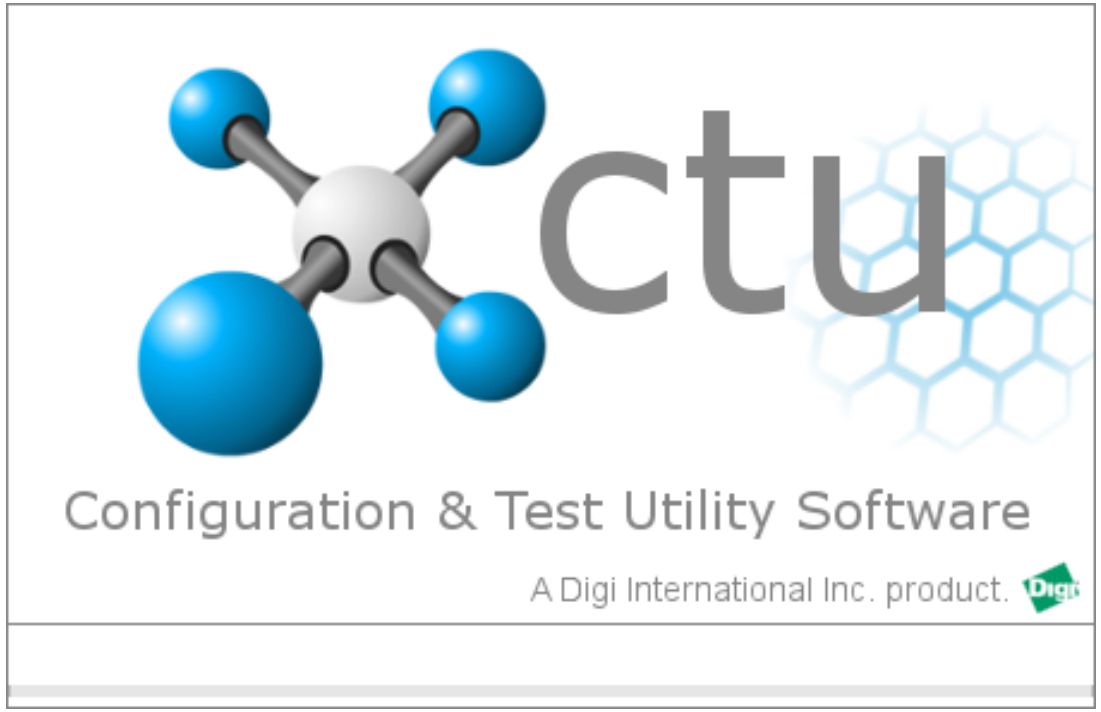


Programming the Receive XBee

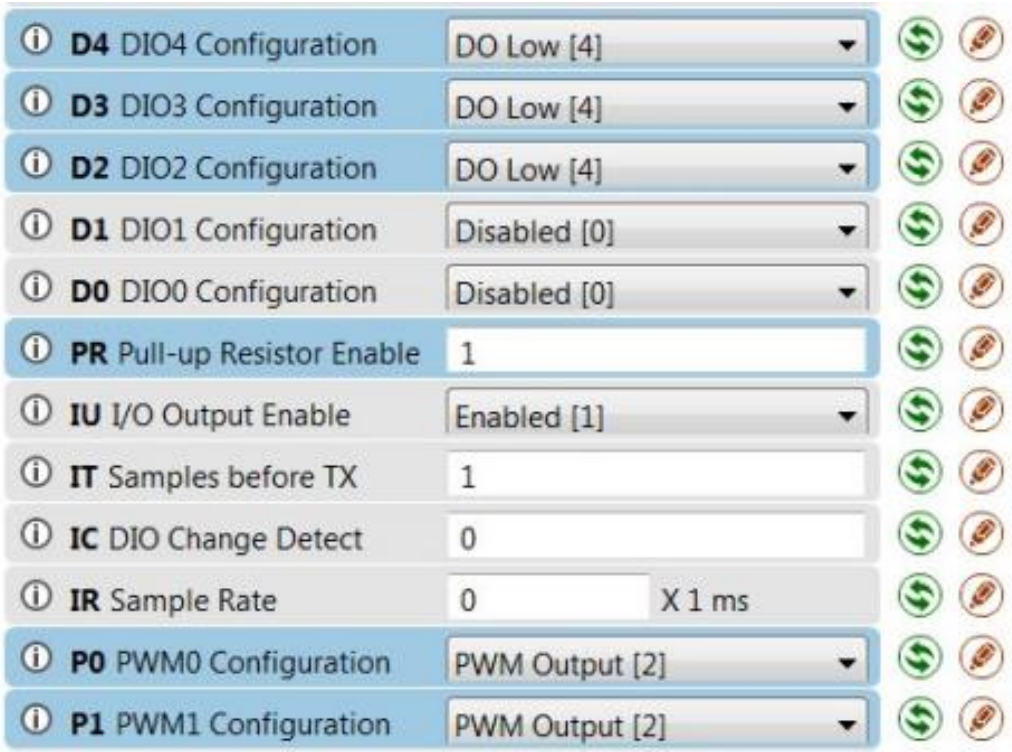
Remember DIO0 is pin 1 on the right side.
DIO1 is pin 2 on the right side.
DIO2 is pin 3 on the right side.
You attach LEDs, or whatever to those pins.

Analog outputs show up on pins 7, 8 on the left side.

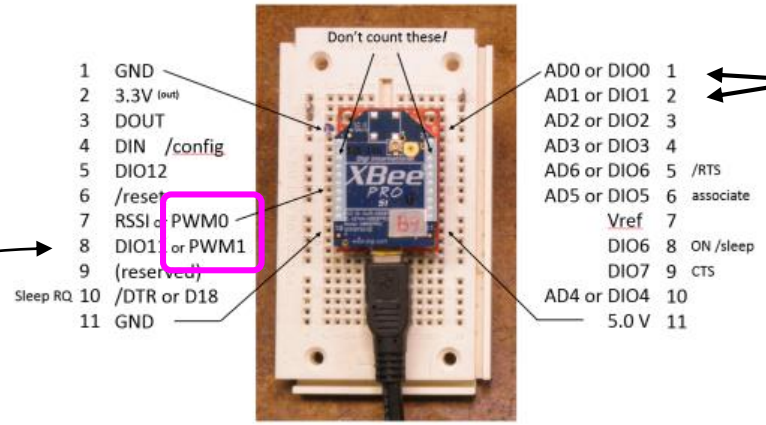




receive XBee's X-CTU



Programming the Receive XBee

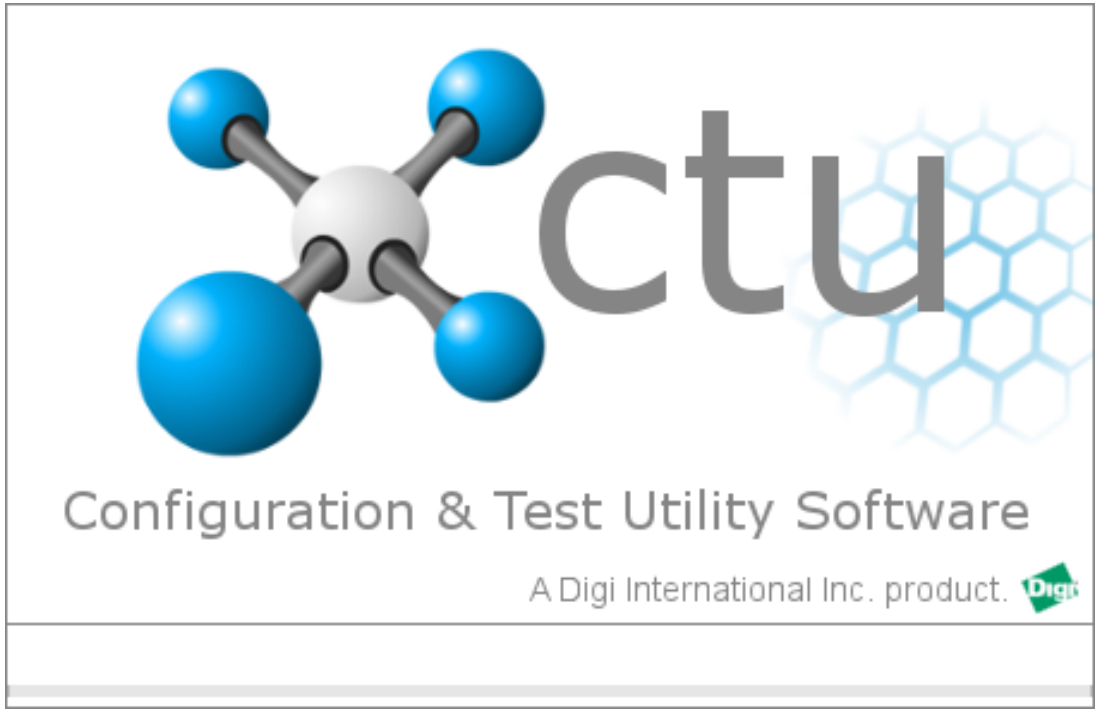


NOT the corresponding pins on the sending XBee.

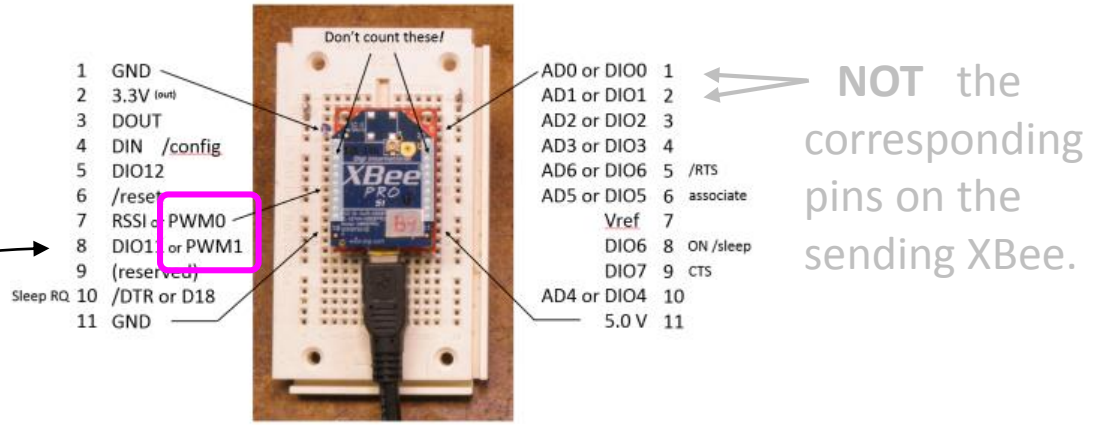
Analog outputs show up on pins 7, 8 on the left side.

receive XBee's X-CTU

D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]



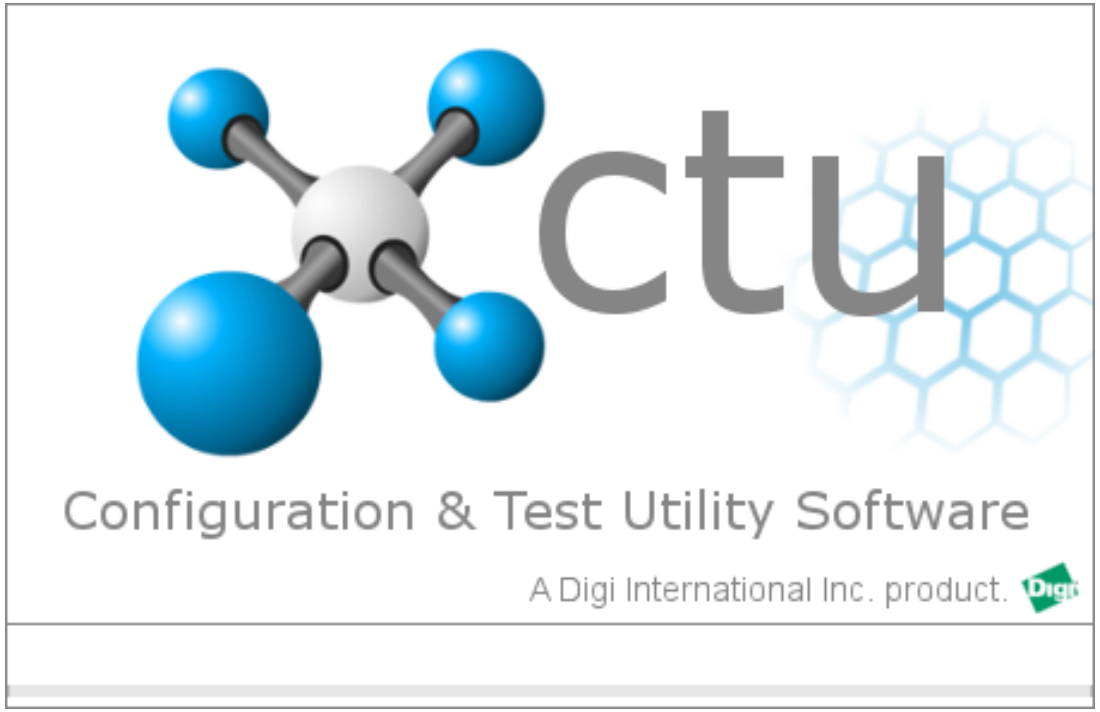
Programming the Receive XBee



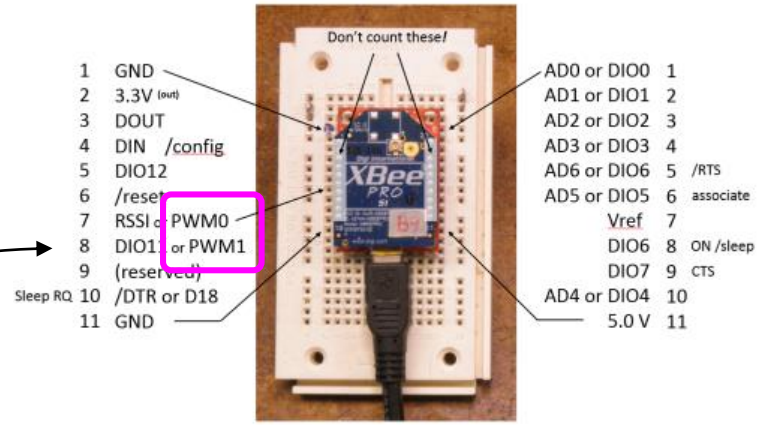
Analog outputs show up on pins 7, 8 on the left side. Click on PWM Output[2] for both.

receive XBee

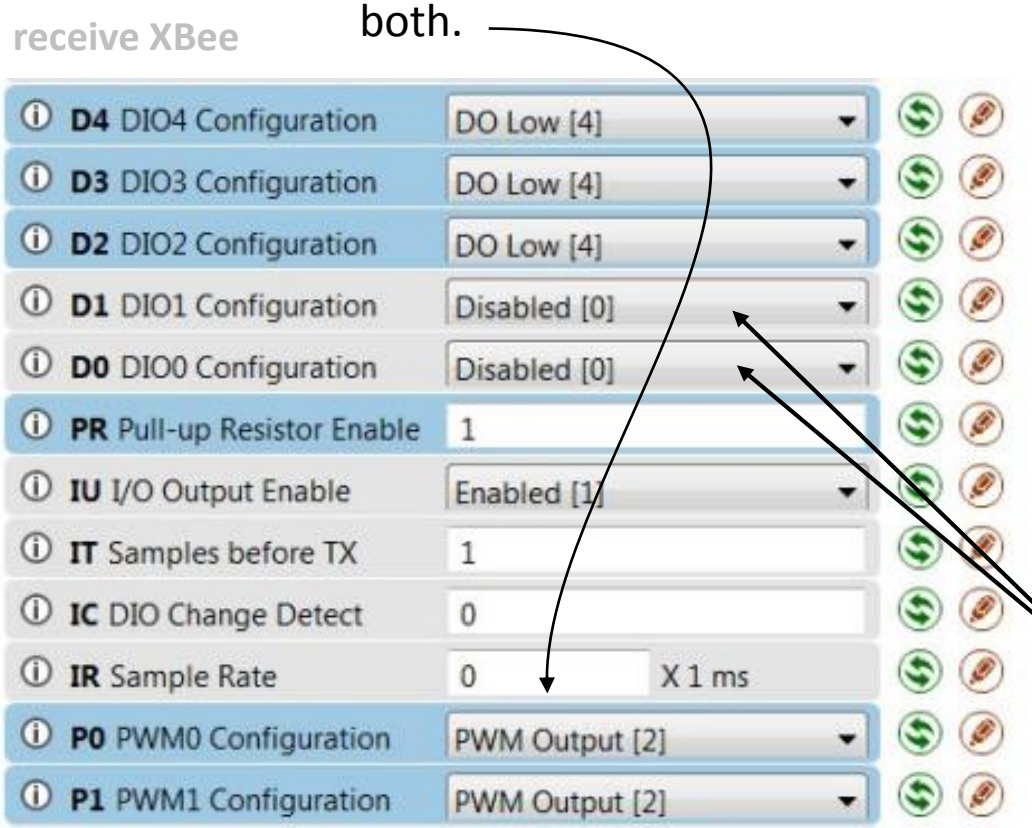
D4 DIO4 Configuration	DO Low [4]
D3 DIO3 Configuration	DO Low [4]
D2 DIO2 Configuration	DO Low [4]
D1 DIO1 Configuration	Disabled [0]
D0 DIO0 Configuration	Disabled [0]
PR Pull-up Resistor Enable	1
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	0
IR Sample Rate	0 X 1 ms
P0 PWM0 Configuration	PWM Output [2]
P1 PWM1 Configuration	PWM Output [2]

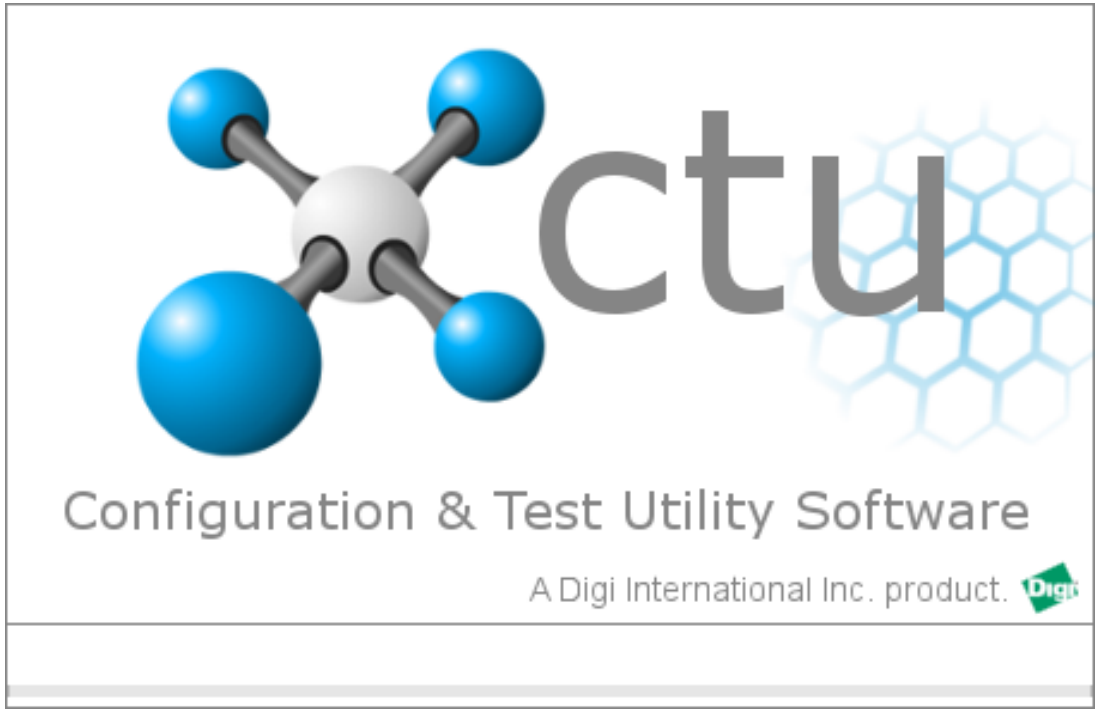


Programming the Receive XBee



Analog outputs show up on pins 7, 8 on the left side. Click on PWM Output[2] for both.





It doesn't matter what goes here, (for output)

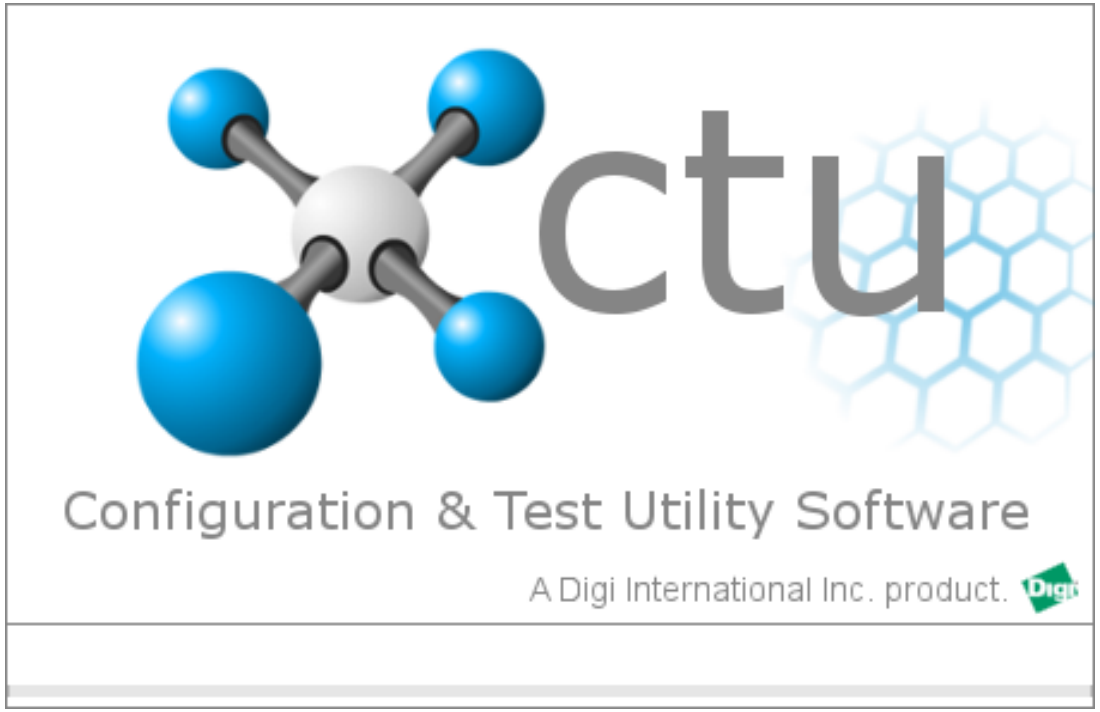
Programming the Receive XBee

Those commands that don't affect a pin, are mostly for advanced users.

default values work fine

receive XBee's X-CTU

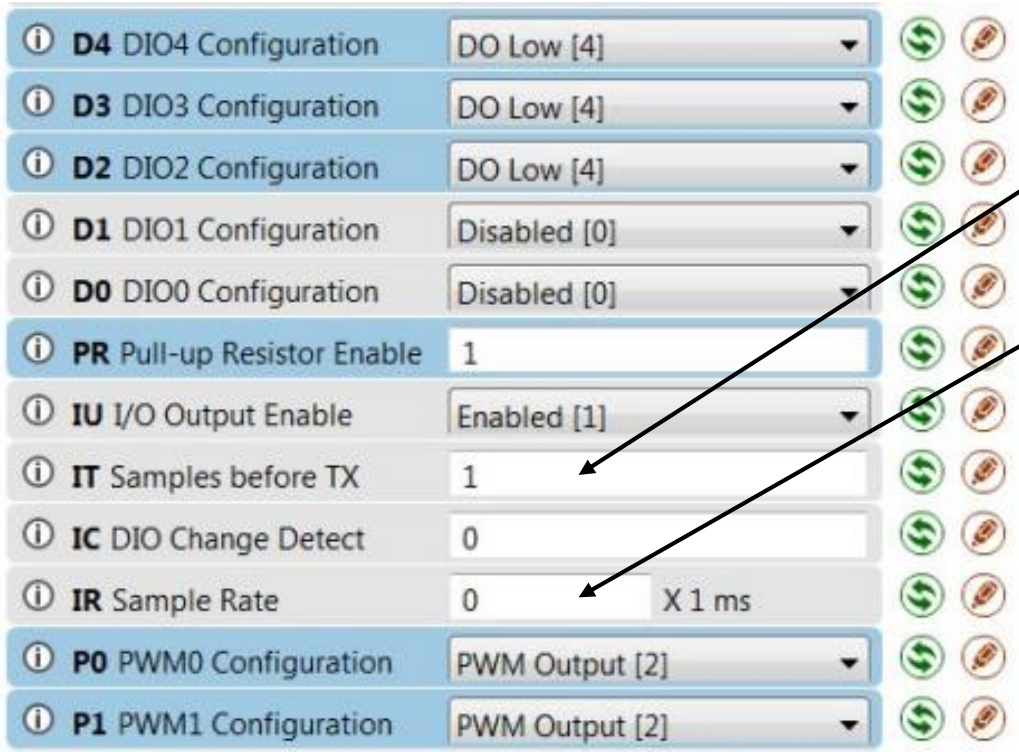
D4 DIO4 Configuration	DO Low [4]	
D3 DIO3 Configuration	DO Low [4]	
D2 DIO2 Configuration	DO Low [4]	
D1 DIO1 Configuration	Disabled [0]	
D0 DIO0 Configuration	Disabled [0]	
PR Pull-up Resistor Enable	1	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	0	
IR Sample Rate	0	X 1 ms
P0 PWM0 Configuration	PWM Output [2]	
P1 PWM1 Configuration	PWM Output [2]	



Programming the Receive XBee

Those commands that don't affect a pin, are mostly for advanced users.

default values work fine



The default values assume good radio link and noise free sensors.
But increasing this to more sample cycles before sending can "average" the data.

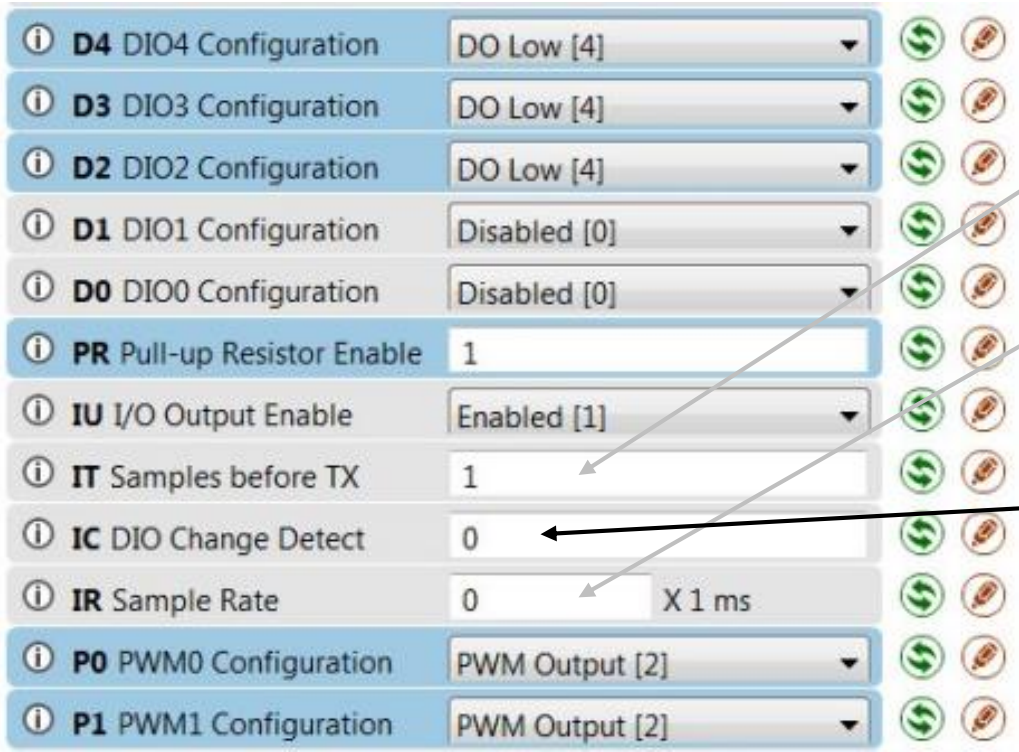
And slowing down the sample rate can increase range in noisy RF environments.

What value?

Programming the Receive XBee

Those commands that don't affect a pin, are mostly for advanced users.

default values work fine



The default values assume good radio link and noise free sensors.
But increasing this to more sample cycles before sending can "average" the data.

And slowing down the sample rate can increase range in noisy RF environments.

Change Detect allows data to be sent if there's a change. That way you won't miss anything if the sample rate is very long.
(See appendix for more on Change Detect.)

Purchase Recommendations

Purchase Recommendations

$38 ea buy two https://www.sparkfun.com/products/11216

The above link is for a 60 mW Series One with built-in antenna.
This webpage has other XBees→ https://www.sparkfun.com/categories/111 There's a 2mW that is $23. And both power levels come with a variety of built-in antennas and connectors for external antennas. Also available is a Series Two XBee. That's for advanced users who want to make a mesh network.

Make sure you buy a pair that are the same "Series" and frequency. (Different antennas OK.)

optional

$30 ea buy one For long range telemetry (buy the kind of XBee that has a connector)

Buy this or any other 16 dB gain antenna: http://www.ebay.com/itm/2-4GHz-20dBi-Yagi-802-11b-g-WiFi-Antenna-RP-SMA-WLAN-/190836223385?pt=US_Directional_Network_Antennas&hash=item2c6eb9ad99
And this U.fl connector for the antenna: http://www.ebay.com/itm/U-FL-IPX-to-RP-SMA-Female-Nut-Bulkhead-Pigtail-1-13-Cable-F-PCI-Wifi-Card-20cm-/300758193471?pt=LH_DefaultDomain_0&hash=item460695d53f

Purchase Recommendations

$25 ea buy at least one https://www.sparkfun.com/products/11812

This XBee Explorer regulates from 5V USB power to 3.3V XBee power and level shifts the serial stream between the USB 5V and the Xbee 3.3V. It also translates that serial stream between the USB protocol and the simpler one of the XBee. This simpler serial stream is also appropriate for any microcontroller that this is attached to.

There is another explorer without the USB: https://www.sparkfun.com/products/11373 It also has a power supply (from a 4.8V or more battery) to the 3.3V power for the XBee. And it also translates between the 5V serial stream logic to 3.3V. But it is a simple level change for microcontrollers. No protocol change.

$1.50 ea buy 1 https://www.sparkfun.com/products/116

This is 0.1” spacing. Break into lengths any number of pins. 11 pins long are needed for going from Explorer to protoboard.

$3 ea buy at least one https://www.sparkfun.com/products/8276

This converts the XBee pins to work with protoboards. You must buy headers for it; two for each side. There’s no level or supply conversion. (needs two AA cells to power it)

0.1” spacing $1.50 ea buy 2 https://www.sparkfun.com/products/116

2mm spacing $1 ea buy four https://www.sparkfun.com/products/8272

Purchase Recommendations

LEDs

35¢ ea buy lots https://www.sparkfun.com/categories/172

Individual resistors for the LEDs (if you don't have them) are available at Sparkfun (search: resistors)
Here's an array of 5 resistors; very handy for LEDs → https://www.sparkfun.com/products/10855

$5 ea buy one bunch https://www.sparkfun.com/products/11026

Other lengths and prototyping tools are available at → https://www.sparkfun.com/categories/141

$5 ea buy at least 1 https://www.sparkfun.com/products/12002

Other shapes and sizes are available at → https://www.sparkfun.com/categories/149

35¢ ea buy lots https://www.sparkfun.com/products/97

Purchase Recommendations

Go to SparkFun: https://www.sparkfun.com/categories
for sensors, prototyping tools, and breakout boards. Breakout boards are interesting in that they make sensors easier to use.

Parallax is a source which has just as many XBee and microcontroller accessories.
http://www.parallax.com/search?search_api_views_fulltext=XBee

Appendix One DIO Change Detect

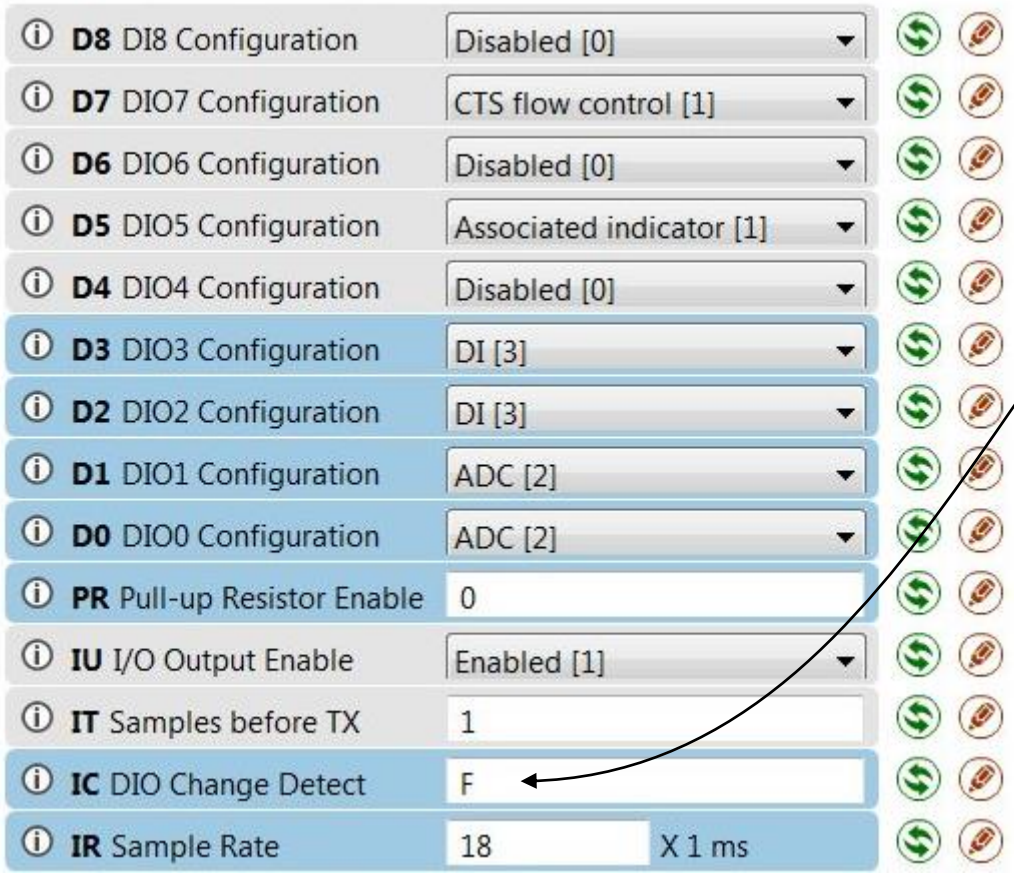
Appendix One DIO Change Detect

To conserve sending XBee's battery, send data only when some sensed data has changed.

Appendix One DIO Change Detect

To conserve sending XBee's battery, send data only when some sensed data has changed.

transmit XBee's X-CTU

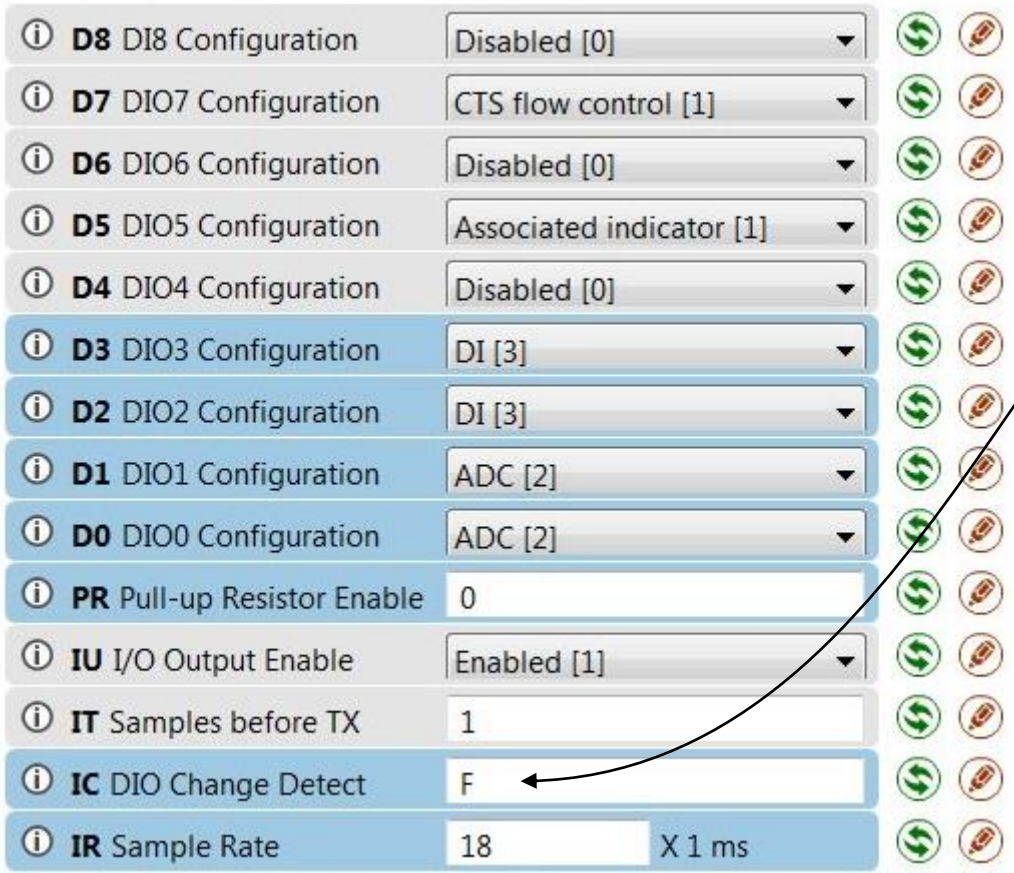


What goes here is a mapping of which digital inputs to monitor.

Appendix One DIO Change Detect

To conserve sending XBee's battery, send data only when some sensed data has changed.

transmit XBee's X-CTU



What goes here is a mapping of which digital inputs to monitor.

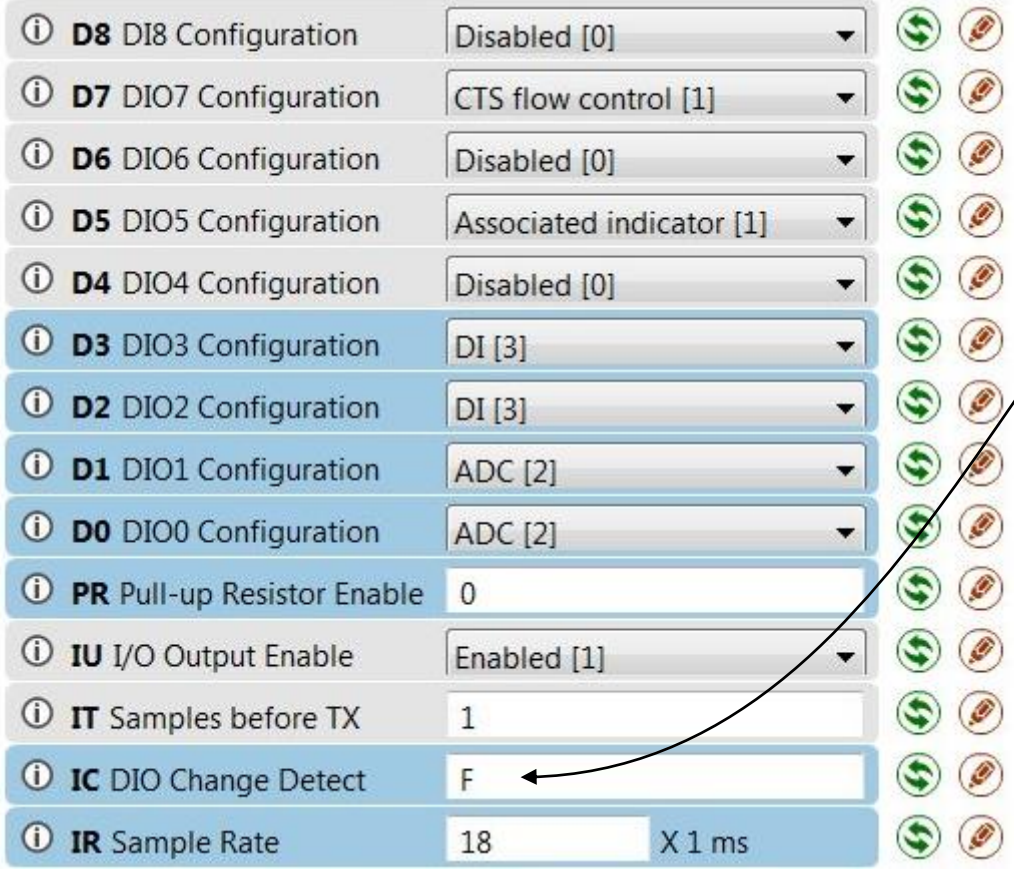
(Not useful for analog data.)

Appendix One DIO Change Detect

1 0 1 0 1 0 1 0 1 0 1

binary map

transmit XBee's X-CTU



What goes here is a mapping of which digital inputs to monitor.

(Not useful for analog data.)

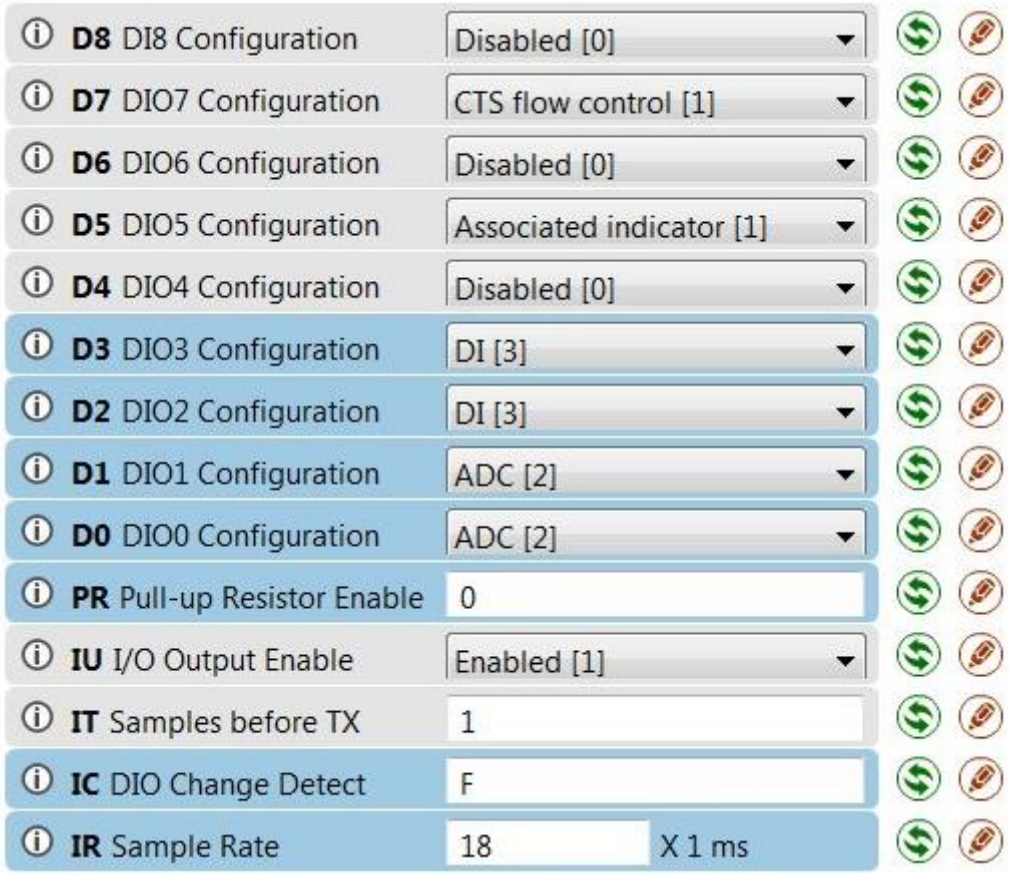
Appendix One DIO Change Detect

input number → 10 9 8 7 6 5 4 3 2 1 0

1 0 1 0 1 0 1 0 1 0 1

binary map → every other input is turned on

transmit XBee's X-CTU



Appendix One DIO Change Detect

input number → 10 9 8 7 6 5 4 3 2 1 0
1 0 1 0 1 0 1 0 1 0 1

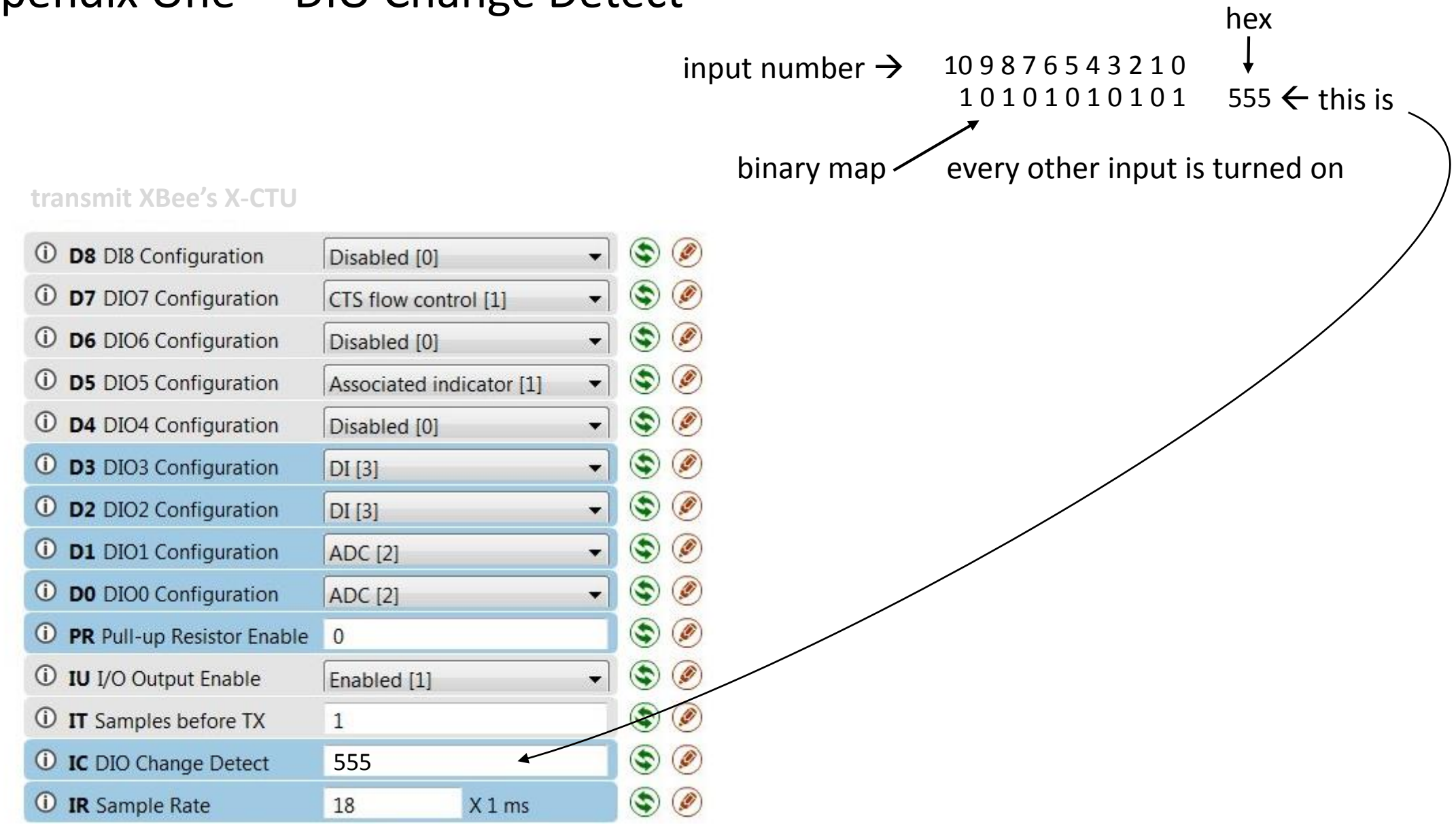
But this isn't what goes in that field.

binary map → every other input is turned on

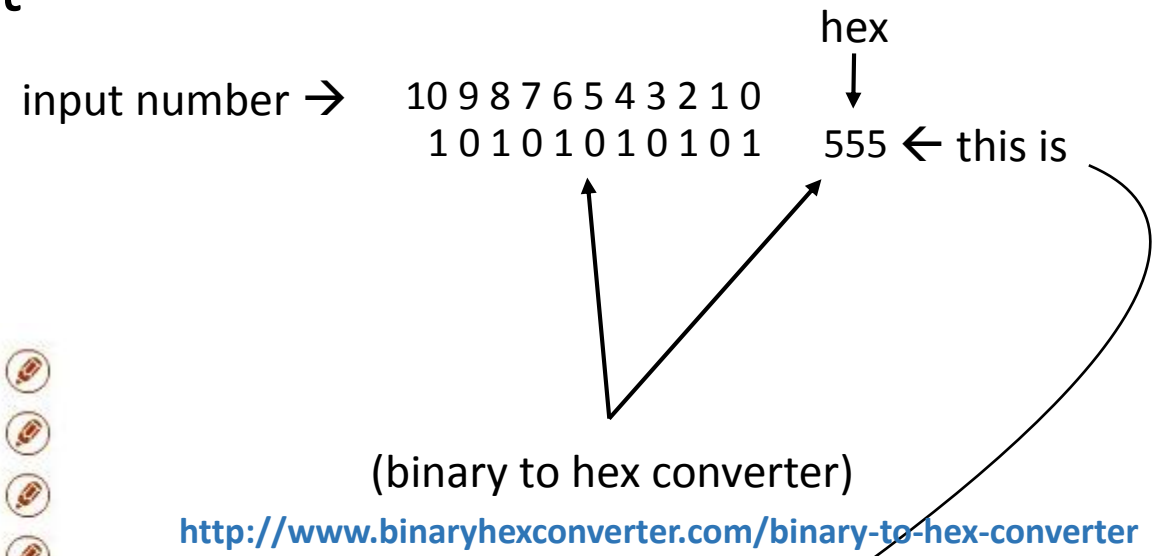
transmit XBee's X-CTU

D8 DI8 Configuration	Disabled [0]	
D7 DIO7 Configuration	CTS flow control [1]	
D6 DIO6 Configuration	Disabled [0]	
D5 DIO5 Configuration	Associated indicator [1]	
D4 DIO4 Configuration	Disabled [0]	
D3 DIO3 Configuration	DI [3]	
D2 DIO2 Configuration	DI [3]	
D1 DIO1 Configuration	ADC [2]	
D0 DIO0 Configuration	ADC [2]	
PR Pull-up Resistor Enable	0	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	F	
IR Sample Rate	18	X 1 ms

Appendix One DIO Change Detect



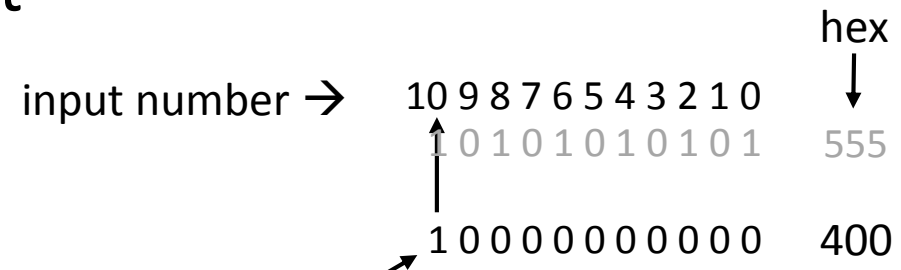
Appendix One DIO Change Detect



transmit XBee's X-CTU

D8 DI8 Configuration	Disabled [0]	
D7 DIO7 Configuration	CTS flow control [1]	
D6 DIO6 Configuration	Disabled [0]	
D5 DIO5 Configuration	Associated indicator [1]	
D4 DIO4 Configuration	Disabled [0]	
D3 DIO3 Configuration	DI [3]	
D2 DIO2 Configuration	DI [3]	
D1 DIO1 Configuration	ADC [2]	
D0 DIO0 Configuration	ADC [2]	
PR Pull-up Resistor Enable	0	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	555	
IR Sample Rate	18	X 1 ms

Appendix One DIO Change Detect

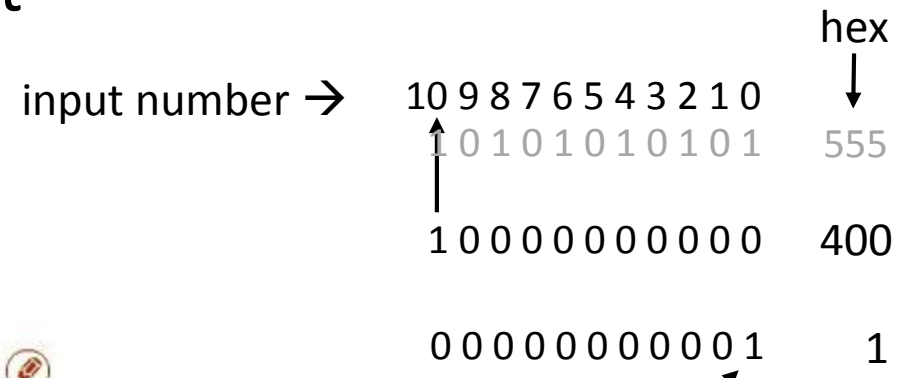


here, only input number 10 is turned on

transmit XBee's X-CTU

D8 DI8 Configuration	Disabled [0]	
D7 DIO7 Configuration	CTS flow control [1]	
D6 DIO6 Configuration	Disabled [0]	
D5 DIO5 Configuration	Associated indicator [1]	
D4 DIO4 Configuration	Disabled [0]	
D3 DIO3 Configuration	DI [3]	
D2 DIO2 Configuration	DI [3]	
D1 DIO1 Configuration	ADC [2]	
D0 DIO0 Configuration	ADC [2]	
PR Pull-up Resistor Enable	0	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	400	
IR Sample Rate	18	X 1 ms

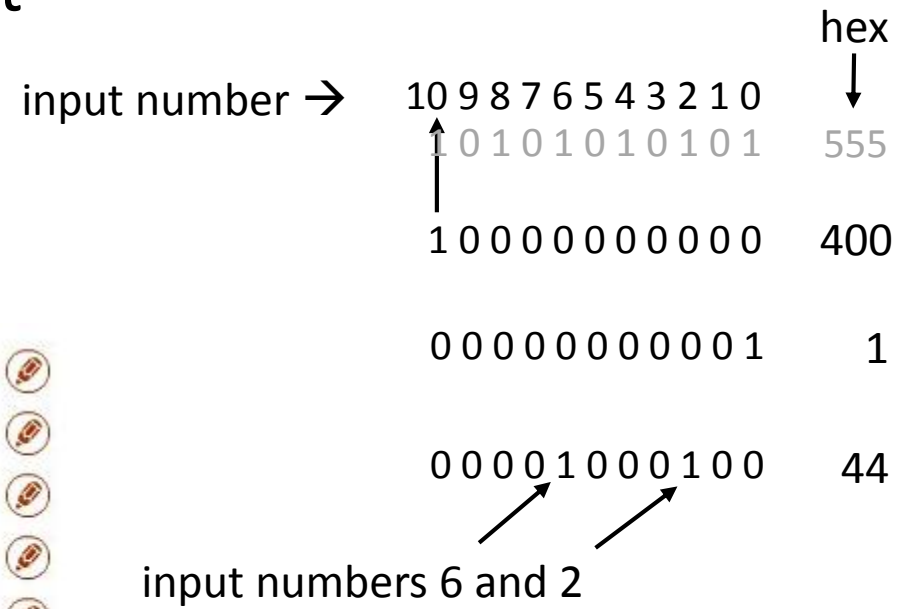
Appendix One DIO Change Detect



transmit XBee's X-CTU

D8 DI8 Configuration	Disabled [0]	
D7 DIO7 Configuration	CTS flow control [1]	
D6 DIO6 Configuration	Disabled [0]	
D5 DIO5 Configuration	Associated indicator [1]	
D4 DIO4 Configuration	Disabled [0]	
D3 DIO3 Configuration	DI [3]	
D2 DIO2 Configuration	DI [3]	
D1 DIO1 Configuration	ADC [2]	
D0 DIO0 Configuration	ADC [2]	
PR Pull-up Resistor Enable	0	
IU I/O Output Enable	Enabled [1]	
IT Samples before TX	1	
IC DIO Change Detect	1	
IR Sample Rate	18	X 1 ms

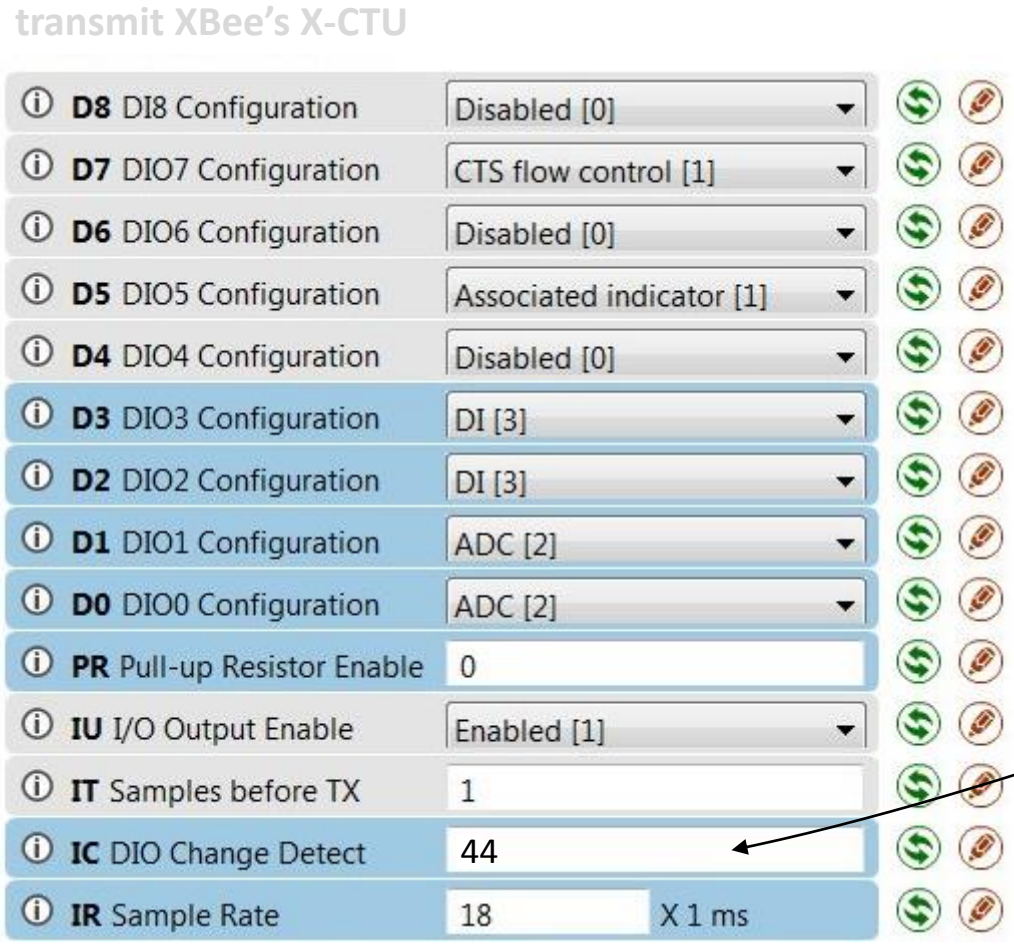
Appendix One DIO Change Detect

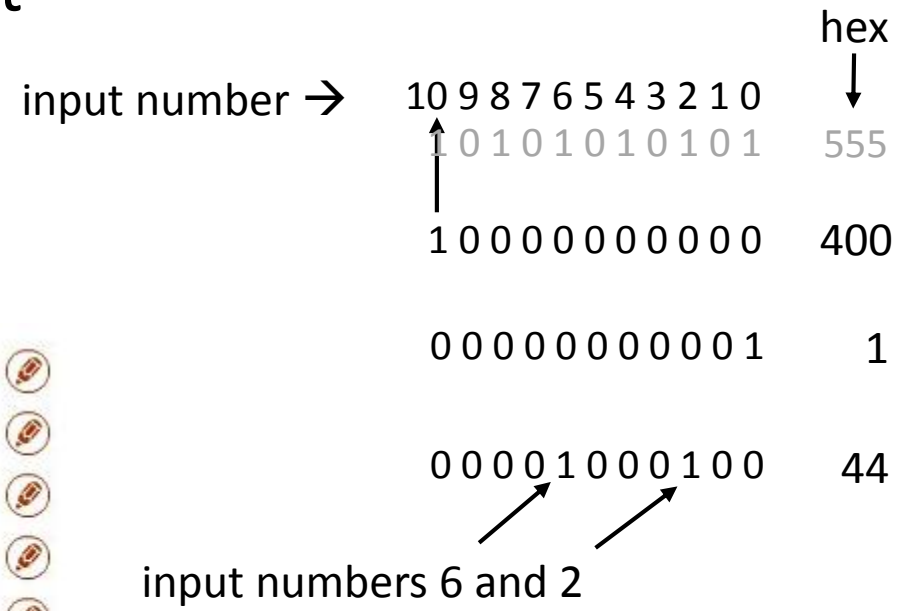


transmit XBee's X-CTU

D8 DI8 Configuration	Disabled [0]
D7 DIO7 Configuration	CTS flow control [1]
D6 DIO6 Configuration	Disabled [0]
D5 DIO5 Configuration	Associated indicator [1]
D4 DIO4 Configuration	Disabled [0]
D3 DIO3 Configuration	DI [3]
D2 DIO2 Configuration	DI [3]
D1 DIO1 Configuration	ADC [2]
D0 DIO0 Configuration	ADC [2]
PR Pull-up Resistor Enable	0
IU I/O Output Enable	Enabled [1]
IT Samples before TX	1
IC DIO Change Detect	44
IR Sample Rate	18 X 1 ms

Appendix One DIO Change Detect





Shortcut:

	binary	hex
first 2 inputs:	11	3
first 3 inputs:	111	7
first 4 inputs:	1111	F
first 5 inputs:	11111	1F
first 6 inputs:	111111	3F

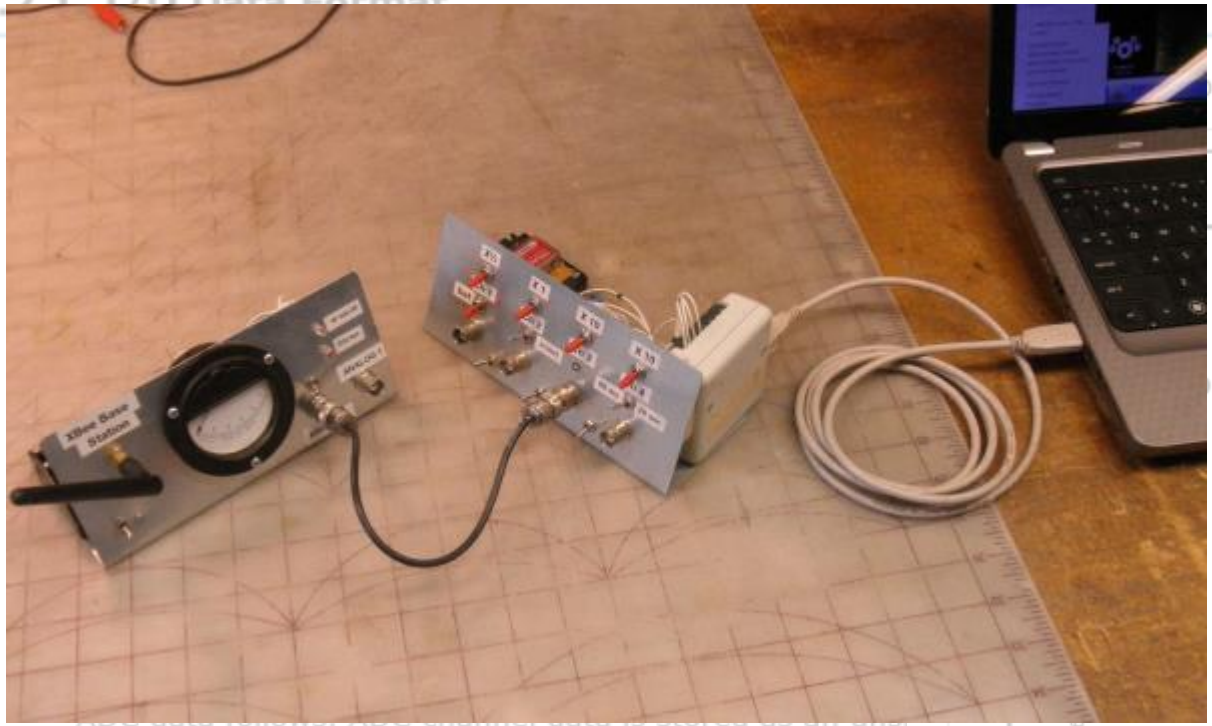
- Solder the headers on the bottom of two Explorer boards. That allows you to plug them into a protoboard.
- Solder the XBee sockets into the top of the two Explorer boards
- Push the two XBee's into their protoboards
- Wire up the protoboards to be the sending unit and the corresponding receiving unit. (details available on the next slide)
- Download X-CTU but don't run it yet.
- Connect one of the units to the PC with the appropriate USB cable.
- Now run X-CTU and load each XBee (one at a time) with the deviations from the default values listed on the next page.
- In testing, one of them can remain connected while the other one (on the same work bench is OK) can be powered by either another computer or powered by a 3 volt battery (into pin 2). If it is more convenient you can run a 4.8V or a 6V battery into the opposite corner pin as shown in the diagram on the next page.

Now that's with XBee's alone.
What I'm not familiar with is that with them attached to computers, anything that normally uses USB can be connected with a separation of a mile.
And
Most commonly, one of the computers would be a microcontroller. The difference is that a microcontroller is really really small and can be interfaced with sensors itself and programmed by the amateur scientist.
And
With or without a computer, XBee can be programmed to talk to the internet by way of a cell phone tower to dump a serial stream of data. That means if it is within ear shot of a cell phone tower, you can put your data on the net to be read by anyone in the world.

junk

Serial Data Format

Format for sending data to a PC



I am not skilled in software enough to do this. BUT I have Dataq. It's an A to D with data logging software.