FlexiPanel

Pixie Switcher™

Switching / Load Controller for ZigBee Wireless

Summary

Pixie Switcher is free switching firmware for Pixie and Pixie Lite. Using the Home Control – Lighting (HC-L) ZigBee profile, it provides up to 8 inputs (control switches) or outputs (load controllers). These may be bound to any HC-L devices in the ZigBee network. For example, a single Pixie Switcher could be configured as 8 inputs, 8 outputs, or 4 of each. Pixie Switcher requires only a few residual components to provide a complete wireless switching system.

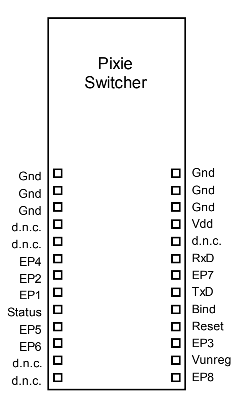
Pixie Switchers have four operating modes: *(i) fast end device*, (*ii*) *sleepy end device* under battery power, *(iii) router*, able to route messages between non-adjacent ZigBee devices, and *(iv) network coordinator*, which manages the network. A lower cost 'Lite' version is also available, that operates as a 6-I/O end device only.

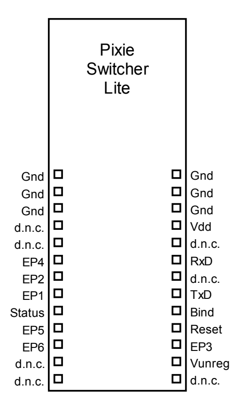
Applications

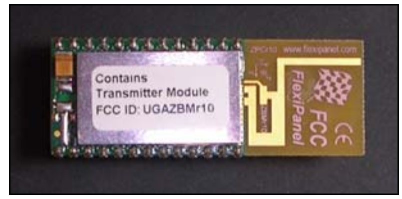
- *Lighting control*
- *Appliance remote control*
- *Security and burglar alarms*
- *Access control systems*
- *Electrically isolated switching*
- *Device fault/missing/stolen alert*
- *Battery needs charging alert*

Hardware Features

- *Free space range approx 120m*
- *FCC / CE / IC compliant*
- *Signature G antenna, low "hand effect" design*
- *Consumes 25mA when active, 2µA in sleep mode*
- *2.4GHz IEEE 802.15.4 compliant, 16-channel DSSS, CSMA-CA, PHY / MAC layers*
- *Surface mount and DIL through-hole versions*
- *Wide temperature range –40ºC to +85ºC*
- *2.1V - 3.6V supply*
- *Optional LDO regulator for 3-20V supply*







Firmware Features

- *8 I/O endpoints each configurable as one of:*
  - *On / off / toggle / timer / programmable input*
  - *On / off / pulse output*
  - *Power control*
  - *Time delay setpoint*
  - *Failsafe alarm reporting when contact is lost, out of range, low battery or device fault*
- *Control I/O for joining & binding, status indication*
- *Battery monitoring*
- *4 operating modes:*
  - *Coordinator router*
  - *Router*
  - *Fast end device*
  - *Sleepy end device*
- *Signal strength indication*
- *Serial port for configuration and diagnostics*
- *ZigBee 1.0 HC-L compatible*
- *Up to 254 end devices per network*
- *Up to 255 binding table entries*
- *Up to 25/24 neighbors per router / coordinator*
- *Pre-allocated unique MAC address*
- *Lite version available:*
  - *End device only*
  - *6 I/O endpoints*

Manufactured to ISO9001:2000

FM76316

Ordering Information

Table 1. Ordering information

Part No	***Description***
PIXIE-SO-PXSC	Switcher coordinator surface mount
PIXIE-DIL-PXSC	Switcher coordinator dual-in-line
PIXIE-SO-PXSR	Switcher router surface mount
PIXIE-DIL-PXSR	Switcher router dual-in-line
PIXLITE-SO-PLFE	Switcher lite fast end device surface mount
PIXLITE-DIL-PLFE	Switcher lite fast end device dual-in-line
PIXLITE-SO-PLSE	Switcher lite sleepy end device surface mount
PIXLITE-DIL-PLSE	Switcher lite sleepy end device dual-in-line
PIXIE-CONFIG	USB configuration tool
UZBEE	ZigBee packet sniffer
EVAL-PIXIE	2-device evaluation kit
Other firmware builds available on request	

Contents

Pin Connections

Pin Number		***Pin Name***	***Description***
Pixie Switcher	***Pixie Switcher Lite***		
1,2,3, 24,25,26	1,2,3,24,25,26	*Gnd*	Power supply ground reference and ground plane connection
4,5,12,13, 22	4,5,12,13,14, 20,22	*dnc*	Do not connect
6	6	*EP4*	I/O Endpoint 4 (note 1,2,5)
7	7	*EP2*	I/O Endpoint 2 (note 1,2,6)
8	8	*EP1*	I/O Endpoint 1 (note 1,2,6)
9	9	*Status*	Status indicator output (note 3)
10	10	*EP5*	I/O Endpoint 5 (note 1,2,5)
11	11	*EP6*	I/O Endpoint 6 (note 1,2,5)
14		*EP8*	I/O Endpoint 8 (note 1,2)
15	15	*Vunreg*	Unregulated voltage input (note 4)
16	16	*EP3*	I/O Endpoint 3 (note 1,2,6)
17	17	*Reset*	Reset input (note 1)
18	18	*Bind*	Bind / join control input (note 1,2,6)
19	19	*TxD*	Configuration / diagnostic serial output
20		*EP7*	I/O Endpoint 7 (note 1,2,5)
21	21	*RxD*	Configuration / diagnostic serial input (note 7)
23	23	*Vdd*	Regulated power supply input Regulated power supply output (note 4)

Table 2. Pin descriptions for Pixie Switcher & Pixie Switcher Lite

1. Active low, requires a 4k7 pullup resistor if connected via a pushbutton to ground.
2. Input debounced in firmware.
3. Active high.
4. Requires optional voltage regulator option to be fitted to be functional.
5. Capable of being a time delay setpoint input.
6. Wakes sleeping device on state change. Should be weakly pulled up, not left floating.
7. Should have a weak pullup high if not used or only used by connector attachment.

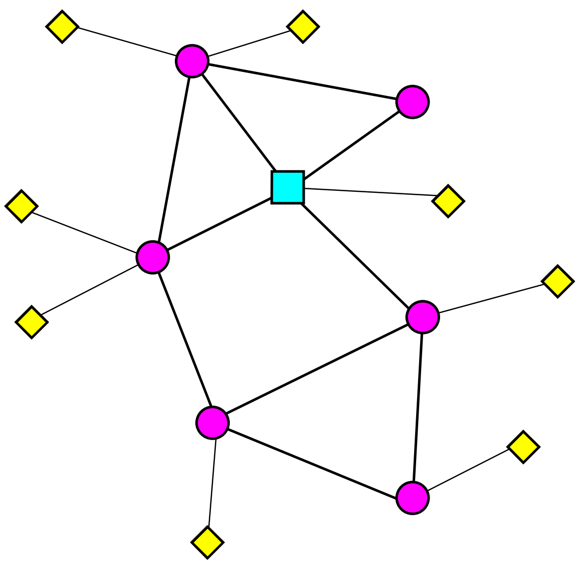


Figure 3. A Pixie Switcher Network

Coordinator

Router

End device

Network backbone

End device / parent router

Network rules:

One coordinator per network
Max 24 connections to coordinator
Max 25 connections per router
Max 6 routers per parent
No device >5 hops to coordinator
Max 255 binding table entries
End devices may be battery powered

Documentation Guide

This data sheet is an engineering reference for the Pixie Switcher wireless switching system. A separate document, the Pixie Switcher Message Reference, provides supplementary information about the diagnostic messages that are available.

FlexiPanel Ltd uses Pixie Switcher modules in its range of wireless switching devices. These have separate documentation which is aimed at product installers and discusses the main topics at a simpler level. If you are new to ZigBee switching networks, refer to these documents to understand its applications.

In addition, refer to the Pixie Eval Kit documentation for an introduction to Pixie Switcher operation.

If you would like copies of our documentation in original Microsoft Word format, please contact us. You may adapt them for use with your own products which use Pixie Switcher modules.

Operational Overview

Referring to figure 3:

- Pixie Switcher devices can send on, off and toggle messages to each other. There can be up to 8 inputs or outputs on a Pixie Switcher. (6 on Pixie Lite)

- Switchers that are configured as *routers* can forward messages on behalf of other Switcher devices to achieve greater range. Every router must be in range of at least one other router unit in order to pass switching messages along. They must be always-on and so are usually mains powered.

- End devices only need to be in range of one router. They can be battery powered, and sleep for as long as they like, but they can't forward messages. They are ideally suited to switch units which may need battery power but only need to wake when a switch is activated.

- One router must be a *coordinator*, which is a special type of router. In a system with one router only, it must be a coordinator.

- To span a range greater than the transmit range of Switcher devices, install intervening routers to act as message repeaters.

How Switcher Tx / Rx Networks Work

Pixie Switcher are ZigBee network devices operating with the HC-L ZigBee profile.

Routers must be always on and form the backbone of the switching network and have the ability to forward messages to their destination. Neighboring routers must be within range of each other, but the overall network may be much larger. Usually these will be load controllers because they will have power available and will tend to be distributed within an environment.

End devices are assigned to a single router within range, with which they communicate exclusively. This 'parent router' will forward messages to the rest of the network on its behalf. End devices are allowed to sleep, and so are ideally suited to battery powered units. Such sleeping units can be triggered to wake up if any of EP1 – EP3 change state, and also at regular intervals.

The Switchers send on/off messages to each other. One switch input can control many outputs and/or one output can be controlled by many inputs. Which inputs affect which outputs is specified during installation in a process known as *binding*. These relationships are stored in a *binding table*.

The binding table may contain up to 255 *binding entries*. One binding entry is required for each switch input and one for each input / output relationship. For example, one switch controlling three lights uses 4 binding table entries. Three switches controlling one light use 6 binding table entries.

One router has a special role known as a coordinator. It sets network-wide rules such as operating frequency, binding table, etc.

The differences between Pixie Switcher Coordinator, Routers and End Devices are firmware differences only and they can be reprogrammed as required. All are based on Pixie and Pixie Lite modules. (Pixie Lite modules can only be end devices, however.)

Physical Layout

Free space range is approximately 120m. In-building ranges of 20m to 40m would normally be expected. Devices must be located within radio range of at least one router in the network. If a device is an 'outpost' and is out of range of all other devices, install one or more repeaters to bring it into range. Any router device can function as a repeater. Please also contact us regarding custom repeater devices.

Devices should be located, where possible, far from conducting and/or strongly dielectric materials such as metals, water and body tissue. (See table 4.) Avoid the use of a metal enclosure for Switcher devices. Also, if possible, avoid high carbon-content plastics.

A high location is recommended to avoid interference. Where possible, orient all the antennas in the same direction. A highly attenuating medium such as a concrete floor may be bridged by placing two routers close to each other, one on either side of the barrier.

Table 4. Typical attenuation of bulk materials

Material	***Reduces range by factor of***
Reinforced concrete floor	30
Brick wall	2
Brick wall with window	1.25
Metal cabinet	3
Vegetation	1.25 per meter
Compact materials, e.g. humans, have an complex effect, in general attenuating most noticeably when closest to the antenna.	

The signal strength indication can be used to measure the quality of a link two locations. To obtain a signal strength indication, press the Bind button on an end device once. The LED will flash a signal strength value as follows: one long flash for each ten the one short flash for each unit. For example 32 would be represented by three long flashes followed by two short flashes. The value reported is the signal strength of the last packet of data received from the parent. Signal strength is on a scale of 0 (-110dBm, weakest) to 110 (0dBm, strongest).

To maximize performance, experiment with antenna orientation and small changes in physical location. Stand well back from the device when measuring signal strengths.

A sniffer tool may be used for further diagnostics. Please also contact us regarding sniffer tools.

Network Configuration

The first device to be installed should be the coordinator. It will scan for an unused frequency on which to establish a network.

When you power up the coordinator, the LED will flash the Morse letter ***L*** (• – • •) to indicate that it is looking for a good frequency to operate on. The LED will flash the letter ***Y*** (– • – –) when it has started the network and is ready.

Other devices may then be joined to the network. When you power them up, the LED will flash the Morse letter ***L*** (• – • •) to indicate that they are looking for a network to join. If they can find a network that will let them join, they will join it and the LED will flash the letter ***Y*** (– • – –) when it has started the network and is ready. If they can't find a network that will let them join, the LED will flash the letter ***N*** (– •) and then enter a sleep state.

To join a new router to the network, select a router that is already in the network, or the coordinator itself, and that will be in range of the new router, and press its bind button. The LED will flash the Morse letter ***J*** (• – – –) to indicate that it is allowing a device to join. Then power up the new device. It will scan for the network and attempt to join it. The LED will flash the letter ***Y*** (– • – –) on both devices when joining succeeds.

End devices are joined in the same way as routers, except you can't thereafter join anything to the end device. The router you select for joining will become the end device's parent.

Binding

After devices have joined the network, inputs can be bound to outputs. To bind an input to output, press the bind button several times in reasonably quick succession. The number of times it should be pressed is equal to one plus the endpoint number of the input or output. The Bind LED will flash as many times as the endpoint number to indicate it is in the correct binding mode. When both input and output are in this state, they will locate each other and bind together.

For example, suppose you want Device A input EP3 to control Device B output EP5. Press the bind button on Device A four times, and Device B six times. The LED in each will flash the letter ***Y*** (– • – –) when binding has successfully completed. (Programmable input endpoints behave a little differently – see Configuration Commands section.)

Note that prior to binding, the input and output endpoints must be configured correctly as input and output. Normally configuration would happen at the factory where the Switcher modules are placed in-circuit. Joining and binding would take place on-site by an installer and do not require a configuration tool.

To unbind two inputs, perform the binding process again.

Once all required inputs and outputs are bound, network installation is complete.

Network Reboot

After a break in power, the network restarts as follows:

1. When the Coordinator powers up or is otherwise reset, it scans for, and selects, a free channel. All other devices must then rejoin the network.

2. Routers and Fast End Devices will automatically search for the network on power-up. If a device had a separate power source (e.g. battery) and did not go through a power-down power-up sequence, a network search must be initiated as described in step 4 below.

3. Sleepy end devices will notice they are no longer in contact with their parent when an input changes and it attempts to send a message, or the watchdog wakes to check for messages. It will initiate a search, and if it fails to find the network, it will enter a sleep state and a network search must be initiated as described in step 4 below.

4. A network search can be initiated at any time on any router or end device by:

   - cycling the power, or
   - changing a Switcher Tx input as described in step 4

Mobile End Devices

Sleepy end devices may be joined to more than one parent. When contact is lost with its current parent, an end device will scan for any parent it has previously been joined to, as described in step 3 of the above network reboot procedure.

This feature allows mobile end devices such as key fobs to perform multiple roles at different sites. Joined parents need to be out of range of each other in order for this to work effectively.

Example Application Circuit

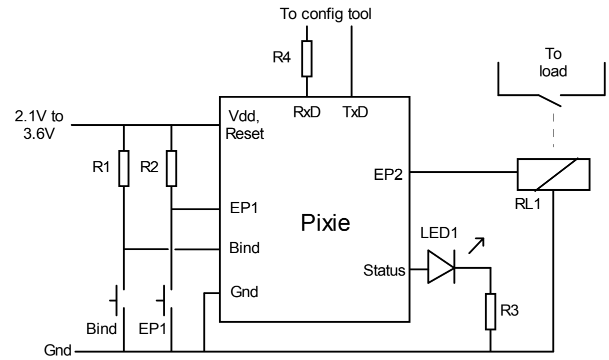


Figure 4. Example Switcher connections

Figure 4 shows an example use of a single Pixie Switcher module. Power is applied to Vdd, and Reset is held high. EP1 is configured as a switching input and has an active low pushbutton input. EP2 is configured as a switching output and drives a relay, which in turn drives a load. (In practice a drive transistor would probably be required to drive a relay.)

The active low Bind button can be used to bind the input and the output to corresponding endpoints on other Pixie Switcher devices. LED1 provides a status indication.

When delivered, the endpoints will need to be configured and, in some cases, the MAC address may need to be set. These options are specified using the Pixie Config Tool via the connections RxD and TxD. The tool also allows diagnostic messages to be monitored. Resistor R4 ensures the RxD input is protected from the 5V signal level from the Config Tool. You may also wish to place a weak pull-up resistor on the RxD input to avoid spurious reception when the configuration tool in not connected.

Pin Descriptions

Power

Only one *Gnd* pin needs to be connected but it is recommended that they are all connected as part of a solid ground plane.

Normally a voltage regulator is not fitted and a regulated 2.1V – 3.6V power source must be connected to *Vdd*. *Vunreg* performs no function.

If a voltage regulator has been fitted, DC power should be connected to *Vunreg*. It may be unregulated but the voltage should never go outside the range 3.0V – 20V. *Vdd* will regulate down to 3.3V and may be used as a 50mA power source (less any load on EP1 – EP8). The quiescent current of the regulator is approximately 10µA.

Bind

The bind input should be connected to a pushbutton so that it is normally held high but is low when the button is pressed. A change of state of the bind input will wake the device from sleep, and so it should have a weak pull-up rather than be left floating.

The input is internally debounced in firmware by virtue of the latency between the interrupt being generated and the internal state machine processing it. This is sufficient for most applications. Some ‘dirty’ switches may benefit from additional hardware filtering, either to prevent missed presses or to avoid waking the device unduly.

Refer to the Network Configuration for details of Bind switch operation.

If the Bind switch is low when the device resets, an *Erase Reset* is performed. This erases all joining and binding information on a device. To perform an erase reset, power up the device with the Bind button held down. Once the Bind LED lights, release the button. The joining and binding data will have been erased.

In the case of routers and end devices, an erase reset causes all network membership information to be deleted. In the case of coordinators, all binding information for the network will also be deleted. The device may then be re-used in a new network.

Status

The status output is active high. It should be connected to an LED.

Table 6 summarizes the status codes which may be observed on the Bind LED. Note that the same codes are used to indicate attempting to bind and confirming programmable endpoint states. (The status codes in the table are the values displayed by the diagnostic messages.)

Table 6. Pixie Switcher Device States

Status code	***State***	***Status LED***
00	Normal	Off
01	Initializing	On
02	Fatal Error	• • – • ***(F)***
03	Yes, operation succeeded	– • – – ***(Y)***
04	No, operation failed	• – ***(N)***
06	Report signal strength, tens	†
07	Report signal strength, ones	†
08	Getting programmable input endpoint setting	• – – • ***(P)***
09	Confirm *Toggle* programmable input	•
0A	Confirm *Off* programmable input	• •
0B	Confirm *On* programmable input	• • •
0C	Confirm *Toggle Latch* programmable input	• • • •
0D	Confirm *Latch* programmable input	• • • • •
0E	Confirm *Timer* programmable input	• • • • • •
0F	Battery Low	– • • • ***(B)***
10	Non-fatal error display	• – • ***(R)***
40	Permit node to join	• – – – ***(J)***
41	Binding / unbind endpoint 1	•
42	Binding / unbind endpoint 2	• •
43	Binding / unbind endpoint 3	• • •
44	Binding / unbind endpoint 4	• • • •
45	Binding / unbind endpoint 5	• • • • •
46	Binding / unbind endpoint 6	• • • • • •
47	Binding / unbind endpoint 7	• • • • • • •
48	Binding / unbind endpoint 8	• • • • • • • •
81	Looking for network Starting network (coordinators)	• – • • ***(L)***

† One slow flash for each ten plus one quick flash for each unit

Reset

The reset input is active low. Power-on reset is automatic, so this pin may be tied high.

EP1 – EP8

EP1 – EP8 are the switcher inputs and outputs for switching and control. Inputs are active low, outputs are active high. EP1 – EP3 wake the device on state change and should have weak pull-ups rather than be left floating.

There are several kinds of input and several kinds of output as detailed in the Configuration Commands section. Endpoints must be correctly configured as inputs and outputs before they can be used.

TxD, RxD

The TxD and RxD pins provide 3.3V serial communications for device configuration and diagnostics. If unused or if the serial connection can be unplugged, TxD should be left floating and RxD should be weakly pulled high. Sleeping end devices cannot receive data while asleep. If you want to send a sleeping device a command, press the bind button once so that it wakes to display the signal strength.

The data rate format is 19200 baud, no flow control, 8 bits, no parity, one stop bit. The baud rate is controlled by an internal oscillator and may drift at operating temperature extremes.

Configuration Commands

Various settings may need to be configured prior to using Pixie Switcher in an application. Configuration is achieved using the serial interface provided by TxD and RxD.

USB Config Tool

A USB Config Tool is available to access the RxD and TxD lines from a Windows PC. You can run the Windows HyperTerminal application to send commands and read responses. It must be configured to communicate with the COM port that the USB Config Tool adopted when it was installed, at 19200 baud, 8N1, no flow control.

Setting the MAC Address

Normally Pixie Switcher is supplied with a MAC address pre-loaded. If for any reason it is not loaded, then after initialization you will be prompted to enter a 10-hex-digit MAC address. You must enter the address we specify. (The first 6 digits of the MAC address are always 0015C8 and these do not need do be entered.) Once set, the MAC address cannot be changed. Example:

```
MAC
>12345abcde
```

(Device then resets)

If you are evaluating Pixie Switcher and do not have MAC addresses allocated, you may use addresses in the range 3841000000 to 384100FFFF for R&D purposes.

It is important that every MAC address is unique. The network will not operate properly if two devices operating with the same MAC address.

MAC addresses may be automatically programmed using the SQTP feature of the Microchip Technology PM3 programmer. Refer to the Pixie data sheet for details.

Commands

The key-press commands in table 7 may be used to diagnose and configure the device.

Note that devices do not register button commands while asleep. To send a command to a sleepy device, first press the bind button once so that it wakes to report the signal strength. You will then have plenty of time to send the command before it falls asleep again.

Table 7. Configuration commands

Key Press	*Command*
A	Failsafe & low battery alarm settings †
B	Print binding table
E	Set input & output endpoint types †
F	Factory reset †
I	Device information
M	Show messages
N	Print neighbor table
P	Press bind button †
Q	Set bind switch mode
R	Reset †
T	Print routing table
V	Report supply voltage
W	Set watchdog mode ‡
Z	Erase reset †

† = device will reset when command is completed
‡ = sleepy devices only

Set failsafe & low battery alarm settings (A)

If an ***A*** command is sent, the failsafe input *re-transmit period* and output *quiet period* are set. The values are in hex seconds, range 0001 to FFFF (18 hours approx). If you are unfamiliar with hexadecimal notation, use Table 8 as a guide.

The under-volt trigger level is specified in hex milliVolts, range 0000 to 0E10. Specify 0000 for no under-volt alarm. Note that below 2.1V, the device may cease to function and will not be able to generate an under-volt alarm. The undervolt trigger level applies to the failsafe alarm and also to the low battery ***B*** indication on the Bind LED.

The quiet period should be greater than the re-transmit period to ensure that the failsafe alarm is not triggered during normal operation. Usually it would be several times longer, to allow for the occasional lost transmission.

Table 8. Hex notation examples

Hex value	Time value	Voltage value
0000		(no alarm)
003C	1 minute	
012C	5 minutes	
0384	15 minutes	
0834	35 minutes	2.1V
0898		2.2V
0834	40 minutes	2.4V
0A8C	45 minutes	2.7V
0E10	1 hour	3.6V
1C20	2 hours	
3840	4 hours	
5460	6 hours	
A8C0	12 hours	
FD20	24 hours	

The following example sets the retransmit period to 1 hour, the quiet period to 4.2 hours and the under-volt alarm to 2.2mV. These are the default values.

```
A
Enter new re-transmit period, hex seconds
>0E10
Enter quiet period, hex seconds
>3B10
Enter under-volt level, hex mV
>0898
```

(Device then resets)

Print Binding Table (B)

If a ***B*** command is sent, the binding table is printed. Refer to the Pixie Switcher Messages Reference for details. This command only implemented on coordinators.

Set input and output channel types (E)

The ***E*** command sets the endpoint (input and output channel) types. Take care to set endpoint types which correspond to electrical connections to the endpoints.

Table 9. Endpoint Types

Code	***Function***
N	*On* input endpoint
F	*Off* input endpoint
T	Toggling input endpoint
L	Latching input endpoint
H	Toggling latch input endpoint
G	Programmable input endpoint, set to *toggle* or unassigned
n	Programmable input, set to *on* †
f	Programmable input, set to *off* †
t	Programmable input, set to *latch* † (Note 2)
h	Programmable input, set to *toggling latch* † (Note 1)
D	Time delay input endpoint ‡
0	Output endpoint, initially off
1	Output endpoint, initially on
P	Pulsing output endpoint
R	Power control output
M	Time delay setpoint input (Note 3)
S	Failsafe alarm input
A	Failsafe alarm output, initially off
B	Failsafe alarm output, initially on
U	Unassigned
Z	*Cancels endpoint entry process*

† Code used for reporting programmed mode only. To set an endpoint as programmable, always use code ***G***

1. Used for latching inputs when other inputs also control the output. The state of the switch will not indicate whether the output is on or off.
2. For latching inputs where no other inputs control the output. The state of the switch will indicate whether the output is on or off.
3. Time limit set by time delay setpoint input, which must be provided, as described in table 8.

When the ***E*** command is sent, the current endpoint types are first listed. The new endpoint settings may then be entered as a series of characters, one each for each of channels 1-8, as summarized in table 9 and detailed below. Enter a ***C*** at any time to cancel. If the Switcher device has fewer than 8 channels, the non-existent channels should be set to the 'unassigned' ***U*** input type.

The following input and output channel operating modes are possible with Switcher products:

An *On input endpoint* generates an On message when the input switches on. It is selected using the letter ***N***.

An *Off input endpoint* generates an Off message when the input switches on. It is selected using the letter ***F***.

A *Programmable input endpoint* allows the message it sends to be programmed after binding. Once binding has completed, the Switcher bind LED will flash the letter ***P*** (•– – •). It is indicating that it needs to know what message to send when its input is switched. The bind button must be pressed a specific number of times to set what message to send as listed in table 10.

Table 10. Setting programmable message types

Number of presses	***Message*** (Note 1)	***Confirmation code***
1	Send 'toggle' message when pressed (Like *T* type endpoint)	•
2	Send 'off' message when pressed (Like *F* type endpoint)	• •
3	Send 'on' message when pressed (Like *N* type endpoint)	• • •
4	Send 'toggle' message when pressed or released. (Note 2) (Like *H* type endpoint)	• • • •
5	Send 'on' message when pressed and 'off' when released. (Note 3) (Like *L* type endpoint)	• • • • •
6	Send 'on' message when pressed and 'off' when timer time limit expires. (Like *M* type endpoint). (Note 4)	• • • • • •

1. The message specified will apply to all outputs bound to the input, not just the most recently bound input.
2. Used for latching inputs when other inputs also control the output. The state of the switch will not indicate whether the output is on or off.
3. For latching inputs where no other inputs control the output. The state of the switch will indicate whether the output is on or off.
4. Time limit set by time delay setpoint input, which must be provided, as described in table 8.

A *Toggling input endpoint* generates a Toggle message when the input switches on. A toggle message tells the output to enter the opposite state to the one it is in already. It is selected using the letter ***T***.

A *Toggling Latch input endpoint* does not need to be programmed after binding. It generates a Toggle message when the input turns on and when the input turns off. It is selected using the letter ***H***.

A *Latch input endpoint* does not need to be programmed after binding. It generates an On message when the input turns on and an Off message when the input turns off. It is selected using the letter ***L***.

A *time delay input endpoint* implements a timed switch. When the input switches on, it generates an *On* message immediately and an *Off* message after a preset time delay. It is selected using the letter ***D***. If the pushbutton is pressed again before the countdown is complete, the countdown starts from the beginning again.

The preset time delay is defined by the voltage on the *time delay setpoint input* (letter ***M***). If there is more than one time delay setpoint input, the one with the next highest input number will apply. For example, if EP1, EP3 and EP5 are time delay inputs and EP4 and EP6 are time delay setpoints, EP4 will specify the delay of EP1 and EP3, and EP6 will specify the delay of EP5. If there is no higher numbered input endpoint, the time delay will be five minutes. Only EP4, EP5 or EP6 may be used as time delay setpoints. If EP5 is used, EP4 should not be an output of any kind. If EP6 is used, neither EP5 nor EP4 should be outputs of any kind.

The delay is specified by the analog voltage level on the pin as specified in table 11.

If a programmable input endpoint is set to timer and the wakeup timer is set to off, it will be temporarily set to a wakeup period of 15 seconds while the timer is operating.

Table 11. Time delay setpoint values

Voltage range	*Time delay*
0.00V – 0.67V	From 1 sec to 10 sec in 1 sec steps
0.67V – 1.33V	Varies linearly from 10 sec to 60 sec
1.33V – 2.00V	Varies linearly from 1 min to 10 min
2.00V – 2.67V	Varies linearly from 10 min to 60 min
2.67V – 3.33V	Varies linearly from 1 hr to 18 hrs

An *output endpoint, initially off* is intended to be connected to a load controller such as a relay. It responds to messages from input endpoints and can be in an *Off* state (output low) or an *On* state (output high). At power-up, it reverts to the *Off* state. It is selected using the digit ***0***.

An *output endpoint, initially on* is intended to be connected to a load controller such as a triac or relay. It responds to messages from input endpoints and can be in an *Off* state (output low) or an *On* state (output high). At power-up, it reverts to the *On* state. It is selected using the digit ***1***.

A *pulsing output endpoint* will automatically revert to the *Off* state 20ms after it receives a message to turn *On*. It is selected using the letter ***P***. Note that stack processing is suspended for the 20ms duration of the pulse, and that the DESI message will not be generated until the pulse has turned off again.

With a *failsafe alarm* input and output pair, the output turns on if any of the following events occurs:

- When the failsafe input is turned on
- If regular contact with the failsafe input device is lost
- If the supply voltage on the failsafe input device is low

When the switch is not activated, the failsafe input still sends regular messages to the failsafe output to confirm that it is still in contact. If radio communication fails for any reason, for example if the transmitter is vandalized or stolen or the battery is run down, the alarm is raised.

The *failsafe alarm input endpoint* is specified using the letter ***S*** and generates an *On* message when the input turns on and an *Off* message when the input turns off. It re-transmits the state of the input immediately after rejoining a network and after every *retransmit period*, even if it hasn't changed. Normally it would be connected to a 'Failsafe Test' or 'Alarm' button or left unconnected. Refer to the *Set failsafe & low battery alarm settings* command for details of how to set failsafe time periods and voltage levels.

A *failsafe alarm output endpoint* is similar to a normal *output endpoint*. It responds to messages from input endpoints and can be in an *Off* state (output low) or an *On* state (output high). In addition, if it does not receive any messages for a pre-specified *quiet period*, it will automatically revert to the *On* state. Typically it would be connected to a 'Fault' light or buzzer. Refer to the *Set failsafe & low battery alarm settings* command for details of how to set failsafe time periods. The letter ***A*** is used to specify a false alarm output if the output is initially off until the first message is received, or the letter ***B*** if the output is initially on until the first message is received.

In normal operation, the failsafe output will be off unless a failure mode occurs. The 'Failsafe Test' button may be used to check the failsafe system has been correctly bound.

The failsafe input and output must be bound together. They are ***not*** automatically bound when other endpoints on the device are bound. One failsafe input may be bound to many outputs, but only one input should be bound to any failsafe output.

Unassigned endpoints are not used. If any of endpoints 1-3 are unassigned, they may be used simply to wake Pixie Switcher when it is in a sleep state. If this is not the desired behavior, the endpoint should be tied high to avoid unintended wakeup during sleep periods.

The following example sets input 1 to *latch* and 2 to *timer*. Channels 5 and 6 are set as time delay setpoint (***M***) and (***R***) respectively:

```
EPs:   PPPPUUUU
>LDUUMRUU
```

(Device then resets)

Factory reset (F)

If an ***F*** command is sent, a factory reset is performed. This includes resetting all configuration options to their initial state. The MAC address will not be erased.

Device Information (I)

If an ***I*** command is sent, informational messages are generated about the switcher unit. Refer to the Pixie Switcher Message Reference to interpret these messages.

Show Messages (M)

The ***M*** command sets and indicates whether diagnostic messages are generated. These may be used for advanced diagnostics. Refer to the Pixie Switcher Message Reference for details. If not used, the messages should be turned off to conserve power.

Messages are not usually implemented in Pixie Lite products, but an alternate build is available for the fast end device where messages are available but failsafe features are not.

Print Neighbor Table (N)

If an ***N*** command is sent, the neighbor table is printed. Refer to the Pixie Switcher Messages Reference for details. This command is not implemented on Pixie Lite.

Press bind button (P)

If a ***P*** command is sent, it has the same effect as pressing the bind button.

Set Bind Switch Mode (Q)

If a ***Q*** character is sent, the device cycles through the bind switch modes. The purpose of this command is to allow switches to be used in potted switching units. Refer to the Pixie Switcher Message Reference for details.

Reset (R)

If an ***R*** command is sent, the device resets as if it were powered down and powered up again.

Print Routing Table (T)

If a ***T*** command is sent, the routing table is printed. Refer to the Pixie Switcher Messages Reference for details. This command is not implemented on end devices.

Supply voltage (V)

If a ***V*** command is sent, the voltage on Vdd is reported in hex milliVolts. Refer to table 8 for translations to decimal voltage levels

Watchdog mode (W)

Sleepy end devices sleep to conserve power. Inputs EP1 to EP3 trigger interrupts and wake the device up automatically. If any other inputs are used, or if any outputs are used, a watchdog must wake the device at regular intervals to check if anything needs to be done. The ***W*** command cycles through the watchdog wakeup modes listed in table 12.

A more frequent watchdog allows faster response but will consume more power. If woken by the watchdog but otherwise idle, the device will be active for approximately 60ms after wakeup before returning to sleep. For minimum wakeup time, specify no diagnostic messages using the ***M*** command.

Failsafe and time delay inputs use the watchdog to time their operations. Their timings will only be as accurate as the wakeup period allows. For minimum power consumption with failsafe and timer operation, the wakeup period should be the largest acceptable value.

Table 12. Wakeup mode options

Mode	Function
`00`	No wakeup on watchdog (default)
`01`	Wakeup every 250ms approx
`02`	Wakeup every 500ms approx
`03`	Wakeup every second approx
`04`	Wakeup every 2s approx
`05`	Wakeup every 4s approx
`06`	Wakeup every 8s approx
`07`	Wakeup every 15s approx
`08`	Wakeup every 30s approx
`09`	Wakeup every minute approx
`0A`	Wakeup every 2 minutes approx
`0B`	Wakeup every 4 minutes approx
`0C`	Wakeup every 8 minutes approx
`0D`	Wakeup every 15 minutes approx
`0E`	Wakeup every 30 minutes approx
`0F`	Wakeup every hour approx
`10`	Wakeup every 2 hours approx
`11`	Wakeup every 3 hours approx
`12`	Wakeup every 6 hours approx
`13`	Wakeup every 12 hours approx
`14`	Wakeup every 24 hours approx

Erase reset (Z)

If a ***Z*** command is sent, an erase reset is performed. The device clears its joining and binding settings and assumes it is not a member of a network.

The following settings remain unchanged during this operation. Resetting them requires a factory reset.

- Endpoint type information
- Watchdog wakeup rate
- Undervolt detect level
- Failsafe periods

An erase reset is also performed if, at power-up, the Bind button is held down.

Version 1.0-3.6-2.4 Notes

This version of Pixie Switcher incorporates the following changes since previous versions:

- SQTP programming of MAC addresses implemented enhanced to allow automatic generation of SQTP values in MPLAB.

This version of Pixie Switcher has the following limitations:

- Security not implemented.

Security will be implemented as soon as it is made available in the ZigBee stack from Microchip Technology.

Regulatory

EMI ratings

Pixie products devices are FCC, CE and IC (Industry Canada) compliant

ZigBee Logo

It is our current understanding that FlexiPanel Ltd will be able to pre-qualify Pixie Switcher firmware solutions to allow OEMs to use the ZigBee logo without further action.

Radio Frequency

Optimizing RF Performance

The G-style integral antenna supplied with Pixie Switcher is a modified quarter wave antenna with an efficiency of approximately 70%. This is comparable to a dipole and about as high as physically possible. It develops and detects electromagnetic fields with reference to a ground plane, which should be considered a vital component of the antenna. Its radiation pattern is approximately omnidirectional.

Free space range is approximately 120m. In-building ranges of 20m to 40m would normally be expected.

The ground plane should be considered a vital part of the antenna Pixie's copper fill areas provide as good a ground plane as can be provided in such a compact area. Superior performance may be obtained, space permitting, if as much grounded copper fill can be placed on the main board as possible, but none on the face directly underneath the Pixie module. All ground pads should connect to the ground plane. Vias should join the layers at irregular intervals approximately 4-8mm apart.

The enclosure employed may affect antenna performance. Avoid the use of metal enclosures. Gray and black plastics should be used with caution. They often contain carbon, which degrades performance. (To test for the presence of carbon, heat the plastic in a microwave oven for one minute. If it melts, it probably contains carbon.) In some cases, a certain carbon content may be required for regulatory reasons not related to radio transmission.

Mechanical

PCB Pad Layout

Refer to the mechanical drawing for PCB layout guidelines. Note that while normally supplied as a surface mount (SO) module, it is possible to supply it with legs fitted.

Soldering Procedure

If soldered using a reflow oven, the surface mount module may be treated like a BGA package. The quality of the joint may be tested by checking for continuity between the pad on the upper side of the board and the protruding part of the pad on the main board.

If soldering manually, use the following procedure:

1. Tin the contact pads on the module, trying to get the same amount of solder on each.

2. Tin contact pads on main board.

3. Place the module in position on the main board.

4. Starting with the pads most likely to be in physical contact, apply heat with a soldering iron to the exposed part of the main board pads. Abut the iron against the edge of the module so that the maximum heat is transmitted to the contact area of the pads. After 10-15 seconds, remove heat. Around 90% of pads should be successfully soldered.

5. Test for continuity between the pad on the upper side of the board and the protruding part of the pad on the main board.

6. Rework non-conducting contacts by applying heat again and a little extra solder, or solder a wire bridge to the top pad.

Location on main board

The module should be located so that the antenna abuts the edge of the board or overhangs it. It should be placed so that it is unlikely that interfering items such as metal, water, cellphones, body tissue, etc, will come into close proximity.

No PCB tracks or components should be placed on the underside of the module, nor near the antenna.

Pixie Switcher Lite

Pixie Lite is a reduced function device based on the 18LF2510 microprocessor. It has sufficient memory to implement end devices only.

Bear the following points in mind when developing applications with Pixie Lite:

- Pin connections EP7, EP8 are not present.
- Diagnostic status messages are not implemented.
- Neighbor table report is not implemented.
- A modified firmware compilation is used for Pixie Lite.

Copy Protection

To protect against copying, if the Pixie Switcher firmware is run on any hardware except FlexiPanel Pixie and Pixie Lite products, it will cease to function after approximately two minutes. Steinlaus tags are also included in the code.

Development Kit

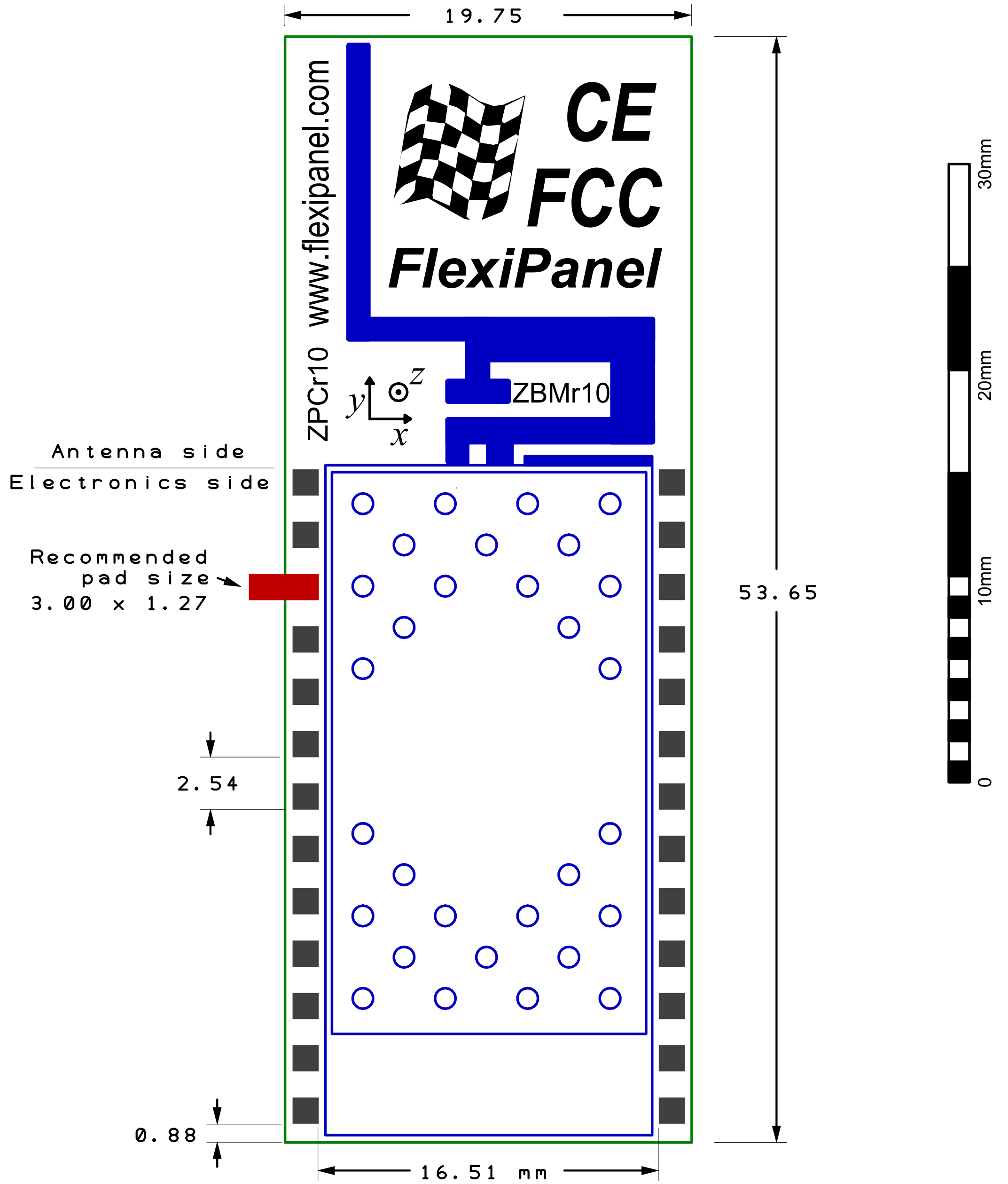
The Pixie Switcher development kit is available to all users who sign a license agreement. It contains the following:

- ***PXSC-1.0-3.6-2.3.hex***, Pixie Switcher Coordinator firmware
- ***PXSR-1.0-3.6-2.3.hex***, Pixie Switcher Router firmware
- ***PXFE-1.0-3.6-2.3.hex***, Pixie Switcher Fast End Device firmware
- ***PXSE-1.0-3.6-2.3.hex***, Pixie Switcher Sleepy End Device firmware
- ***PLFE-1.0-3.6-2.3.hex***, Pixie Switcher Lite Fast End Device firmware
- ***PLSE-1.0-3.6-2.3.hex***, Pixie Switcher Lite Sleepy End Device firmware
- ***PLFV-1.0-3.6-2.3.hex***, Pixie Switcher Lite Fast End Device firmware, alternate compilation with diagnostic messages enabled and failsafe disabled.
- ***15.4_Sniffer 2.0.hex***, ZigBee Sniffer firmware.
- ***FCS Switcher.pdf*** configuration settings for Pixie Switcher
- ***FCS Switcher Lite.pdf*** configuration settings for Pixie Switcher Lite
- ***Pixie Switcher DS490-4.pdf*** documentation.
- ***Pixie Evaluation Kit DS482-2.pdf*** documentation.
- ***Switcher Message Reference DS492-1.pdf*** documentation.
- ***Switcher Tx / Rx Basic DS494-1.pdf*** documentation.
- ***Switcher Tx / Rx Advanced DS494-1.pdf*** documentation.

Bibliography

ZigBee for Applications Developers, white paper downloadable from *www.flexipanel.com*.

ZigBee Specification, downloadable from *www.zigbee.org*.



FlexiPanel
www.flexipanel.com

Drawing	DRWG-ZPCr10
Date	11 June 06
Drawn by	R G Hoptroff
Description	Pixie ZigBee module (rev 10)

Notes

1. Dimensions in mm
2. Module height 3.6mm
3. Keep antenna side as free of components as possible, preferably overhanging the edge of the main board
4. Pour as much grounded copper as possible on the main board, but none on top layer below Pixie module
5. If pins fitted, pin pitch is 20.32mm
6. Pixie Lite same size & footprint as Pixie
6. Incorporates FCC / CE / IC certified EasyBee transceiver ZBMr10

Reference

Electrical

Supply Voltage (unregulated) Vunreg	3V – 24V line power 2.1V – 3.6V battery power (not all models)
Current consumption, active	30mA
Current consumption, sleep mode	2µA

Radio Frequency

Max RF output power	1mW = 0dBm
RF frequency range	2400MHz to 2485MHz
Communications protocol	IEEE 802.15.4 (DSSS O-QPSK chip encoding) ZigBee 1.0 HC-L profile
Raw data rate	250kbit/s
RF channels	16
Free space range	Approx 120m node-to-node, freespace

Mechanical

Max operating/storage temperature	-40ºC to +85 ºC
Dimensions W×H×D mm (D = depth from top of DIN rail)	78×75×33

Regulatory

FCC compliance	G-antenna version compliant, awaiting certificate
CE compliance	G-antenna version compliant, awaiting certificate
IC (Industry Canada) compliance	G-antenna version compliant, awaiting certificate
ZigBee compliance	Awaiting compliance testing by Microchip Technology Inc

Ordering Contact

The Pixie Switcher range is manufactured and distributed by:

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Technical Information

The Pixie Switcher range is owned and designed by:

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