


**ZIGBEE SENSOR**

**NETWORK**

**PROJECT REPORT**

	TITLE	ZIGBEE SENSOR NETWORK	CHECKING DATE	19/1/2010
	DOCUMENT TITLE	REPORT	EDITION NUMBER	01

## **PREFACE.**

### **Introduction.**

This final Project is developed in the Noordelijke Hogeschool Leeuwarden University, The Netherlands.


The author is Héctor Fuentes, who is studying technical electronic engineering.

The tutor is Hendrik Bijlsma, teacher in the engineering department from NHL University.

The working period for the job is between the end of August 2009 and the end of January 2010.

This project has the stipulated amount of 30 credits ECTS and it is essentially based on electronic engineering and more specifically in the micro-controlling and instrumentation field.



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### **Scope:**

The application field for this project is home appliance, as well as industry and educational measurements, but indoor use only.

The range of temperature must be between -20 and 70 °C, at least.

### **Precedents:**

#### Sensor:

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example, a mercury-in-glass thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube.

A thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, all sensors need to be calibrated against known standards.



#### Wireless:

Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometres for radio communications). When the



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context is clear, the term is often shortened to "wireless". Wireless communication is generally considered to be a branch of telecommunications.

It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of wireless technology include GPS units, garage door openers and or garage doors, wireless computer mice, keyboards and headsets, satellite television and cordless telephones.

#### Early wireless work:


Jagadish Chandra Bose has been credited with the invention of the first wireless detection device and the discovery of millimetre length electromagnetic waves and considered a pioneer in the field of biophysics. David E. Hughes, eight years before Hertz's experiments, transmitted radio signals over a few hundred yards by means of a clockwork keyed transmitter. As this was before Maxwell work was understood, Hughes' contemporaries dismissed his achievement as mere "Induction". In 1885, T. A. Edison used a vibrator magnet for induction transmission. In 1888, Edison deploys a system of signalling on the Lehigh Valley Railroad. In 1891, Edison obtained the wireless patent for this method using inductance (U.S. Patent 465,971).



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## **1. SUMMARY.**

In this report it can be found the description about Héctor Fuentes Final Project.


It starts with some basic concepts which introduce the reader to the working field. After that there is the index, in order to make a fast search for a specific content, followed by the introduction which gives a general vision about the aim of the project.

The main description which continues enumerates in detail every work done about the project. It starts with a work description in time and contents, and then there is every board design proof, which explains widely the PCBs operation as well as hardware and software matters.

The conclusion talks about what has been done, what could be done instead, and how good is the project implementation.

Every document used in this project (datasheets, PDFs, and so on) is named in the literature section.

At the end, there is the appendix, where is possible to find the PCB schematics, information about how to program the microcontroller and DVD index.

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## **2. INTRODUCTION.**

The system which is going to be built is based on semiconductor electronics, in order to manage information about several variables.

These variables are collected by some sensors, which relate an outside input signal (pressure, temperature, humidity...) with an electrical output signal (voltage, frequency, current...).

These sensors are grouped in PCBs, which have a wireless communication module, in order to send data through ZigBee microcontroller.

The data is collected by the datalogger module and then stored in the memory device, in this case a SD card.

A USB to RS232 interface is used complemented by a level shifter for communicating the flash memory from the microcontroller with the PC, and then download software to it.



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### 3. MAIN DESCRIPTION.

#### 3.1 GETTING THE PROBLEM KNOWN.

The object of the project is to develop several sensor modules which can communicate with a data logger module by radio. This is going to be built with zigbee modules in each PCB.

The overview should be as shown on this diagram:



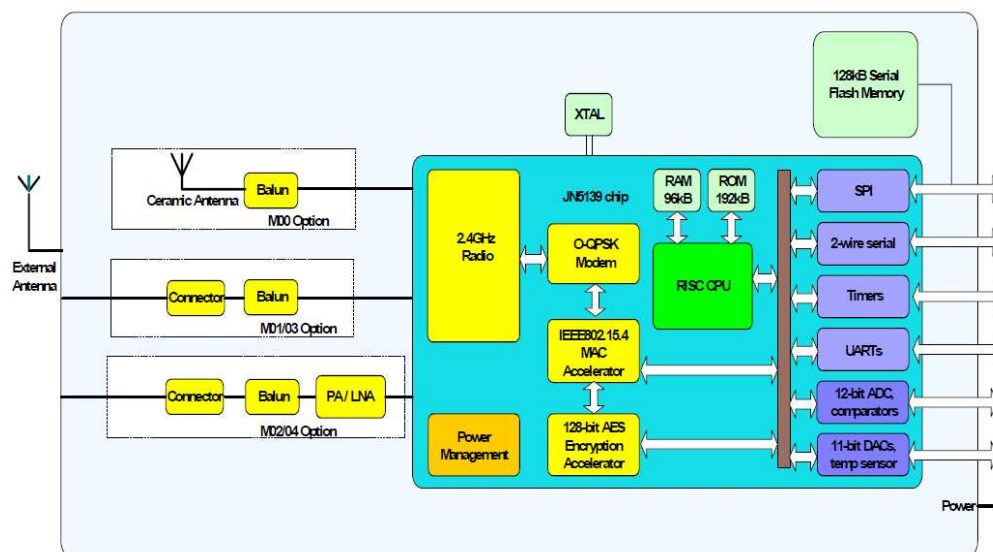
As we can see, there are some end-devices, which are the sensor modules, and a ZigBee coordinator module, in this case the datalogger module.


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Then, the problems involved are:

- Hardware problems:** build the sensor modules, find a way to communicate the datalogger with the PC and program the micro-controllers included in the design.
  - Sensor modules: group similar sensors in the same PCB, fit out sensor signals, choose a suitable power source.
  - PC to datalogger interface: choose a memory device for the datalogger and then guess which the best communication protocol is.
  - Programming the modules: what kind of link is necessary for programming the controller? How can be made a carrier board for developing software and testing the rest of the hardware?
- Software problems:** program the ZigBee modules for the sensor modules and the datalogger, which includes ZB stack, DIO, ADC and timers managing.

#### JN5139 MODULE BLOCK DIAGRAM.



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### 3.2 SYSTEM REQUIREMENTS.

It is required to build a system which includes:

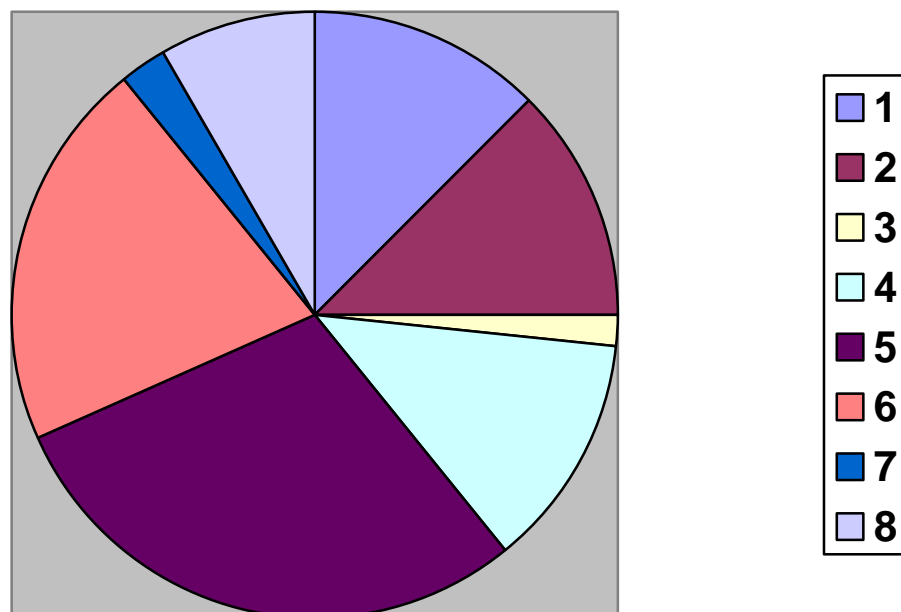
- Data logger module. Wireless device which can acquire at least 1 measurement per minute, 4 days long. The power source might be an AC/DC adapter, 9 Volts, or same voltage battery.  
This part is able to be plugged to a personal computer in order to download the measurements to it.
- Several sensor modules. There must be more than one sensor, a wireless transceiver and signal fitting out.
- Wide temperature range, between -20 and 70° C at least.  
Humidity range between 5% and 85%.
- Consider the size of the PCB. SMD components preferred.
- Single or double side PCBs.


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### 3.3 TASK DESCRIPTION.

1. Find the most suitable ZB module for the project. This means to find A ZB microcontroller with the best relationship between price and functionality.
2. Design the different modules: sensor, datalogger, carrier board and interface.
3. Order the components for building the boards.
4. Make the boards and fix any mistake done on it.
5. Develop the software for every micro-controller.
6. Test the systems.
7. Finish the assembling of the definitive modules.
8. Write the project's report.

TEMPORAL TASK GRAPHIC



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### 3.4 SOLUTION ANALYSES.

#### 3.4.1 FIRST DECISIONS.

##### *ZigBee Module:*

One of the most important things to do for this project is choosing a ZigBee module for the system.

The first ruled out idea was to use a standard microcontroller joined to a ZigBee module for the wireless communication, because the ZigBee microcontrollers were powerful enough for managing DIO, timers, ADCs and every peripheral required.

Then the election is to find a ZB module with a good relation price-performance.

Possible options:

- **Zigbee microcontroller**, without antenna, oscillator, or other devices passive elements.

*Pros:* it's the cheapest options.


*Cons:* bigger size after adding not included parts, cost of the components not included (i.e.: external memory), designing time, building time.

- **Zigbee module.** Antenna, oscillator, external memory, ZB microcontroller and a short number of passive components.

*Pros:* medium prize, small size, shorter designing time, shorter building time and large memory available.

*Cons:* less developing flexibility, higher cost than the ZB microcontroller itself.

**CHOICE:** I choose the zigbee module JN-5139. Its prize is one of the lowest in this kind of device; it has a 32 bits RISC processor, 4

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12-bits ADCs, low power consumption, up to 21 GPIO, SPI and UART interface for communications.

**Datasheets** in the DVD, folder .../Datasheets/JN5139


*Programming method:*

After choosing the ZigBee module, the immediate question is: ¿How is it programmed?

There are two different ways to do it:

- By the **development tool kit**, provided by Jennic.  
*Pros:* there are four Zigbee modules included, with temperature, humidity and light sensors. The complete stacks and software needed is in it too. Debug mode available.  
*Cons:* very high cost!!
- By my **own development board**.  
*Pros:* flexibility in the design, cheapest solution.  
*Cons:* much harder to design and also to obtain the software and the documentation necessary (Module development datasheets, Zigbee and integrated peripherals stacks) to develop the modules. The programming method is by the boot loader, so the flash is able to be written and erased but it is not possible to enter debug mode. This means a longer time for software developing.

**CHOICE:** the development tool kit has a lot of nice stuff on it, but it is not affordable. The only way to design software for JN5139 this time is with our **own development board**.

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Surfing on the internet, a carrier board was founded, so with it and a USB to RS232 interface it is possible to program the device's flash memory. This will be explained in section "3.4.4 PCB4: Carrier board".


#### *Voltage regulator system:*

The voltage regulator system provides a stable pre-fixed voltage level. This is necessary for every electronic device, specially the integrated circuits, in order to obtain reliable results. The most common voltage levels are 5V and 3.3V. These voltages could be easily obtained by a linear voltage regulator.

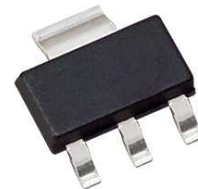
The **choices** in these cases are:

- **5V: LM7805CT:** Its maximum output current (1A) is much higher than the required by the boards (below 300mA), being the cheapest integrated circuit with these characteristics and the most common too.



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- **3.3V: TLV1117-3.3CDCY:** This chip has an output current up to 0,8A and is the cheapest option to obtain this voltage level. The package (SOT223) was also considered a pro, because it is a small size SMD.



#### *Power Source:*

It is possible to choose between battery, AC/DC adapter or both systems.


**Battery** makes the system more portable, but the durability decreases considerably, and it would be needed to charge or replace these batteries.

**AC/DC** provides high stability, low voltage ripple and it is cheap. Only a capacitor next to the board is needed in order to filter the AC component. On the other hand, it makes the system non portable.

**The mixture** of this ways is to use an integrated circuit which manages the power system. It would supply power from battery when the adapter would be disconnected, and it would take the current from this device for charging the battery and feed the system.

**CHOICE:** I choose the AC/DC adapter because of its reliability, price and the low cost 2-pin connector which is needed in the PCB for power supplying.



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### 3.4.2 PCB 1: USB TO RS232 INTERFACE.

#### *Introduction:*

This board is built for communicating the PC with the flash memory of the microcontroller, in order to program it by RS232 protocol.

#### *Main Chosen elements:*

##### **FT232RL - Dual USB UART/FIFO IC:**

In this part of the project, Hendrik showed me a board which was similar to the one I needed. He advised me to use the FT232RL. I looked for some one else which could fit better but it looked like the best choice (price and protocols supported). It is able to manage SPI and RS232 protocols at once from the USB source.

The option of buying a card or adapter wire from RS232 to USB was also considered, but it was much more expensive.

The design is based on the FT232RL datasheet founded in the manufacturer's website


<http://www.ftdichip.com/Projects/MPSSE/FTCSPi.htm>.

The way for getting enable several protocols is with an EPROM memory which should be placed in order to be read at booting time by the FTDI chip. In my design is not included because the default protocol used by the chip is RS232, the one I need for flash programming the controller.

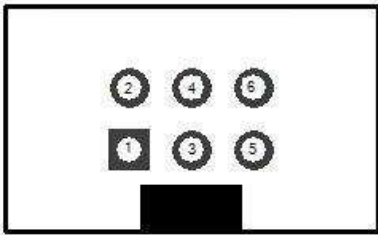
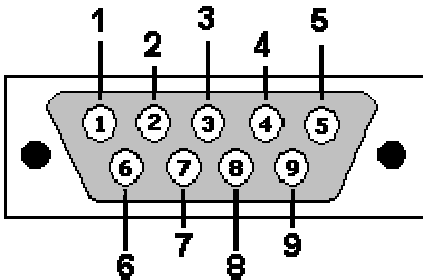
**Datasheets** in the DVD folder: .../Datasheets/Others

#### **Connectors:**

The board has one USB "B" connector, one 6-pin header and one DB9 plug.

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The USB is used to link the computer with the other side device, which is connected to one of the others plugs. The pin description goes below:

DUAL RS232 CONFIGURATION					
6 PIN CONNECTOR (PORT A)			DB9 CONNECTOR (PORT B)		
1	3V3		1	DCD	
2	RXD		2	RXD	
3	RTS		3	TXD	
4	CTS		4	DTR	
5	TXD		5	GND	
6	GND		6	DSR	
			7	RTS	
			8	CTS	
			9	RIA	
					

#### SP213EHCA:

This is a +5V high performance RS232 transceiver which is needed due to level converting the RS232 signals from the FTDI chip (+5V, 0V) to the standard serial communication levels for this protocol (+10V, -10V). It is used on port B, so **ONLY PORT B, DB9 CONNECTOR** has this voltage levels. Please note that **port A, 6 pin connector has low-voltage-TTL levels (3.3V, 0V).**

**Datasheet** in the DVD folder: .../Datasheets/Others

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### Power acquisition:

The board has a 2 pin header for plugging a DC voltage. The maximum voltage allowed for this board is 16V, being the minimum 7.5V. This is required for the correct feeding of LM7805:

$$I_{abs} = I_{ft2232} + I_{sp213ehca} + I_{Led} = 130 + 15 + 20 \text{ mA} = 165 \text{ mA} ;$$

$$P_{max} = (V_{cc_{max}} - 5V) * I_{abs} ; \quad T_{j_{max}} - T_a = P_{max} * (\sigma_{jc} + \sigma_{ca}) ;$$

$$\boxed{V_{cc_{max}} = 16,21V} \rightarrow \text{for ambient temperature} = 25^{\circ}\text{C}$$

### *Operation and board description:*

For getting started, it is recommended to plug the communication cables first. It is necessary a USB cable and also another cable which could be the DB9 or 6-pin connector cable or both.

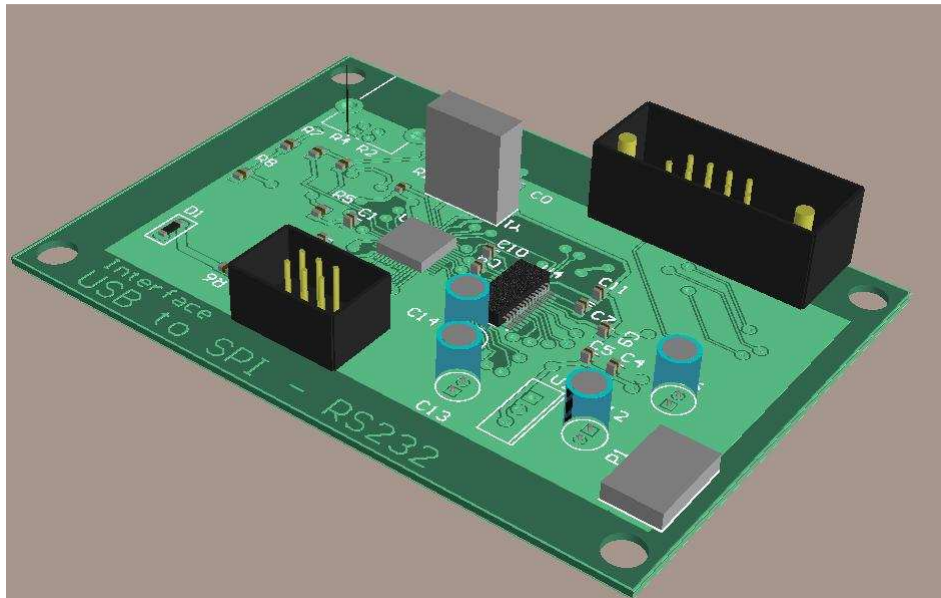
After doing that, the power has to be attached. Then the board is ready for bidirectional communication. The construction made allows having two RS232 ports, being the first one a low TTL level reduced RS232 (see signals for the 6-pin header above). The second port is called port B and it is a complete RS232 port with signals between +10V and -10V (see the DB9 connector in the table above).


### *Future revisions:*

- Flip the DB9 connector signals: 1.-GND, 2.-DTR, 3.-TXD, 4.-RXD, 5.-DCD, 6.-RIA, 7.-CTS, 8.-RTS, 9.-DSR.
- Pull high (+5V) pin 24 for the SP213EHCA.

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*PCB Overview:*



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### 3.4.3 PCB 2: TEMPERATURE – PRESSURE – HUMIDITY SENSOR MODULE.

#### *Introduction:*

This board is part of the ZigBee network, being an end-device on it. It has two chip sensors for measuring 3 magnitudes: temperature, pressure and humidity; these measurements are sent to the coordinator device due to store the data.

#### *Main chosen elements:*

##### **Pressure sensor:**

The prices of this kind of sensors in farnell website were considerably high. Then, the priority was to find a cheap detector which measure was absolute press (that's the way to quantify the atmospheric pressure). On the other hand it becomes necessary a 10 V voltage source, which will be built with a pump charger switching voltage regulator.

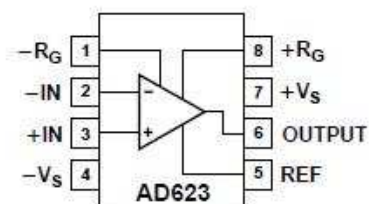



It is also necessary to collect information about the relationship pressure – output voltage, and that is because the output is not lineal over 100kPA. The elected CI for this purpose is the **MPXM2102**.

**Datasheet** in the DVD folder: .../Datasheets/Sensors

##### **Instrumentation differential amplifier:**

Due to the low output signal given by the pressure sensor, it is needed to amplify it by an instrumentation amplifier. The one chosen is called AD623. Main properties: single supply operation, low cost, low current consumption (less than 1 mA) and a wide range of gains



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between  $[1, 1000]$ , being  $V_o = (1+100k/R_g) * V_{in}$ .

**Datasheet** in the DVD folder: .../Datasheets/Others

### Switched capacitor voltage converter:

Because of the fact that the pressure sensor needs a +10V voltage power source, a voltage doubler is required. The choice is the LM2766 because of the low cost, high efficiency and easy to build for doubling the input voltage.

### Humidity and temperature sensor:

Humidity is difficult to measure because the sensor element is used to be a variable capacitor. Its capacity range is short and it is necessary to quantify an AC value. That is the reason why the **choice** for this aim is an integrated sensor with serial digital interface; the **SHT11**. It's easy to manage, the cost is affordable and it has a temperature sensor integrated.



**Datasheet** in the DVD folder: .../Datasheets/Sensors

### Power acquisition:


Input power source required: DC voltage source between 7.5V and 14V:

$$I_{abs} = I_{MPXM2102AS} + I_{SHT11} + I_{JN5139} + 2I_{LED} =$$

$$= 6+1+150+40 \text{ mA} \approx 200 \text{ mA}$$

$$P_{max} = (V_{cc} - 5V) * I_{abs} = (T_j - T_a) / (\sigma_{jc} + \sigma_{ca});$$

$$V_{ccMAX} = 14V \rightarrow \text{for ambient temperature} = 25^\circ\text{C}$$

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### *Operation and board description:*

In order to boot the system, is required the power to be plugged to the 2 pin-header power connector.

After power-up, the microcontroller routine acquires one measurement every minute and sends it to the datalogger module by ZB protocol. During the data acquisition the LED "D2" blinks in order to advice that the system is working. LED "D3" indicates that the module is correctly powered up.

There is one analog input, the one from the pressure sensor, which goes to an ADC input, specifically the ADC input n<sup>o</sup> 1. This input is voltage limited by a zener diode to 3.6V.

The microcontroller also has a reset button and a digital output which is used for managing the data LED "D2".

### *Software:*

The software for every board is in C language, using CodeBlocks programming environment which has a GNU code compiler. The software has to be transferred to the JN5139 flash memory by the plug-in called Jennic Flash GUI (Tools/flash GUI).

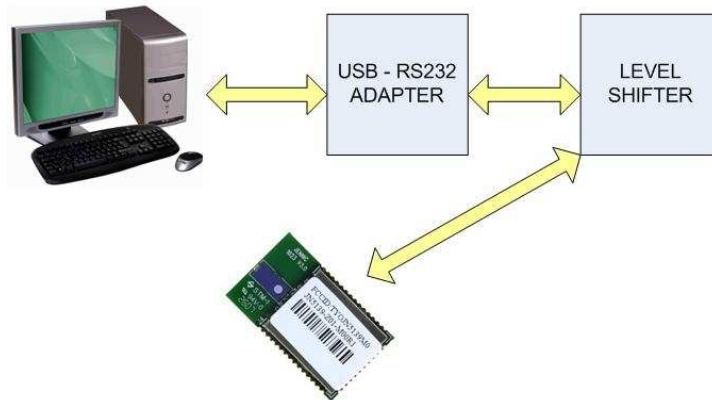
Further information in the DVD, directory: .../Datasheets/JN5139/ JN-UG-3007-Bin to Flash (flash programmer).pdf

### *Future revisions:*

- Modify MPXM2102 and TLV1117-3.3 footprints.
- Modify reset switch footprint.
- Use a DIP header for the AD623.
- Add C2 ( $\approx 2\mu\text{F}$ ), a diode for the output (1N4148) and decrease the C1 value ( $\approx 1-2\mu\text{F}$ ), for the voltage doubler.

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## FLASH PROGRAMMING SYSTEM



### Functions:


**tempMeasurement:** this is a function which receives no parameter and sends the correct commands (by lines data and clk) to the SHT11 sensor in order to get the temperature. The result must be stored in a 16 bit variable (type uint16) for subsequent format adaption by the function calcTemp.

**calcTemp:** uses the temperature data obtained by the function above and gives it a format which consists on 4 BCD digits: tens, units, tenths and hundredths. This 4 BCD variable is returned by the function.

**humMeasurement:** this is a function which receives no parameter and sends the correct commands to the SHT11 sensor in order to get the humidity. The result must be stored in a 16 bit variable (type uint16) for subsequent format adaption by the function calcHum.

**calcHum:** uses the temperature and humidity data obtained by the functions above and returns a variable which consist on 4 BCD digits: tens, units, tenths and hundredths. This humidity 4 BCD variable is expressed in % and it is temperature compensated.



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**LedToggle:** this procedure toggle a LED in the selected DIO pin by pulling high or low this output. No parameter and no variable returned.

**delay:** this function uses one parameter which is a 16 bit integer (type uint) for establishing the delay time in milliseconds. When it works the microcontroller dozes and wakes up by a timer.

**tictac:** this function pulls high and down the clock signal for the SHT11 and it is necessary for the communication with it.

**transmissionStart:** the object of this function is to make a delay for correct powering up the SHT11 and send the command start of transmission.

The ADC functions are included and descript in the document "JN-RM-2001-Integrated-Peripherals-API-2v8.pdf". The ADC is tested and it works properly.

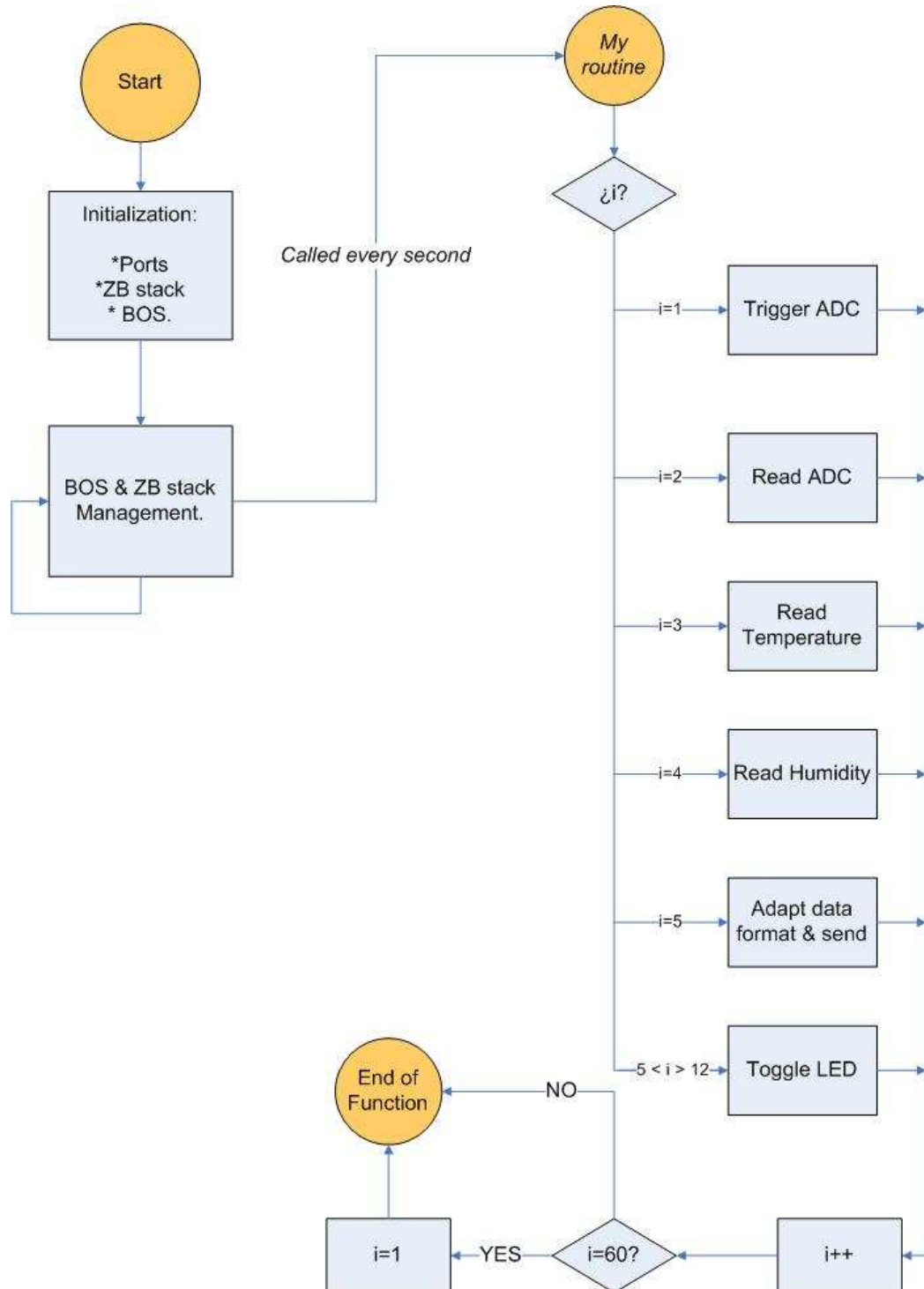
Signals are checked on the oscilloscope but communication not tested on the SHT11.

The structure for this module software was taken from the Jennic example "JN-AN-1024-Zigbee-Wireless-Lightswitch".

CodeBlocks project can be found on the DVD:  
.../Software/CBProjects

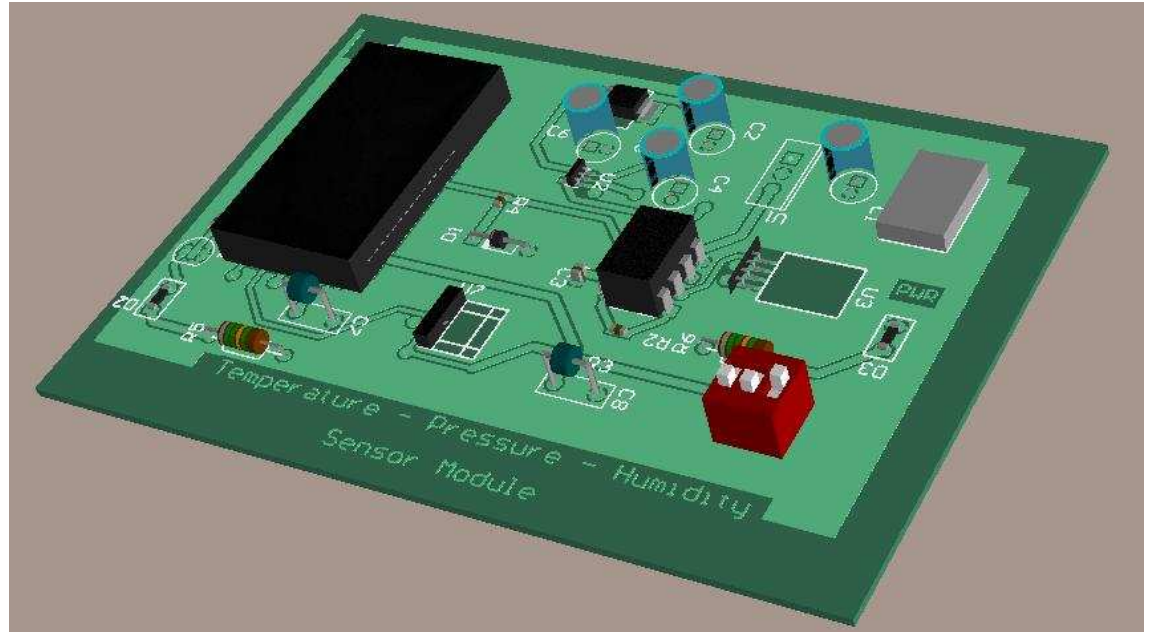
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### Block diagram:



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*PCB Overview:*



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### 3.4.4 PCB3: DATALOGGER MODULE.

#### *Introduction:*

This board is part of the ZigBee network, being the coordinator device on it. It includes a SD card socket for data storing, a SPI header for possible communication with the PC and a switch for power source selection. The data acquired by radio is saved to the SD card.

#### *Main chosen elements:*

##### **Memory device:**










The datalogger must be able to acquire one sample per minute from each sensor for 4 days. Including the date and time in each data package the total of memory necessary for the system is pretty big. Then the best choice is to buy a cheap and massive amount of memory device. The memory which compliments these requisites is flash memory.


There are two protocols widely implanted in the industry: USB flash drives and SD / MMC cards. The election was the SD card because of its size and the amount of information founded over internet about its implementation in several projects.

The SD card manual is located in .../Datasheets/Others

Amount of memory calculation:

##### **BASIC DATA PACKAGE:**

								 = BCD digit
1	2	3	4	5	6	7	8	

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1. Data type.	}	TOTAL  10 bytes
2. Year.		
3. Month.		
4. Day.		
5. Hour.		
6. Minute.		
7. Second.		
8. Sensor data.		

Memory needed per sensor= 10B x 4 days x 24 hours x 60 minutes =  
57600 Bytes / sectors per sensor.

#### *Operation and board description:*

First of all the board should be powered up. There are two ways for powering up the board. Most common way for this matter is to connect a DC power source to the power header, same way as the other boards. If a SPI communication with the computer or another device is able, the board can be fed by the 6-pin connector. There is a switch for selecting one or the other way.

The ZigBee module must work as a coordinator. It receives the data from the sensors and then it becomes a data package by adding the data type, hour and date. Once the data package is ready, it is stored in the SD card. The microcontroller also is responsible of the time managing.

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### *Future revisions*

- Modify reset switch footprint.

### *Software:*

For this module I use the ELM-FAT file system for the SD card, found on [http://elm-chan.org/fsw/ff/00index\\_e.html](http://elm-chan.org/fsw/ff/00index_e.html). The FAT functions are explained on this webpage, but I will comment the modified ones, which are referred to low level SPI operations.

**diskio.c:** this is the part of the FAT file system which has to be modified in order to work in different platforms. Concretely the macros:

**SELECT():** activates the CS signal for the SD card. CS=low.

**DESELECT():** deactivates the CS signal for the SD card pulling it high.

**FCLK\_SLOW():** configures the SPI for a low speed clock signal (133Khz in this case). This is used for booting and getting started with the card.

**FCLK\_FAST():** configures the SPI for a high speed clock signal (8 MHZ in this case). This is used for normal card operations such as writing or reading a block.

**xmit\_spi(dat):** transmits "dat" through SPI bus. "dat" is an 8 bit variable.

**rcvr\_spi:** this is not a macro but a function which returns an 8 bit data received by the SPI bus.

**power\_on:** it is a procedure that sets up the SPI bus for low clock speed and a timer for making an interrupt every 10 ms.

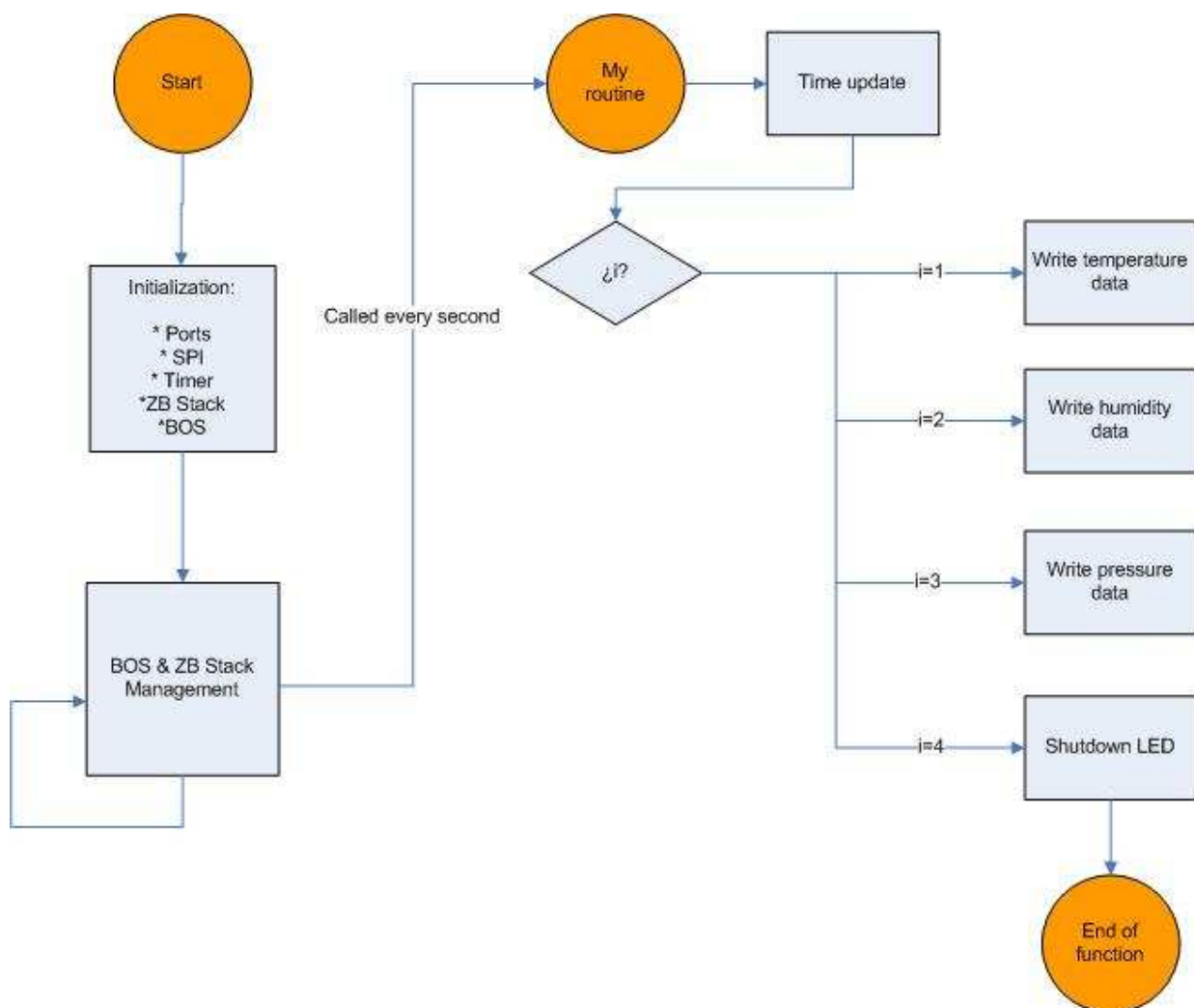
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Then there is a 30 ms delay and the LED is turned on if everything is OK.

**vTimer1ISR:** this is the timer interrupt procedure which is called every 10 ms due to detect card insertion, write protected cards or other card status.

The developed software for this module is a SD card test which has to create on it a text file called "a.txt" in the folder "test". At this moment it is not functional yet.

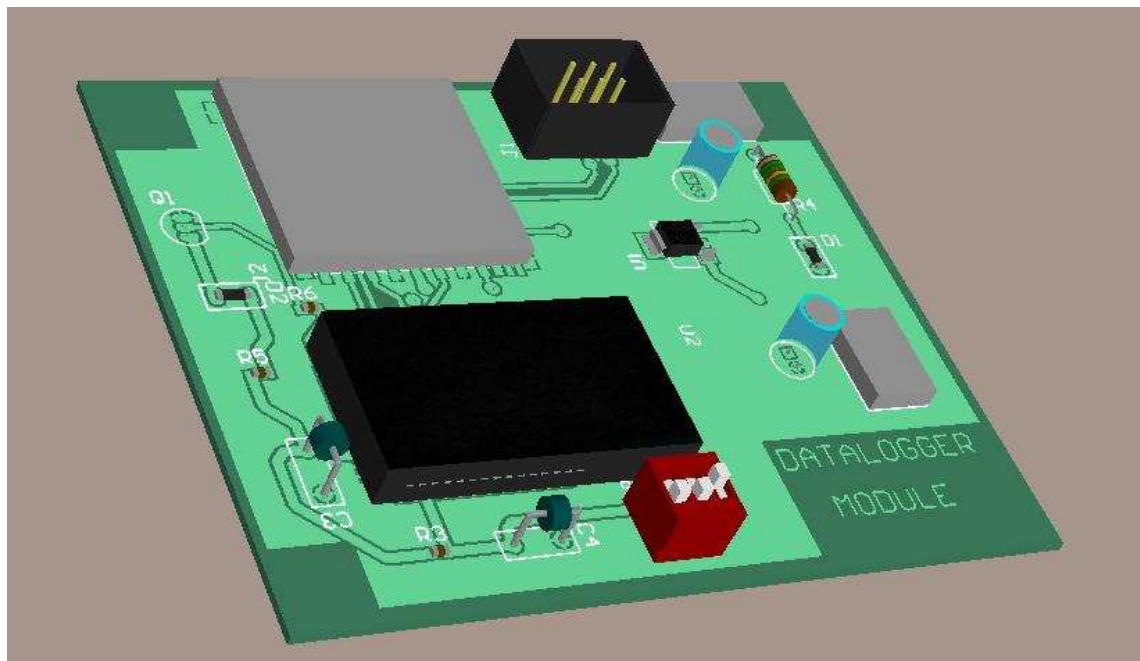
This is the block diagram about how this module should work:




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CodeBlocks project located in ../Software/CBProjects

*PCB Overview:*





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### 3.4.5 PCB4: CARRIER BOARD.

#### *Introduction:*

Due to the JN5139 microcontroller footprint, it is needed a carrier board for testing designs and programming the device by the boot loader. That is because the chip may be able to be soldered once but doing it for several times could damage the chip.

The carrier board allows flash programming by SPI interface, RS232 interface and normal operation also.

#### *Main chosen elements:*

The design is taken from the website <http://alastair.d-silva.org/jennic-5139-modules>. Because of that there was no design election to do. In addition, this board has no special element added, except for the JN5139 module.

#### *Operation and board description:*

The board is powered by the 6-pin SPI interface, or the RS232 header, or even the pad pins.

There are two jumpers and two switches.

The jumper in the up-left corner is used for linking the SPI selection signal from the JN5139 to its flash memory or leaving it disconnected for SPI programming the device with a flash programmer.

Second jumper is in the low-middle area of the board. It is a write protection pin which allows or not the flash to be erased.

The switch down the SPI connector is used to reset the microcontroller.

The switch which is in the left part of the 6-pin header is used for enter programming mode. That is done by holding the programming

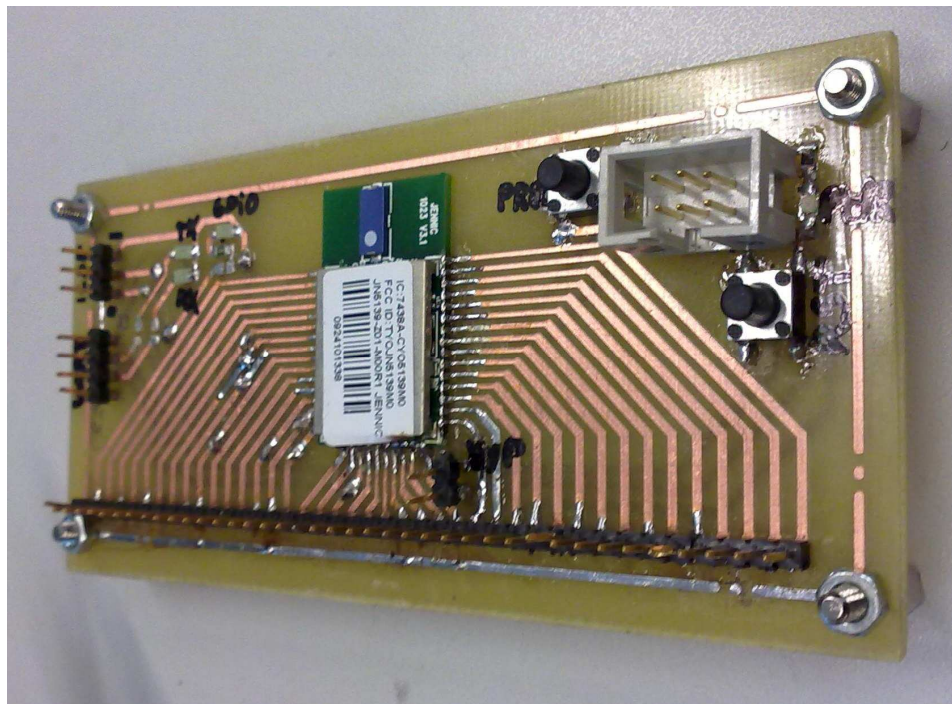
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button while reset. That makes the MISO pin went low (0V) while resetting the device, and enter programming mode through UART as a consequence.

There is one LED which indicates the correct power up, other one for GPIO test and two more for transmitting and receiving data visualization.

For activate normal mode it is only required to press and release the reset button.

#### *PCB Overview:*



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### 3.4.6 PCB5: ZIGBEE BASE.

#### *Introduction:*

This module is another version of the carrier board, which is simpler, and its aim is to carry the JN5139 module. It offers the possibility of attaching a 40-pin connector for general purposes.

Nothing more is included so every application has to be built in a separate board.

#### *Main chosen elements:*

##### **40-pin header:**

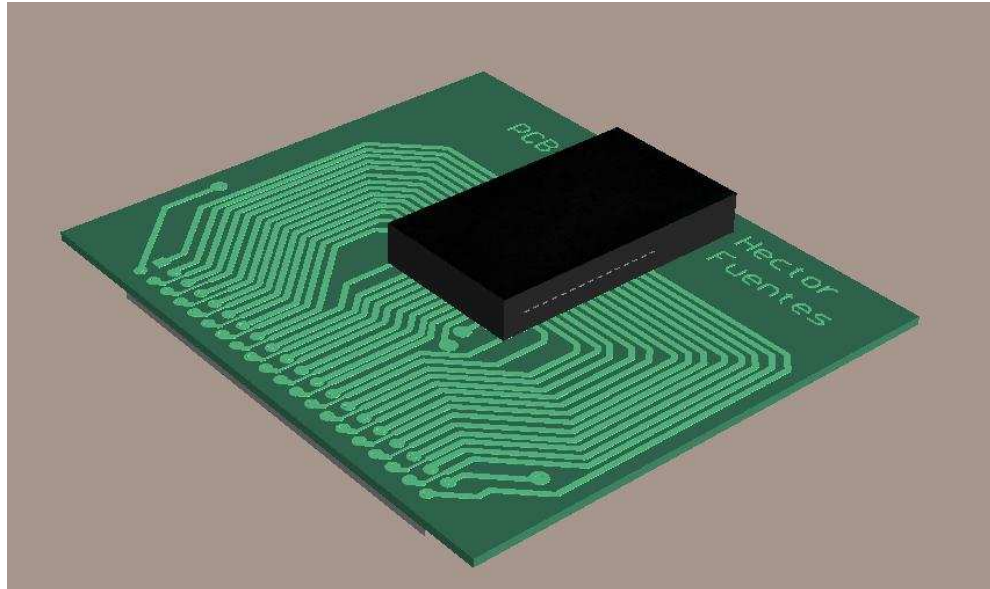
The JN5139 has 41 pins but two of them are always tied together. Those pins are digital ground and analog ground. That is why all pins are able to be used with a 40-pin connector.

#### *Operation and board description:*

The operation mode and purpose of this board is decided by the user. All kind of uses for the JN5139 module are allowed to be built and it depends only on the designer choice.

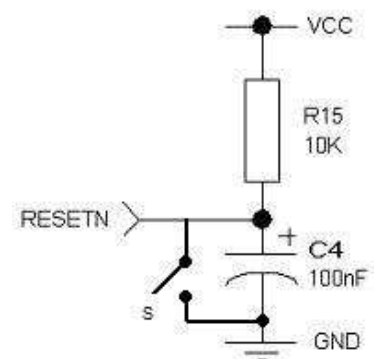
<b>NHL</b> HOGESCHOOL	TITLE	ZIGBEE SENSOR NETWORK	CHECKING DATE	19/1/2010
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*PCB Overview:*



### 3.4.7 GENERAL MODIFICATIONS.

- Increase the clearance in ground planes.
- Remove ground plane in the power header area.
- Modify the holes for the power header ->  $\phi=1.2\text{mm}$
- Allow on board programming for the new modules:
  - Add jumper/switch for SPWP pin which switches between Vcc and GND.
  - Switch for the MISO pin to pull it low.
  - Header for connecting TX and RX signals.
- Use the following reset circuit:



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#### 4 **CONCLUSION.**

##### 4.1 USB TO RS232 INTERFACE.

This board is working properly, but it is not as simple as it could be. For this project I only need the low TTL RS232 reduced protocol (Rx,Tx). It could be done with only one communication port USB to RS232. Then SP213EHCA wouldn't be needed, a level shifter neither.

##### 4.2 PRESSURE, TEMPERATURE AND HUMIDITY SENSOR MODULE.

In this board I would change the pressure sensor, because the chosen one is not lineal over 100KPA, which is quite usual in atmospheric pressure.


I would also add the possibility of on board programming (3.4.7 General modifications).

This board's hardware is done, but not tested. Due to the long time taken by the software development I could not finished with that. The SHT11 communication software is written but not tested, while the ADC for the pressure sensor is tested and works fine, as well as DIOs.

The ZigBee routines are almost codified but no tested because one of the modules has its flash memory broken.


##### 4.3 DATALOGGER MODULE.

Due to the SD card, there is no need for communicating the board with the PC. Then the 6 pin header could be removed. This means that there is only one way for powering up the device, so the switch is not useful. The hardware is finished, but not the software. The FAT32 file system is almost codified, it only needs to be tested and debugged for correct operation.

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#### 4.4 CARRIER BOARD AND ZB BASE.


Making the on board programming available means that no carrier board would be needed. This could be possible by adding LED diodes for debugging the software in some unused DIO pins.

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## 5. LITERATURE.

### 5.1 LINKOGRAPHY.

- <http://www.wikipedia.com>:
  - Preface/Measurement :  
<http://en.wikipedia.org/wiki/Measurement>
  - Preface/Wireless, Early wireless work:  
<http://en.wikipedia.org/wiki/Wireless>
  - RISC processors:  
[http://en.wikipedia.org/wiki/Reduced\\_Instruction\\_Set\\_Computer](http://en.wikipedia.org/wiki/Reduced_Instruction_Set_Computer)
  - ZigBee communication:  
<http://en.wikipedia.org/wiki/ZigBee>
- Devices operation, datasheets: <http://www.farnell.com>
- Carrier board, programming method for JN5139:  
<http://alastair.d-silva.org/jennic-5139-modules>
- SD card programming and connections:  
<http://www.forosdeelectronica.com/f24/lecto-grabador-tarjetas-mmc-sd-microsd-pic16f877a-8177> (Spanish)  
[http://www.mcu.fluxfocus.com/index.php?option=com\\_content&view=article&id=50&Itemid=61](http://www.mcu.fluxfocus.com/index.php?option=com_content&view=article&id=50&Itemid=61)
- <http://www.jennic.com> :
  - Jennic module datasheets:  
[http://www.jennic.com/support/application\\_notes/](http://www.jennic.com/support/application_notes/)
  - ZigBee learning centre:  
<http://www.jennic.com/elearning/zigbee/index.htm>
  - Software development:  
<http://www.jennic.com/support/software/>
  - Other doubts about Jennic product JN5139:  
<http://www.jennic.com/support/forums/index.php>

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- Devices datasheets: <http://www.datasheetcatalog.com/>
- USB to RS232 interface datasheets, example projects :  
<http://www.ftdichip.com/Projects/FTDIChip-ID.htm>
- FAT file system software and code examples for different controllers: [http://elm-chan.org/fsw/ff/00index\\_e.html](http://elm-chan.org/fsw/ff/00index_e.html)
- Complete SD Project with low level code example for FAT file system above:  
[http://frank.circleofcurrent.com/cache/fat\\_sd.htm](http://frank.circleofcurrent.com/cache/fat_sd.htm)


## 5.2 BIBLIOGRAPHY.

- "Apuntes de microprocesadores" Bonifacio Martín del Brío, Antonio Bono Nuez: notebook from EUITIZ, University of Zaragoza.
- "Transductores y sistemas de instrumentación" Bonifacio Martín del Brío, Antonio Bono Nuez: notebook from the EUITIZ, University of Zaragoza.

## 5.3 PDFs.

- *Sensors:*
  - Humidity and temperature sensor SHT1X.
  - Pressure sensor MPXM2102AS.
- *ZigBee Module:*
  - MAC address and ZigBee license installer, JN-AN-1066.
  - JN51xx Flash Programmer User Guide, JN-UG-3007.
  - Boot Loader Operation, JN-AN-1003.
  - Using DIO Interrupts, JN-AN-1040.
  - Storing Data in Flash, JN-AN-1044.




	TITLE	ZIGBEE SENSOR NETWORK	CHECKING DATE	19/1/2010
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- Data Sheet JN513X, JN-DS-513X.
- Integrated Peripherals API, JN-RM-2001.
- Module Development, JN-RM-2006.
- CodeBlocks, JN-UG-3028.
- ZigBee Stack User Guide, JN-UG-3017.
- ZigBee Wireless Light Switch, JN-AN-1024.

- *Others:*

- Bipolar transistor BC547B datasheet.
- Bit mode functions for the FT2232, AN2232-02.
- Instrumentation amplifier AD623 datasheet.
- SD card socket SDCMF-10715W1T0 datasheet.
- Switched capacitor voltage converter LM2766 datasheet.
- FT2232D Dual USB UART/FIFO I.C. datasheet.
- USB to SPI Bus interface sample project.
- 1206 - Bipolar monochrome LED datasheet.
- SD card manual v1.9 datasheet.
- High Performance RS232 Transceiver SP213EHCA datasheet.
- LM78XX series voltage regulator datasheet.
- Adjustable and fixed low-dropout 3.3 V voltage regulator TLV1117 datasheet.
- LT1X40A leadless chip LED datasheet.


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#### 5.4 SOFTWARE:

- Altium designer 6.8.1.11816
- Eagle 5.6
- Multisim 10.0
- Jennic CodeBlocks svn 3466.
- Jennic MAC address / ZigBee license installer 1.3.0
- Notepad++ 5.5.1
- Jennic Flash Programmer 1.5.12
- Microsoft Virtual PC.

#### 5.5 OTHER REFERENCES:

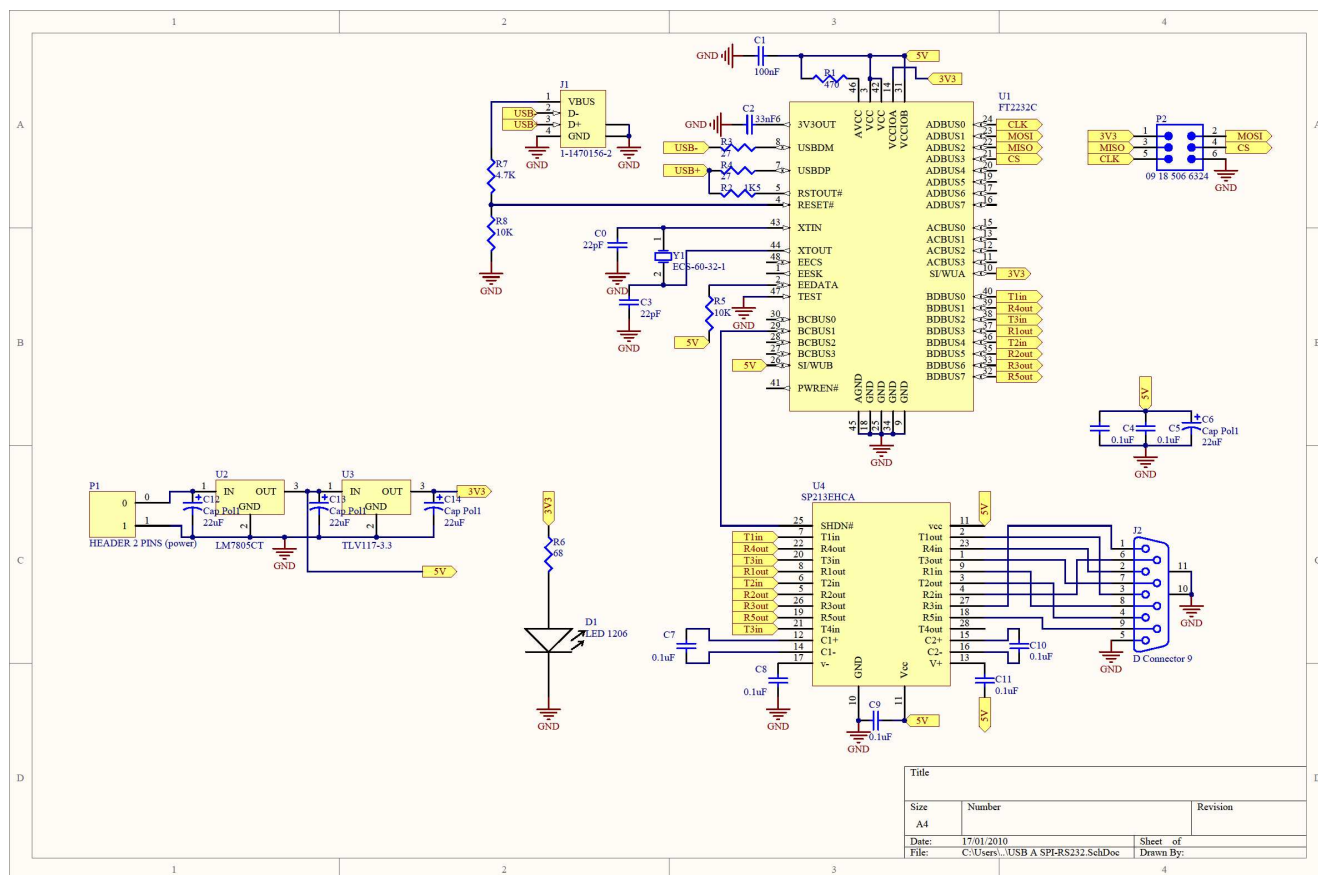
- Laboratory components list sheets and boxes:
  - Available chip resistors/capacitor list.
  - Electronic material cabinets.
  - 0805 resistors/capacitors box.
- Department-mates.

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## 6 APPENDIX.

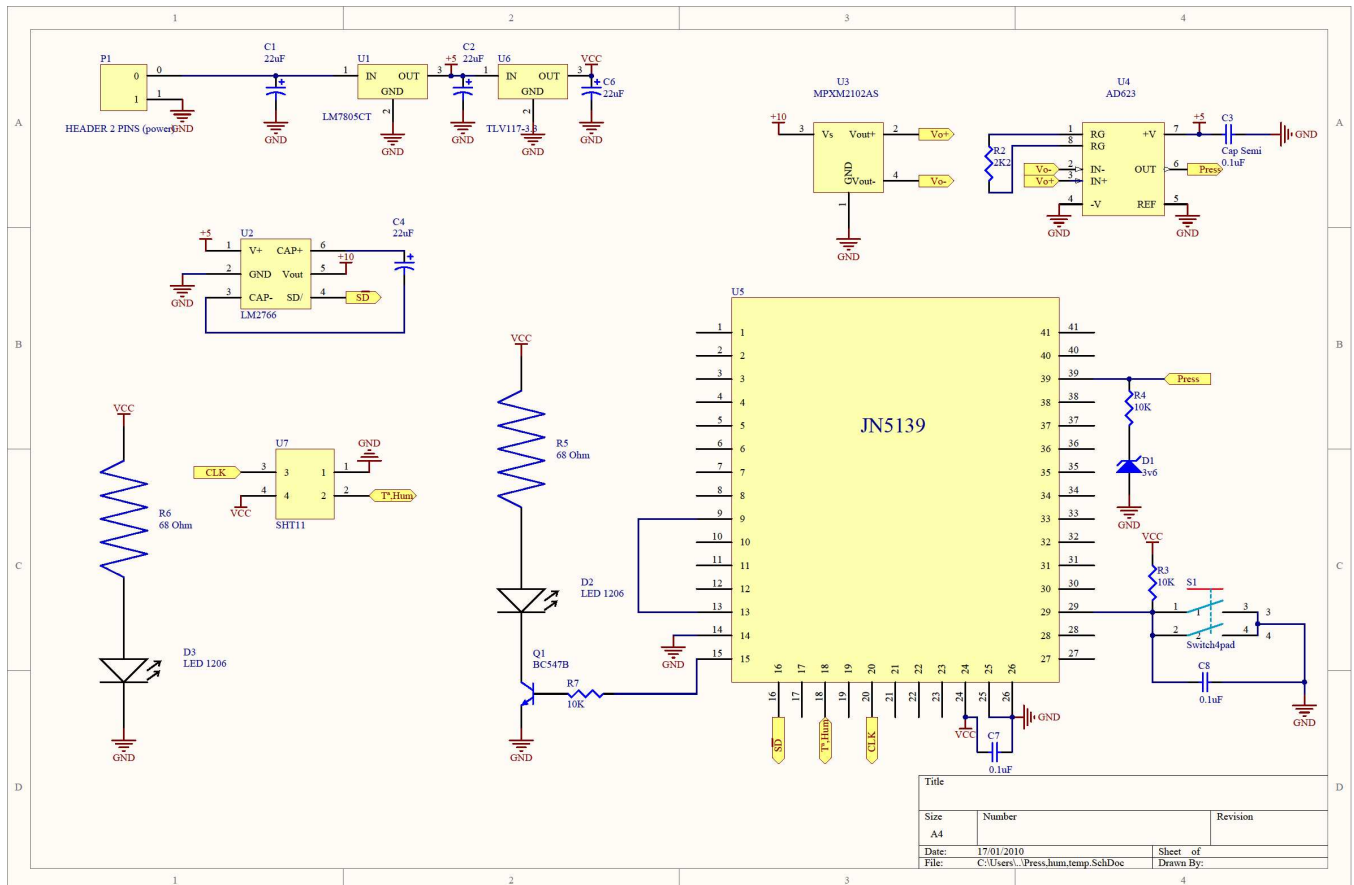
### 6.1 SCHEMATICS.

#### 6.1.1 USB TO RS232 INTERFACE.



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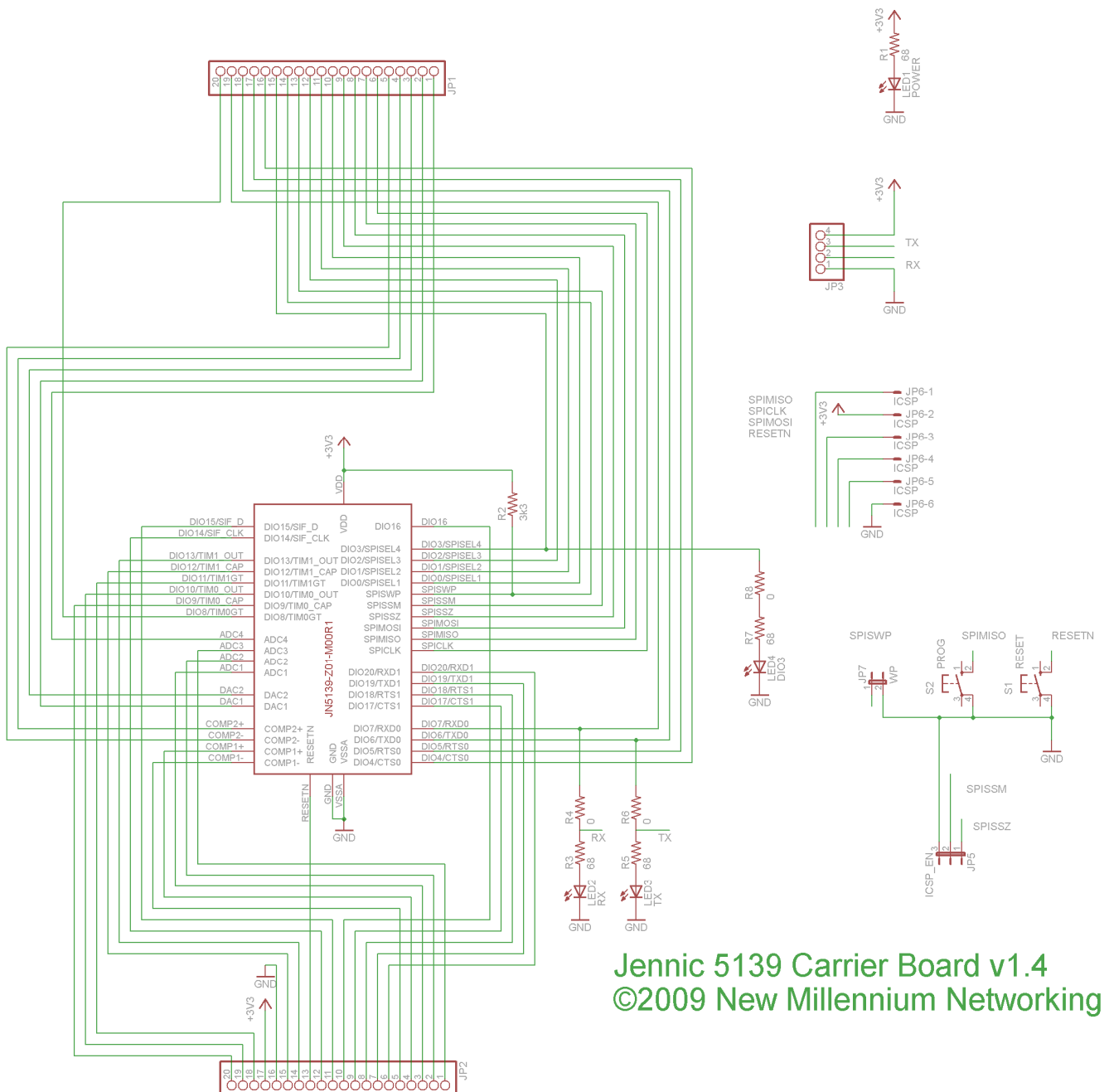
### 6.1.2 PRESSURE, TEMPERATURE, HUMIDITY SENSOR MODULE.





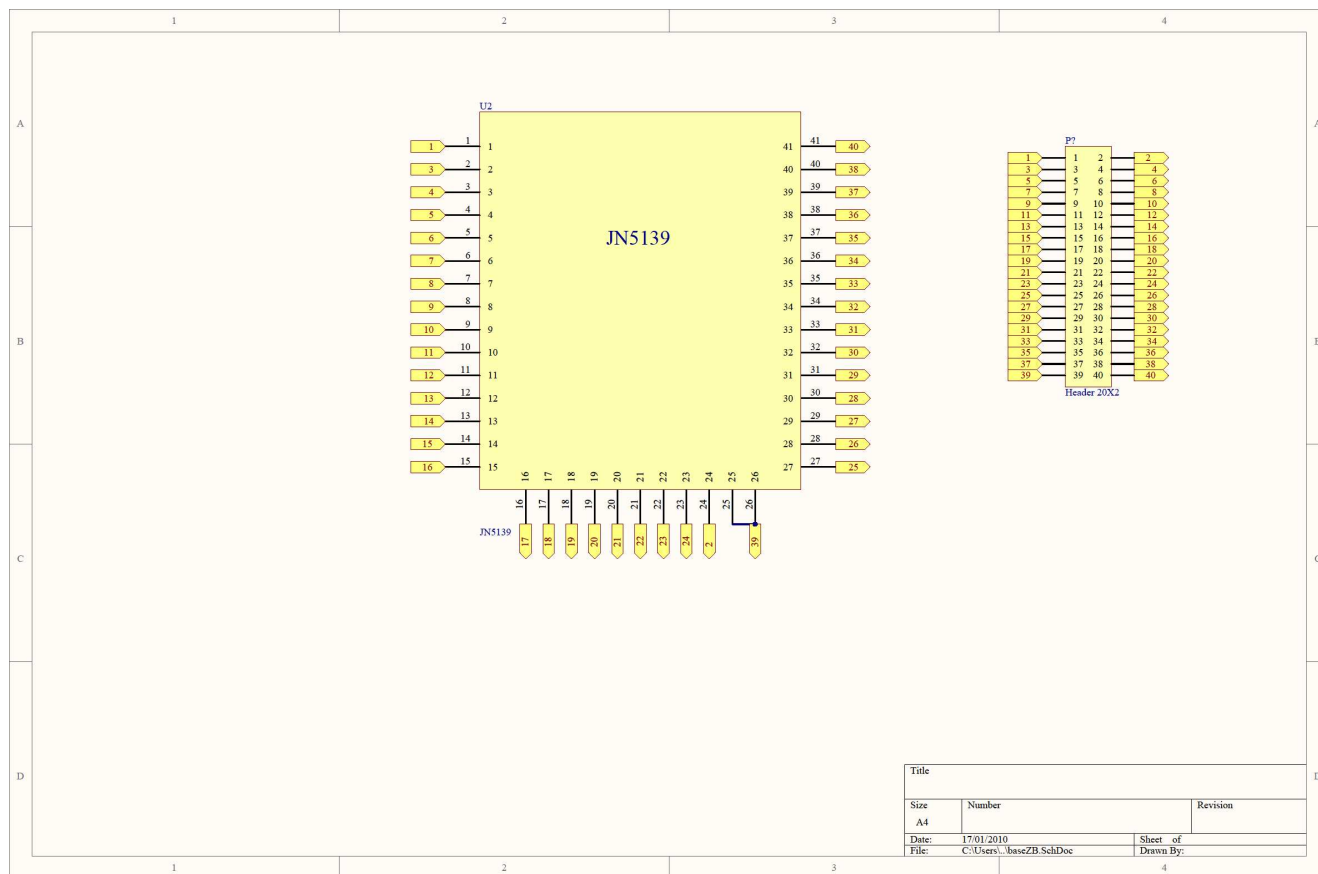
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#### 6.1.4 CARRIER BOARD.



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### 6.1.5 ZB BASE.

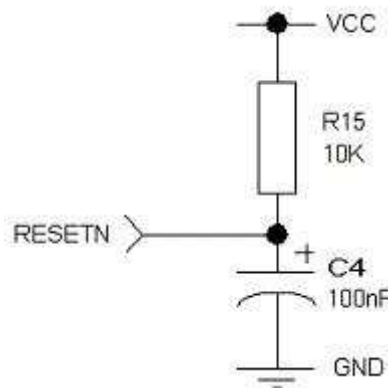


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## 6.2 ENTERING PROGRAMMING MODE FOR JN5139.


*What are the minimum connections required for programming modules?*

- 1) Connect power and ground on pins 24 (VDD), 25 (GND) & 26 (VSSA).
- 2) Ensure that pins 9 (SSZ) and 13 (SSM) are tied together. This allows the SPI Select signal from the JN5121 device to communicate with the FLASH.
- 3) Disable the write protect on the FLASH by tying pin 14 (SWP) HIGH.
- 4) To ensure correct power up, the reset circuit shown below must be applied to pin 29 (RESETN). If required a switch can be applied between RESETN and GROUND.



- 5) At power up or reset the Boot Loader first looks at pin 7 (MISO) to determine whether to go into programming mode. To enter programming mode, pin 7 (MISO) must be held LOW at power up or reset and then released.
- 6) Serial communications are made on pins 18 & 19 (TXD, RXD). These signal levels must be level shifted to 3.3V.



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### 6.3 DVD CONTENTS:

- .../Index.txt: DVD contents.
- .../PCBs: PCBs layouts for building the boards.
- .../PCBProjects: altium designer 6 and eagle 5 projects for different boards.
- .../Datasheets:
  - /sensors: different sensor datasheets.
  - /JN5139: Jennic ZigBee module related datasheets.
  - /Others: different devices datasheets.
- .../Software: free code software:
  - Codeblocks developing environment and license installer for ZB modules.
  - /CBProjects: My own programs for the JN5139 module.
- .../Report: Project report.