International Journal of Electronics and Communication Engineering & Technology (IJECET)
Volume 6, Issue 8, Aug 2015, pp. 07-11, Article ID: IJECET_06_08_002
Available online at
http://www.iaeme.com/IJECETissues.asp?JTypeIJECET&VType=6&IType=8
ISSN Print: 0976-6464 and ISSN Online: 0976-6472

ESP 8266: A BREAKTHROUGH IN WIRELESS SENSOR NETWORKS AND INTERNET OF THINGS

Manan Mehta
ARK Techno solutions, Mumbai, India

ABSTRACT

Imagine how millions of sensors around the world can be so helpful if its data is published online. Imagine the power when instant data can be available for purposes such as education, medical, government, businesses, and much more. This interesting outcome can be possible by the interconnection of objects under a vast and ever growing umbrella called the Internet of Things (Iot). However, live projects are not yet as omnipresent as you would expect. There are plenty roadblocks we are yet to overcome. However, this paper is to educate people on some of the solved issues of the technology via a small Wi-Fi to serial module called ESP 8266.

Key words: ESP8266, Espressif Systems, Internet of Things (IoT), Low Power Communication Systems, System on Chip (SoC), Wi-Fi, Wireless Technologies and Wireless Sensor Network (WSN)

Cite this Article: Manan Mehta. ESP 8266: A Breakthrough in Wireless Sensor Networks and Internet of things. *International Journal of Electronics and Communication Engineering & Technology*, **6**(8), 2015, pp. 07-11. http://www.iaeme.com/IJECET/issues.asp?JTypeIJECET&VType=6&IType=8

1. INTRODUCTION

Wireless Sensor Networks are channels where data from the physical world can be accessed and utilized by any computation device in the world. On similar lines, Internet of things is the connection of various such devices with the ability to share information across multiple platforms through a unified framework such as cloud computing. These two streams are similar such that both collect data for analysis and processing.

Surprisingly, these technologies aren't totally in action yet because of its problems, such as costings of a project, power efficiency and simplification in interfacing [1]. What makes this interesting is that IoT and WSN is the future of the rapidly growing field of Data Collection and Analysis.

Research and development in the fields of VLSI has a solution to these roadbloacks; Espressif System's ESP8266 variants. The paper first talks about the ESP8266 and its various variants. It then covers how it has simplified Iot and WSN projects and in extension how it has solved the above mentioned problems faced.

2. ESP 8266

Projects and initiative from major giants, such as Cisco's Planetary Skin, HP's central nervous system for the earth (CeNSE), and smart dust, will populate the world with billions of sensors, connected to the Internet [4].To achieve this task we need to solve the basic challenges faced by these IoT and WSN initiatives and projects. The ESP 8266 is a low cost, high performance System on Chip Wi-Fi to serial module, part of Espressif System's 'Smart Connectivity Platform' that aims to provide mobile platform designers to innovate systems with embedded Wi-Fi Capabilities at the lowest cost with the greatest functionality.

The module has various variants; ESP8266-xx (01-13). Each module is just a development over the previous in terms of hardware capabilities with ESP8266-01 being the cheapest and the one with minimal features to ESP8266-13 being the most expensive with maximum features. The various features iclude number of GPIO pins, presence of shield, antenna, type of package (Through-hole or Surface mount), memory and handling external analog signals. We will talk more in general with references more to ESP8266-01 and ESP 8266-12.

The most basic board, the ESP8266-01 consist of 2 GPIO pins, UART communication, low powered 32-bit CPU and a PCB antenna. Other modules also have ADC input capabilities, SPI, I2C and more GPIO pins.

Despite the advantages of the module, there is still limited published data on the internet as it is still relatively new. The module gained popularity towards the end of the 2014 calendar year.

3. HARDWARE SETUP

The ESP8266 family requires a 3.3v and up to 250mA power supply. Various power supply breakout boards can be designed using an LM1117 voltage regulator as shown in fig. 1

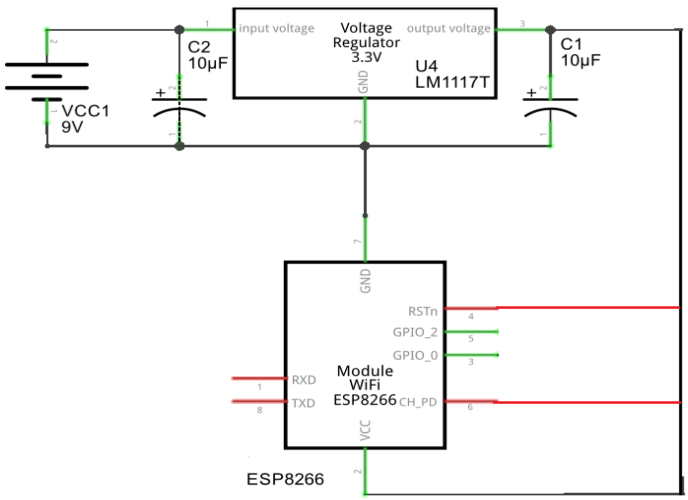

Figure 1 Circuit digram to use a LM1117 voltage regulator to setup a 3.3 volts power source using a battery for the ESP8266.

4. SYSTEM ADVANTAGES

The ESP8266 is packed with features and hence it requires minimal external circuitry and the entire solution, including the front-end module, is designed to occupy minimal PCB area.

4.1 Economical

Amongst the major advantages of the module include its price. You can get a module at lower than $5. In comparison, most other Ethernet and Wi-Fi modules/shields cost in the range from $30 to $60.

TABLE 1 Some Transceivers, Ethernet and Wi-Fi module prices:

ESP8266-01	$ 5
Ethernet Shield for Arduino	$ 60
Zigbee	$ 25
Wify Shield Sparkfun	$ 40
Wi-Fi Shield For Arduino	$ 80
Huzzah Wi-Fi shield by Adafruit	$ 40
ESP8266-12	$ 7

Not just in terms of purchasing price, the module is economical in terms of developing a system. The on board 32bit CPU with memory eliminates any requirement for an external controller boards such as an Arduino making it a standalone SOC having capabilities to process and transmit data over the internet.

Originally in place of ESP8266 in WSN, various transceivers were used such as the NRF24L01+ or Zigbee which are connected to central systems which upload data to the web. This gives rise to added hardware and increases costs. The ESP8266 in contrast can directly connect to the internet without the need for any extra, in between hardware and reducing interfacing issues. This means each sensor node can be directly accessed and does not depend on a central system to retrieve its data as far as the node is connected to the internet.

Thus, presence of an on board CPU, low purchase cost and ability to directly connect to the internet makes various WSN/IoT projects economical

4.2 Power

ESP8266 modules operate in various modes which optimize the system and yields power efficient systems. The power saving architecture operates in 3 modes: active mode, sleep mode and deep sleep mode.

The various power management states are:

- OFF: CHIP_PD pin is low. The RTC is disabled. All registers are cleared.
- DEEP_SLEEP: Only RTC is powered on – the rest of the chip is powered off. Recovery memory of RTC can keep basic ‘Wi-Fi Connecting’ information.
- SLEEP: Only the RTC is operating. The crystal oscillator is disabled. Any wakeup events (MAC, host, RTC timer, external interrupts) will put the chip into the WAKEUP state.
- WAKEUP: In this state, the system goes from the sleep states to the PWR state. The crystal oscillator and PLLs are enabled.
- ON state: the high speed clock is operational and sent to each block enabled by the clock control register. Lower level clock gating is implemented at the block level,

including the CPU, which can be gated off using the WAITI instruction, while the system is on.

In terms of numbers, the Power down leakage current is < 10uA, has +19.5dBm output power in 802.11b mode and Standby power consumption of < 1.0mW (DTIM3) ESP8266 consumes less than 12uA in sleep mode and less than 1.0mW (DTIM=3) or less than 0.5mW (DTIM=10) [5] to stay connected to the access point.

TABLE 1 Current Ratings in Various Modes

Mode	Typ	Unit
Transmit 802.11b, CCK 1Mbps, POUT=+19.5dBm	215	mA
Receive 802.11b, packet length=1024 byte, -80dBm	60	mA
Standby	0.9	mA
Deep Sleep	10	uA
Power save mode DTIM 1	1.2	mA
Power save mode DTIM 3	0.86	mA

4.3 Ease of Interfacing

The most important part of a node, in both IoT and WSN, is that it has to communicate with multiple sensors [2] and be easily callibrated when required by reprogramming it. As each package of ESP8266 has various features, we can choose the exact module to fit a particular system and satisfy the various needs of the system.

For communication, all the ESP8266 have UART communition pins; Rx and Tx. Higher versions such as the ESP8266-12 have the master serial interface (SI) which can operate in two, three or four-wire bus configurations to control the EEPROM or other I2C/SPI devices. In fact, multiple I2C devices with different device addresses are supported by sharing the 2-wire bus. Multiple SPI devices are supported by sharing the clock and data signals, using separate software controlled GPIO pins as chip selects. The SPI can also be used for controlling external devices such as serial flash memories, audio CODECs, or other slave devices.

ESP8266-12 has an analog input available meant to handle analog signals. The analog to digital circuit (ADC) has a resolution of 10 bits and with a voltage range of 0-1v.

The above gives rise to multiple options in terms of hardware interfacing. Along with hardware interfacing, it is also simple to program the ESP8266 in multiple ways.

The NodeMCU is an open source firmware and hardware kit for easier IoT project using the ESP8266 as the base and using interactive LUA scripting language for programming. This development makes it easier for beginners as a lot of example codes and instructions have been provided by the NodeMCU community.

We can also use Arduino IDE to program the ESP8266 [6]. In fact the programming is very familiar to what was used originally for IoT projects using the Wi-Fi Shield.

A simple Blink program for the ESP8266, GPIO pin 2:

```
int ledPin = 2;

void setup() {

pinMode(ledPin, OUTPUT);

}
```

```
void loop() {
digitalWrite(ledPin, HIGH);   // turn the LED on
delay (1000);                 // wait for a second
digitalWrite(ledPin, LOW);    // turn the LED off
        delay (1000);                 // wait for a second
}
```

Using an open source platform such as Arduino IDE along with an FTDI programmer makes the system very simple to interface and program.

5. CONCLUSION

There still exist a lot of bugs present and as time passes various firmware issues would be solved. The absence of concrete paper work and detailed instruction manual still leaves a lot of room for research and development. However, there is finally a technological leap in the field of internet in terms of what systems are connected. With IoT and WSN projects rampant and in demand, ESP8266 surely becomes a key component to drive the research and development of these technologies forward. The very existence of such a cheap and easy to use module is an indicator that soon the whole world will have a lot of data to analyse and make life easier and more comfortable.

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