



**DESIGN AND DEVELOPMENT OF AN
ELECTRONIC BELT SCALE IN AGGREGATE
CRUSHER SYSTEMS**



A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report “**DESIGN AND DEVELOPMENT OF AN ELECTRONIC BELT SCALE IN AGGREGATE CRUSHER SYSTEMS**” is the bonafide work of **Mr.SIVABALAKRISHNAN.R (13BEC141), Mr.VIGNESH.T.V (13BEC166), Mr.SATHIESH.G (13BEC211), and Mr.DINESH.M (13BEC240)** who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other project or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

Belt scales were used in industries as an equipment to measure the flow rate of material travelling over a conveyor belt. Load cell which is mounted on a well-supported straight section of belt, converts the stress into electrical signals. Analog signal from the load cell is amplified and converted into digital signal by using HX711. Controller calculates the flow rate by using digital signal from the HX711 and speed of the belt. The main aim of this project is to design a remote monitoring system for Electronic Belt scale for monitoring the rate of production through internet from any part of the world.

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LIST OF ABBREVIATION

LVDT	Linear Variable Differential Transformer
SG	Strain Gauge
PGA	Programmable Gain Amplifier
ESCP	Espressif Systems' Smart Connectivity Platform
SOC	Software on Chip
SDK	Software Development Kit
RDBMS	Relational Database Management System
SQL	Structured Query Language
DTP	Distributed Transaction Processing
MVC	Model View Controller
IoT	Internet of Things
I2C	Inter-Integrated Circuit
PWM	Pulse Width Modulation
UART	Universal Asynchronous Receiver/Transmitter
HDMI	High-Definition Multimedia Interface

1. INTRODUCTION

1.1. History of Belt Scales

The belt scales was invented by Blake Dennison in 1896. Then in 1908, the belt scale with unique 'rotating wheel' was invented by Herbert Merrick. Those belt scales were large and big in size because they follow their own structural housing. All the belt scales are purely mechanical and no electronics components were used. The Research and Development of belt scales was ravaged due to the world wars and the depression. This period was known as Dark ages of Belt Scales (1920-1950). After the World War II the Linear variable differential transformer was invented and electronic integrator was starting to appear. LVDT was introduced in 1946. They were temperature sensitive and needed heaters [13].

1.2. Basic Operation

Most of the plant situations require the transport of materials like coal, sand, salt aggregate gravel, lime etc. With the advent of fast mode of transportation, accounting the quantity of material transferred assumes great importance. Belt scales are most common type continuous weighing devices and consists of one or more conveyor idlers mounting on a weigh frame. Since weight remains as the most reliable index of material accounting and can be measured directly and precisely, designers can offer accurate weighing systems to maintain higher accuracy and better accountability in the process.

The belt load is transmitted from weigh frame either direct or via a lever system to a load cell. The combined output from load cell and speed sensor provides the flow rate of the material passing over the scale.

The Main features of Load cell are

- High reliability and accuracy.
- Trouble free operation under severe environmental conditions.
- Practically no effect of belt tension on weighing.
- Simple installation and easy maintenance.

1.3. Block Diagram

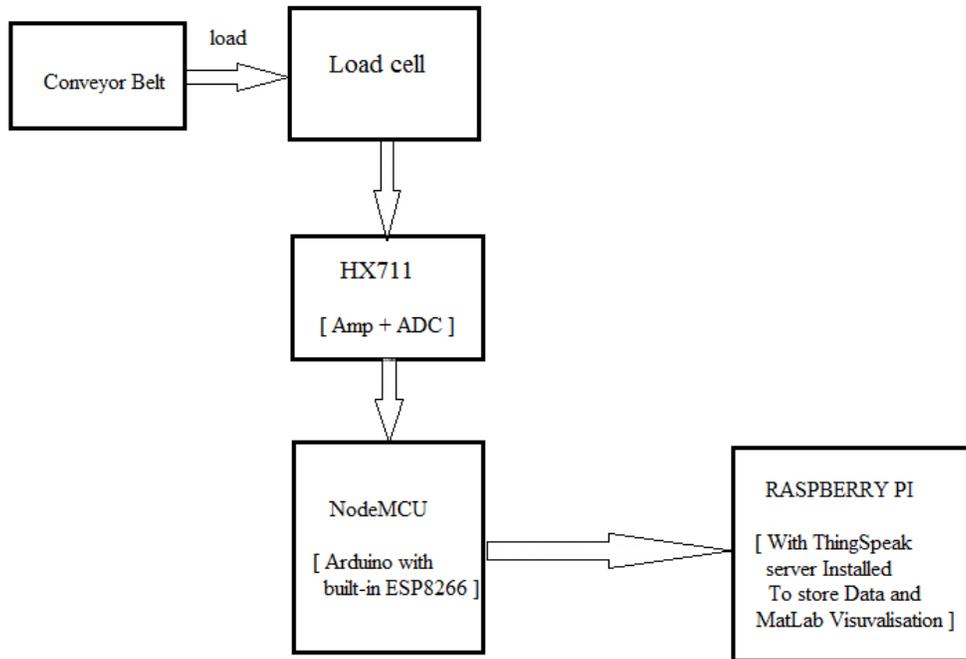


Fig 1.1 – Block Diagram for remote monitoring system

Load cell input is given to the instrumentation amplifier circuitry, which amplify the input signal and is given to ADC. The digital output from ADC is given to the micro controller. The DAC will produce an analog 4-20 mA output corresponding to flow rate.

1.4. Calculation of Flow Rate

Belt scales are integrating weighing devices that use a simple integral Calculus summation process to measure a conveyed quantity of material. The weight function measure small section of conveyor. The material passing over a Belt Conveyor exerts a downward force proportional to its weight. The product of this force and the speed of the belt is the rate of flow, the unit being kg/minute or Tons/hour.

Taking a section of unit length between 'aa' and 'bb' on the belt, the reaction 'R' at the center of that section equals the weight of the material including the belt weight, on that section. The tension of the belt 'T' has got no influence on reaction 'R' if 'T' and 'R' are mutually perpendicular.

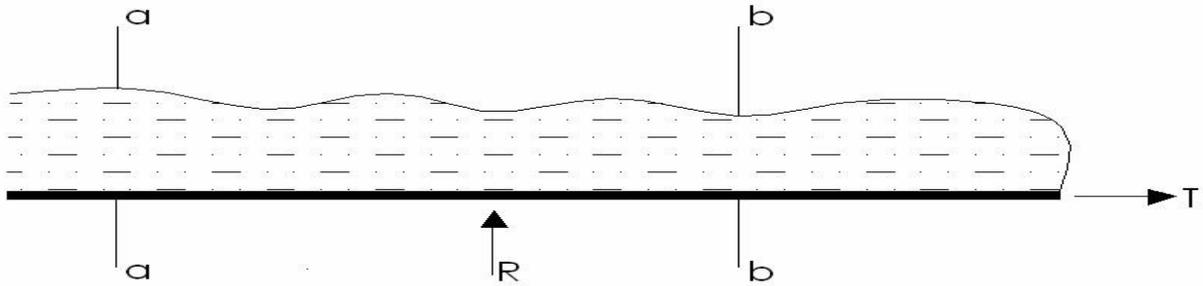


Fig 1.2 – Conveyor belt

Let the weight between 'aa' and 'bb' (unit length) = w kg/m

Let the speed of belt = s m/s

Therefore, material flow/min. = $w \times s$

The rate of flow $w \times s$ integrated over a period of time gives the total quantity of material transferred over that time [3].

2. HARDWARE TOOLS

2.1. Load cell

Day-in and day-out we have been using electronic scales or weighing machines. If we go to any grocery store or a jewelry shop; the items are weighed using electronic weighing machines

At the heart of electronic scales or weighing machines is a sensor called load cell. These sensors sense the force (or weight) of the items and the electronic circuitry processes the sensors' output and displays it on the indicator. Load cells are highly accurate transducers which provide the user with information not generally obtainable by other technology due to commercial factors. Usage of load cell is not limited to electronics scales, they are also used in load testing machines, industrial scales, flow-meters, etc., In short, load cell can be used wherever there is a requirement of "force measurement".

As per dictionary, a load cell is described as a "weight measurement device necessary for electronic scales that display weights in digits." However, load cell is not restricted to weight measurement in electronic scales.

Load cell is a passive transducer or sensor which converts applied force into electrical signals. They are also referred to as "Load transducers" [1].



Fig 2.1- Load cell

Load cells uses different operating principles. They are

- Load Cells based on fluid pressure.
- Load Cells based on elasticity.
- Load Cells based on piezoelectric effect.

2.1.1. Types of load cells

Strain gauge Load cell

Through a mechanical construction, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as a change in electrical resistance, which is a measure of the strain and hence the applied forces. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (Quarter Bridge) or two strain gauges (half bridge) are also available. The electrical signal output is typically in the order of a few millivolts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer. Sometimes a high resolution ADC, typically 24-bit, can be used directly.

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms/stretches/contracts when the material of the load cells deforms appropriately. These values are extremely small and are relational to the stress or strain. The change in resistance of the strain gauge provides an electrical value change.

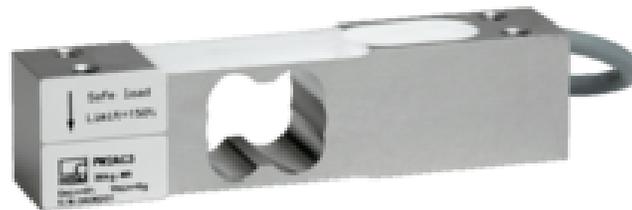


Fig 2.2-Double bending beam load cell element

Strain gauge load cells convert the load acting on them into electrical signals. The gauges themselves are bonded onto a beam or structural member that deforms when weight is applied. In most cases, four strain gauges are used to obtain maximum sensitivity and temperature compensation. Two of the gauges are usually in tension can be represented as T1 and T2, and two in compression can be represented as C1 and C2, and are wired with compensation adjustments.

The strain gauge load cell is fundamentally a spring optimized for strain measurement. Gauges are mounted in areas that exhibit strain in compression or tension. When weight is applied to the load cell, gauges C1 and C2 compress decreasing their resistances. Simultaneously, gauges T1 and T2 are stretched increasing their resistances. The change in resistances causes more current to flow through C1 and C2 and less current to flow through T1 and T2. Thus a potential difference is felt between the outputs or signal leads of the load cell. The gauges are mounted in a differential bridge to enhance measurement accuracy. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load. Other load cells are fading into obscurity, as strain gauge load cells continue to increase their accuracy and lower their unit costs.

Piezoelectric Load cell

Piezoelectric load cells work on the same principle of deformation as the strain gauge load cells, but a voltage output is generated by the basic piezoelectric material - proportional to the deformation of load cell. It is very useful for dynamic/frequent measurements of force. Most applications for piezo-based load cells are in the dynamic loading conditions, where strain gauge load cells can fail with high dynamic loading cycles. It must be remembered that the piezoelectric effect is dynamic, that is, the electrical output of a gauge is an impulse function and is not static. The voltage output is only useful when the strain is changing and does not measure static values. However, depending on conditioning system used, "quasi static" operation can be done. Another advantage of piezoelectric load cell, conditioned with a Charge amplifier, is the wide measuring range that can be achieved. Users can choose a load cell with a range of hundreds of kN and use it for measuring few N of forces with the same Signal to Noise ratio, again this is possible only with the use of a "Charge amplifier" conditioning.

HYDRAULIC LOAD CELL:

The cell uses conventional piston and cylinder arrangement. The piston is placed in a thin elastic diaphragm. The piston doesn't actually come in contact with the load cell. Mechanical stops are placed to prevent over strain of the diaphragm when the loads exceed certain limit. The load cell is completely filled with oil. When the load is applied on the piston, the movement of the piston and the diaphragm results in an increase of oil pressure. This pressure is then transmitted to a hydraulic pressure gauge via a high pressure hose. The gauge's Bourdon tube senses the pressure and registers it on the dial. Because this sensor has no electrical components, it is ideal for use in hazardous areas. Typical hydraulic load cell applications include tank, bin, and hopper weighing.

PNEUMATIC LOAD CELL:

The Load cell is designed to automatically regulate the balancing pressure. Air pressure is applied to one end of the diaphragm and it escapes through the nozzle placed at the bottom of the load cell. A pressure gauge is attached with the load cell to measure the pressure inside the cell. The deflection of the diaphragm affects the airflow through the nozzle as well as the pressure inside the chamber.

2.1.2. Load cell Specification

The main Specification of Load cell are,

- **Rated Capacity or Rated Load**

Rated capacity is defined as the maximum load that a load cell can measure while meeting its specifications.

Example: Rated capacity: 100 kg

- **Rated Output**

Rated output is the difference when there is no load and when there is a load of rated capacity. It is generally expressed in output per excitation voltage (mV/V); alternatively called “span.”

Example: Rated Output: 1 mV/V

- **Safe Overload**

Safe Overload is the maximum load that can be applied without producing a permanent shift in the performance characteristics beyond those specified; specified as a percentage of the measuring range (i.e. 150% of rated capacity).

- **Compensated Temperature Range**

Compensated temperature range is the temperature range within which the rated output and the zero balance are compensated to meet load cell specifications.

- **Zero Balance**

Zero balance is the electrical output generated when a rated excitation voltage is applied without any load on the cell. It is generally expressed as a percentage of rated output.

Example: Zero Balance: $10 \pm 5\%$ of Rated output.

- **Temperature Effect on Zero Balance**

Temperature Effect on Zero Balance is the drifting of the zero balance caused by changes in the ambient temperature. This value is expressed as a percentage of rated output.

Example: Temperature effect on zero balance: 0.04% of Rated output/ 10°C

- **Temperature Effect on Rated Output**

Temperature Effect on Rated Output is the drifting of the rated output caused by changes in the ambient temperature.

Example: Temperature effect on span: 0.014% of Load/ 10°C typically.

- **Nonlinearity**

Nonlinearity is the maximum deviation in output from a linear calibration curve linking the zero balance and the rated output.

- **Hysteresis Error**

Hysteresis error is the maximum difference in output generated when a load increases and decreases.

- **Combined Error**

Combined error is the maximum deviation of output from a linear calibration curve linking the zero balance and the rated output, including when a load increases and decreases. It is specified as a percentage of the rated output.

- **Recommended/Maximum Excitation Voltage**

The recommended/maximum excitation voltage is the voltage applied to the input terminals of a load cell. Typical excitation is 10 V DC.

- **Insulation Resistance**

Insulation resistance is the direct current resistance between a load cell unit and its circuit.

Example: Insulation resistance: 500 M/DC 50 V.

2.1.3. Load cell Configurations

On application of external force, strains generated in the spring material are transformed to resistance change by strain gages. Since the change in resistances is very small, Wheatstone bridge, a circuit used to detect minor changes in resistance, is used. Wheatstone bridge is the network of four resistors as shown in Fig 2.3.

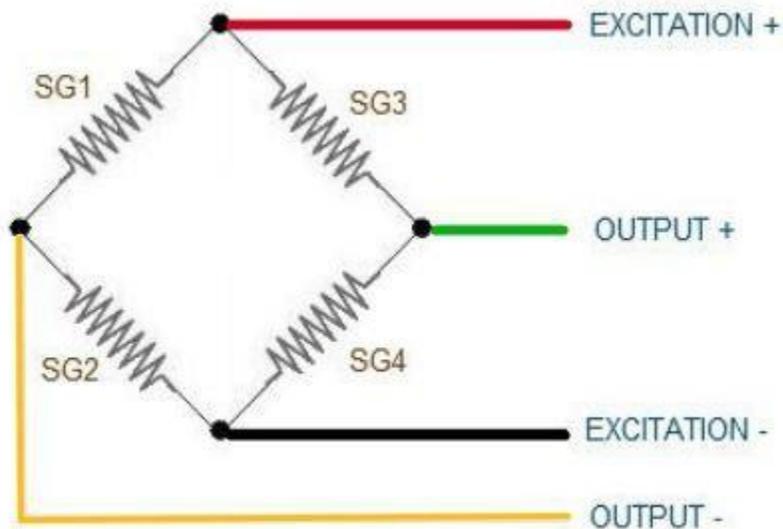


Fig.2.3 – Load cell configuration

Depending upon the number of strain gages used in the load cell, load cell is used in following three configurations

- **Quarter Bridge**

In this configuration, only one strain gage (out of the four) is used to sense the strains. It forms one arm of the Wheatstone bridge. Rest three resistances of the bridge are provided in the bridge completion network in the signal conditioning circuit.

- **Half Bridge**

In this configuration, two strain gage are bonded in the load cell to sense the strains and these two forms two arms of the strain gage. Rest two resistances of the bridge are completed in the signal conditioning circuit.

- **Full Bridge.**

In this configuration, all the four strain gages are bonded in the load cell to sense the strains. This configuration provides maximum sensitivity and is not affected by temperature changes.

2.1.4. Load cells – selection

Few things must be taken into account while selecting a load cell are,

- **Capacity**

Apart from the load to be measured, impact coefficient, load eccentricity coefficient should be taken into account. Thus capacity of the load cell selected should be higher by minimum of 10% of the maximum load to be measured.

- **Dynamic Range**

If load cell of very high capacity is selected, it may not be measure very small loads very accurately. As a rule of thumb, loads to be measured should be in the 10% to 90% of the rated capacity of the load cell.

- **Shape**

Shape of the load cell primarily depends upon the application and mounting arrangements of the load cell. For example, S-type is suitable for applications where force is applied on both the ends, whereas diaphragm type is suitable for applications wherein force is applied only at one end. Besides this, other specifications like rated output, temperature range, errors, and protection class should be given appropriate attention.

However, the only load cells which are prevalent are the load cells based on strain gages. Hence, the term 'load cell' means 'strain gage-based load cells'. The reason behind the wide adoption of strain gage-based load cells is their characteristics. They are,

- Highly precise and linear measurements
- Little influence due to temperature changes.
- Small size compared with other types of load cells.
- Long operating life due to lack of moving parts or any parts that generate friction.
- Ease in production due to small number of components.
- Excellent fatigue characteristics

2.1.5. Load cell – Benefits

The Benefits of Load cell are,

- Load cells are used in various industries to measure the mass or weight of the products electronically. Electronic data can be used for automated product check.
- Load cells provide quick and precise measurements.
- Compared with other sensors, load cells are relatively more affordable and have a longer life span.
- Ease in production due to small number of components [2].

2.2. CONVEYOR BELT:

2.2.1. INTRODUCTION:

A conveyor belt is the carrying medium of a belt conveyor system (often shortened to belt conveyor). A belt conveyor system is one of many types of conveyor systems. A belt conveyor system consists of two or more pulleys with an endless loop of carrying medium. One or both of the pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler pulley. There are two main industrial classes of belt conveyors. They are general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport large volumes of resources and agricultural materials, such as grain, salt, coal, ore, sand, overburden and more. The output signals from the checkweighers are always contaminated with noises due to vibrations of the conveyor belt and the object in motion. An employed digital filter is of Finite-duration Impulse Response (FIR) type that can be designed under the consideration on the dynamics of checkweighers [12].



Fig 2.4 - Load cell fixation in conveyor belt

2.2.2. Measurement in Conveyor Belt:

The basic principle for weighing a material flow on a conveyor belt is, that the material weight kg/m on the belt, travelling with the speed ($V = ds/dt$) m/s, is measured and integrated as it passes over an idler placed on a load cell (LC), whereby the mass flow rate (M) is:

$$M = q \cdot (ds/dt) = q \cdot v \quad \text{kg/s}$$

However, also the belt itself has a certain weight (b) per unit length (ds) kg/m, and in addition to this there is also the weight of the idler (I) kg, so that the total weight acting on the load cell is:

$$W = (q+b) \cdot ds + I \quad \text{kg}$$

In practice the dead load of the idler (I) is set to zero in the belt weighing instrument, and the total weight (B) kg for a complete revolution with the length (L) of the conveyor belt, is tare out on the weighing instrument:

$$B = \int_0^{s=L} b \cdot ds = 0 \quad \text{kg}$$

Hence, the quantity (Q) of the material conveyed over a certain time (minimum one full revolution of the belt) can be integrated as,

$$Q = \int_{t_1}^{t_2} M \cdot dt \quad \text{i.e.} \quad Q = \int_{t_1}^{t_2} q \cdot V \cdot dt \quad \text{kg(t)}$$

Hence, the total material quantity (Q) conveyed over a period of time is,

$$t = (t_2 - t_1) \quad \text{sec}$$

$$Q = q \cdot V \cdot t = q \cdot V \cdot (t_2 - t_1) \quad \text{kg}$$

Where (q) is the average material weight per unit length during the Integration period of time (t), which however should correspond to Minimum one full revolution of the belt.

2.2.3. Electronic Belt Scale - Principal Lay-out:

An electronic belt scale consists of one or more load cells (**LC**) carrying one or more idlers in a conveyor belt, a velocity/tachometer (**T**) measures the belt transfer or speed, and an electronic belt weighing instrument (**BW**) [3].

The electric signals from the load cell and tachometer is used to calculate the material flow rate (**FR**) and the total amount of material passing over the scale can be integrated and displayed on a digital counter (**C**).

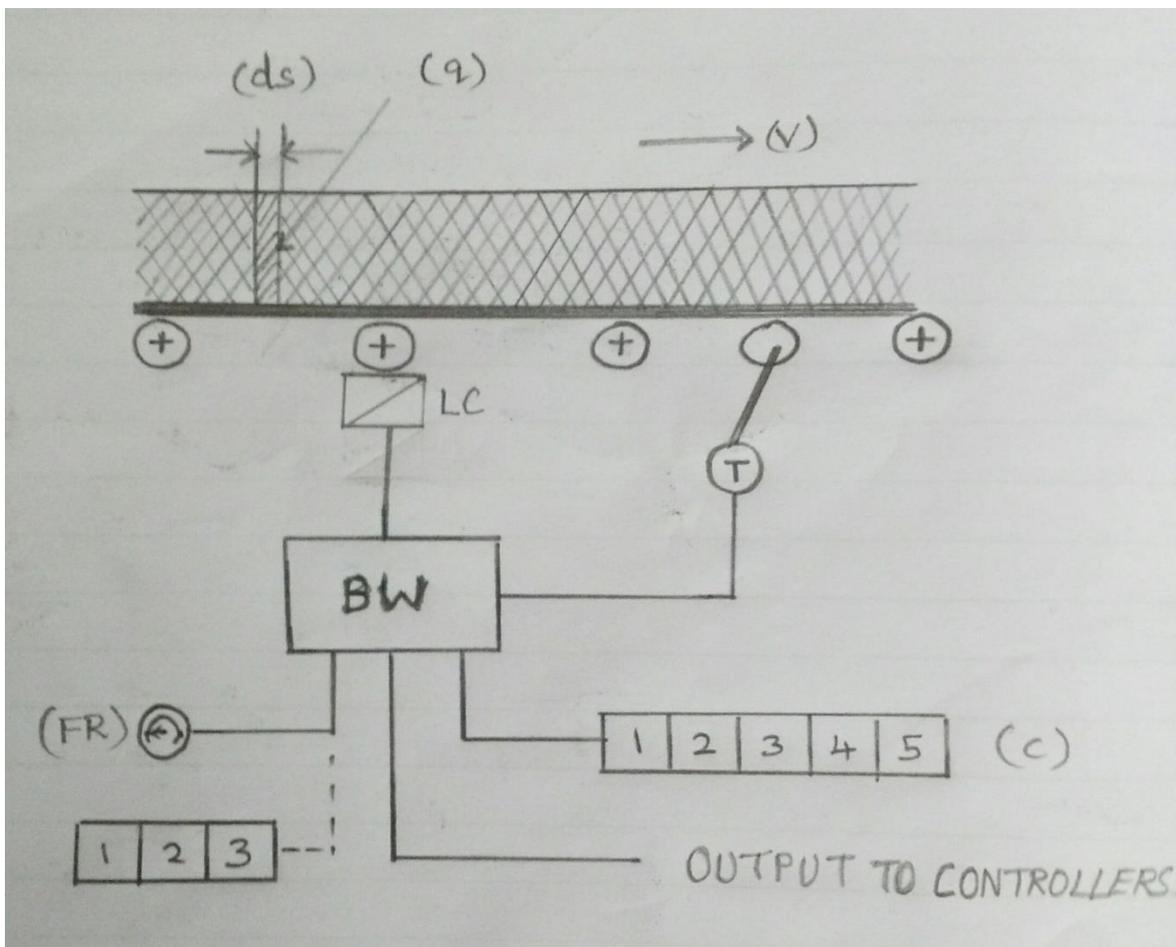


Fig 2.5 - Block diagram electronic belt scale

2.3. HX711 Load cell Amplifier

2.3.1. Introduction

Based on Avia Semiconductor's patented technology, HX711 is a precision 24-bit analog to-digital converter (ADC) designed for weigh scales and industrial control applications to interface directly with a bridge sensor. The input multiplexer selects either Channel A or B differential input to the low-noise programmable gain amplifier (PGA). Channel A can be programmed with a gain of 128 or 64, corresponding to a full-scale differential input voltage of $\pm 20\text{mV}$ or $\pm 40\text{mV}$ respectively, when a 5V supply is connected to AVDD analog power supply pin. Channel B has a fixed gain of 32. On chip power supply regulator eliminates the need for an external supply regulator to provide analog power for the ADC and the sensor. Clock input is flexible. It can be from an external clock source, a crystal, or the on-chip oscillator that does not require any external component. On-chip power on-reset circuitry simplifies the digital interface initialization. All controls to the HX711 are given through the pins.

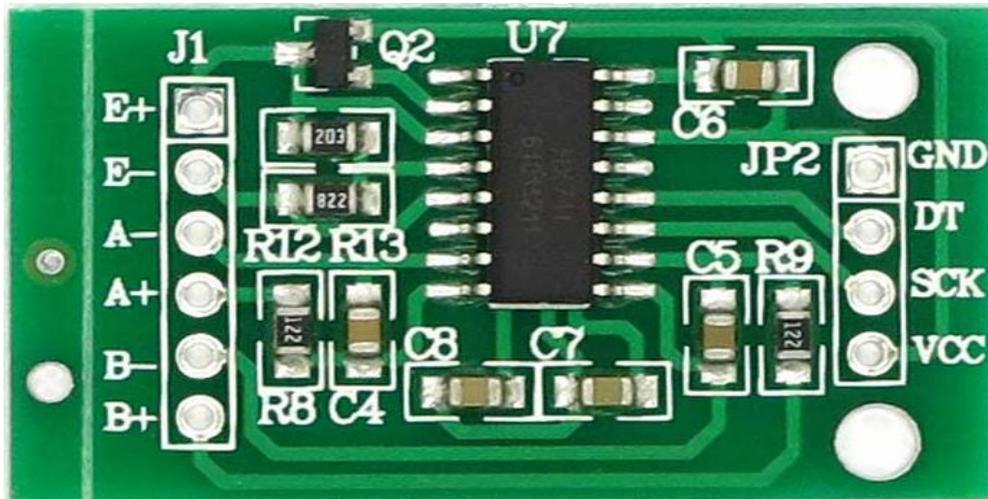


Fig.2.6 – HX711 load cell amplifier

2.3.2. Hx711 Circuit Diagram:

The circuit diagram for HX711 is given below

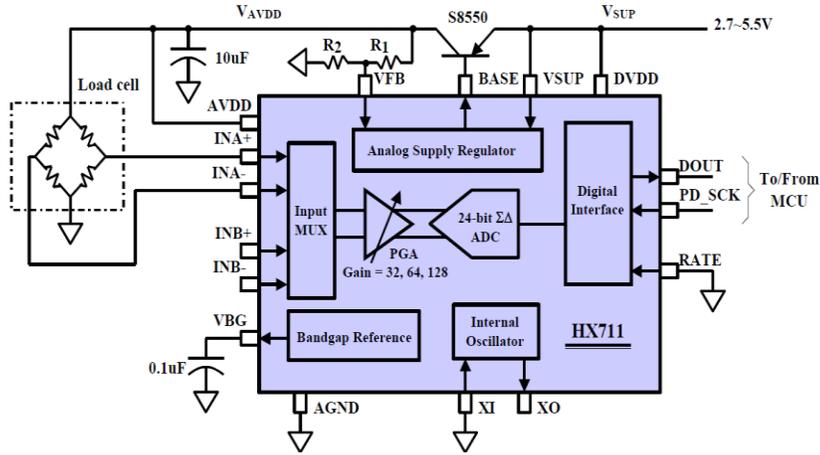


Fig.2.7 – HX711 Circuit diagram

2.3.3. Pin Diagram

The pin diagram for HX711 is given below,

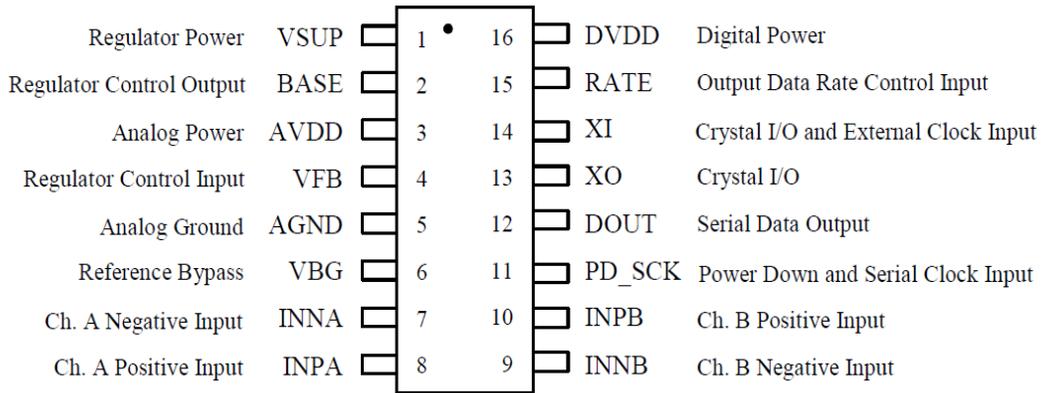


Fig 2.8 – HX711 – Pin diagram

2.3.4. Analog Inputs

Channel A differential input is designed to interface directly with a bridge sensor's differential output. It can be programmed with a gain of 128 or 64. The large gains are needed to accommodate the small output signal from the sensor. When 5V supply is used at the A_{VDD} pin, these gains correspond to a full-scale differential input voltage of $\pm 20\text{mV}$ or $\pm 40\text{mV}$ respectively. Channel B differential input has a fixed gain of 32. The full-scale input voltage range is $\pm 80\text{mV}$, when 5V supply is used at the A_{VDD} pin.

2.3.5. Power Supply:

Digital power supply (D_{VDD}) should be the same power supply as the MCU power supply. When using internal analog supply regulator, the dropout voltage of the regulator depends on the external transistor used. The output voltage is equal to $V_{A_{VDD}} = V_{BG} * (R1 + R2) / R1$. This voltage should be designed with a minimum of 100mV below V_{SUP} voltage. If the on-chip analog supply regulator is not used, the V_{SUP} pin should be connected to either A_{VDD} or D_{VDD} , depending on which voltage is higher. Pin VFB should be connected to Ground and pin BASE becomes NC. The external 0.1 μF bypass capacitor at the VBG output pin is then not needed.

2.3.6. Clock Source

By connecting pin XI to Ground, the on-chip oscillator is activated. The nominal output data rate when using the internal oscillator is 10 (RATE=0) or 80SPS (RATE=1). If accurate output data rate is needed, crystal or external reference clock can be used. A crystal can be directly connected across XI and XO pins. An external clock can be connected to XI pin, through a 20pF AC coupled capacitor. It can come directly from the crystal output pin of the MCU chip, with amplitude as low as 150 mV. When using a crystal or an external clock, the internal oscillator is automatically powered down.

2.3.7. Output Data Rate and Format:

When using the on-chip oscillator, output data rate is typically 10 (RATE=0) or 80SPS (RATE=1). When using external clock or crystal, output data rate is directly proportional to the clock or crystal frequency. Using 11.0592MHz clock, crystal results in an accurate 10 (RATE=0) or 80SPS (RATE=1) output data rate. The output 24 bits of data is in 2's complement format.

When input differential signal goes to the 24 bit range, the output data will be saturated at 800000h (MIN) or 7FFFFFFh (MAX), until the input signal comes back to the input range. On chip power supply regulator eliminates the need for an external supply regulator to provide analog power for the ADC and the sensor. Clock input is flexible.

2.3.8. Serial Interface:

Pin PD_SCK and D_{OUT} are used for data retrieval, input selection, gain selection and power down controls. When output data is not ready for retrieval, digital output pin D_{OUT} is high. Serial clock input PD_SCK should be low. When D_{OUT} goes to low, it indicates data is ready for retrieval. By applying 25~27 positive clock pulses at the PD_SCK pin, data is shifted to the D_{OUT} output pin. Each PD_SCK pulse shifts out one bit, starting with the MSB bit first, until all 24 bits are shifted out. The 25th pulse at PD_SCK input will pull D_{OUT} pin back to high. Input and gain selection is controlled by the number of the input PD_SCK pulses. PD_SCK clock pulses should not be less than 25 or more than 27 within one conversion period, to avoid causing serial communication error [7].

2.3.9. Features

The features of HX711 Amplifier as follows,

- Two selectable differential input channels
- On-chip active low noise PGA with selectable gain of 32, 64 and 128
- On-chip power supply regulator for load-cell and ADC analog power supply
- On-chip oscillator requiring no external component with optional external crystal
- On-chip power-on-reset
- Simple digital control and serial interface: pin-driven controls, no programming needed
- Selectable 10SPS or 80SPS output data rate
- Simultaneous 50Hz and 60Hz supply rejection
- Current consumption including on-chip analog power supply regulator:
Normal operation < 1.5mA, power down < 1uA
- Operation supply voltage range: 2.6V to 5.5V
- Operation temperature range: -40°C to +85°C

2.4. NODEMCU

2.4.1. Introduction

Espressif Systems' Smart Connectivity Platform (ESCP) is a set of high performance, high integration wireless SoCs, designed for space and power constrained mobile platform designers. It provides unsurpassed ability to embed Wi-Fi capabilities within other systems, or to function as a standalone application, with the lowest cost, and minimal space requirement.

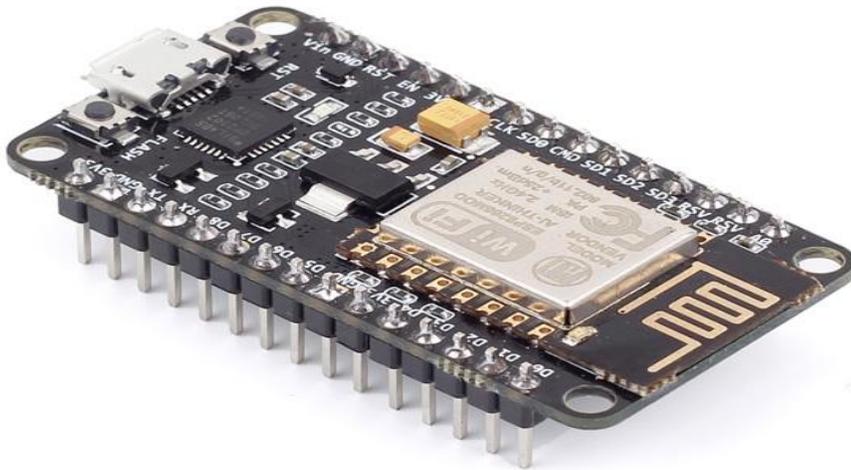


Fig 2.9 - NODEMCU

ESP8266EX offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor.

When ESP8266EX hosts the application, it boots up directly from an external flash. It has integrated cache to improve the performance of the system in such applications.

ESP8266EX is among the most integrated Wi-Fi chip in the industry; it integrates the RF antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.

ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the Wi-Fi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs; sample codes for such applications are provided in the Software Development Kit (SDK) [8].

2.4.2. Features

The features of NODEMCU are given below,

- 802.11 b/g/n
- Integrated low power 32-bit MCU
- Integrated 10-bit ADC
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLL, regulators, and power management units
- Supports antenna diversity
- Wi-Fi 2.4 GHz, support WPA/WPA2
- Support Smart Link Function for both Android and iOS devices
- SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO
- STBC, 1x1 MIMO, 2x1 MIMO
- A-MPDU & A-MSDU aggregation & 0.4s guard interval
- Deep sleep power <10uA, Power down leakage current < 5uA
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)
- Operating temperature range -40°C to 125°C

2.4.3. Parameter

The parameter of NODEMCU is as follows,

Categories	Items	Values
WiFi Paramters	Certificates	FCC/CE/TELEC/SRRC
	WiFi Protocles	802.11 b/g/n
	Frequency Range	2.4G-2.5 G (2400M-2483.5M)
	Tx Power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: -91 dbm (11 Mbps)
		802.11 g: -75 dbm (54 Mbps)
802.11 n: -72 dbm (MCS 7)		
Types of Antenna	PCB Trace, External, IPEX Connector, Ceramic Chip	
Hardware Paramaters	Peripheral Bus	UART/SDIO/SPI/I2C/I2S/IR Remote Control
		GPIO/PWM
	Operating Voltage	3.0~3.6 V
	Operating Current	Average value: 80mA
	Operating Temperature Range	-40 °~125°
	Ambient Temperature Range	Normal temperature
	Package Size	5x5mm
External Interface	N/A	
Software Parameters	WiFi mode	station/softAP/SoftAP+station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network)
	Software Development	Supports Cloud Server Development / SDK for custom firmware development
	Network Protocols	IPv4, TCP/UDP/HTTP/FTP
	User Configuration	AT Instruction Set, Cloud Server, Android/iOS App

Table 2.1 NODEMCU Parameters

2.4.4. Electrical Characteristics

The Electrical parameter of NODEMCU is as follows,

Parameters		Conditions	Min	Typical	Max	Unit
Storage Temperature Range			-40	Normal	125	C
Maximum Soldering Temperature		IPC/JEDEC J-STD-020			260	C
Working Voltage Value			3.0	3.3	3.6	V
I/O	V_{IL}/V_{IH}		-0.3/0.75 V_{IO}		0.25 $V_{IO}/3.6$	V
	V_{OL}/V_{OH}		N/0.8 V_{IO}		0.1 V_{IO}/N	
	I_{MAX}				12	mA
Electrostatic Discharge (HBM)		TAMB=25C			2	KV
Electrostatic Discharge (CDM)		TAMB=25C			0.5	KV

Table 2.2 - ESP8266EX Electrical Characteristics

2.4.5. Application

Major Fields of ESP8266EX applications to Internet-of-Things include,

- Home Appliances
- Home Automation
- Smart Plug and lights
- Mesh Network
- Industrial Wireless Control
- Baby Monitors
- IP Cameras
- Sensor Networks
- Wearable Electronics

2.5. RASPBERRY PI:

2.5.1. Introduction

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a small device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

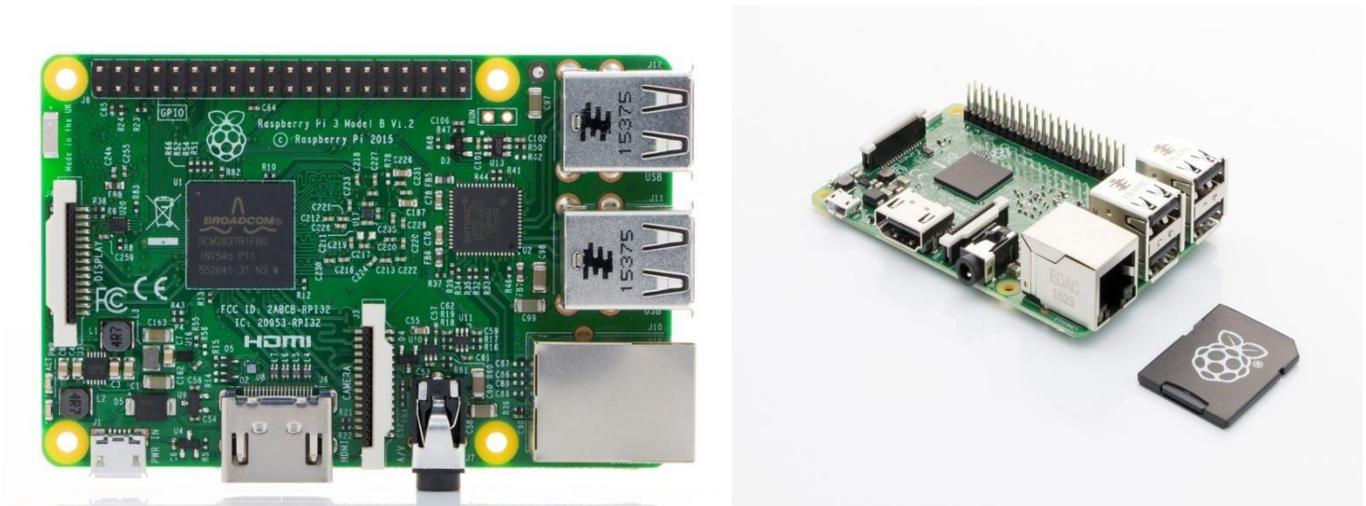


Fig 2.10 - Raspberry pi-2

In Fig 2.10, the picture of Raspberry Pi2 board is shown. It has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras.

CPU speed range from 700 MHz to 1.2 GHz for the Pi2 Model B and on board memory range from 256MB to 1GB RAM. Secure Digital SD cards are used to store the operating system and program memory in either the SDHC or Micro SDHC sizes. Most boards have between 1 and

4 USB slots, HDMI and composite video output, and a 3.5mm phone jack for audio. Lower level output is provided by a number of GPIO pins which support common protocols like I2C.

2.5.2. Technical Specification

Chip	Broadcom BCM2836 S0C
Core architecture	Quad-core ARM Cortex A7
CPU	900 MHz
GPU	Dual Core Video IV Multimedia Co-Processor
Memory	1GB LPDDR2
Operating System	Boots from Micro SD card, running a version of Linux Operating system
Dimensions	85x56x17 mm
Power	Micro USB socket 5V, 2A

Table 2.3 – Technical Specification of Raspberry Pi

CONNECTORS:

Ethernet	10/100 Base T Ethernet socket
Video Output	HDMI
USB	4x USB 2.0 Connector
Display Connector	Display Serial Interface(DSI)
Memory Card Slot	Micro SDIO

Table 2.4 – Connectors in Raspberry Pi

2.5.4. RASPBERRY PI 2 MODEL B FEATURES:

The Features of Raspberry Pi2 are,

- Broadcom BCM2837 with ARM7 Quad Core Processor powered Single Board Computer running at 900MHz
- 1GB RAM
- Identical board layout and footprint as the Model B+, so all cases and 3rd party add-on boards designed for the Model B+ will be fully compatible.
- Fully HAT compatible
- Connect a Raspberry Pi camera and touch screen display.
- Stream and watch Hi-definition video output at 1080P
- Micro SD slot for storing information and loading your operating systems.
- Advanced power management:
- 10/100 Ethernet Port to quickly connect the Raspberry Pi to the Internet
- Combined 4-pole jack for connecting your stereo audio out and composite video out [9].

3. SOFTWARE TOOLS:

3.1. ARDUINO SOFTWARE (IDE):

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuine hardware to upload programs and communicate with them [5].

3.1.1. Writing Sketches:

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

3.2. MySQL

MySQL is an open source relational database management system. The MySQL is owned by Oracle Corporation. The MySQL development project has made its source code available under the terms of the GNU General Public License. MySQL provides an interactive shell for creating tables, inserting data, etc. It handles very large databases and its performance also very fast. MySQL has no built in method for doing db size limits.

SQL provides a structured language for querying/updating multiple databases. MySQL is compatible with Standard SQL. MySQL is frequently used by PHP and Perl. MySQL is a central component of the LAMP open-source web application software stack. MySQL mainly runs on UNIX based environments. Applications that use the MySQL database include: TYPO3, MODx, Joomla, WordPress, phpBB, MyBB, and Drupal. MySQL is also used in many high-profile, large-scale websites, including Google, Facebook, Twitter, Flickr, and YouTube [10].

Benefits

The Benefits of MySQL are,

- Able to handle large databases that can be accessed over the web.
- Flexible and secure password system to protect your data.
- It's a relational database management system.
- This system can run virtually on any platform.
- MySQL is used at the enterprise level because of its security.
- MySQL allows users to connect to a specific database on the server and issue requests.
- Concurrent access.

Overview

MySQL is written in C and C++. Its SQL parser is written in yacc, but it uses a homebrewed lexical analyser. MySQL works on many system platforms, including AIX, BSDi, FreeBSD, HP-UX, eComStation, i5/OS, IRIX, Linux, macOS, Microsoft Windows, NetBSD, Novell NetWare, OpenBSD, OpenSolaris, OS/2 Warp, QNX, Oracle Solaris, Symbian, SunOS, SCO Open Server, SCO UnixWare, Sanos and Tru64. A port of MySQL to OpenVMS also exists.

Support can be obtained from the official manual. Free support additionally is available in different IRC channels and forums. Oracle offers paid support via its MySQL Enterprise products. They differ in the scope of services and in price. Additionally, a number of third party organisations exist to provide support and services, including Maria DB and Percona.

Features

The main Features of MySQL are,

- A broad subset of ANSI SQL 99, as well as extensions.
- Cross-platform support.
- Stored procedures, using a procedural language that closely adheres to SQL/PSM.

- Triggers.
- Cursors.
- Updatable views.
- Online DDL when using the InnoDB Storage Engine.
- Information schema.
- Performance Schema that collects and aggregates statistics about server execution and query performance for monitoring purposes.
- A set of SQL Mode options to control runtime behaviour, including a strict mode to better adhere to SQL standards.
- ACID compliance when using InnoDB and NDB Cluster Storage Engines.
- SSL support.
- Query caching.

3.3. Ruby on Rails

Ruby on Rails is a web application framework written in Ruby, a dynamic programming language. Ruby on Rails uses the Model view Controller (MVC) architecture pattern to organize application programming. A model in a Ruby on Rails framework maps to a table in a database. A controller is the component of Rails that responds to external requests from the web server to the application, and responds to the external request by determining which file to render. A view in the default configuration of Rails is an erb file. It is typically converted to output html at runtime.

Ruby

It is a dynamic, general-purpose **object-oriented programming** language. Ruby combines syntax inspired by Perl, also influenced by Eiffel and Lisp. It supports multiple programming paradigms, including functional, object oriented, imperative and reflective. This consists of dynamic type system and automatic memory management system. Ruby is a metaprogramming language.

Rails

Rails is an open source Ruby framework for developing database-backed web applications. The Rails framework was extracted from real-world web applications. Thus it is an easy to use and cohesive framework that's rich in functionality. All layers in Rails are built to work together and uses a single language from top to bottom. Everything in Rails (templates to control flow to business logic) is written in Ruby, except for configuration files – YAML.

Overview

Like many web frameworks, Ruby on Rails uses the model–view–controller (MVC) pattern to organize application programming.

In a default configuration, a model in the Ruby on Rails framework maps to a table in a database and to a Ruby file. For example, a model class User will usually be defined in the file 'user.rb' in the app/models directory, and linked to the table 'users' in the database. While developers are free to ignore this convention and choose differing names for their models, files, and database table, this is not common practice and is usually discouraged in accordance with the "convention-over-configuration" philosophy.

A view in the default configuration of Rails is an erb file, which is evaluated and converted to HTML at run-time. Alternatively, many other templating systems can be used for views.

Ruby on Rails is most commonly not connected to the Internet directly, but through some front-end web server. Mongrel was generally preferred over WEBrick in the early days, but it can also run on Lighttpd, Apache, Cherokee, Hiawatha, Nginx and many others. From 2008 onwards, Passenger replaced Mongrel as the most-used web server for Ruby on Rails.

Ruby on Rails is also noteworthy for its extensive use of the JavaScript libraries, Prototype and Script.aculo.us, for scripting Ajax actions. Ruby on Rails initially utilized lightweight SOAP for web services; this was later replaced by RESTful web services. JQuery is fully supported as a replacement for Prototype and is the default JavaScript library in Rails.

Framework Structure

Ruby on Rails is separated into various packages, namely Active Record, Active Resource, Action Pack, Active Support and Action Mailer. Prior to version 2.0, Ruby on Rails also included the Action Web Service package that is now replaced by Active Resource. Apart from standard packages, developers can make plugins to extend existing packages. Earlier Rails supported plugins within their own custom framework; version 3.2 deprecates these in favor of standard Ruby "gems".

Deployment

Ruby on Rails is often installed using RubyGems, a package manager which is included with current versions of Ruby. Many free Unix-like systems also support installation of Ruby on Rails and its dependencies through their native package management system.

Ruby on Rails is typically deployed with a database server such as MySQL or PostgreSQL, and a web server such as Apache running the Phusion Passenger module [11].

3.4. ThingSpeak

According to its developers, "ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the logging in applications, location tracking applications, and a social network of things with status updates".

ThingSpeak has integrated support from the numerical computing software MATLAB from Math Works. It is allowing ThingSpeak users to analyze and visualize uploaded data using Matlab without requiring the purchase of a Matlab license from Mathworks.

ThingSpeak has a close relationship with Mathworks Inc. In fact, whole ThingSpeak documentation is incorporated into the Mathworks Matlab documentation site and even enabling registered Mathworks user accounts as valid login credentials in the ThingSpeak website [4].

3.4.1. ThingSpeak INSTALLATION PROCESS IN RASPBERRY PI

ThingSpeak server is installed on the Raspberry Pi as a local server with the following process,

INSTALL required packages

```
sudo apt-get -y install build-essential git mysql-server mysql-client libmysqlclient-dev libxml2-dev libxslt-dev libssl-dev libsqlite3-dev
```

MySQL Database configuration

```
mysql --user=root mysql -p useyourpasswd
mysql> CREATE USER 'thing'@'localhost' IDENTIFIED BY 'speak';
mysql> GRANT ALL PRIVILEGES ON *.* TO 'thing'@'localhost' WITH GRANT OPTION;
mysql> commit;
mysql> exit;
```

Ruby / Rails install

```
wget http://cache.ruby-lang.org/pub/ruby/2.1/ruby-2.1.5.tar.gz
tar xvzf ruby-2.1.5.tar.gz
cd ruby-2.1.5
./configure
make
```

Install ruby

```
sudo make install
cd ..
echo "gem: --no-rdoc --no-ri" >> ${HOME}/.gemrc
sudo gem install rails
```

ThingSpeak Server install

```
git clone https://github.com/iobridge/thingspeak.git
cp thingspeak/config/database.yml.example thingspeak/config/database.yml
cd thingspeak
bundle install
bundle exec rake db:create
```

Check MYSQL DB

```
mysql --user=root mysql -p
mysql> show databases;

#+-----+
#| Database          |
#+-----+
#| information_schema |
#| mysql              |
#| performance_schema |
#| thingspeak_development |
#| thingspeak_test    |
#+-----+
mysql> exit;
```

If MYSQL DB is OK, then run:

```
bundle exec rake db:schema:load
```

Run the ThingSpeak Server

```
rails server webrick.
```

3.4.2. STEPS TO RUN THINGSPEAK IN RASPBERRY PI

The steps to run THINGSPEAK in Raspberry Pi is as follows,

- Open a browser and enter *<your PC's IP address>:3000*
- **Sign Up** for a ThingSpeak account
- Create a new Channel by going to your Channels page and clicking **Create New Channel**
- Update your Channel via URL: *http:// <your PC's IP address>:3000/update?api_key=YOUR_CHANNEL_API_KEY&field1=7*
- View your Channel feed: *http:// <your PC's IP address>:3000/channels/YOUR_CHANNEL_ID/feeds.json* [6].

4. IMPLEMENTATION:

4.1. WORKING MODEL:

The Working Model is as follows,

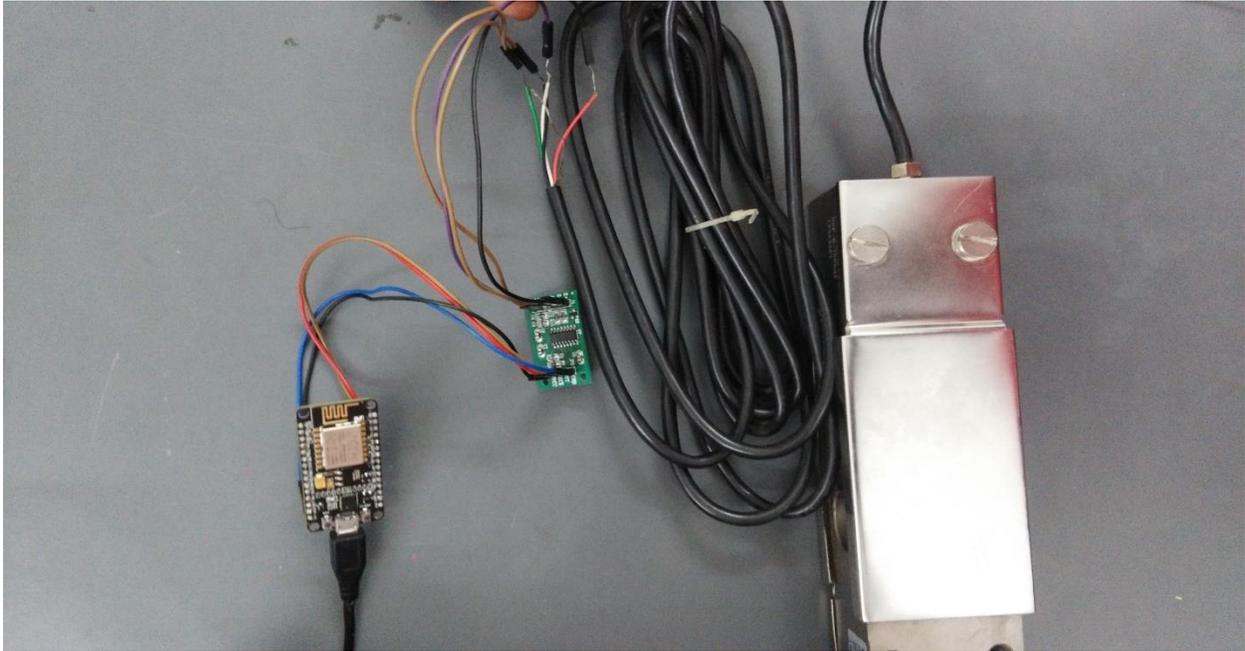


Fig 4.1 – Working model

4.2. FLOW DIAGRAM WITH CONNECTION

The Flow Diagram with connection is as follows,

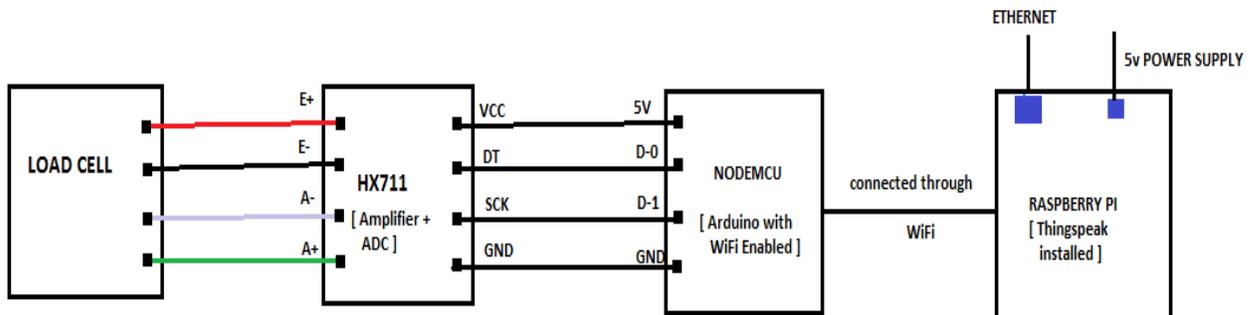


Fig 4.2 – Connection flow diagram

4.3. SNAPSHOT – LOADCELL CALIBRATION

The Calibration of Loadcell is as follows,

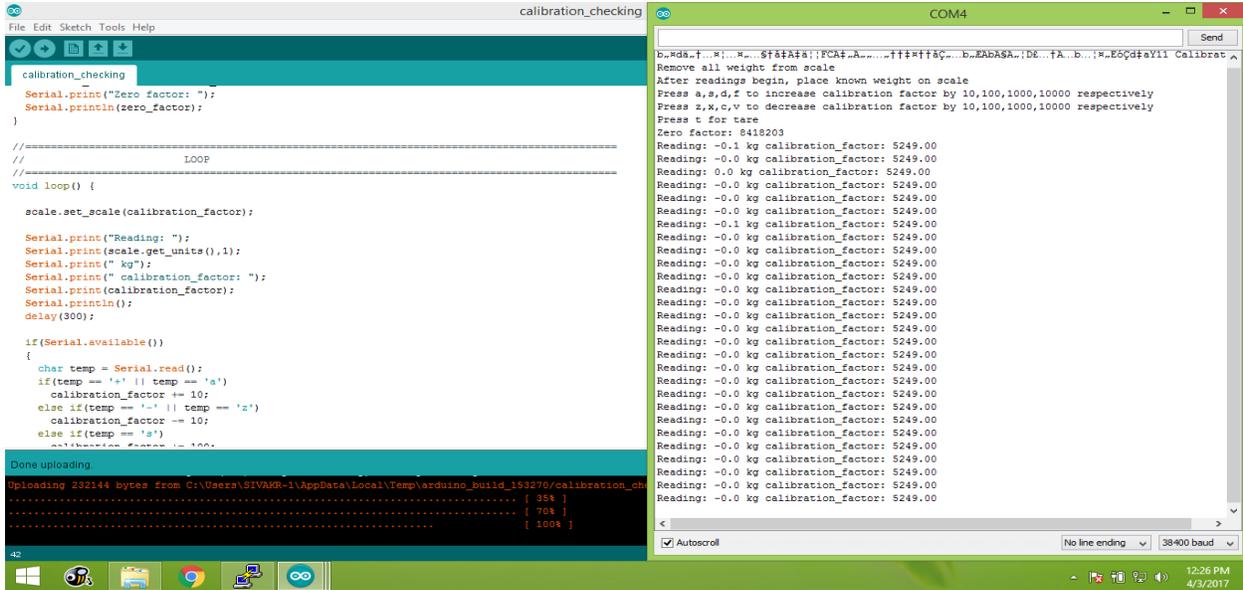


Fig 4.3 – Calibration of loadcell

4.4. SNAPSHOT – THINGSPEAK SERVER

The Output at THINGSPEAK is as follows,

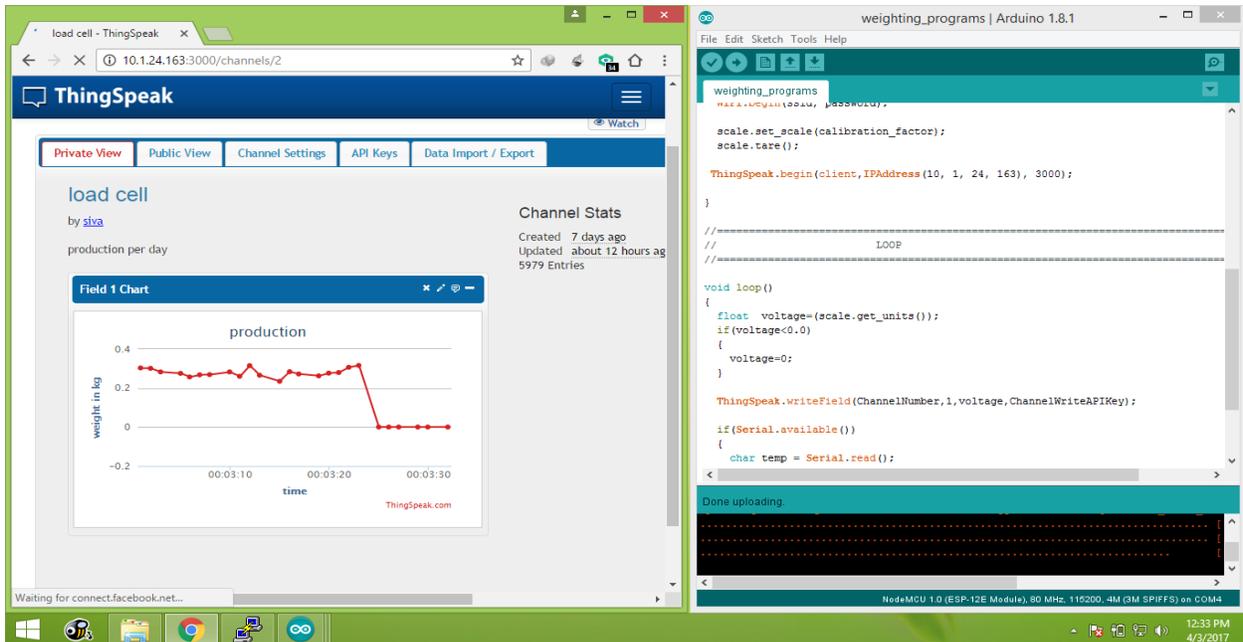


Fig 4.4 – Output at ThingSpeak

5. CONCLUSION:

In our project, the remote monitoring on crusher system enables any average person to monitor the data from an aggregate crusher system leisurely and safely at their comfortable place, which would otherwise be practically impossible as we are moving towards the trend of, “Making life simpler and automatic”. Thereby we have come up with a fascinating idea that, with the help of just a few interfaces with a basic micro-controller to control the entire interface, it is feasible to save time and work of some men. Also any fault resulting in reduced production rate is also made evident immediately to the user. It can reduce the time taken to identify faults in the crusher system and reduce man power.

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