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Design and Build Mini Digital Scale using Internet of Things

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Abstract: *The weight measurement system is carried out manually using a manual scale. The existing weighing system is still considered inefficient because it takes a long time if it is done repeatedly and there are too many errors in its measurement. To overcome this, an electronic weighing device was designed using the NodeMCU ESP 8266 microcontroller as a controller and a load cell as a sensor. This journal presents the development of electronic weighing indicators for digital measurements. The purpose of this system is to read the measured weight in conventional analog form to digital form, achieving high precision in measurement and calibration. The components used in this research are Load Cell, Load Cell Hx711 amplifier, NodeMCU ESP 8266 microcontroller, and LCD module. In this study, a 4 kg load cell was used. The load cell sends the output signal of the measured mechanical weight to the Hx711 module which amplifies and sends the output to the NodeMCU microcontroller. The microcontroller calibrates the output signal with the help of the load cell amplifier module before sending the converted signal to digital form to the LCD module for display. The developed system has proven that digital electronic weighing systems can be low cost, miniature, discrete, and can take accurate readings without errors.*

Keywords: *Weight measurement system, Hx711 module, LCD, NodeMCU ESP8266, Microcontroller*

INTRODUCTION

Scales are tools used to determine the weight of an object. Weighing modules on the market generally still use manual scales which often still produce inaccurate measurements due to lack of accuracy and level of accuracy. In addition, other measuring instruments are only in the form of pendulum balances or analog scales whose output is only indicated by a pointer. Scales have long been known to humans, ranging from manual scales. Even humans in the past have been able to measure objects, meaning that since that time humans have used tools to measure weight.

Several types of scales vary, starting with manual scales, digital scales and others. The results of the scales between manual and digital accuracy are not much difference. Scales before use should be done with a valid test. In order to get accurate and precise results.

Currently the use of the Internet of Things is very much in daily application. Internet of Things is a piece of hardware that can communicate with one another using the means of communication with the internet. If an electronic object cannot communicate, it cannot be said to be an Internet of Things device. These objects can be sensors, motors, actuators and others. While communication can use such as WIFI (IEEE 802.11b) (Zhang et al., 2019), Bluetooth Low Energy (BLE) (Park et al., 2020) or Zigbee and others. Besides, the development of internet technology currently supports various platforms for collaboration. Storage platforms and other platforms can also be used for Internet of Things (Ahmed, 2021) purposes. One of the platforms is Google Firebase, where this platform can be used for data storage media from equipment using the IoT platform.

Some digital weighing devices on the market, it is very difficult to find a weighing device that can provide weighing results in real time. So if the scales are placed far from the head office and easy to control. In

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connection with the above description, the following problems arise: How to develop a digital weighing device with good accuracy? (RQ1). How to get the weighing results from the weighing device that is located far from the weighing place? (RQ2). The purpose of this research is to design a digital weighing system that will be placed far from the head office. For this reason, a communication media is needed that the head office can monitor the results of weighing scales at any time.

Table 1. Research on digital scales

Research topic	Advantages	Weakness
Open-source digitally replicable lab-grade scales (Hubbard & Pearce, 2020)	The digital weighing device in this study uses an Arduino Microcontroller Nano, Loadcell as a sensor in measuring weight. The use of LCD as a medium for displaying the results of measurements. Perform calibration and tare for accuracy of weighing.	This device still does not use a communication tool as a medium for sending measurement data. So this device is not included in the Internet of Things-based device.
Design of Digital Scales Based on 5 Kg Load Sensor Using Atmega328 Microcontroller (Yandra et al., 2016)	Perform calculations using the Arduino Mega microcontroller to accurately determine the weight value.	Have not used communications such as WIFI or Bluetooth, so it is not optimal if it is used in the application system or recording with a database
Design and experimental investigation on 3- component force sensor in mini CNC milling machine (Lapsomthop et al., 2019)	The device in this study uses a microcontroller, LCD and loadcell HX711, which can accurately determine the weight.	Have not used communication such as WIFI or Bluetooth, so it is not optimal if it is used in the application system or recording with a database. So the device in this research does not include the Internet of Things.
Human Body Weight Calculator With Standard Body Mass Index (Bmi) Using Load Cell Sensor Based On Arduino Mega 2560 R3 (Dewantara & Sasmoko, 2015)	The design of scales for humans uses microcontroller, loadcell and LCD devices. The results show good accuracy.	Have not used communication such as WIFI or Bluetooth, so it is not optimal if it is used in the application system or recording with a database. So the device in this research does not include the Internet of Things.

This research complements previous research, where at this time the need for the Internet of Things (Deepika et al., 2020)is very useful. There is a Research Gap where previous studies did not use equipment communication. Equipment can not be defined as the Internet of Things if the equipment has not been able to communicate with other equipment. State of the art in this study is the use of communication facilities in digital weighing equipment using a micro-controller in which already uses a means of communication with WIFI, namely NodeMCU ESP8266 (Kashyap et al., 2018).

LITERATURE REVIEW

Before designing a digital scale, it is necessary to plan the components to be used from several reference sources. Digital weighing devices require a micro-controller (Cézar et al., 2020), load measuring sensors, communication sensors and online data storage media.

NodeMCU is an open source micro-controller for the ESP8266 wifi chip that uses the LUA programming language. Espruino, Mongoose OS, Espressif software development kit (SDK), and the Arduino add-on ESP8266 are just a few of the development platforms that can program the ESP8266. Through a standalone Wi-Fi networking solution, the ESP8266 can host applications or offload all Wi-Fi network activity from other application processors. The ESP8266 has significant on-board compute capabilities and ample storage, enabling it to be integrated with select sensor devices with minimal initial work and minimal loading during runtime via GPIO (General Purpose Input/Output). The ESP8266 has a low cost and many functions, making it an excellent Internet of Things (IoT) module.

The load cell is a sensor for weighing the load, which works when there is a load, the sensor is compressed and the length of the sensor turns curved. The length of the sensor acts as a primary transducer because the force is changed in curvature. The change in length, is not measured directly, while the strain gauge connected to the

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load column is compressed. While the load column acts as the primary sensor, the strain gauge acts as a secondary sensor as it records the displacement of the load column. Although the strain gauge is compressed and its length varies depending on the amount of force applied to the top load cell. When the length of the strain gauge changes, the resistance of the strain gauge also changes. Changes in resistance based on the measurement of changes in output voltage, can be amplified by using a differential amplifier.

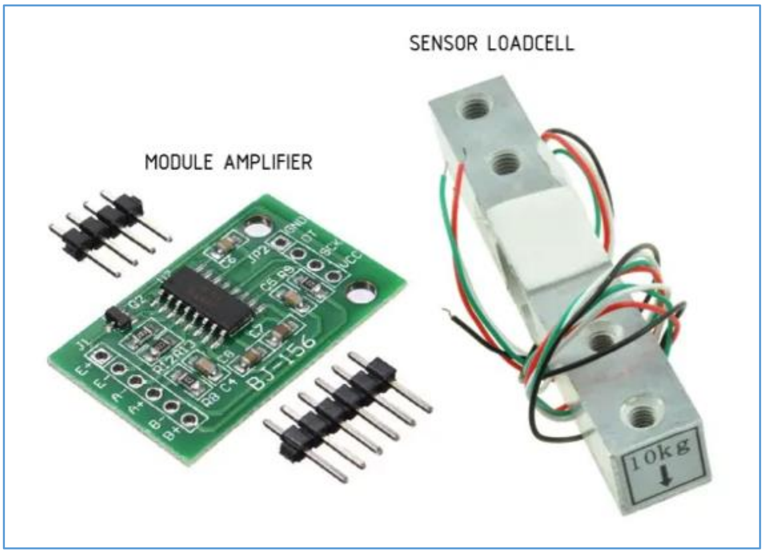

Figure 1. Load Cell and Module Amplifier Hx711

Module Amplifier can see in figure 1, is an amplifier module and as an Analog to Digital Converter module which functions to convert analog signals into digital signals. This amplifier section contains HX711 Chips, 16 pins as input and output. The 24-bit HX711 gets the analog input voltage and converts it into a digital signal.
Some of the features of the HX711 are as follows:

- Has an ADC converter with two differential input channels
- Has an integrated low-noise active PGA in the chip providing 32, 64 and 128 . gain
- Power-on-reset capability that simplifies digital interfaces.
- All control to the IC is done via pins and does not require programming in the chips.
- Can select 10SPS and 80SPS data rate on output.
- Provides simultaneous supply rejection of 50Hz and 60Hz supply.
- Has supply voltage range is from 2.6V to 5.5V
- Works at temperatures from -40 °C to +80 °C

LCD (Liquid Cristal Display), Liquid Crystal Display is a display media and liquid crystals that produce visuals. Liquid Crystal Display has been widely used in several products; notebook monitors, mobile phone monitors, computer monitors and others as visuals. The components in the Liquid Crystal Display are divided into two parts; Backlight section and Liquid Crystal section. LCD does not emit light and transmits light. Then the LCD requires Backlight as a light source. Liquid Crystal is an organic liquid located on two sheets of glass on a transparent surface. The white color in the Backlight can produce Liquid Crystal light. The liquid crystal then performs filtering and transmits according to the required color. The Liquid Crystal angle changes when it gets a voltage input. Due to the change in angle and filtering of the backlight light on the liquid crystal. The backlight can change color according to the input voltage.

Google Firebase (Albertengo et al., 2019) is a platform developed by Google for mobile and web application needs. This platform created by Google provides various facilities in developing high-quality applications, increasing usage from the user's side. Starting from platforms for Android, platforms for iOS, C++ platforms and platforms for Game or Unity purposes. For application purposes, there are Clod Firestone, Machine Learning Kit, Cloud Function, Authentication, Hosting, Cloud Storage, Realtime Database. For quality purposes like Crashlytics, Performance Monitoring, Test Lab. For business development like Analytics, Prediction, Firebase A/B Testing. This platform is used to store data generated from weighing scales. The data will later be sent via the WIFI module of the NodeMCU ESP8266 and then connected to the firebase realtime database. The data will be stored in cloud storage, where later the data will be read by the Android platform using the MIT App Inventor to be displayed on a mobile device.

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MIT App Inventor for Android, actually this platform was originally developed by Google and is currently maintained by the Massachusetts Institute of Technology. This platform is very powerful where to do programming just by clicking and dragging. The use of App Inventor is also very widely used in studies that use various sensors to be displayed in an attractive Mobile GUI (Salem et al., 2019). It is suitable for beginners to quickly create Android Mobile applications. The features and completeness of functions and modules that make this platform the right choice in developing Apps for the needs of the Internet of Things. For example, by creating a monitoring application that is used to control equipment in real time. Development with this application platform is very low cost in developing applications. App Inventor also provides a large library so as to produce a GUI that suits the needs of Mobile Applications (Sheu, 2019).

METHOD

The design of the digital scale using the NodeMCU ESP8266 Microcontroller, Loadcell and the HX711 Amplifier module can be depicted in Figure 2.

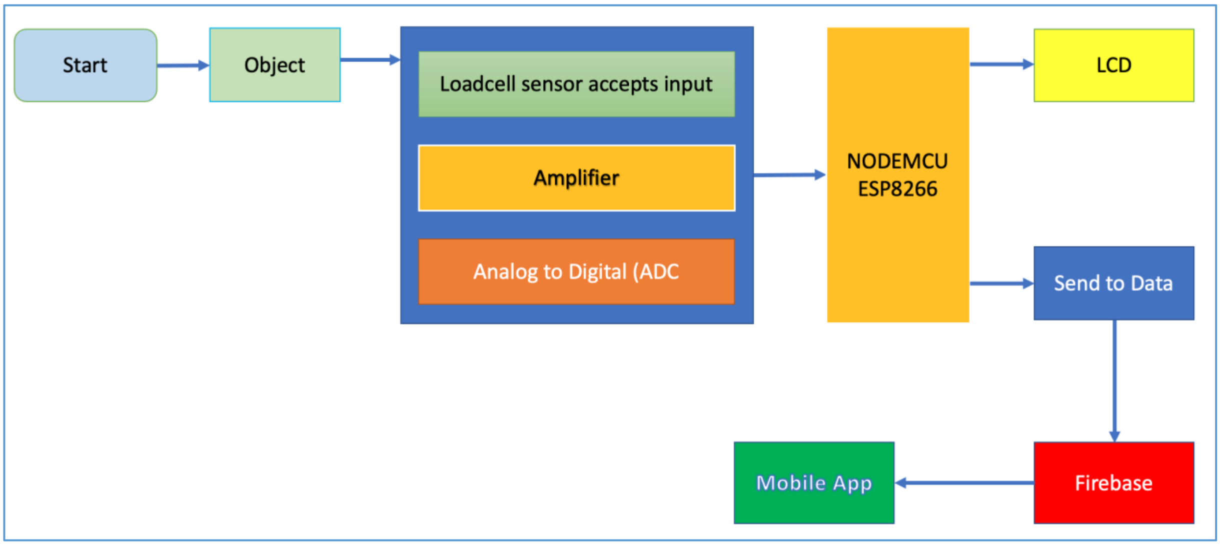

Figure 2. Flow data from Loadcell to LCD and Mobile App

The workings of this device are as follows:

1. The object is placed into the loadcell, the loadcell will stretch, causing the voltage to change, so the sensor will read the analog signal experiencing a changing value.
2. The sensor amplifier amplifies the signal generated from the loadcell sensor. The analog signal that comes out of the loadcell still produces a signal whose value is small, so that if it is converted into a digital signal it will not be read, so it does not issue a value. For this problem it is necessary to do with signal amplification, therefore signal amplification is needed for an Op Amp which is in charge of multiplying the analog output value to be larger. So that later the signal can be read.
3. Analog to Digital (ADC) (Celik et al., 2021) sensors perform the conversion from analog signals to digital signals. In the ADC module used in the HX711 module is 24 bits equal to 16,777,216. This value range is very large, so any value in that range can translate into a digital signal. This module has a very high accuracy. So that the measurement of digital scales is very accurate.
4. Weighing data managed by NodeMCU ESP8266 will be sent to LCD Monitor (Held et al., 2021) and WIFI sensor. The use of the NodeMCU as a microcontroller is very useful by adjusting the digital signal of the scales and then in charge of controlling the output of the scale signal into the LCD and sending it to the WIFI communication media and forwarding it to the storage media.
5. WIFI will forward to Google Firebase using internet media. WIFI as a communication device is tasked with sending scale signals to storage media via the internet. This WIFI task is only as a medium for intermediary wireless data instead of cables.
6. Firebase is used as data storage for digital weighing results.
7. App Inventor is used as a platform for the front end (Udjaja, 2018) or GUI in mobile app applications. The use of this platform is very good and fast in making car applications and low cost in doing development, so it is fast in producing software products.

The circuit used in digital scales is as follows:

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1. The LCD used already has an output module that is used to connect to the NodeMCU ESP8266 microcontroller. The SDA pin is connected to the D2 pin of the NodeMCU. The SCL pin is connected to the D1 pin of the NodeMCU.
2. Module HX711 pin DT is connected to pin D5 NodeMCU, pin SCK HX711 is connected to pin D6 NodeMCU.

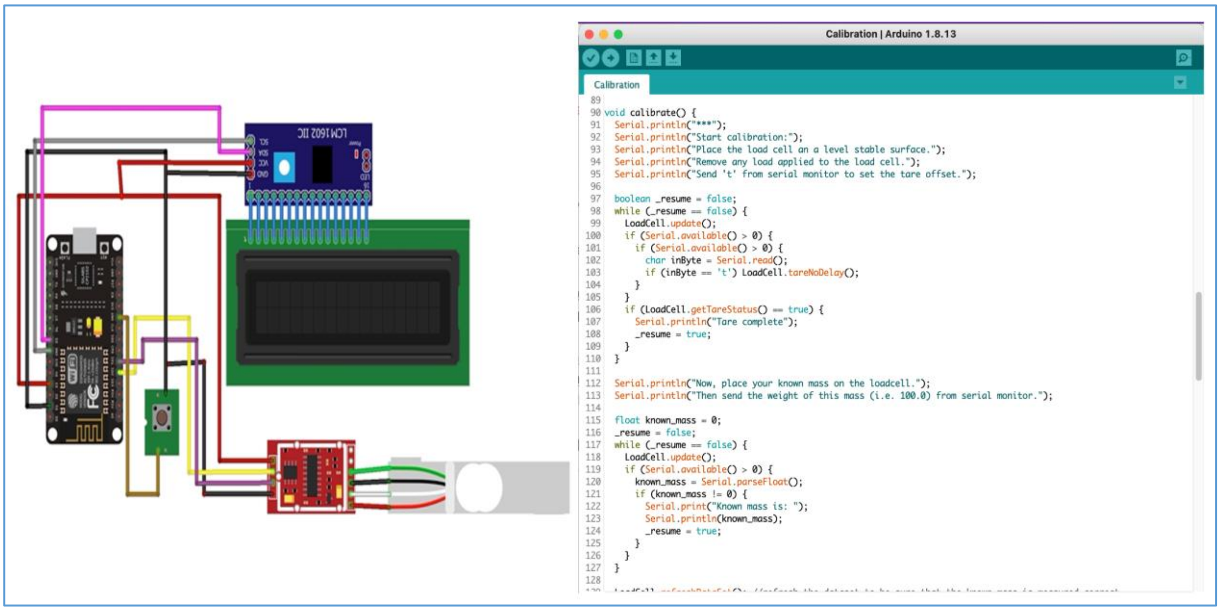

Figure 3. Design cabling and source code Digital Scale

In Figure 3, the circuit for making scales is very simple, not complicated in assembling them. Because in this digital weighing device everything is available in a module, so it is very fast and easy to manufacture.

Design Front End with App Inventor (Mikolajczyk et al., 2018), This platform is very easy to use, if making mobile applications can be made very quickly. This use is focused on how to produce a GUI display by reading data from Google Firebase in real time. If you use other tools or software it may take longer. Programming with the App Inventor platform will be more productive in creating mobile app software.

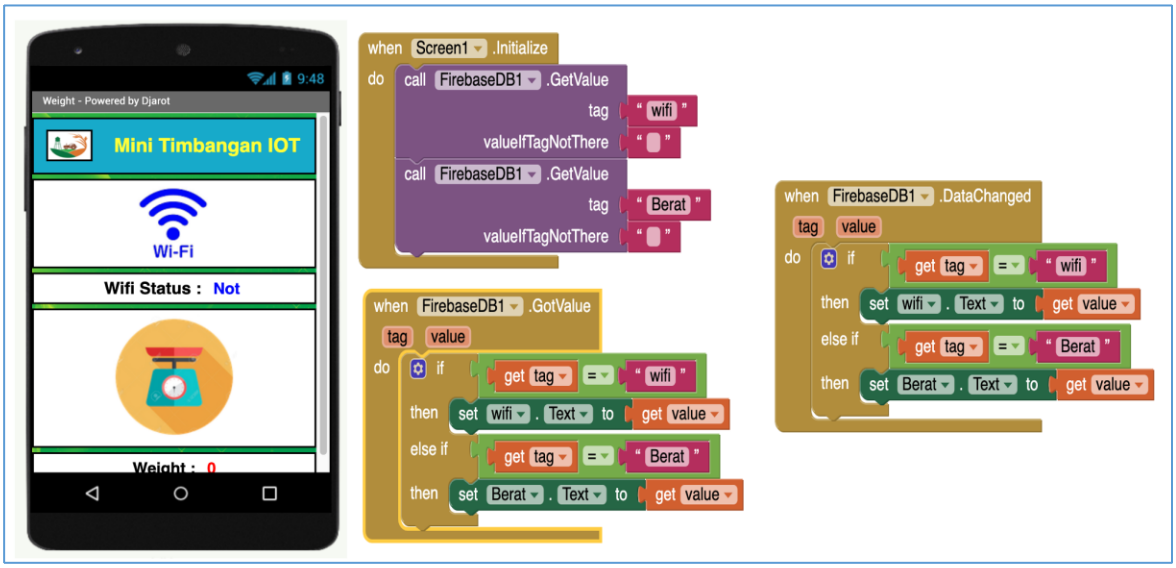

Figure 4. Design and coding in App Inventor

In Figure 4, on the left is the GUI display that will appear on the mobile screen. By simply clicking and dragging, the GUI display will appear. On the right is the coding view of App Inventor where to easily read the

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database in Firebase, it has been formed, just adjust it to the needs of the system to be developed. If the application is saved as an APK file, then the APK file will run on the Android mobile without any interruption.

RESULT

The results of the design of digital scales are as shown in Figure 5, where all loads can be measured using this scale. This device can weigh a maximum of 4 kg, due to the limitations of the loadcell which is capable of measuring up to 4 kg. The display of the mobile app can also be seen in Figure 5.

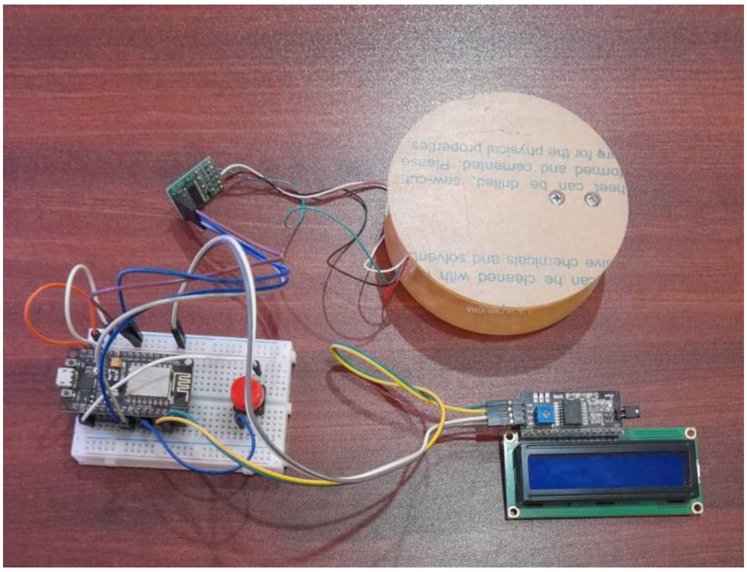

Figure 5. Mini Digital Scale

The accuracy displayed is quite precise, although it is not optimal for the accuracy value. This is if the Tare process is carried out to ensure the level of accuracy. The Tare process is a process for calibrating in order to increase the accuracy of the scale value.

The results of several weighing times can be presented in table 2 and this shows the level of accuracy in the digital weighing device.

Table 2. The results of measuring scales using a digital scale prototype

No	Actual weight (Kg)	Measurement weight (Kg)	Different scales
1	3,500	3,501	0,001
2	0,026	0,026	0,000
3	0,290	0,290	0,000
4	2,210	2,211	0,001
5	2,500	2,502	0,002
6	0,021	0,021	0,000
7	0,310	0,312	0,002
8	0,450	0,451	0,001
9	0,400	0,400	0,000
10	0,320	0,321	0,001

The tolerance or difference of the digital scale is close to 0.001 and still meets a good level of accuracy. The difference that is not too much is caused by the value factor which during the calibration process is carried out many times to get a very good level of accuracy.

DISCUSSIONS

From what has been explained above, it can answer several research questions.

Research Question 1: How to develop a digital weighing device with good accuracy? This research question has been answered by designing a prototype digital scale. Carry out a calibrating or calibration process to determine the level of accuracy of the scale value. The calibration process will determine the accuracy of the

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scales. In this case the tolerance or error limit is not too far away. In the results of testing with 10 objects in table 2, the results are very good.
Research Question 2: How to get the weighing results from the weighing device that is located far from the weighing place? This device is equipped with WIFI, so it can send the results of the scales via the internet. The weighing data will be stored into Google Firebase and can be accessed via the Mobile App.

CONCLUSION

The results of the digital scale design and connected to Internet of Thing platforms such as Firebase, add to the complete features of the IoT device design. The purpose of this system is to read the measured weight in digital form and tare it to achieve high precision in measurement. Monitoring Mini Scales can use Android Apps, making it easy to monitor, because the measurement results are always real time.

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