

# Application Note

## Overweight Indicator

**AN-CM-261**

### Abstract

*This application note introduces the implementation of a load cell to indicate overweight. It was based on the Wheatstone bridge network principle. This overweight indicator can be used in multiple applications such as airline baggage limit, elevator capacity, etc. In this app note we will use strain gauges as the weight sensor, SLG88104 as differential amplifier, and SLG46140V GreenPAK as ADC and signal conditioning. If the weight is over 60 Kg, SLG46140V will sound an alarm with 1 Hz frequency.*

*This application note comes complete with design files which can be found in the References section.*

## Overweight Indicator

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## Overweight Indicator

### 1 Terms and Definitions

ADC Module	Analog to digital converter module to convert analog signal voltage to weight scale
Sound Alert	Sound made to indicate weight limit

### 2 References

For related documents and software, please visit:

[GreenPAK™ Programmable Mixed-Signal Products | Renesas](#)

Download our free [GreenPAK™ Designer software](#) [1] to open the .gp files [2] and view the proposed circuit design. Use the [GreenPAK](#) development tools [3] to freeze the design into your own customized IC in a matter of minutes. Find out more in complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the GreenPAK IC.

- [1] [GreenPAK Designer Software](#), Software Download and User Guide
- [2] [AN-CM-261 Overweight Indicator.gp](#), [GreenPAK](#) Design File
- [3] [GreenPAK Development Tools](#), [GreenPAK](#) Development Tools Webpage
- [4] [GreenPAK Application Notes](#), [GreenPAK](#) Application Notes Webpage
- [5] [SLG46140V](#), Datasheet
- [6] [SLG88103/4](#), Datasheet, Rail to Rail I/O 375 nA/Amp.
- [7] [AN-1056](#) Macro circuit design ADC PWM

## Overweight Indicator

### 3 Introduction

The main goal of this application is to measure the weight of an object then indicate with an alarm sound in case of overweight. Input of the system comes from a load cell. Input is an analog signal that has been amplified by a differential amplifier. The analog signal is converted to a digital signal using an ADC. The value of the ADC reading result is then compared to a certain value that is set so that it represents the desired load limit. If an overweight occurs, then the alert turns on with a frequency of 1 Hz. In this app note, we will use a strain gauge as the weight sensor, SLG88104 as the differential amplifier, and SLG46140V as ADC and signal conditioning. The system can be proven by applying a load exceeding the desired load limit (60 Kg). System functionality is correct if at that condition the alarm is on with a frequency of 1 Hz.

The key advantages of designing with [GreenPAK](#) is that the product is smaller, lower cost, simpler, and easy to develop. [GreenPAK](#) has a simple GUI interface in [GreenPAK](#) Designer, allowing engineers to quickly and easily implement new designs and respond to changing design requirements. If we want to develop it further, this solution is an excellent choice. Using [GreenPAK](#) makes this design very simple, light weight, and only a small area occupied to implement it on most applications. Because of the internal circuit resources available within [GreenPAK](#), this design can be enhanced with more features without having to add too many additional IC's. To verify the functionality of this system, we just need to implement the circuit designed with the [GreenPAK](#) simulation tool.

## Overweight Indicator

### 4 Design Approach

A key idea of this design is to facilitate the calibration of weight on a digital scale, as illustrated in the diagram below. Suppose there are four states to describe how this system works.

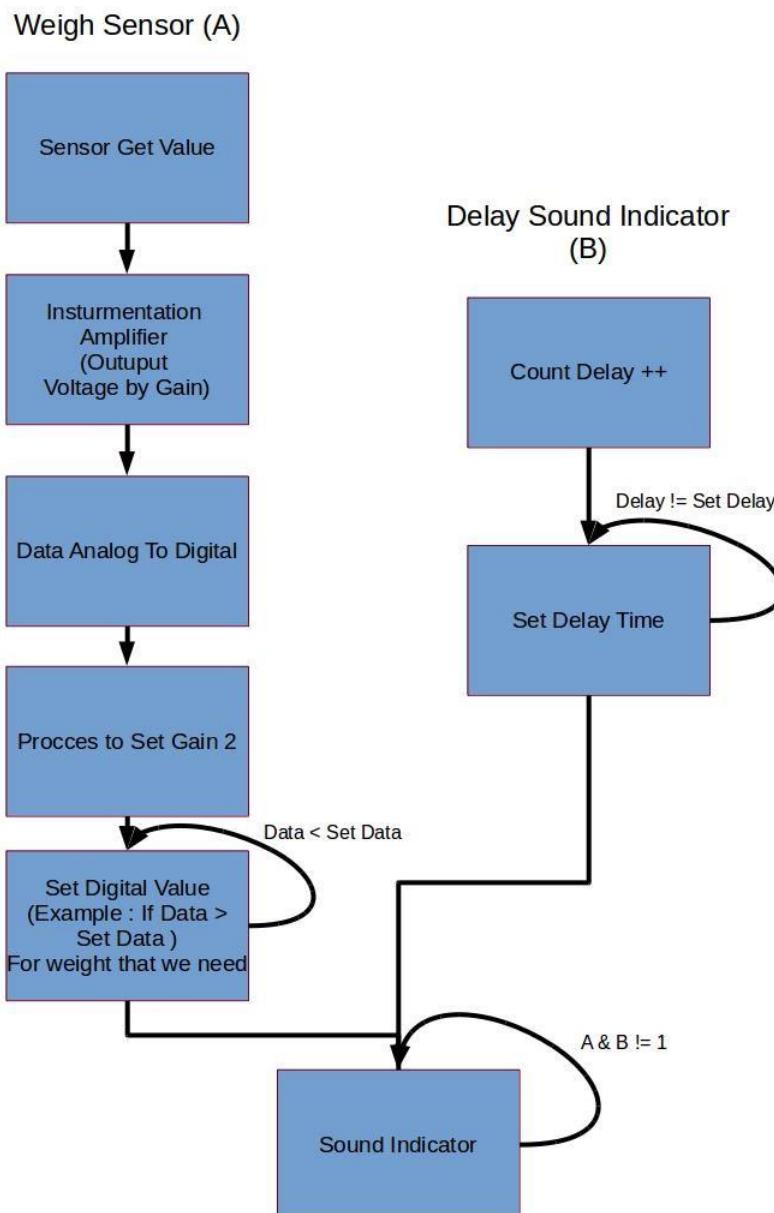


Figure 1: Flow or State Diagram of System

The system has a typical Weight Sensor Section (A), and then does a conversion of Analog to Digital data. Sensors typically generate very low-level analog values and can be processed more easily after conversion into digital signals. The signal to be used will have readable digital data. The data obtained in digital form can be reprocessed into the desired digital value (for heavy or light objects). To indicate the state of the final value, we use a buzzer, but it can be changed easily. For a voice

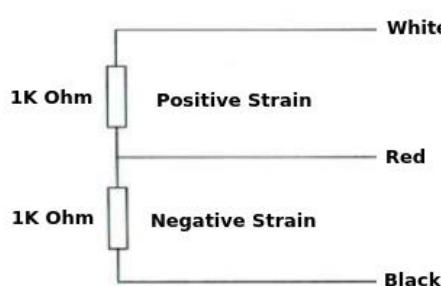
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indicator, one can use a well-known blink (Delay Sound Indicator (B)). In this experiment we used an existing scale having four load cell sensors connected using the Wheatstone bridge principle. As for the LCD already on digital scales, it is left only for validation of the value generated with existing scales.

### 4.1 Feedback Input

Input feedback for this system comes from the pressure obtained by the sensor to provide an analog signal in the form of a very low voltage but can still be processed into weight scales data.

The simplest circuit of the digital scanning sensor is made from a simple resistor that can change its resistance value according to the weight / pressure applied. The sensor circuit can be seen in [Figure 2](#).



**Figure 2: Sensor Load Cell**

From this digital scale we make use of four load cell sensors. The sensors that are placed at each corner of the scale will provide accurate values for the total input. The main components of the sensor resistors can be assembled into bridges that can be used to measure each sensor. This circuit is commonly used in digital circuits that use four sources that are interdependent. We only use the four sensors embedded on a scale for our experiments, and pre-embedded systems on this scale such as LCD and the controller are only kept for validating our design. The circuits we used can be seen in [Figure 3](#).

## Overweight Indicator

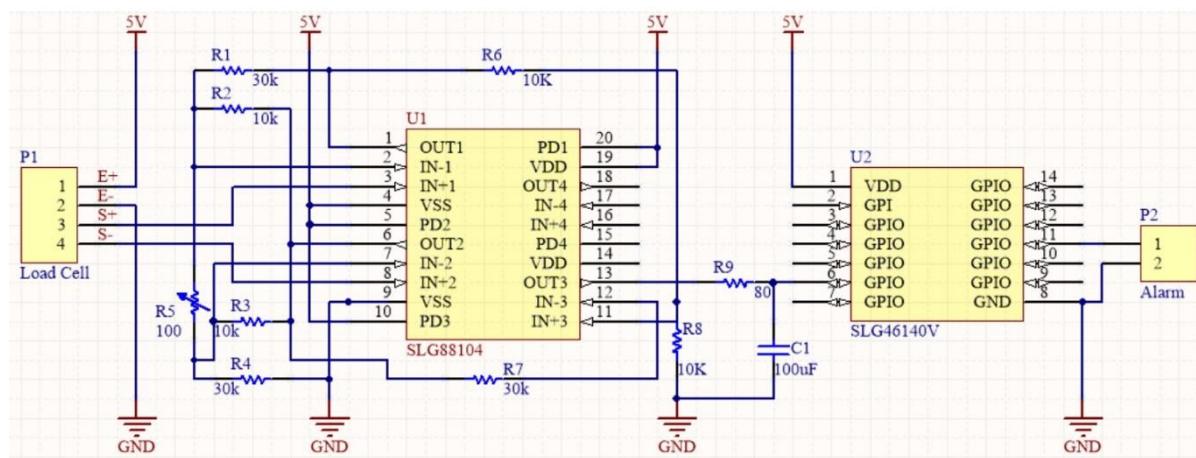
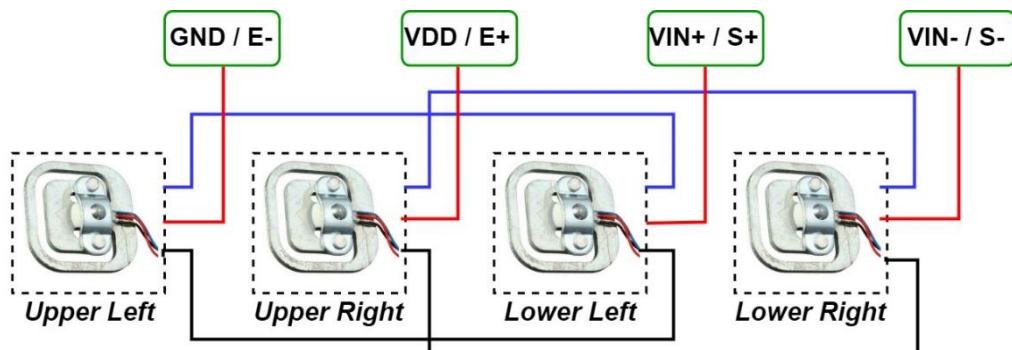


Figure 3: Electronics Circuit Sensor &amp; Instrumentation Amplifier

A Wheatstone bridge is typically used for calibrating measurement instruments. The advantages of a Wheatstone bridge is that it can measure very low values in the milli-ohm range. Because of this, digital scales with fairly low resistance sensors can be very reliable. We can see formula and Wheatstone bridge circuit in Figure 4.

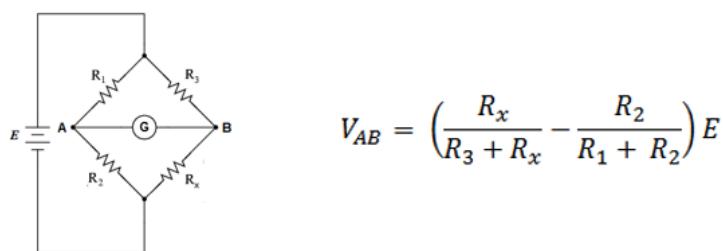
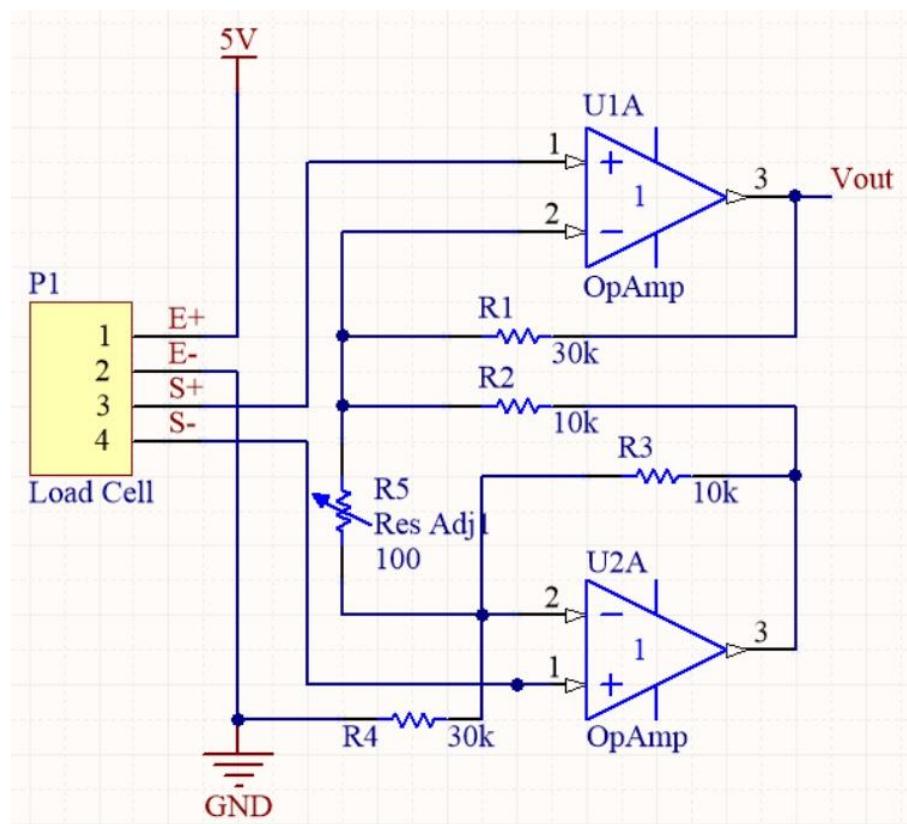


Figure 4: Wheatstone Bridge Circuit

Because the voltage is so small we need an instrumentation amplifier so that the voltage is amplified enough to be read by a controller.

The feedback voltage obtained from the input instrumentation amplifier is processed into a voltage that can be read by the controller (0 to 5 volts in this design). We can appropriately adjust the gain by setting the gain resistor in the SLG88104 circuit. Figure 5 shows the formula to determine the output voltage of the SLG88104 circuit that was used.

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$$V_O = (V_{IN}^+ - V_{IN}^-) G$$

$$G = 4 + \frac{60k\Omega}{R_G}$$

**Figure 5: Differential Amplifier Circuit**

From this formula, the gain relationship is described. If the value of the gain resistor is increased, then the gain obtained will be lower, and vice versa if the gain resistor value is decreased. The output response will be quite accentuated even if the increase or decrease in value is small. Digital scales can become more sensitive to the input (with only a little weight, the value has changes dramatically), or vice versa if the added sensitivity decreases. This can be seen in the result section.

## 4.2 Control Gain

This is a design that can control the gain again after going through the hardware gain calibration process (gain resistor calibration). From the weight sensor section (A) design, when the data obtained from the instrument amplifier, the data can be processed again so that the gain can be more easily set. The advantage is that we can avoid a hardware gain resistor change.

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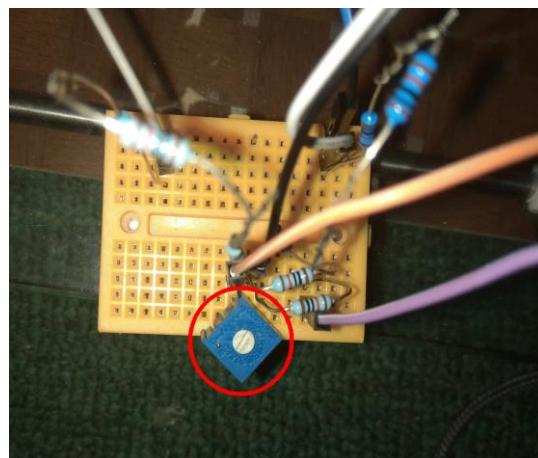


Figure 6: Resistor Gain

In Figure 5, with the ADC module there is a PGA that can adjust the gain before the analog value is changed to digital. We provide the input reference from the Vout output of the SLG88104 circuit. The PGA gain will be set in such a way according to the measurements we need. We use x0.25 gain with single-ended ADC mode. With x0.25 the gain is not so large that the input obtained by the ADC converter can measure the weight of large enough or maximally according to what we have tried using Arduino which is 70 Kg. After that, we use Compare data with CNT2 counter as ADC comparator, so we can know the change with sound indicator. The trick is the comparator we make by means of calibration change of CNT2 value so that when the weight > 60 kg, then the Output of DCMP0 is "1". The Sound indicator will light up with a predetermined frequency using block delay sound indicator so that the block will be logic "1" when the time is 0.5 s. The delay we can set the CNT0 counter data adjust the output period of 500 ms.

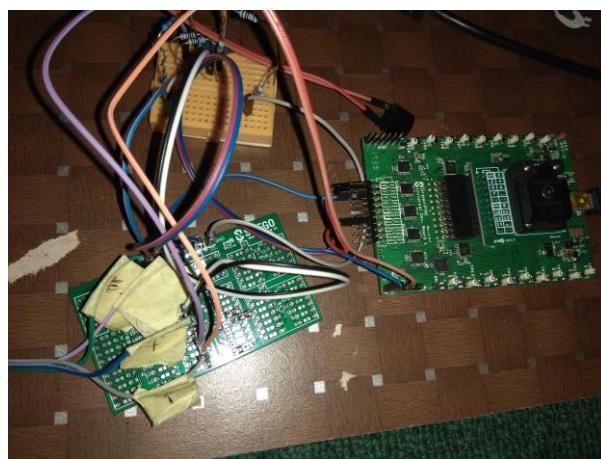


Figure 7: Actual Hardware (Development Kits)

## Overweight Indicator

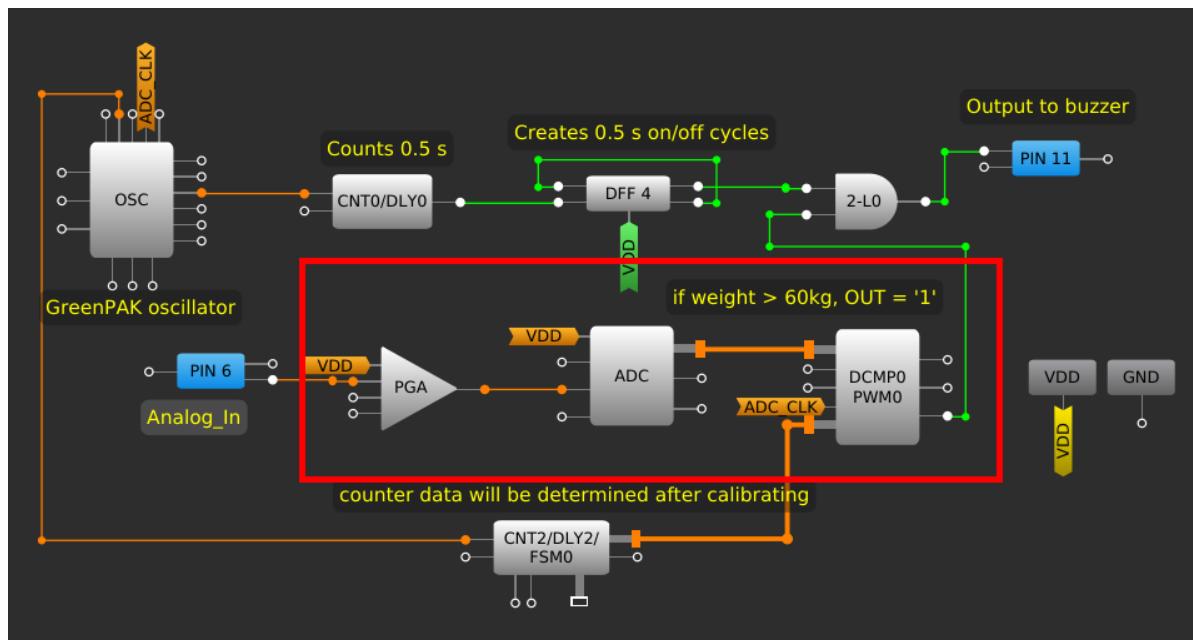


Figure 8: ADC Module GreenPak Design

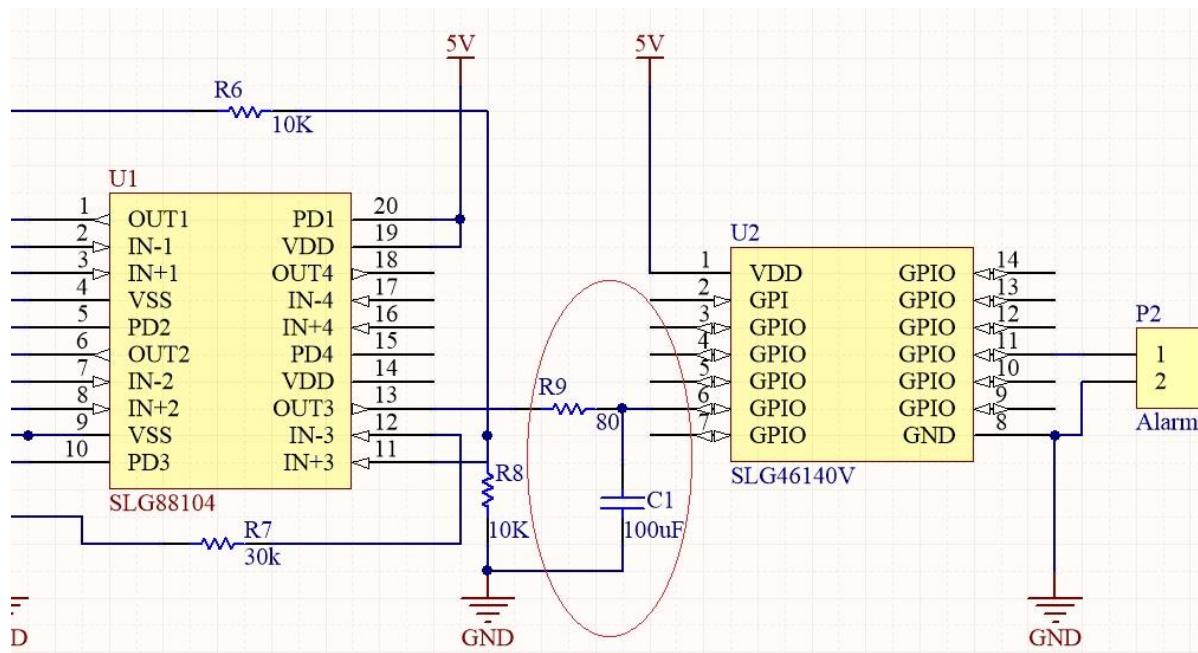
## 4.3 Low Pass Filter

It is preferable to filter the differential amplifier output signal. It helps to reject interference and reduces wideband noise. The low pass filter (LPF) implemented reduces unnecessary noise. This simple low-pass filter circuit consists of a resistor in series with a load, and a capacitor in parallel with the load. Some experiments showed the noise component was detectable in the band-pass filter having 32.5- 37.5 Hz passband during frequency spectrum analysis. The cutoff frequency,  $f_{co}$ , of the LPF was set to 20 Hz, by using the formula  $1.75f_{co} = f_{peak}$ . Usually, the capacitors should be very small, for example 100  $\mu$ F.

$$f_{co} = \frac{1}{2\pi CR}$$

Obtained  $R = 80 \Omega$ .

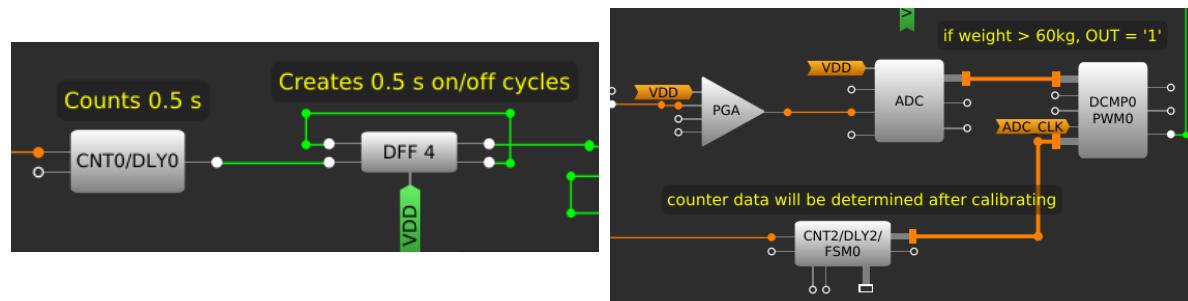
## Overweight Indicator



**Figure 9: Low Pass Filter**

## 4.4 GreenPAK Design Component

We can see from Figure 8 GreenPAK contains the components we need the ADC module, and Counter for waiting time.



**Figure 10: Counter Delay and ADC Module**

In the ADC Module section, PGA gain can decrease or increase the gain as needed. The PGA gain has the same function as the gain resistor in the SLG88104 circuit.

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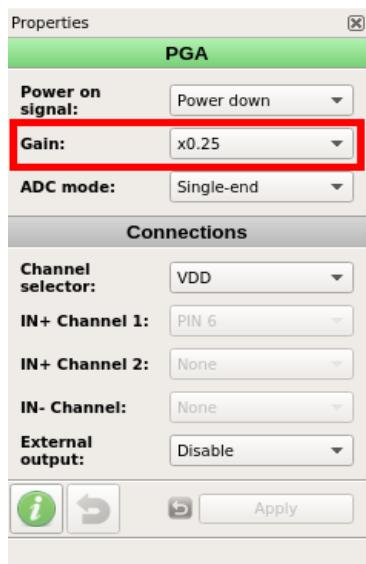


Figure 11: Gain Setting

The output data obtained by the ADC, arranged in such a way by counter calibration data by adding or reducing the counter data value. We can set it according to the hardware we have created and the appropriate weight to be output. For this demo we get and set the counter data value of 250 for 60 kg.



Figure 12: Counter Data Setting for ADC Comparison

The Counter for waiting time is CNT0. Counter data on CNT0 will determine how long the sound indicator will be on. We can set this value as we need. For this demo we use the data counter 3125 for 0.5 s.

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Figure 13: Counter Setting for Waiting Time

We use LUT0 to compare with standard AND gates so that if the exact time of 0.5 s and weight exceeds 60 kg, then the Sound indicator will sound.

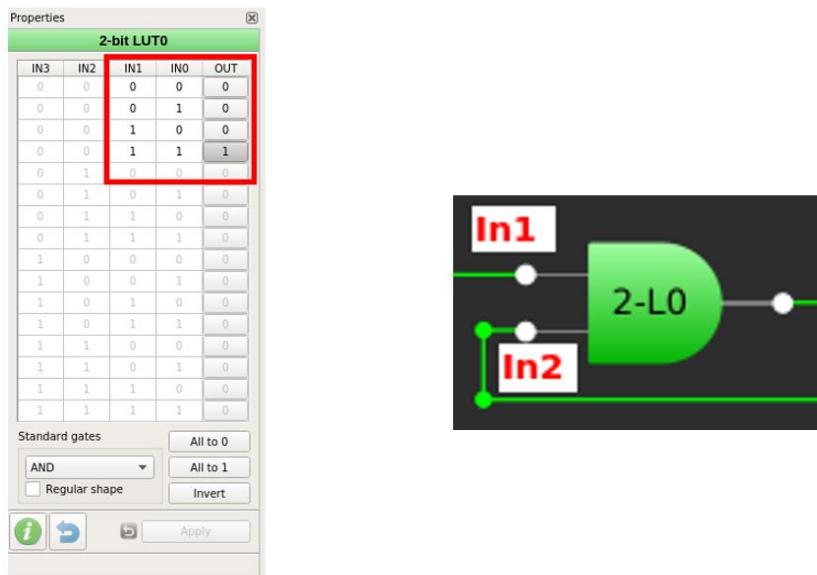


Figure 14: Logic Control Delay &amp; ADC

**Overweight Indicator****5 Result**

For this simulation we did two tests. First, we try to know the effect of Resistor Gain to the input obtained later to be processed and get the calibration value of the gain resistor that best matches the digital scale made. The second is to make the design using SLG46140 to be able to perfect the gain you want to get.

After the test, we searched for the highest point of resistor value for digital scales to maximize the capability of the amplifier circuit created and the capabilities of the developed digital scales. With this design we get the highest gain resistor value of  $\pm 6.8$  Ohm and the maximum weight measured is  $\pm 60$  Kg. It is quite complicated to adjust the value of the gain resistor because the design also greatly affects the required gain resistor. For the digital scale used in this example, it has been difficult to exceed 6.8 Ohm in an attempt to achieve higher weight.

**Table 1: Data Resistor Value and Max Kg**

No	Resistor Value	Max Kg
1	1 Ohm	$\pm 0$ kg
2	2 Ohm	$\pm 0$ kg
3	4 Ohm	$\pm 0$ kg
4	6 Ohm	$\pm 20$ kg
5	6.8 Ohm	$\pm 60$ kg

Furthermore, from the second test (using SLG46140 and its features), the maximum weight you want to measure can be set using the PGA module that sets the gain. We test with a gain setting  $\times 0.25$  and the sound indicator is triggered with weight  $>60$  kg.

Based on the above results, functionally, digital scale calibration goes well. This is very helpful in setting the amplifier compared to manual hardware changes. We also compare favorably in size against a controller that can adjust the amplifier gain calibration and has ADC feature as well. The design advantages presented here include smaller physical size, simplicity, power consumption, price, and easily customizable.

**Conclusion**

This Overweight indicator using the SLG46140 is an ideal solution for a preset weight indicator. The **GreenPAK** design above is completed by using the SLG88104. The lower comparative cost, small area, low power, along with the ease of programming **GreenPAK** makes this stand out compared to a microcontroller design. The Wheatstone bridge, differential amplifier, and adjustable gain principles were demonstrated. This design example can also be extended to other Wheatstone bridge applications, as it is highly reliable on very low resistance instrumentation.

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**Overweight Indicator**

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**Revision History**

Revision	Date	Description
1.0	14-Nov-2018	Initial Version

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