A WEIGHT CHECKER BASED ON DIGITAL TECHNIQUE

I.O. Oladejo and G.O. Fadiran

Electrical Engineering Department the Polytechnic, Ibadan.

ABSTRACT

Recent advances in digital computer and digital communication systems have led to a corresponding growing interest in digital weight techniques because of engineering advantages offered by digital systems over its analogue counterpart. In this work a digital weight checker with liquid crystal display has been designed. The weight checker uses Linear Voltage Differential Transformer (LVDT) transducer in which position of displacement of spiral is proportional to the output voltage of transducer. Its accuracy and provision of constant output impedance with infinite resolution makes it suitable for most applications. The system has its range from 0 to 20v corresponding to 0 to 20kg.

Keywords: Transducer, Digital, Display LVDT, voltage, Analogue.

INTRODUCTION

A digital weight checker is a digital signal transducer sensor that converts position of displacement to an equivalent voltage. Digital weight checker serves the same purpose as conventional analogue weight checker, but has several advantages over its analogue counterpart. It can be more accurately obtained. They are highly reliable and stable and thus permit high degree of flexibility. The efficiency of weights checker can be measured by its capacity to test the sample and its high accuracy.

The equipment measures the weight of a luggage in digital form. To achieve this objective, the system is subdivided into three main stages.

The stage that generates a clock and digital sinewave, consists of NE555 timer (wired in an astable mode) and working ring counter IC_2 (4018B) are the main active components as shown in Fig. 4. It also includes op-amp IC_1b (LM324) as band-pass Filter.

The stage that produces the output voltage proportional to the displacement of the movable ferrite core, consists of LVDT which is the main component in this stage.

The last stage is the one that amplifies the output of LVDT to produces a D.C. voltage linearly proportional to the displacement of LVDT. The main component in this stage is LM324.

The frequency of the sinewave generated by the working ring counter is 10KHz. Capacitor C_6 filters the digital sinewave approximation from IC_2. The resulting signal which is a much better sinewave is fed to IC_{1b}. This is configured as a standard 10KHz active band pass filter and gives a very pure sinewave in its output for driving the LVDT as shown in Fig. 3 and Fig. 4.

Amplification of voltage output of LVDT is achieved with the aid of IC_{1C} which has a high input impedance and gain of about 20. The second op-amp IC_1d (LM324) is wired as an inverter. It also has two CMOS analog switches IC_{4a} and IC_{4b} which are switched alternately using logic inverter IC_{3c} from IC_2. The resulting phase detector signal is a low pass filter actuated by resistor R_{28} and capacitor C_{12} to produce D.C. voltage proportional to the displacement of LVDT.

A built in power stage which is expected to produce stabilized 9v D.C. to Q1 consists of four units transformer Ti (220 Va.c/12 Va.c), rectifying units which help in converting A.C. voltage into pulsating D.C. voltage; filter unit (shunt input capacitor filter C_1) which helps in reducing unwanted ripple contents of rectified A.C. and the last stage for regulation purposely consist of Zener diode with three terminals regulator to produce constant 9V D.C. at its output.

The stability of voltage level is ensured by using a precision 5v supply based on reference diode D_1. The op-amp used to regulate this (IC_{1a}) actually powers itself from the 5v. Its output, thus stabilizing its own power rails. The 5v rail supplies all the circuitry but separate digital ground is used for logic ICs. This prevents digital noise from affecting the analogue signal.

The Scientific Literature

Most medical input measuring systems employ springs of one sort or another. The displacements are usually small and engineering approximation for small deflection for springs are therefore applicable. There are various common spring ranging from cantilever, helical and spiral spring to tortion bar, proof ring and spring flexure pivots. There are well known design formulas for this spring configuration (Barry, 1997).

The design makes use of the non-electrical change in position (displacement) measured into electrical quantities proportional to the weight of luggage. Transduction implies energy conversion and transducers may be genuine energy converter (called active transducers) or they may require an auxiliary energy source and therefore energy controller (called passive transducers) (Barry, 1997). In this design, passive transducer was used.

The widely used inductance transducer is the Linear Variable Differential Transformer (LVDT) as shown in Fig. 1. Displacement of the core produces the output voltage versus core displacement characteristics as shown in Fig. 1. This is linear over a considerable range but flattens out at both ends, and the voltage phase changes by 180^0 as the core moves through the center position.

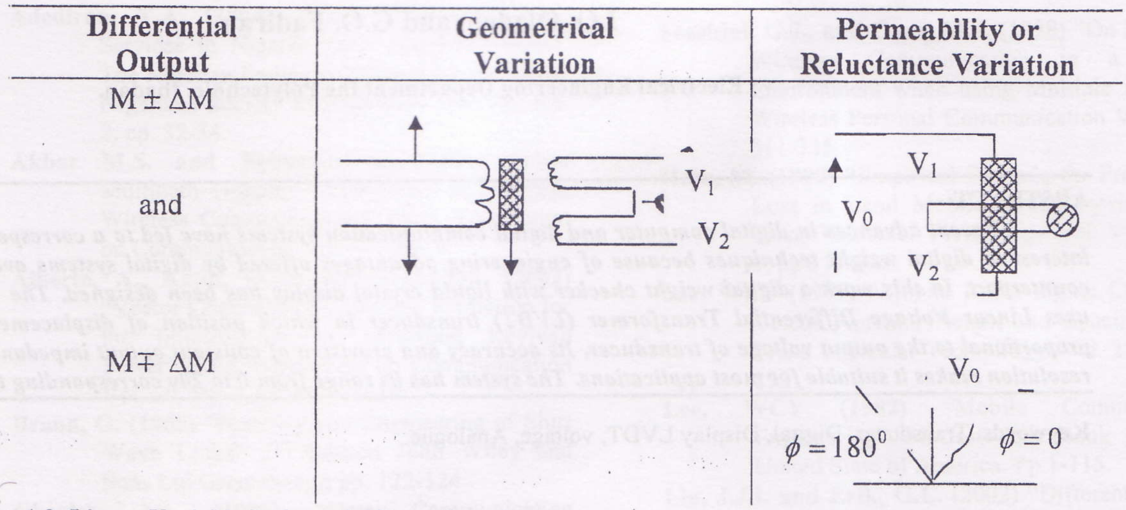


Fig. 1.0: Linear Variable Deferential Transferred

The principal advantage of LVDT when compared with potentiometer displacement transducer is the absence of contacts which deteriorate and the provision of constant output impedance with infinite resolution.

The efficiency of weight checker should be measured by its capacity to test its samples and its high accuracy. This equipment will separate the non-conforming products that have weight out of the specification from the product on specification. Thus its advantages are to control the quality of weight of products for correct action on time.

MATERIALS AND METHOD

Materials/Components Used

The materials/components used in each stage of the circuit shown in Fig. 4 are listed below.

(a) Power Supply Stage

Types and description of components Fig. 4

- One band gap reference diode D_1 (2N423)
- One transformer T_1, 220V/12Va.c.
- One Zener diode Z_{DI}, 2.7V 400BN
- One bridge rectifier IN5401
- One capacitor (electrolytic) C_1, 3,200µf
- One resistor R_1, 3kilo-ohm, $^1/_2$ Watt
- One 9v regulator LM 7809
- One transistor BD 131
- One blown fuse FS (13 ampere)
- One main plug

(b) Clock and Sinewave Generator Stage

- Four ICs, IC_1, IC_2, and IC_4 with values LM324, 4018B, 4093B and 4066B respectively.
- Two resistors R_5 and R_8, 33kilo-ohms $^1/_4$ Watt
- Three resistor R_6, R_7 and R_{16}, 22kilo-ohms $^1/_4$ Watt
- Resistors R_{14} (68KΩ) and R_{15} (5.6KΩ), $^1/_4$ Watt
- Resistors R_9 (1KΩ) and R_{10} (7KΩ)
- Two capacitors C_8 and C_9, 1.8nf
- Capacitor C_4 (22nf) and C_3 (10nf)
- One transistor NE555 timer.

(c) Transducer, Amplifier and Output Stage

- Four resistors R_{17}, R_{18}, R_{22} and R_{24}, 10kilo-ohms, $^1/_4$ Watt
- Two resistors R_{21} and R_{25}, 15kilo-ohms, $^1/_4$ Watt
- One variable resistor PR_1, 190kilo-ohms 2 Watts
- One capacitor C_{16} 10µf
- One weigh balance
- One LCD wired as digital Voltmeter (DVM)

Method and Deign Procedure

(a) Power Supply Stage

A 220v/12v r.m.s., 1.0A transformer was used in the design. A bridge rectifier used in the design was chosen with the following rating to withstand surge from input supply.

Current rating = 1A
Peak inverse voltage (PIV) = 500V
Forward current I_f = 300A
Operating temperature = 130°C
(***Sources:*** Floyd, C. 1990).

(b) Filter Unit

Type of filter used in the shunt input capacitor C_1

$$V_{d.c} = V_p / 4f\pi C \quad (1)$$

(***Sources:*** Ryder, J.D. 1987).

$$V_p = 2 \times v.d.c. \quad (2)$$

Vd.c = (12– 1.4) volts, diode voltage drops
= 10.6 volts

From equation 2

V_p = 21.2 volts

$$I_p = 2 \times 1 \text{ d.c.} \quad (3)$$

But

$I_{d.c} = 21m/\pi$ (for full wave rectifier)

$I_m = 1x\sqrt{2} = 1.411$

Therefore, I d.c. = 1.414 x $2/\pi$
= 0.9A

By substituting for Vp, Vd.c. and f in equation (1). We have

C_1 = 3183, microfarad. Therefore, preferred chosen value is 3200µf, 30 volts.

(c) **Clock Generator Unit**

The value of resistors used in this stage can be calculated using the expression.

$$T_1 = 0.693\,(R_9 + R_{10})\,C_2 \quad (4)$$

$$T_2 = 0.693\,(R_{10}\,C_2) \quad (5)$$

Where

T_1 – ON TIME and T_2 = OFF TIME

And

Total period $T = T_1 + T_2 = 0.693\,(R_9 + 2R_{10})\,C_2$ (6)

The frequency

$$\therefore f = \frac{1}{T} = \frac{1}{0.693(R_9 + 2R_{10})C_2} \quad (7)$$

Select F = 100KH

C_2 = 0.001, µf and R_9 = 1kΩ

By substituting these values in equation (7)

R_{10} = 6.7kΩ

Preferred chosen value is 7kΩ

Note: $R_{10} > R_9$ while keeping $R_9 > 500$ so that $T_1 \cong T_2$ to obtain close to 50% duty cycle (Ronald, 1998).

(d) **D.C. Amplifier Unit**

In design the IC_{1C} amplifier, the gain of 20 is chosen

$$Gain = \frac{V_{out}}{V_{in}} = \frac{R_{20} + PR_1}{R_{20}} \quad (8)$$

Select R_2 = 20k

By substituting Gain = 20 and R_{20} = 10kΩ in equation (8)

PR_1 = 190KΩ

Preset Resistor PR_1 = 190KΩ

For IC_{1d} which is configured as an inverter, the

$$Gain = \frac{V_{out}}{V_{in}} = \frac{R_{24}}{R_{22}} \quad (9)$$

Select R_{22} = 10KΩ

And Gain = 1

By substituting in equation (8) and taking its absolute value

R_{24} = 10KΩ

Testing and Reliability

The project was tested after completion in Electronics Laboratory of the Polytechnic Ibadan. The voltage measured at the terminal of power supply is 9v. Also output of the band-pass filter was tested on oscilloscope in which perfect sinewave was observed.

Workability Testing

The system was tested for about two different occasions with various weights. Table 1 shows the reading obtained for different weights used.

Table 1: Reading obtained with different weights

	Weight Used (Kg)	Measured Output of DVM (Volts)
1st Test	5	5.00
	10	9.98
	15	15.00
	20	19.97
2nd Test	6	6.00
	10	10.00
	12	11.98
	17	17.00
	20	20.00

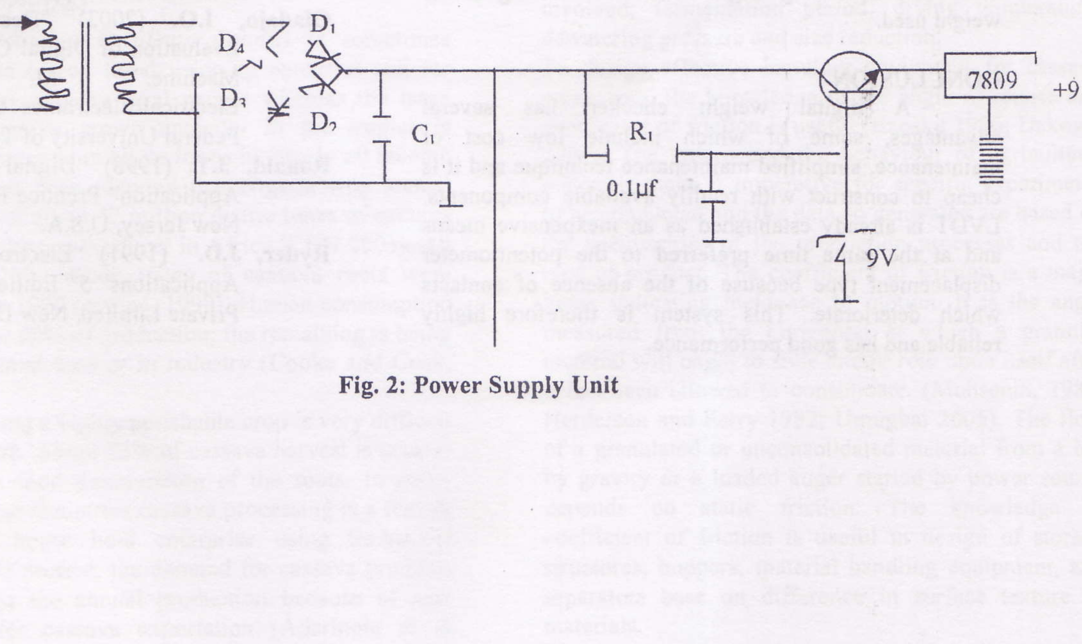
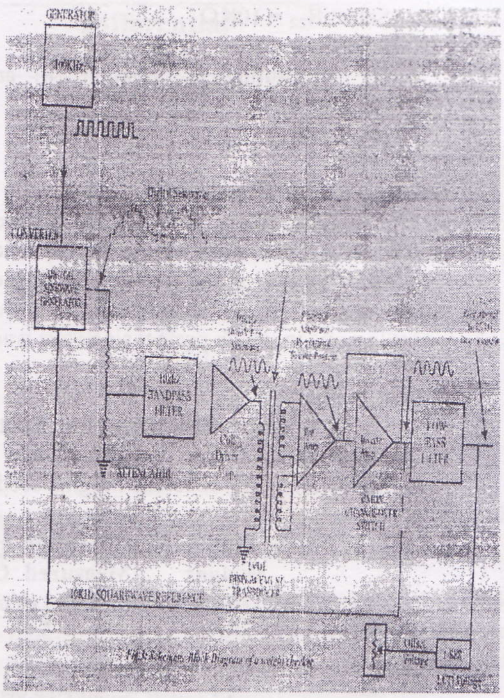
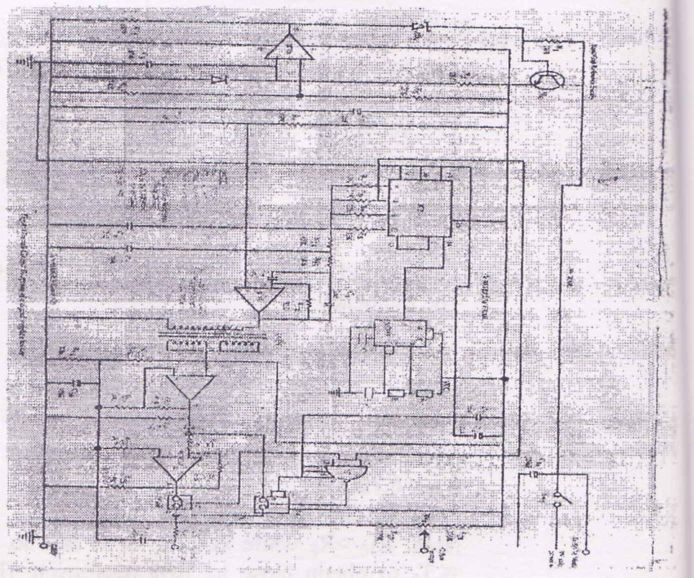


Fig. 2: Power Supply Unit





ANALYSIS OF RESULT

From the result of measurements carried out on the weight checker, it will be observed that the system performance is efficient and of high accuracy (i.e. the actual weights used more or less correspond to measurement of the output of DVM). The small difference in reading might be due to wearing of the weight used.

CONCLUSION

A digital weight checker has several advantages, some of which include low cost of maintenance, simplified maintenance technique and it is cheap to construct with readily available components. LVDT is already established as an inexpensive means and at the same time preferred to the potentiometer displacement type because of the absence of contacts which deteriorate. This system is therefore highly reliable and has good performance.

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