# Gait Trainer For Hemiplegic Cerebral Palsied Children

Aybike Dirikol, Erkan Kocakaya, Hasan Dinçer, and Sinan Fank
The University Of Kocaeli Electronic and Communication Systems Research and Application Center
(EHSAM), İzmit/ Turkey
National Metrology Institute (UME)Gebze-Kocaeli / Turkey
Email: hdincer@kou.edu.tr , erkanko@hotmail.com , sinan.fank@ume.tubitak.gov.tr

*Abstract* **Although protection methods are known, Hemiplegic Cerebral Palsy is a disease that often seen nowadays. This disease causes patients to have difficulty in gait. To cure this gait problem a microcontroller and a strain gauge based system is used. A strain gauge is placed in between floor and the patient's heel so the applied force can be measured. Once a treshold level is selected , then if the patient's force excess this level an audio–visual signal warning produced. This warning helps the patient to correct the walking by himself.**

*Index term* - Gait Trainer, Force Measurement, Biofeedback Therapy

## I - Introduction

Cerebral Palsy is a physical disabilities causes by damage to brain during its development, which can occur during pregnancy , birth and new-born period movement and posture are impaired , and the presence of other conditions such as intellectual damage , epilepsy , blindness or deafness depends on parts of brain damage. It should be expected the most people with Cerebral Palsy can think like healthy people ,but those who are unable to their movements example walk, speech etc. There are different forms of Cerebral Palsy , Spastic Cerebral Palsy is most common type occurring in about %80 of all causes. Spastically refers to the extreme stiffness or tightness in the muscles, which is caused by the brain damage. Athetoid Cerebral Palsy can be described by uncontrolled writhing movements and individuals with this type of motor disability often have very week muscle. Ataxia is the least common type and it is characterised by unsteady, shaky movements accompanied by problems with balance.

Despite whole development in research causes of the disease are completely unknown and there is no a certainly cure. But therapy can help the patients to correct their human motions. Various methods or treatment have been developed with have shown varying degrees of successful in different children. These include , The Bobaht method of neurodevelopment therapy conductive education [1], point pressure therapy [2], hydrotherapy [3], and horseback riding [4]. Some methods therapy are effective only in certain types of Cerebral Palsy and current research in techniques such as Dotulinum toxin therapy , posterior dorsal rhizotomy surgery lycrasplinting neuromuscular electrical stimulation [5] is aimed to identify characteristics of the individual and the form of his or her disability which contribute to a successful outcome.

In this work it is aimed to improve the unbalanced walking in Cerebral Palsied children. Therefore a system, which is measured the applied force in the patient's heel during walking and processing the biofeedback signals that is attained from the heel to warn the patient of excessive or insufficient weight. The force which is applied to floor will be shown in LCD display as Newton . This signals will record to a microcontroller and when we want , we can see results in screen. We are aimed to use the system for biofeedback therapy to achieve symmetrical gait in Hemiplegic Cerebral Palsied Children.

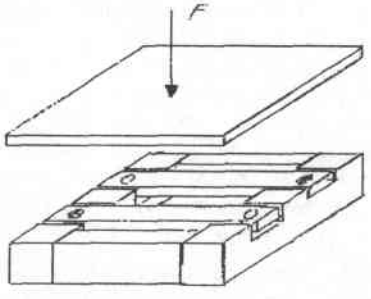



Fig. 1 The System under the Patient's heel

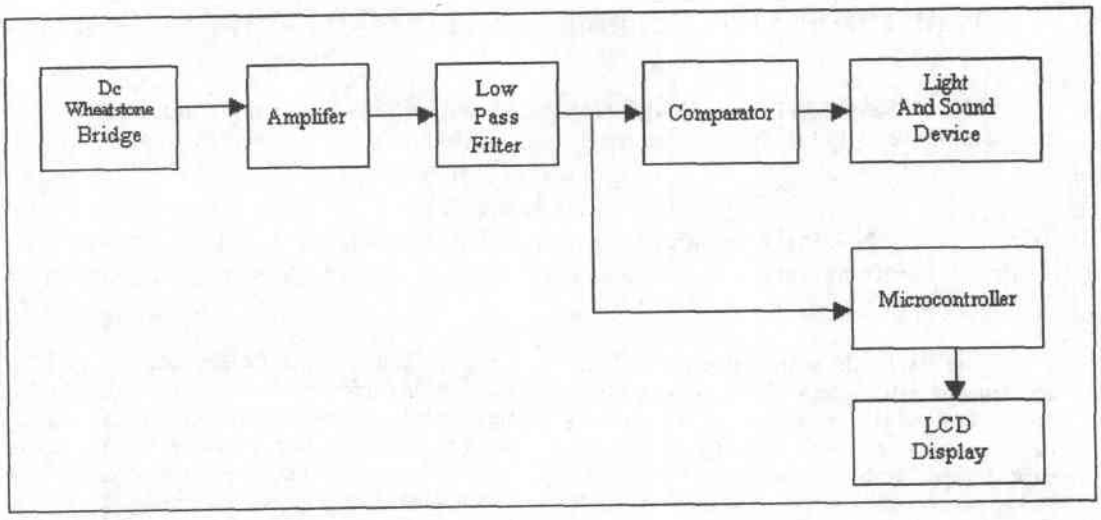



Fig 2. The Block diagram of the Gait Trainer

II. SYSTEM DESCRIPTION

We study **Gait** Trainer for Hemiplegic Palsied Children **whose block** diagram is given in Fig 2. This system **consist of** a whetstone bridge , amplifier stage, **comparator** stage , warning stage and microcontroller **block**. The Whetstone bridge has two strain gauges to measure the strain and we use Phillips 87C552 microcontroller to control the system and save the datas which come from the amplifier stage.

A strain gauge which measure the stretch applied force to plate by causing change of resistance is an useful transducer . If a length of electrical wire is exposed to a force it will be stretched , let we think $\delta L$ the amount of change in length , $\delta L$ is proportional to the load and the elastic limit of the materials is not over because the wire can convert to the original shape when load is removed . Hence there will be a decrease in the cross sectional area of the wire and since resistance of a conductor $=\delta L/A$ . Where $\delta$ is resistivity of the material , L is length and A is cross-sectional area , increase in length , decrees in area will cause an increase in the resistance of the stretched wire. In spite of change is small in metal , it causes to change in resistance. The dimension of the strain gauge depend on the desired application but resistance gauges are which was used in this experiment 5mm in length **from around** 3mm to 150 mm. Their nominal resistance values are from $120\Omega \mp 0{,}3\Omega$ .In this application HBM product 6/120LY43 type strain gauges have been used. These strain gauges have been bonded to aluminium material by HBM-270 type rapid adhesive. The definition of mechanical strain is the ratio change in length the original length in another expression $\delta L/L$ and is denoted by symbol $\varepsilon$ .

To relate these definitions a factor found as the strain sensivity as follows

$$\text{Strain Sensitivity} = \frac{\frac{\Delta R}{R}}{\frac{\Delta L}{L}} = \frac{\frac{\Delta R}{R}}{\varepsilon} \quad (1)$$

Note that $\varepsilon$ is often used as microstain for example micrometers per meter. The description of the gauge factor is the strain sensivity of a manufactured strain gauge. The majority of strain gauge have a gauge factor 1.9, 2 or 2.1 . It is denoted symbol by K .The gauges used in this experiment have $K = 2.07 \mp 1$. When a strain gauge is used for a motion state , the frequency response of the gauge becomes because of vibrations . It should be considered difficulties of causing vibration in measurement . For this point it should be used a low pass filter.

**1- Wheatstone Bridge :**

For the sensing of foot force two cantilever type beam have been used in the transducer. After application of the force on the an end of beam. It is bended in the limited range . This range is calculated according to applied force F , elastic modulus of material(E) which is aluminium in this experiment , and length of cantilever beam L using the hook's law , b' stress $\sigma$ can be calculated as below,

$$\sigma = E * \varepsilon \quad (2)$$

$$\sigma = \frac{F * L}{W} \quad (3)$$

$\sigma$ =Bending stress

E = Modulus of elasticity of aluminium , 72.1 Gpa

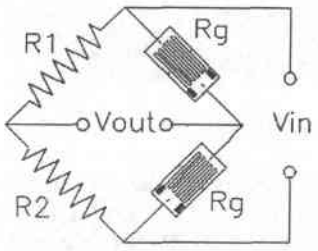
$\varepsilon$ = Bending strain which is limited in 1500 $\mu$m/m according to strain gauge measurement range.

L = Length of cantilever beam (m)

W = Section module of rectangular shape is

$W = \frac{bh^2}{6}$

Wheatstone bridge circuits are very advantageous for measurement of resistance , inductance and capacitance. Wheatstone bridges are commonly used for strain measurement. A Half wheatstone bridge is shown below




It consist of 4 resistors 2 of them is strain gauges. An input Dc voltage is applied between node1 and node2. The output voltage is measured across the middle. When the output the voltage is zero, the bridge is balance . One or more of the legs of the bridge maybe a resistive transducer such as a strain gauge. The other legs of the bridge are resistors with resistance the same strain gauge(s). As the resistance of one of the legs changes , the previously balanced bridge is now unbalanced. This unbalance causes a voltage , that calculated as follows

The unstrained resistance of each gauge is 120 Ω
The gauge factor is 2
The strain gauges are subjected to a strain of 100 microstrain

The Vin voltage is 10 V dc

$$\varepsilon : 2.08.10^{-7}$$

With this values

$$K = \frac{\delta R}{R\varepsilon} \quad \delta R = K.R.\varepsilon$$

$$\delta R = 2.120.2.08.10^{-7} = 0.05m\Omega$$

$$Vout = \text{Vin}\,\frac{\delta R}{2R} = 10.\frac{0.05.10^{-3}}{2\times120} \cong 2\mu V$$

Note: This calculation is mode for 100 Newton which is applied to plate. It is applied the voltage which is attained from the wheatstone bridge output to an amplifier state because output voltage is μV degrees so that it is used for an amplifier circuit that consist of TL082 IC as follows.

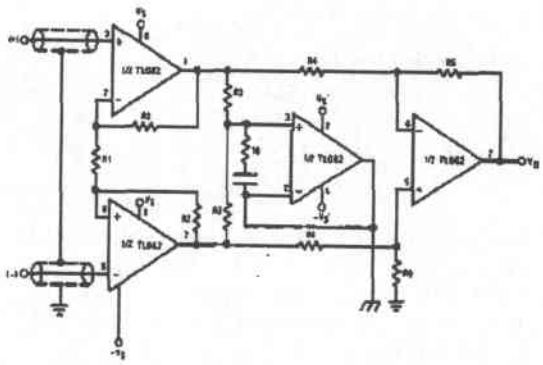


**Fig 4. Amplifier Stage**

The voltage gain of the amplifier state is,

$$Av = \left(\frac{2R_2}{R_1} + 1\right)\frac{R_5}{R_4}$$

Matching of R2's, R4's and R5's control CMRR
With A V T e 1400, resistor matching = 0.01%:
CMRR = 136 dB

- Very high input impedance
- Super high CMRR

With this circuit it is obtained the enough voltage by increasing the wheatstone bridge output. Considering load has values between 10 kg and 50 kg , signals which is obtained from measuring system with strain gauges , will be approximately 4 mV to 20 mV . We should increase those voltage values in normally . The gain of amplifier should be 62.5 . To supply this gain it is used circuit in figure 3. By connecting three times cascade each other (three state amplifier).

To remove the effect of the vibration which is using strain gauges during the gait training causes it , it should be connected a low pass filter in the last state of amplifier output. In shown Figure 5. The circuit has the cut-off frequency is 100Hz

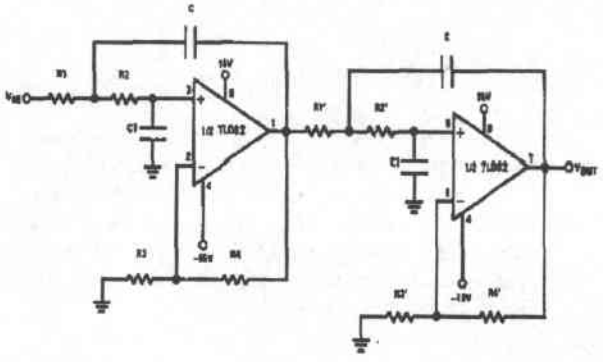


Fig 5. Fourth Order Low Pass Butterworth Filter

- Corner Frequency
- Pass Band Gain

$$(f_c)=\sqrt{\frac{1}{R_1R_2C_1^2}}\bullet\frac{1}{2\pi}=\sqrt{\frac{1}{R_1R_2C_1^2}}\bullet\frac{1}{2\pi}$$

- First Stage Q=1.31
- Second Stage Q=0.541

$$(H_Q)=\left(1+\frac{R_4}{R_3}\right)\left(1+\frac{R_4'}{R_3'}\right)$$

- Circuit shown uses 5% tolerance resistor values for a filter with a corner frequency of 100 Hz and pass band gain of 4
- Offset nulling necessary for accurate DC performance

We aimed to with this system to help patients attain partial weight bearing on a lower floor with fracture or recent hip or knee endoprosthesis . A Threshold level is set to indicate the maximum allowable weight to be applied on the floor. When weight bearing exceeds the threshold an audible tone is emitted.

**II- Comparator State**

The signals on the amplifier's output is applied to the comparator's noninverting input and the reference voltage that is 6 V is applied to the inverting output. At the same time this reference voltage is going to be the adjustable threshold voltage. This voltage value can be adjusted by a potentiometer. This state is shown in Fig. 6.

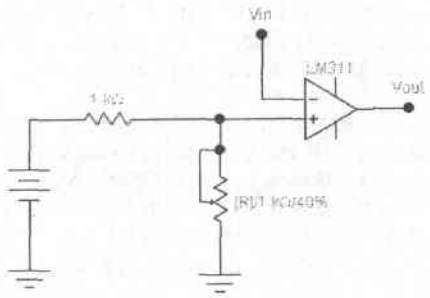



Fig. 6 Comparator Stage

If the voltage which is applied to the comparator excess the threshold voltage the output will be +Vcc and diodes will be forward bias .The audio system will be active. If the signal level is less than threshold voltage the output is –Vcc and the green led is open this shows that the conditions are normal .

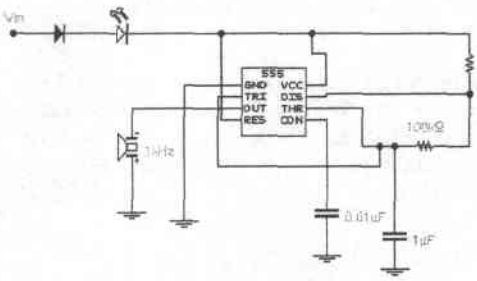



Fig.7 Audio System

**III- Microcontroller Stage**

It is necessary to store the data which is obtained the heel and if it is desired it has seen on the screen to observe the development in the gait training .Due to the fact that it is going to use P87C552 microcontroller manufactured by Philips . The 87C552 single-chip 8 bit microcontroller is a derivate of the 80C51 microcontroller family and it has the same instruction set as the 80C51

Features

- 80C51 central processing unit
- 8Kx8 EPROM expandable externally to 64 Kbytes
- An additional 16-bit timer/counter coupled to four capture registers and three compare registers
- Capable of producing eight synchronised, timed outputs
- Fast 8-bit ADC option
- Full static operation 0 to 16 MHz
- Operation Voltage range : 2.7V to 5.5V

Firstly the signal which apply to the ADC inputs of microcontroller converted to the digital signal. The data which is sampled at 1 kHz. These samples is taken an average in 1 second and this average is stored in the EPROM. At the same time it will shown in LCD display

**CONCLUSIONS**

The result of current research and studies Unbalanced walking which Hemiplegic Cerebral Palsied causes . We made this study about this project. With this project the prototype was made . In the future we aimed to correct its deficiency

**References**

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