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Biomedical Sciences and Engineering

Master Thesis

Title
Study of Contractile activity of Organic Muscle using an Optical sensor Исследование сократительной активности гладких мышц оптическим методом

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ABSTRACT:

This paper presents the system for detection of elastic movement of an object and measure the contractile activity of the object. An optical sensor is used to detect the Elastic object contraction, which is described. In the initial experiments, we used elastic. Next object will be animal muscle, so that we can determine the muscle contraction. Optical light is passed to the reflective plate fixed on the muscle, the backscattering is observed, and the contraction is detected by measuring the change of the distance, that occurs during muscle contraction and corresponds to muscle activity. The optical sensor converts the distance to voltage, which is recorded by digital oscilloscope. With respect to electromyography and to optical absorption-based sensors, our device has the advantage of lower invasiveness, of lower sensitivity to electromagnetic noise and to movement artifacts, and of being able to distinguish between isometric and isotonic contractions. Here electrical activity and optical activity is used to analyze the wave characteristics and muscle contractile activities.

CHAPTER-I

1.0 INTRODUCTION:

Optics is the branch of science that deals with the behavior of light and its properties which includes light interactions with substances. The instruments which is used to detect it. Optics describes the behavior of visible, ultraviolet, and infrared light. Light is a electromagnetic radiation such as X-rays, microwaves, and radio waves exhibit similar properties. The science of optic is relevant to many related topics including astronomy, different types of engineering fields, photography and medicines specifically ophthalmology and optometry. The applications of optics are present in various types of technologies. Objects may includes mirrors, lenses, telescopes, microscopes, lasers, and fiber optics. In this experiment we are using object as laser.

In an optical sensor light rays are converted into electronic signals, it measures the physical quantity of light and then translates it into a form that is readable by an instrument. An optical sensor integrates a source of light, a measuring device and the optical sensor which is often connected to an electrical trigger. The trigger reacts to a change in the signal within the light sensor. It can measure the changes from one or several light beams. This optical sensor works as a photoelectric trigger, when a change occurs, therefore electrical output either increases or decreases.

Electromyography (EMG) is an instrument which is used to record the electrical activity of the muscles and to determine whether muscle is contracted or not. This measurement is also important for myoelectric control of prosthetic devices. Finally output is displayed and recorded on Digital storage oscilloscope. It is a type of electronic test instrument which allows observation of constantly varying signal voltages and signals as a function of time. Other signals like sound or vibration can be converted to amplitude and which is displayed.

CHAPTER-2

2.0 LITERATURE REVIEW

2.1 LITERATURE REVIEW-I

"MECHANISMS OF SMOOTH MUSCLE CONTRACTIONS", Horowitz, Arie, Constance B. Menice, Regent Laporte, and Kathleen G. Morgan., Mechanisms of Smooth Muscle Contraction.

Work done with differentiated contractile smooth muscle tissue over the last two decades has made that clear that covalent modification of myosin by phosphorylation of the 220 kDa myosin light chain significant mode of regulation of contractile activity in smooth muscle especially in regards to the generation of phasic contractions and initial development of tonic contractions. This mechanisms appears to be unique importance of smooth muscle compared with the striated muscles. It plays an important role for protein kinase C in the regulations of smooth muscle tone maintenance particularly in vascular smooth muscle. The outline of protein kinase C is involved by the several possible signal transduction cascades. There is an increasing evidence suggests a link between protein kinase C and actin based regulatory mechanisms. This review shows that up-to-date biochemical facts to the physiological realities of smooth muscle cell.

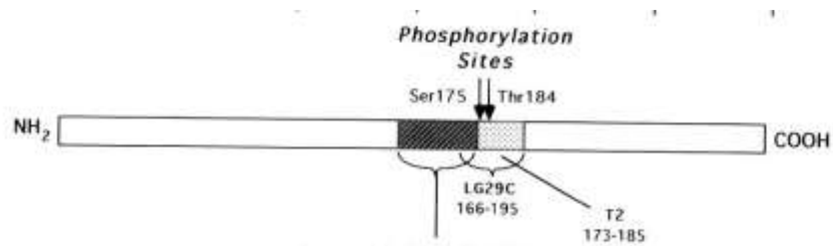


Fig. 1. Actin/Binding Inhibitory.

2.2 LITERATURE REVIEW-II

"MEASUREMENT OF ELECTRICAL ACTIVITY IN SKELETAL MUSCLE", Bekey, George.

In our human body in order to strengthen life bio-potentials, voltage differences, must be maintained throughout the body. These potentials are maintained through continual consumption of energy. A bio-potential allows for signals which send information throughout the body. These signals and bio-potentials are important to the function of body systems including muscle contractile activity, neural activity, and sensory functions. Some signals are localized, while others travel throughout our body. In this project they will be experimenting with the signals located in the Bicep muscle. Analyzing more about these complex signals not only expands our understanding of the human body, but it can also aid in efficiently diagnosing problems. In this project they are going to use the Cleve Med Bio Radio as an electroencephalogram (EEG). The EEG will record the signals through electrodes which connected to our bicep.

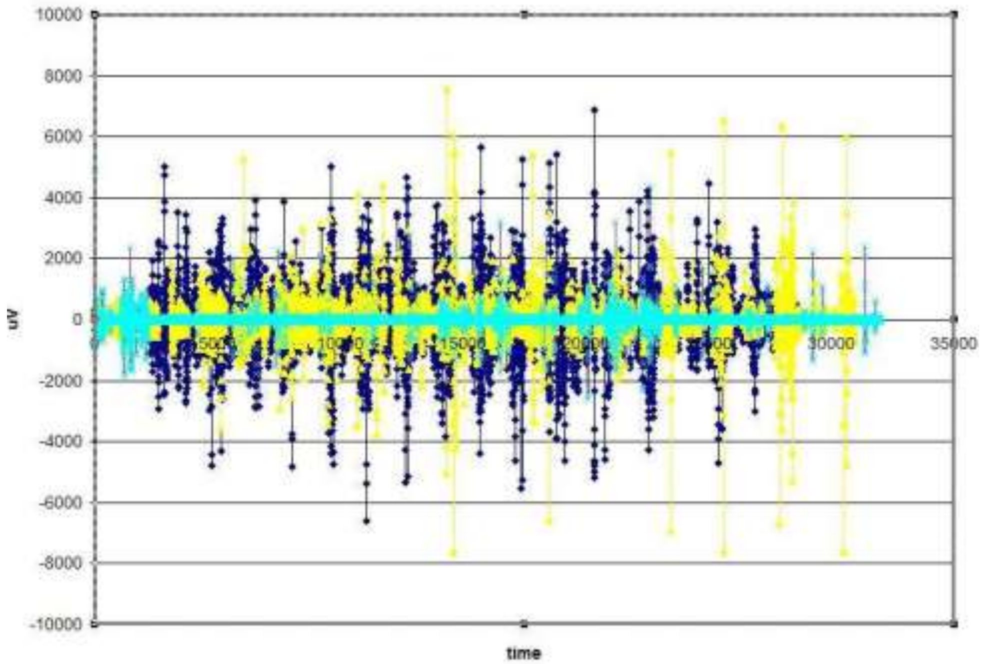


Fig. 2. Multiple signal recordings.

2.3 LITERATURE REVIEW-III

"A SURVEY ON DETECTION OF MUSCLE CONTRACTION", Human colonic smooth muscle: electrical and contractile activity in vitro, R C GILL, K R COTE, K L BOWES, AND Y J KINGMA.

The activity of extracellular electrical and contractile was recorded, the human colonic smooth muscle strips can be obtained during surgery. The electrical activity of longitudinally oriented strips from the taenia and intertaenial section was summarized by continuous oscillation at a frequency. Contractions were noted electrically by a series of oscillations upon which spikes were superimposed and from the sub mucosal surface of circularly oriented strips exhibited oscillations at these electrical activity recorded and frequency significantly lower than recorded from the serosal surface of similar preparations. Then the contractile force and frequency was depends on the part of the colon from which the strip originated.

The contractions were recorded from strips of sigmoid colon. The contractile frequency of circularly oriented strips from the right colon, significantly higher than that of strips from the left colon. Stretching these strips causes an increase in contractile frequency to the electrical oscillation.

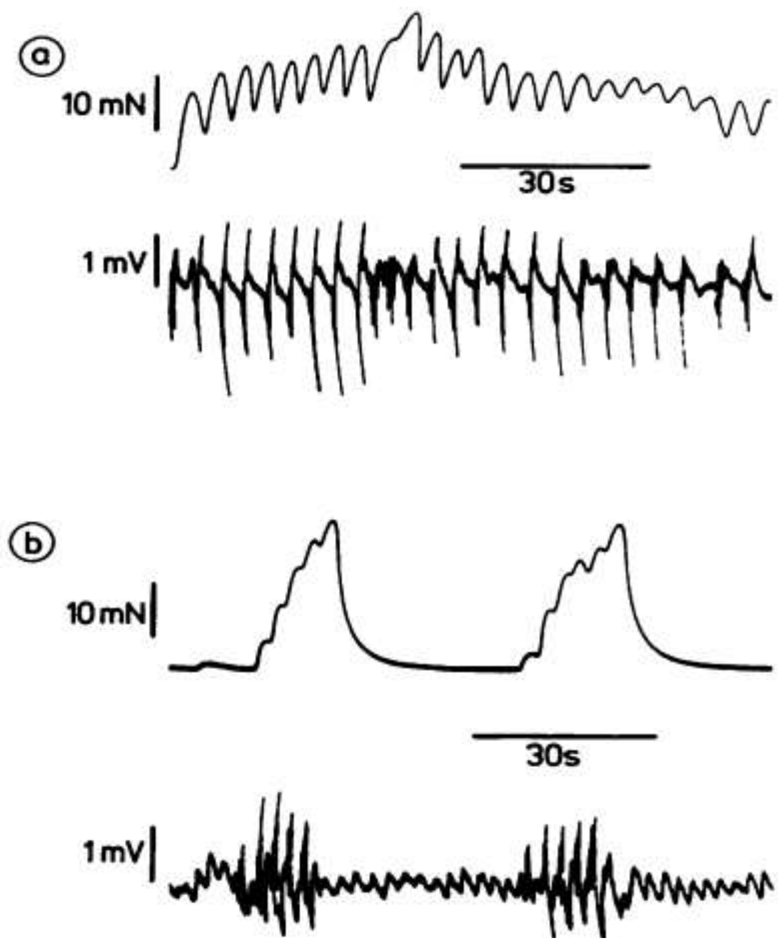


Fig. 3. Contractile (upper panels) and sub mucosal electrical (lower panels) activities of circularly oriented strip of smooth muscle obtained from the transverse colon to which 40 mN of basal tension had been applied. Contractions were observed at the frequency of the electrical oscillation (A), these contractions could summate and give rise to contractions of long duration (B).

2.4 LITERATURE REVIEW-IV

"KINETICS OF CONTRACTION IN DEPOLARIZED SMOOTH MUSCLE FROM GUINEA-PIG TAENIA COLI AFTER PHOTODESTRUCTION OF NIFEDIPINE", Ulf Malmqvist and Anders Arner.

The kinetics of force development following the activation by opening of L-type Ca2+ channels was investigated using photo destruction of the Ca2+ channel blocker nifedipine in smooth muscle from the guinea pig taenia coli. In muscles activated using high potassium and Calcium. It inhibits subsequently with nifedipine, photo destruction of the drug using a strong ultraviolet light flash initiated a rapid contraction. The force initiated by photodestruction of nifedipine reached near maximal levels. This procedure eliminates diffusional delays and can thus be used to investigate the kinetics of depolarization induced contractions. The rate of force development of contractions initiated by photodestruction of nifedipine was slower than that observed in maximally thiophosphorylated skinned fibres. This suggests the rate of force development is controlled by activation steps in the activation cascade prior to the force generation of the cross bridge system. The rate of force development and the plateau force were dependent on the extracellular [CaCl2] suggesting that the intracellular [Ca2+] determines the rate of phosphorylation and force development. The delay between illumination and increase in force was about 300 ms. The delay was similar at low and high extracellular [CaCl2] indicating that buffering by superficial sarcoplasmic reticulum does not introduce a delay in force development following activation of Ca2+ channels in this muscle.

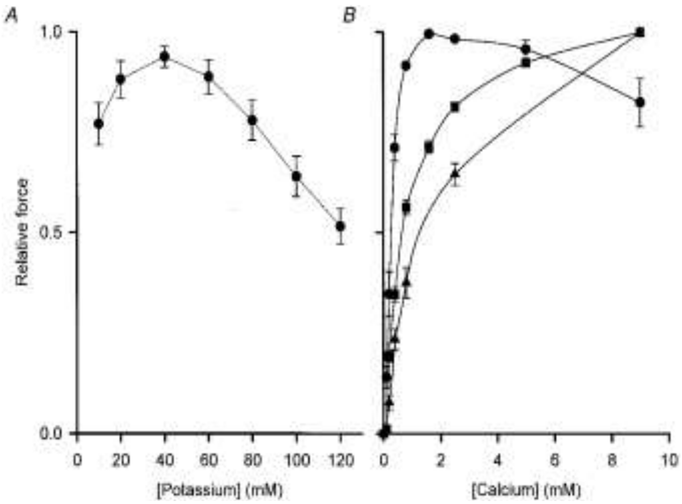


Fig. 4. Potassium and calcium dependence of active force.

2.5 LITERATURE REVIEW-V

"STIMULATION OF ISOLATED VENTRICULAR MYOCYTES WITHIN AN OPEN ARCHITECTURE MICROARRAY", Norbert Klauke, Godfrey L. Smith, and Jonathan M. Cooper.

This paper deals with the physiological responses of single heart cells in the chambers, with response to stimulation by integrated microelectrodes. The stimulation is done by the application of transient current pulses to the cells through the electrodes which results in transient contractions with constant amplitude, with confirmation that the excitation contraction coupling was same. The paper shows the electrical stimulation of isolated adult cardiac cells in micro chambers for a prolonged time. The open architecture of the heart provides access for drug dispensation without any interference between the neighboring micro structures. This paper deals with the stimulation of single cardio-myocytes using a microwell array, in order to provide an open system for drug tests on electrically stimulated adult ventricular myocytes. The results of the paper showed that individual ventricular myocytes that are continuously stimulated in non-perfused microwells of nL volume maintain the integrity of the cell components involved in EC coupling.

2.6 LITERATURE REVIEW-VI

"THE ROLE OF PH RANGE IN REGULATING THE FUNCTION OF SMOOTH MUSCLE IN THE INITIAL PART OF THE LARGE INTESTINE", POGUDIN Y. A.

In this paper they explains about the smooth muscle of the gastrointestinal tract are characterized by a great diversity of electrical and contractile properties, which are under complex control of the nervous and humoral regulation of organism. In connection with the search for new methods of treating disorders of motor activity of the smooth muscle of the digestive tract the necessary new knowledge for understanding not only the General regularities of the functioning of smooth muscle, but also knowledge of the fundamental nature of the individual characteristics of the individual formations of smooth muscle of the gastrointestinal tract.

Special attention in this respect, deserve not only the formation of the sphincter of the gastrointestinal tract but also the adjacent smooth muscle structures which have a number of peculiarities of the functioning of the myogenic nature, as well as regulation by neuro-humoral and cellular-intercellular and tissue information intermediaries.

2.7 LITERATURE REVIEW-VII

"**MECHANOTRON",** Berlin G. S. Elektronnye pribory s mekhanicheski upravliaemymi elektrodami.

Mechanotron has some characteristics features which are the displacement of one or more movable electrodes with respect to the fixed c athode makes a change in the value and configuration of the electric field between the electrodes and thus the anode current strength value changes. The total number of electrodes might be two (diode), three(triode), or four (tetrode) . The most common type of mechanotron is the diode mechanotron, which usually has a dual design (a fixed cathode and two movable anodes) and which is used in bridge measuring circuits. The chief advantages of mechanotrontransduc ers are the high current sensitivity (up to 7 A/cm for diode mechanotrons), the high voltage sensitivity (up to 25kV/cm), the high stability and reliability of the reading s, the simplicity of the design and circuitry, the small size, and the low weight.

It has some disadvantages. It is impossible to derive the absolute value of the input, one does not know the sign of the deviation of the tip from a nominal dimension, and a long time is required to operate the pulse counter, which means that the readout time is long. Advances in digital measurements have made it possible to build a device completely eliminating these disadvantages and providing measurement of parameters in absolute units together with the sign of the deviation from the nominal value, and also with considerable reduction in the measurement time. It shows the scheme of a device for measuring linear dimensions. The transducer is the string, which is attached on one side to the measurement lever 1 and on the other side to the body. Parallel to the string there is the similar tie. The measurement lever is mounted on the elastic hinge 2 and provides a given measurement range. The string is connected to a positive-feedback amplifier and is excited in self-oscillation, which provides undamped transverse vibrations in the string with an amplitude of 1-3 ~m at the frequency of its natural mechanical oscillations in the range 3-7 kHz, which is dependent on the tension and strain. A signal with frequency fx dependent on the displacement x is produced by the generator G and passes through the shaper S to the frequency divider DI, whose output is the time interval time a formed by the number of periods in the frequency to be measured.

In this paper, we replaced Mechanotron instead of that we use optical sensor. It is very accurate and reliable. It is not more expensive and gives digital output and output signal is recorded and that is stored in digital recorder.

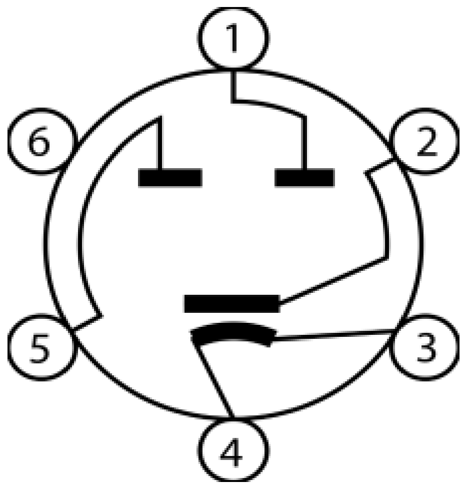


Fig. 5. Mechanotron.

2.8 LITERATURE REVIEW-VIII

" ELASTIC BENDING AND ACTIVE TILTING OF MYOSIN HEADS DURING MUSCLE CONTRACTION ", Randall Institute, National Institute for Medical Research, Mill Hill.

Muscle contraction is formed by the change of shape of myosin's head region that links the actin and myosin. The head Tilt towards the light-chain domain with respect to its actin-bound catalytic domain is thought to be coupled to the ATPase cycle. By using X-ray diffraction and mechanical data from isolated muscle, we characterize an elastic bending of the heads that is independent of the presence of ATP. The tilting and bending motions explains the generation of force in isometric muscle, when filament sliding is prevented. The elastic strain in the head is 2.0±2.7nm kept under these conditions, which provides 40± 50% compliance of the muscle sarcomere. We present an atomic model for changes in head conformation that accurately reproduces the changes in the X-ray diffraction pattern seen when rapid length changes are applied to muscle both in active contraction and in the absence of ATP and this model predictions are relatively independent of which parts of the head are presumed to bend or tilt, but depends on the measured values of sliding and elastic strain.

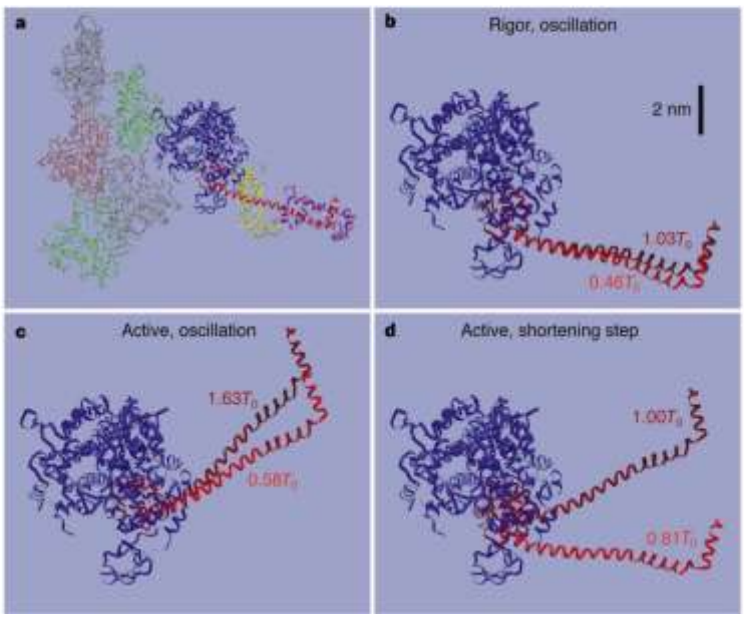


Fig. 6. Structural model for elastic bending and ATP-driven tilting of the light chain domain of the myosin head.

2.9 LITERATURE REVIEW-IX

“ EPIDERMAL ELECTRONICS ” , Dae-Hyeong Kim, Nanshu Lu, Rui Ma,Yun-Soung Kim, Rak-Hwan Kim,Shuodao Wang, Jian Wu, Sang Min Won, Hu Tao, Ahmad Islam, Ki Jun Yu,Tae-il Kim, Raeed Chowdhury, Ming Ying, Lizhi Xu, Ming Li, Hyun-Joong Chung, Hohyun Keum, Martin McCormick, Ping

Liu, Yong-Wei Zhang, Fiorenzo G. Omenetto,Yonggang Huang, Todd Coleman, John A. Rogers.

In this report explains electronic systems that achieve thicknesses, effective elastic moduli, bending, stiffness, and areal mass densities matched to the epidermis. Unlike traditional wafer-based technologies, laminating such devices onto the skin leads to conformal contact and adequate adhesion based on van der Waals interactions alone, in a manner that is mechanically invisible to the user. We describe systems incorporating electrophysiological, temperature, and strain sensors, as well as transistors, light-emitting diodes, photo detectors, radio frequency inductors, capacitors, oscillators, and rectifying diodes. Solar cells and wireless coils provide options for power supply. We used this type of technology to measure electrical activity produced by the heart, brain, and skeletal muscles and show that the resulting data contain sufficient information for an unusual type of computer game controller.

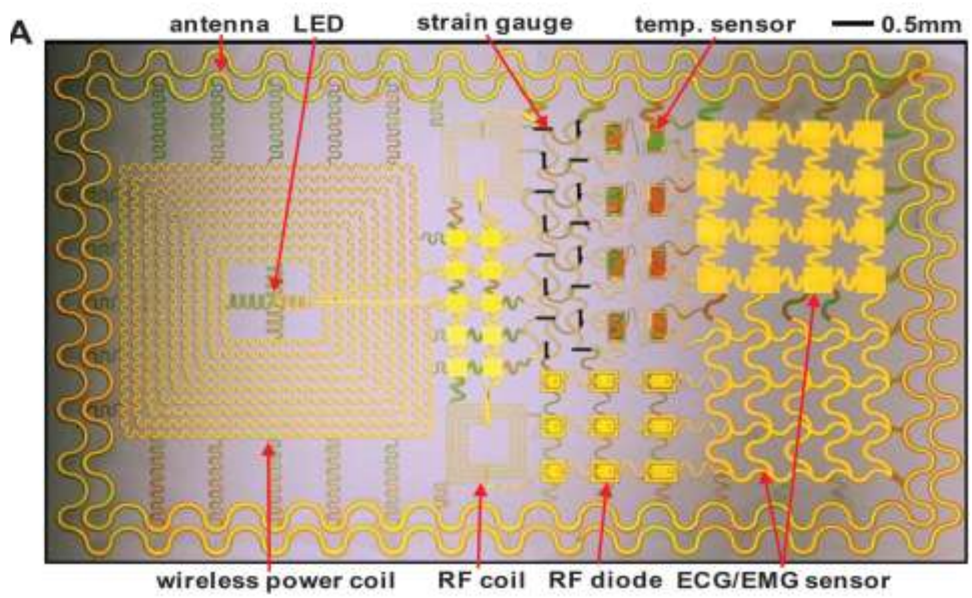


Fig. 7. Image of a demonstration platform for multifunctional electronics with physical properties matched to the epidermis.

2.10 LITERATURE REVIEW-X

"NON INVASIVE OBSERVATION OF SKELETAL MUSCLE CONTRACTION USING NEAR INFRARED TIME-RESOLVED REFLECTANCE AND DIFFUSING-WAVE SPECTROSCOPY", Journal of Biomedical.

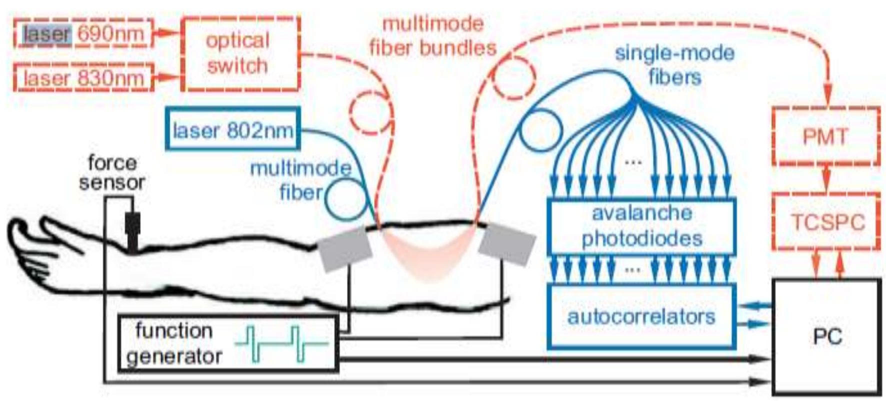


Fig. 8. Experimental setup and stimulation protocol. The excitation and detection paths for DWS and time-resolved reflectance spectroscopy are shown in blue and red, respectively.

This paper introduces a method for noninvasively measuring muscle contraction based on near-infrared diffusing-wave spectroscopy DWS. The method exploits the information about time-dependent shear motions within the contracting muscle that contains in the temporal autocorrelation function of the multiply scattered light field measured as a function of lag time, g, l, t, and time after stimulus, t. The analysis of g, l, t measured on the human biceps brachia during repetitive electrical stimulation using optical properties measured with time-resolved reflectance spectroscopy shows that the tissue dynamics giving rise to the speckle fluctuations can be described by a combination of diffusion and shearing. The evolution of the tissue strain shows a strong correlation with the force, indicating that a significant part of the shear observed with DWS is due to muscle contraction. The evolution of the DWS decay time shows quantitative differences between the biceps brachii and the gastrocnemius, suggesting that DWS allows to discriminate contraction of fast and slow twitch muscle fibers.

2.11 LITERATURE REVIEW-XI

" MORPHOLOGICAL AND FUNCTIONAL DIFFERENTIATION OF CULTURED VASCULAR SMOOTH-MUSCLE CELLS ", Motoki Tagami , Yasuo Nara, Akiyoshi Kubota x, Toshiaki Sunaga , Hidenori Maezawa ,Hideaki Fujino , and Yukio.

In numerous investigations using cultured smooth-muscle cells, investigators have consistently added 10 to 20% fetal calf serum (FCS) to the medium to maintain viable cells. In the present study we utilized an optical technique to investigate whether smooth-muscle cells, cultured with or without FCS, maintain their contractile activity in vitro. With such optical measurement, we were able to detect signals due to spontaneous contractions, in muscle cells cultured in FCS-free medium for up to 8 days, and for the first time, were also able to observe the conduction of these cell contractions. The ultra structural characteristics of cultured smooth muscle cells during contractile activity, were also examined by electron microscopy. The cells were mature and well differentiated, and were packed with numerous myofilaments. They had developed long cell processes, and were linked to one another by gap junctions. These observations indicated that the smooth-muscle cells, cultured without FCS for 7 to 8 days, were morphologically mature and maintained their contractile activity, whereas the cells cultured in FCS-containing medium showed no detectable signs of contractile activity.

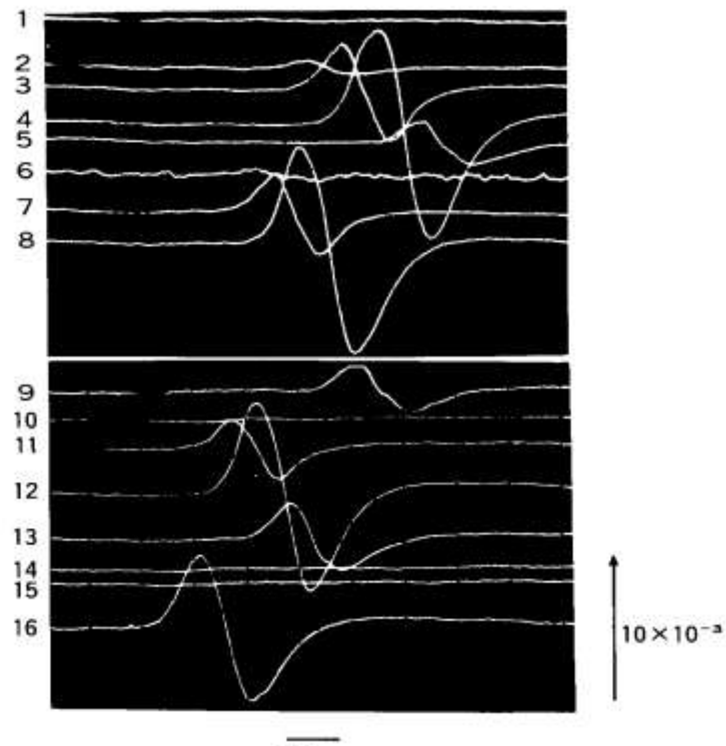


Fig. 9. A photodiode matrix array was positioned on the image of the area of cultured smooth muscle tissue.

2.12 LITERATURE REVIEW-XII

"THE CHARACTERISTICS OF INTRINSIC COMPLEX MICRO-CONTRACTILE ACTIVITY IN ISOLATED STRIPS OF THE RAT BLADDER", Springer-Verlag Berlin Heidelberg.

The present study was done to explore the cholinergic systems operating in the wall of the isolated rat bladder. In a first set of experiments, bladder strips in vitro were subjected to cumulative concentration-response curve (CRC) to non-selective muscarine agonist carbachol or the partially M2>M3 selective agonist arecaidine to establish optimal concentration to be used thereafter. In a second set of experiments, the effects of drugs (solifenacin, isoproterenol and mirabegron) were tested on urinary bladder contraction induced by the non-selective muscarinergic agonist carbachol. For both agonists, the contractile responses are qualitatively similar: an initial transient rise in tension followed by complex bursts of high-frequency small ‘micro’-contractions superposed on a tonic contraction, with immediate transient ‘rebound’ contraction after the agonist is washed from the reparation. This rebound contraction is greater with carbachol than arecaidine. Components of the responses to cholinergic stimulation, notably the micro-contractions, were found to be differently stimulated and inhibited by the M3>M2 selective antagonist solifenacin and by the β-adrenoceptor agonists isoprenaline and mirabegron. A physiological role for the muscarinic dependent phasic contractions and the microanatomical elements that might be involved are not known but may be related to non-voiding activity observed during filling cystometry in conscious animals related to afferent discharge and possibly sensation. Furthermore, suggestions for the potential impact of these findings and design of further studies in relation to bladder physiology, pharmacology and pathology are discussed.

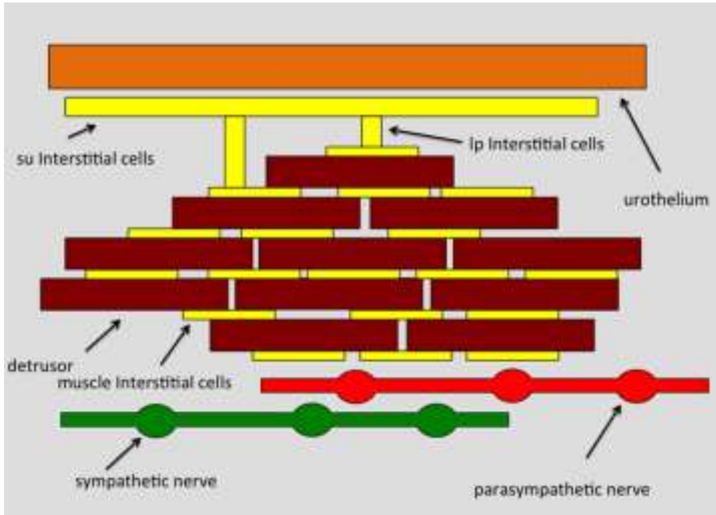


Fig. 10. Cartoon illustrating the possible modular arrangement of muscle motor units in the rat bladder wall.

Finally I have done this project with the help of the above literature reviews for the muscle contractions using optical device. All the above described papers have some advantages and disadvantages. But in my project I have been used optical device instead of mechanotron. Optical absorption-based sensors, our device has the advantage of lower invasiveness, of lower sensitivity to electromagnetic noise and to movement artifacts, and of being able to distinguish between isometric and isotonic contractions. Here electrical activity and optical activity is used to analyze the wave characteristics and muscle contractile activities. Optical sensor light rays are converted into electronic signals. It measures the light's physical quantity and then converted it into a form that is readable by using device. It's reliable and easy to use.

2.13 LITERATURE REVIEW-XIII

"ELECTRICAL MUSCLE STIMULATION", Alexander Franciscus Kolen Agathe Melanie Puszka.

The invention relates to a method and an apparatus for electrical stimulation of muscle tissue. Electrodes of an electrode array are activated in accordance with a sequence of activation patterns, each pattern defining a subset of the electrodes to be activated, each subset consisting of at least one electrode, by providing an electrical muscle stimulation signal to the muscle tissue via the subset of electrodes. Alternately with said activating of electrodes, a response signal associated with the respective activation pattern is received from a sensor. Optionally, at least one electrode is then selected for stimulation, corresponding to a location determined as being suitable for stimulation, and the muscle tissue is stimulated. The process may be repeated in order to track the location suitable for stimulation in a dynamic situation. Optionally, the orientation of body part is estimated from the measured response signals.The invention relates to the field of electrical muscle stimulation. More specifically, the invention relates to a method for providing an electrical muscle stimulation signal to body tissue that contacts muscle tissue, and to an apparatus for electrical stimulation of muscle tissue.

2.14 LITERATURE REVIEW-XIV

"AN EPIDERMAL STIMULATION AND SENSING PLATFORM FOR SENSORIMOTOR PROSTHETIC CONTROL, MANAGEMENT OF LOWER BACK EXERTION, AND ELECTRICAL MUSCLE ACTIVATION", DR.B. XU**.**

Skin-mounted sensors of physiological signals are useful in areas ranging from clinical diagnostics to human–machine interfaces. The recent development of concepts in "skin-like" semiconductor technologies, sometimes referred to as epidermal electronics, create important opportunities in long-term, noninvasive, conformal interfaces to the body.

These systems offer advantages in device mechanics and user mobility Skin-mounted sensors of physiological signals are useful in areas ranging from clinical diagnostics to human–machine interfaces. The recent development of concepts in “skin- like” semiconductor technologies, sometimes referred to as epidermal electronics, create important opportunities in long- term, noninvasive, conformal interfaces to the body.

These systems offer advantages in device mechanics and user mobility over traditional technologies for healthcare monitoring and disease diagnostics, with demonstrated capabilities in precision measurement of hydration, strain, pressure, temperature, and other parameters of interest. Additional recent work shows that similar platforms designed for the fingertips can offer advanced capabilities in electrotactile stimulation. This previous work focused, however, on materials and circuit design aspects without any demonstrated application.

Combining these functions in a single, simple device platform designed for operation on the trunk or limbs of the body is attractive for neuromuscular electrical stimulation, neuro-modulation rehabilitation therapy, pain mitigation and prevention, human–machine interfaces, and sensorimotor control in prosthetic and orthotic devices, where electromyography (EMG) and electrostimulation can serve as sensing and actuating platforms. Here, we present systems of this type, where multiple transcutaneous electrical stimulation electrodes co-integrate on a common substrate with sensors for electromyography, temperature, and mechanical strain. Abilities for simultaneous recording of physiological data and presentation of neural stimulatory inputs provide valuable functionality, as illustrated in examples of sensorimotor prosthetic control, management of lower back exertion, and electrical muscle activation.

2.15 LITERATURE REVIEW-XV

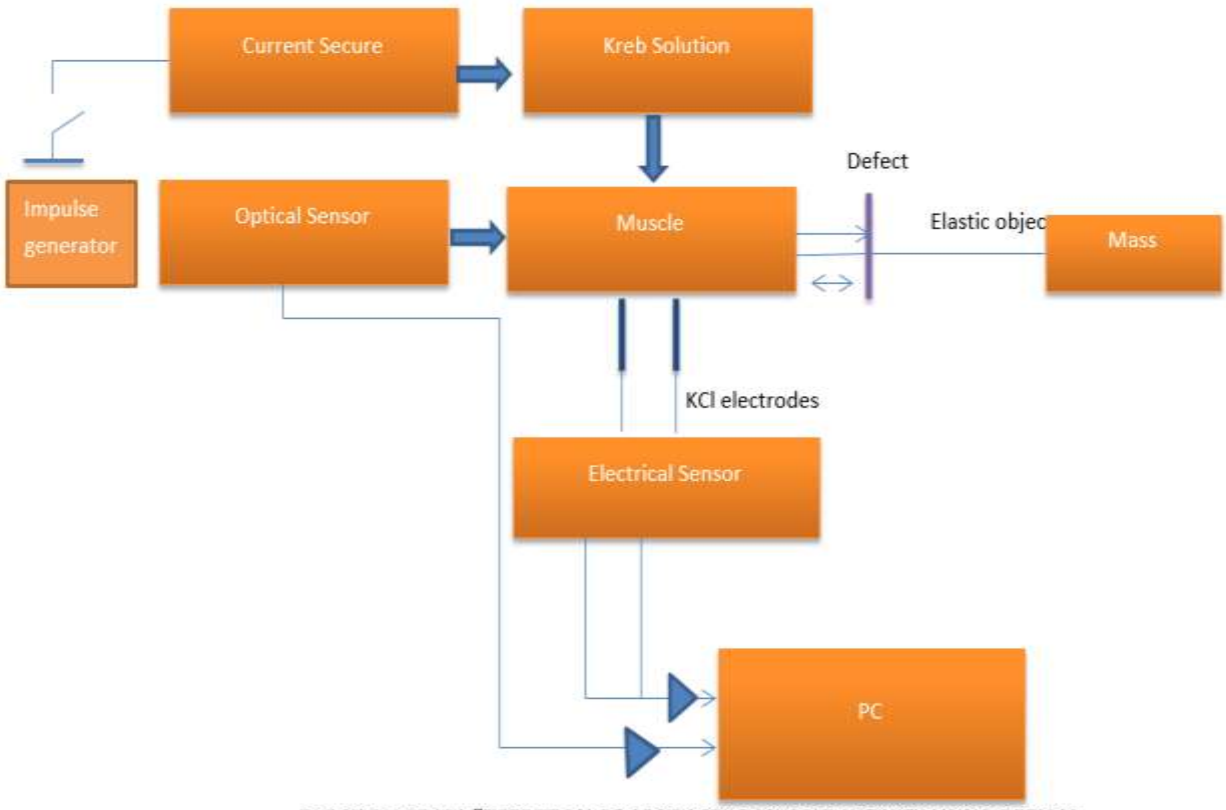
“ROLE OF INTRACELLULAR PH IN THE REGULATION OF ELECTRICAL AND CONTRACTILE ACTIVITY OF THE SMOOTH MUSCLE OF THE PROXIMAL COLON”.

The dependence of many intracellular processes from cytoplasmic pH leads to the existence of complex mechanisms regulating the concentration of protons in the cell. Non equilibrium distribution of hydrogen ions between the inner and outer surface of the plasma lemma is provided by a system that carries monovalent ions through the plasma membrane, in most cases the most important role in maintaining intracellular pH belongs to the sodium proton and chloride - bicarbonate exchange. Their presence is established in smooth muscle of blood vessels and the gastrointestinal tract. Thus, it is relevant to obtain versatile data characterizing the electrical and contractile activity of the MMC in the initial part of the large intestine alone, by the action of electric stimuli and changing conditions of external and internal environment.

CHAPTER-3

EXPERIMENTAL SETUP

3.0 BLOCK DIAGRAM



BLOCK DIAGRAM-"DETECTION OF CONRACTILE MUSCLE ACTIVITY USING OPTICAL SENSOR".

Fig. 11. Block diagram.

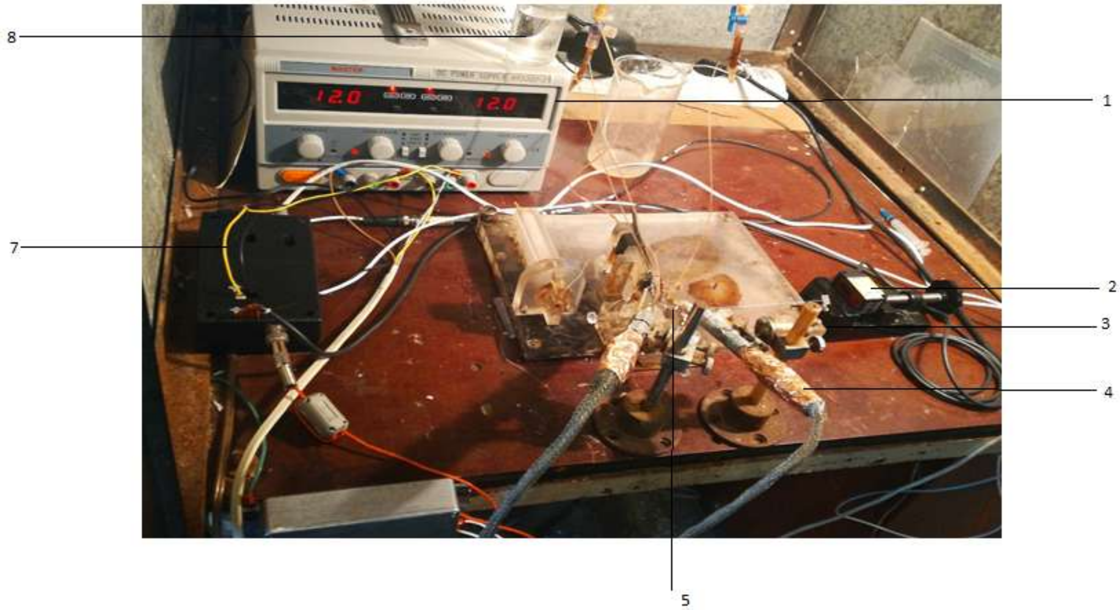


Fig 12. Experimental setup using Organic Muscle.

1. Power Supply
2. Optical Laser
3. Mass
4. Agcl Electrode
5. Organic Muscle In Krebs Solution
6. Analog To Digital Converter
7. Electrical Current Source
8. Krebs Solution

3.1 CURRENT SOURCE AND ITS CIRCUIT DIAGRAM:

Three important circuits blocks used here for power source.

- MONOSTABLE MULTIVIBRATOR 555TIMER
- CURRENT SOURCE
- RELAY CIRCUIT

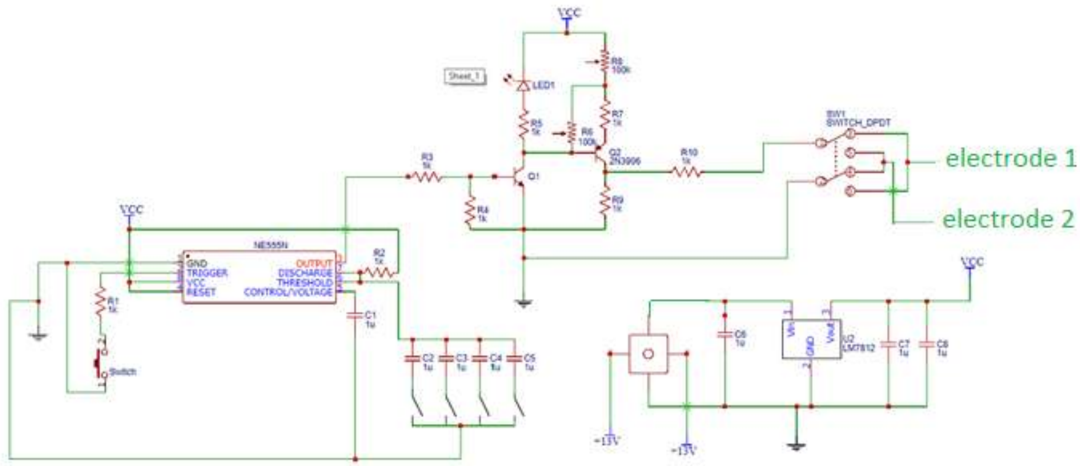


Fig 13. Circuit Diagram.

3.2 OPTICAL SENSOR

Optical sensing techniques that can be used to measure distances to objects, and related parameters such as displacements, surface profiles, velocities and vibrations. Displacement is the change in distance relative to some reference point whose absolute distance may or may not be determined to the same accuracy. Optical techniques for distance measurement have a large variety of uses and applications. An optics-based technique may be employed to provide fast or automated measurement when a noncontact method is needed, or because it is the best or only solution. Some optical distance measurement techniques require continuous light sources and other techniques use pulsed light sources. Similarly, some techniques require highly coherent, narrow bandwidth light.

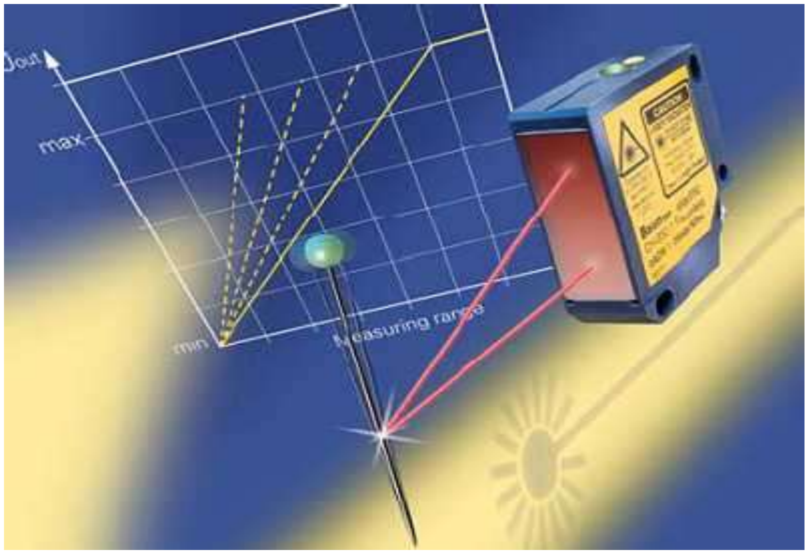


Fig. 14a. Laser.

3.2.1 INTENSITY-BASED SENSORS

Intensity-based sensors, one of the simplest and thus one of the first types of optical distance measurement systems used. It consists of a light source and a detector, in which the light intensity reflected from the object onto the detector is a function of the distance between the light source/detector and the object. These sensors commonly use optical fibers to transmit the light from the source to the object and from the object to the detector. Intensity-based fiber optic sensors have been commercially available for more than 40 years. The name "Fotonic Sensor," coined by a veteran manufacturer, has sometimes been adopted as a generic term for this type of sensor. Note that the sensor may use either single fibers or fiber bundles for illumination and detection. If a bundle is employed, the illumination (transmitting) and detection (receiving) fibers may be arranged in numerous ways—segregated, ordered, or random. Single-fiber sensors may be arranged in an antiparallel geometry.

3.2.1.1 NPN Output Type

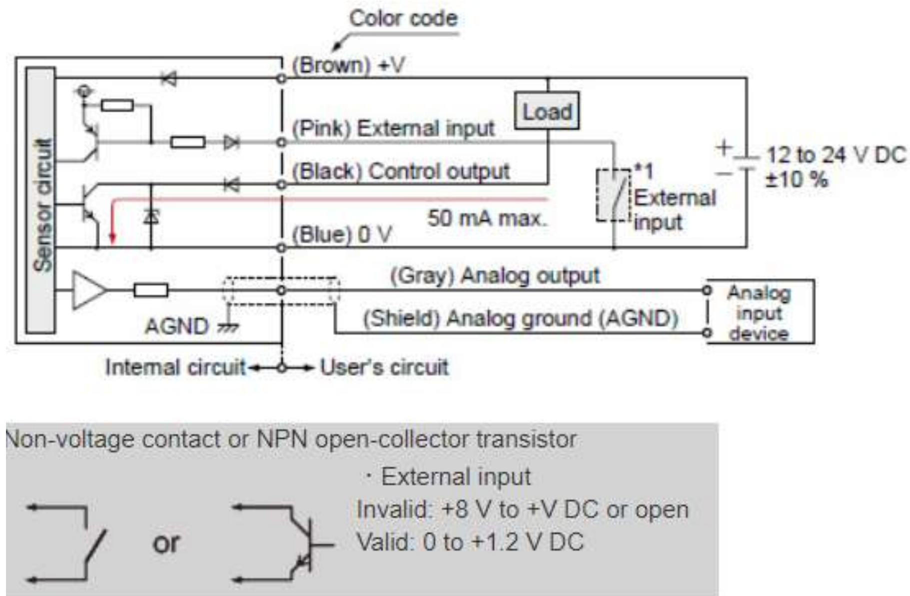


Fig. 14b. NPN Output Type.

3.2.2 HG-C series

As compact as a photoelectric sensor, the CMOS laser sensor allows to display actual measured distance as accurately as a displacement sensor.This type of sensor is used as an optical sensor.

3.2.2.1 CHARACTERISTICS:

- Accurate > Linearity: +/-0.1% F.S.
- Compact & light weight > W20mm x H44mm x D25mm
- Precise level detection > Repeatability: 10µm
- Equipped with 0 to 5 V analog output and 4 to 20 mA analog current output
- The value can be measured with a distance measurement sensor.

  ･Linearity：±0.1%F.S.*

・ Temperature characteristics：0.03%F.S./℃

- The sensor not only indicates measured values in mm but also produces analog voltage outputs.
- Various calculations and storage (logging) can be performed when output is taken into a PLC + analog unit.

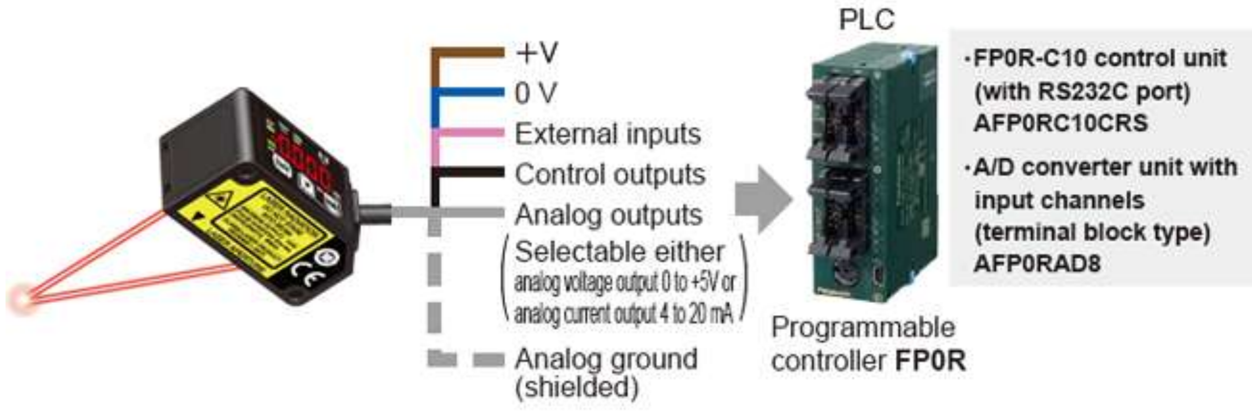


Fig. 15. Characteristics of laser.

- Compact and light-weight.
- A new optical system with a built-in mirror.
- In general, more accurate and stable measurements can be obtained by increasing the optical path length between the light-receiving part and the light receiving element (CMOS), but this also increases the sensor depth and the sensor body gets bigger.
- The HG-C series sensors incorporating a new optical system with a built-in mirror provides smaller sensor depth as well as higher measurement accuracy equivalent to displacement sensors.

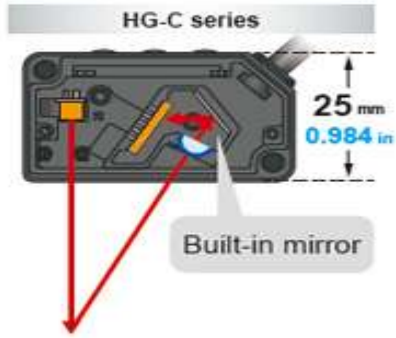


Fig. 16. Laser construction.

- An aluminum die-cast casing protects from strain and heat.
- A light-weight but strong die-cast aluminum casing has been adopted.
- A compact, solid body casing reduces the impact of strain and heat on the measurement accuracy.

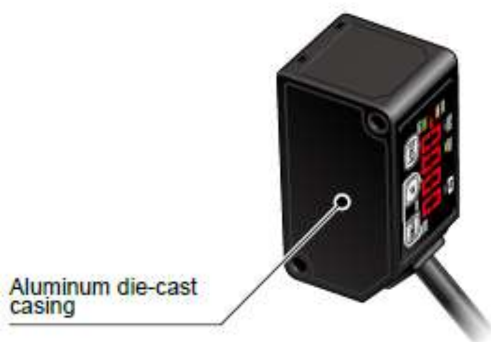


Fig. 16a. Laser aluminum die cast casing.

- Overwhelmingly stable.
- Precise measurements on the order of 1/100 mm 0.0003 inch.
- Fitted with a precise CMOS image sensor and an original algorithm.
- A precise CMOS image sensor, it is now possible to perform highly precise measurements in the order of 1/100 mm 0.0003 in.
- The existing adjustable range reflective sensors cannot achieve such

accuracy.

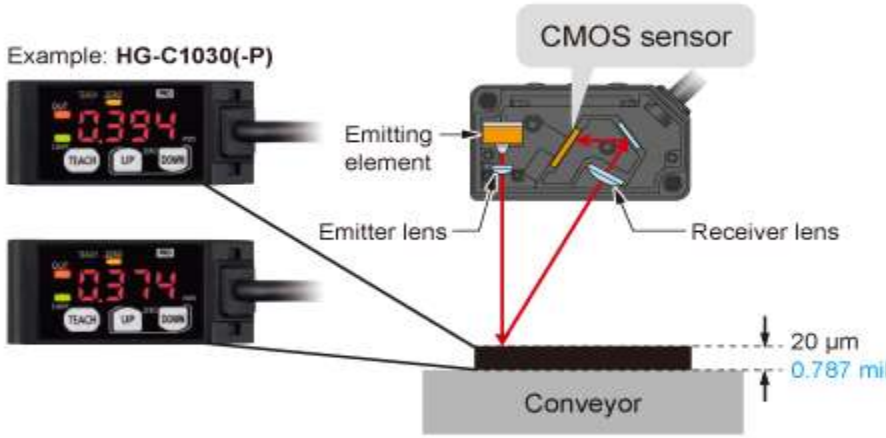


Fig. 17. Laser display.

3.2.2.3 USEFUL FUNCTIONS:

3.2.2.3.1 TEACHING & WINDOW COMPARATOR MODE:

- With an object below the sensor, press the TEACH key to set the valid range for distances via threshold values. There are 3 methods for setting the valid range: 1-point, 2-point, and 3-point teaching.

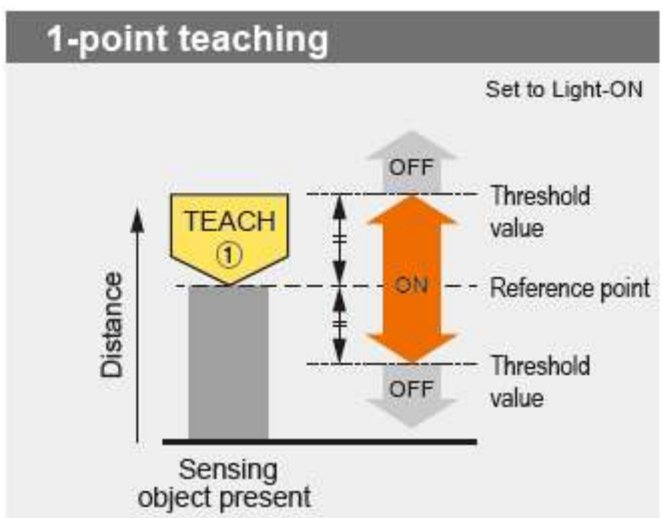


Fig. 18. Characteristics.

- Perform 1-point teaching and the threshold range is set for the distance from the reference surface of the sensing object.This is used for sensing within the threshold range.

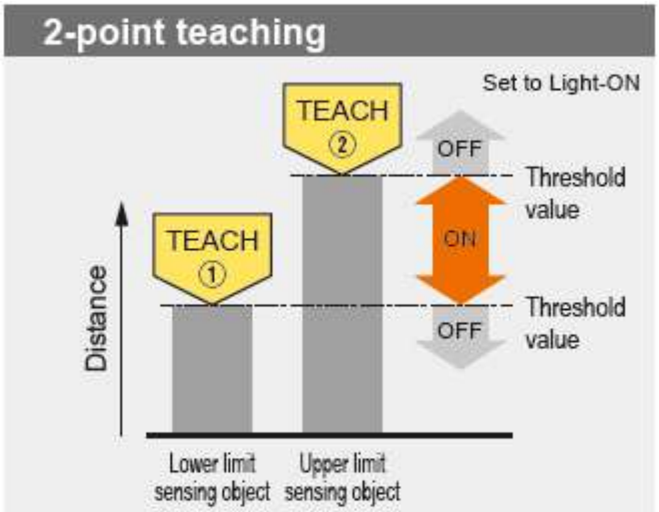


Fig. 19. 2-point teaching.

Press TEACH once for the lower (first point) and once for the upper limit (second point).

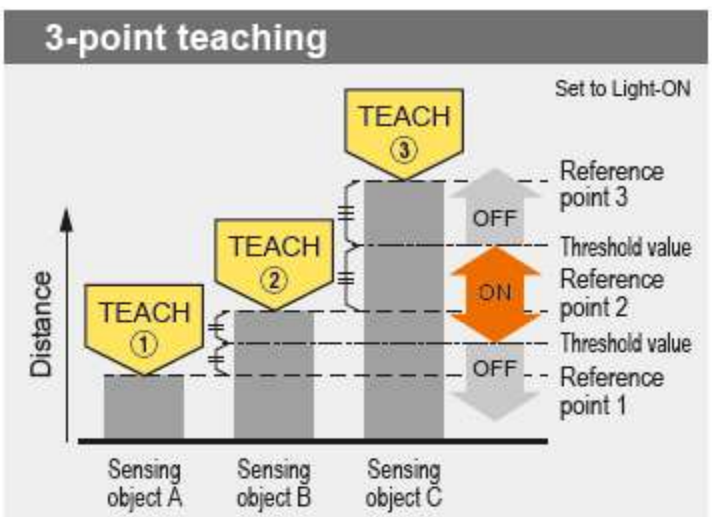


Fig. 20. 3-point teaching.

This is the method to set the threshold range by conducting the teaching at 3 points (sensing object A, B and C). After teaching, the reference points are automatically sorted in ascending order (reference point 1, 2 and 3). The thresholds are set at the midpoints between reference point 1 and 2, and 2 and 3, respectively.

Fig.21. Window comparator mode.

In addition to the teaching & window comparator mode, the "rising differential mode", "trailing differential mode" and "normal sensing mode" are available. In normal sensing mode, "2-point teaching" as basic teaching and "limit teaching," which is useful for very small objects and backgrounds, are possible.

3.2.2.3.2 TIMER SETTING FUNCTION

The time mode options are "off-delay timer," "on-delay timer," "one-shot timer" and "no timer." The counting time is fixed to 5 ms.

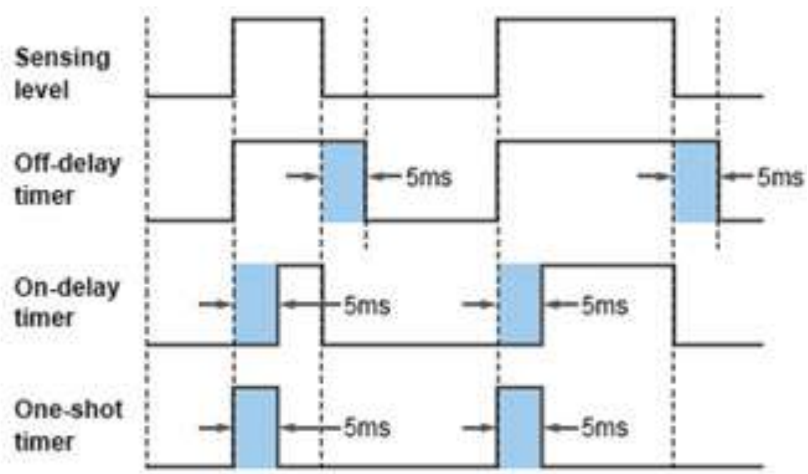


Fig. 22. Timer Setting Function.

3.2.2.3 ZERO SET FUNCTION.

This function compulsorily sets the measured value to "zero." The zero point can be set at a desired value. It is useful when measuring steps or tolerance with reference to the height of a sensing object.

Fig. 23. Zero Set Function.

* The zero set indicator (yellow) will turn ON while the zero set is valid.

* When the zero set function is executed while the peak hold function or the bottom hold function is valid, the held measurement value is reset.

* When the display setting is set to offset, the zero set function cannot be set.

3.2.2.3.4 EXTERNAL INPUT SETTING FUNCTION

One of four functions, “zero setting function,” “teaching function,” “emission stopping function” and “trigger function” can be assigned to an external input line.

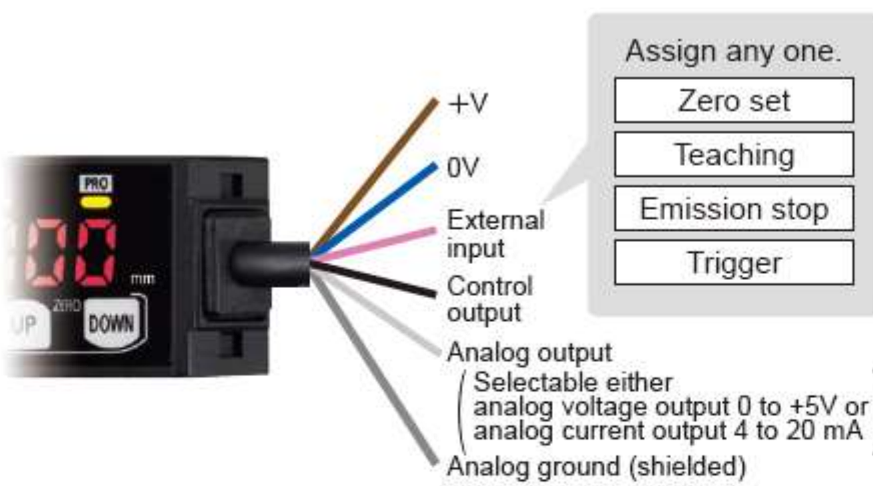


Fig. 24. External Input Setting Function.

3.2.2.3.5 DISPLAY SETTING FUNCTION

How to indicate measured values of the moving sensed object can be chosen from three options, "Normal," "Invert" and "Offset."

Example : HG-C1050

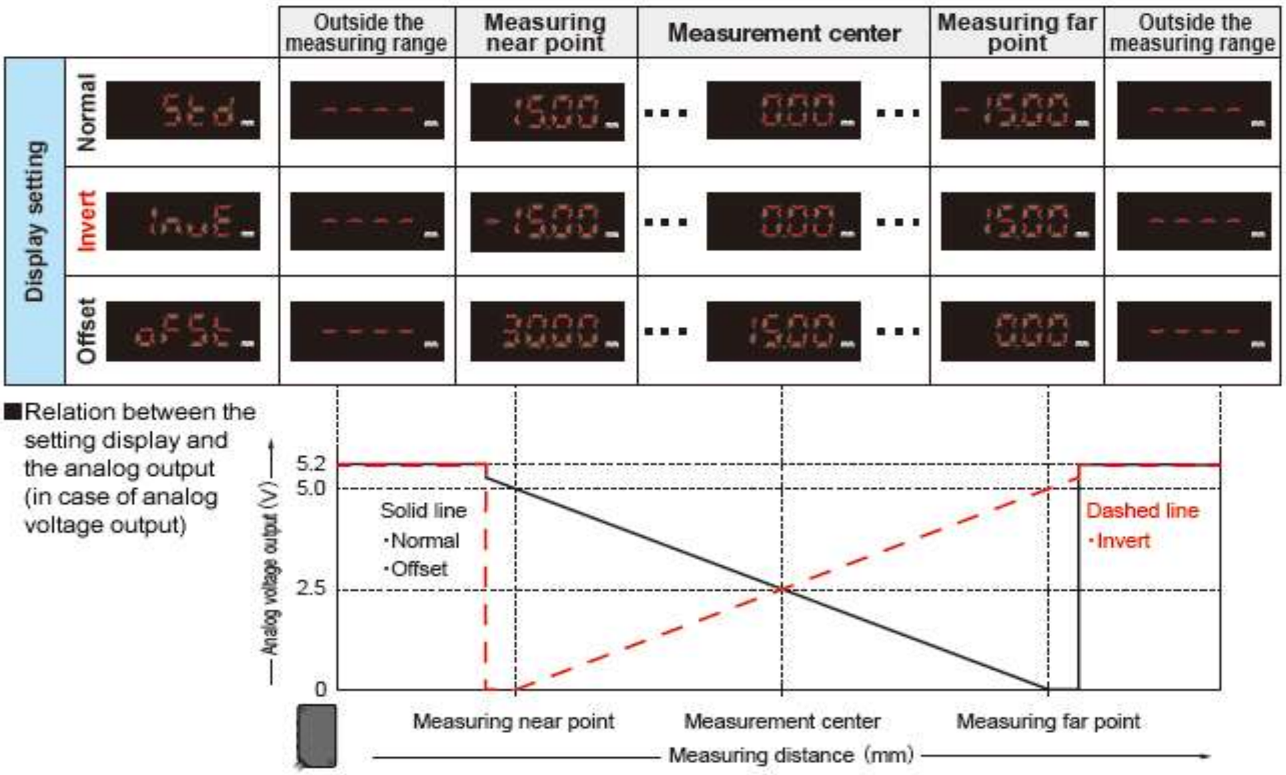


Fig. 25. Display setting functions.

3.2.2.3.6 PEAK AND BOTTOM HOLD FUNCTIONS:

The peak hold function holds the maximum measured value which is output and displayed. The bottom hold function holds the minimum measured value which is output and displayed.

* The peak hold function and the bottom hold function cannot be set at the same time.

* When the zero set function is executed while the peak hold function or the bottom hold function is valid, the held measurement value is reset.

3.2.2.3.7 THRESHOLD VALUE FINE ADJUSTMENT FUNCTION:

Fine adjustment of threshold values can be performed while measurement is proceeding on the display, and even after teaching.

CHAPTER-4

4.0 DETECTION OF ELASTIC CONTRACTION AND ORGANIC MUSCLE CONTRACTION USING OPTICAL SENSOR

4.1 DESCRIPTION:

- We place a elastic object in the holder one side which connected into fixed. And in that we fix a target in that rubber and another end of the rubber is connected to the mass.
- Optical sensor is focused on that target and it shows the displacement between the target and the optical sensor. Output values of optical activity of the
- muscle contraction can be displayed in the sensor.
- And this is connected to the oscilloscope which is used to measure the electrical activity of the muscle contraction.
- Electrical and optical activities of muscle contractions are measured and recorded.
- It gives high accuracy and optical sensor is less size weight and has many advantages.
- The optical sensor converts the distance to voltage, which is recorded by digital oscilloscope. So digital and analog characteristics can be achieved.
- With respect to electromyography and to optical absorption-based sensors, our device has the advantage of lower invasiveness, of lower sensitivity to electromagnetic noise and to movement artifacts.
- High accuracy.
- Compact and light weight.

- The sensor not only indicates measured values in mm but also produces analog voltage outputs.
- Various calculations and storage (logging) can be performed when output is taken into a PLC + analog unit.

4.2 EXPERIMENTAL SETUP ELASTIC OBJECT:

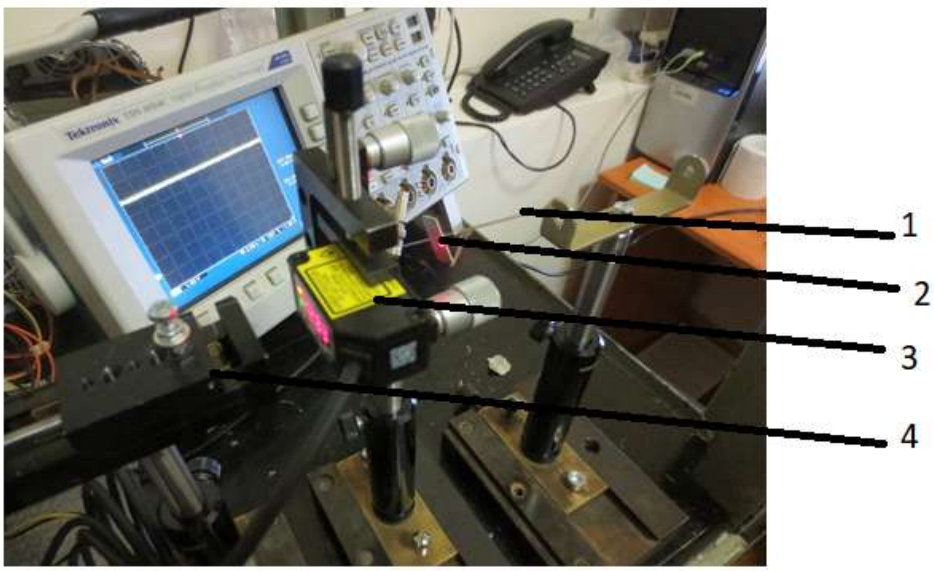


Fig. 26. Experimental setup using elastic Object.

1.Elastic Object;   2.Target;   3.Optical Laser; 4.Stand;

In the above Diagram we can see the experimental setup. Here we use elastic object and elastic object is connected to the mass and another end is fixed. Light from the optical sensor is emitted to the target and then reflected back to the sensor so that received information can be analyzed the displacement values and object contractions from the target by using the optical sensor.

4.2.1 OUTPUT GRAPH

Figure 27 shows the optical sensor response when slightly touch the elastic.

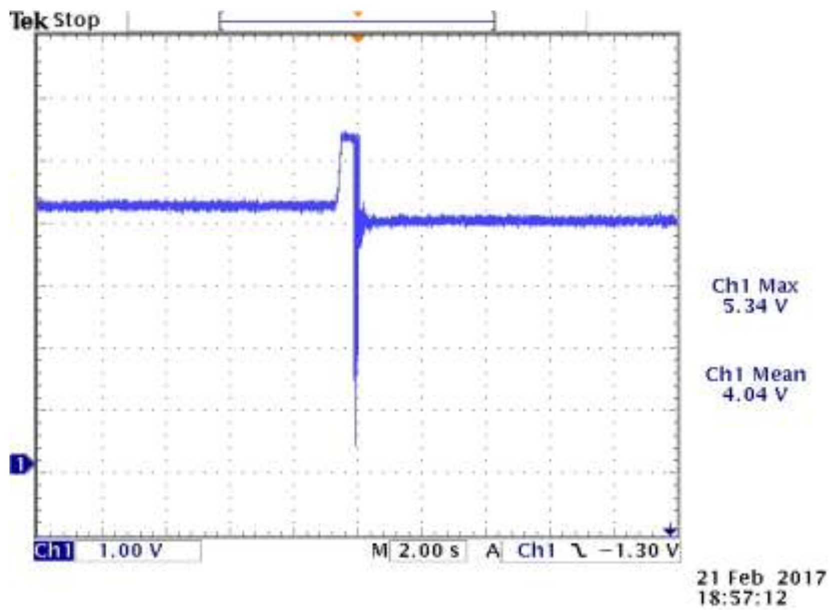


Fig. 27. Optical sensor response.

4.2.2 CALIBRATING OF THE SENSOR

To calibrate the set-up we attached the thread bound with elastic to the vernier. Rotating vernier we set the distance.

DISTANCE, μm	SENSOR OUTPUT, V
0	2.111
50	2.572
100	3.031
150	3.505
200	3.976
250	4.46

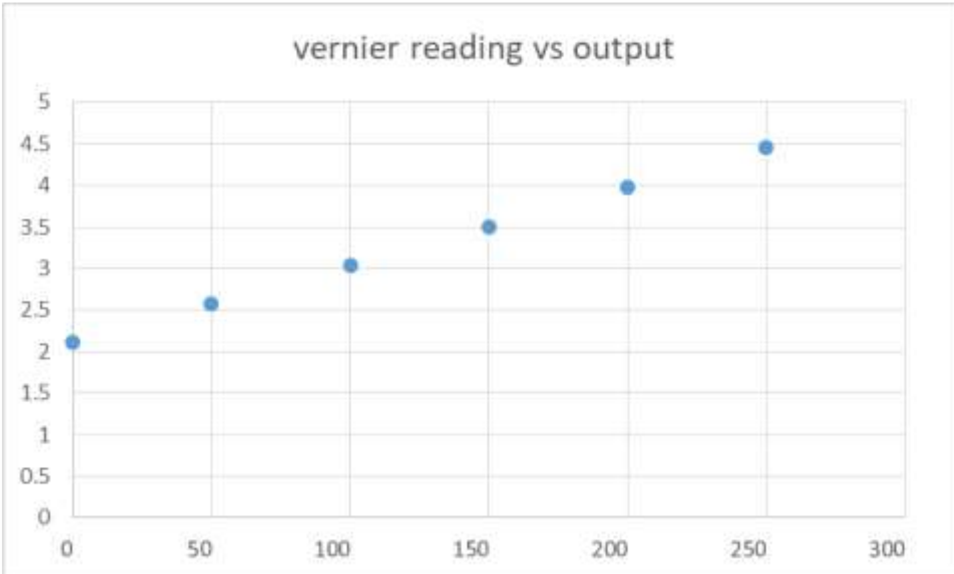


Fig. 29. Dependence of Distance vs Sensor Displacement.

4.3 EXPERIMENTAL SETUP USING ORGANIC MUSCLE

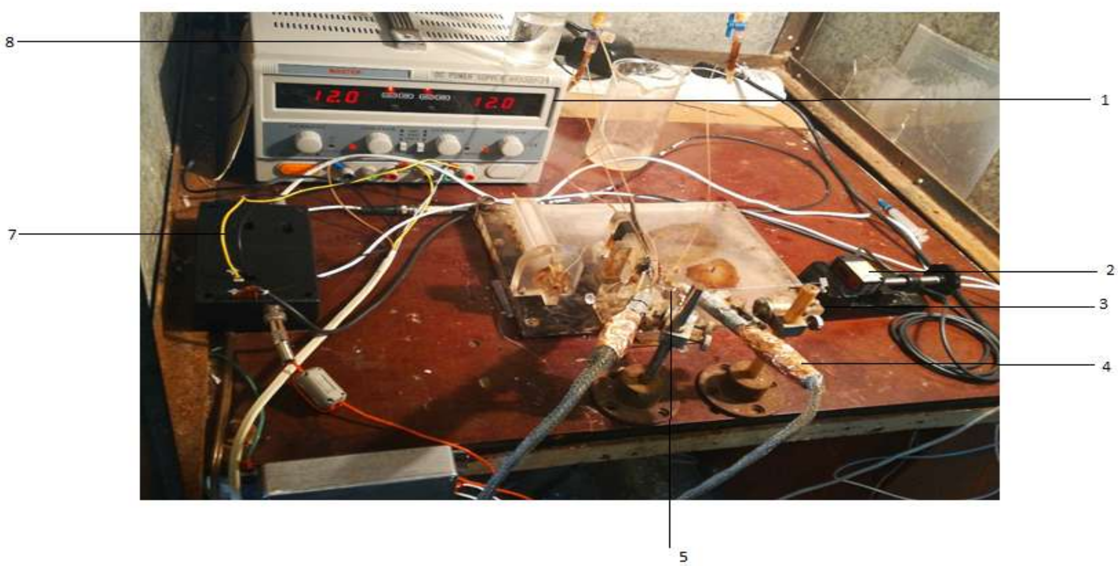


Fig. 30. Experimental setup using muscle.

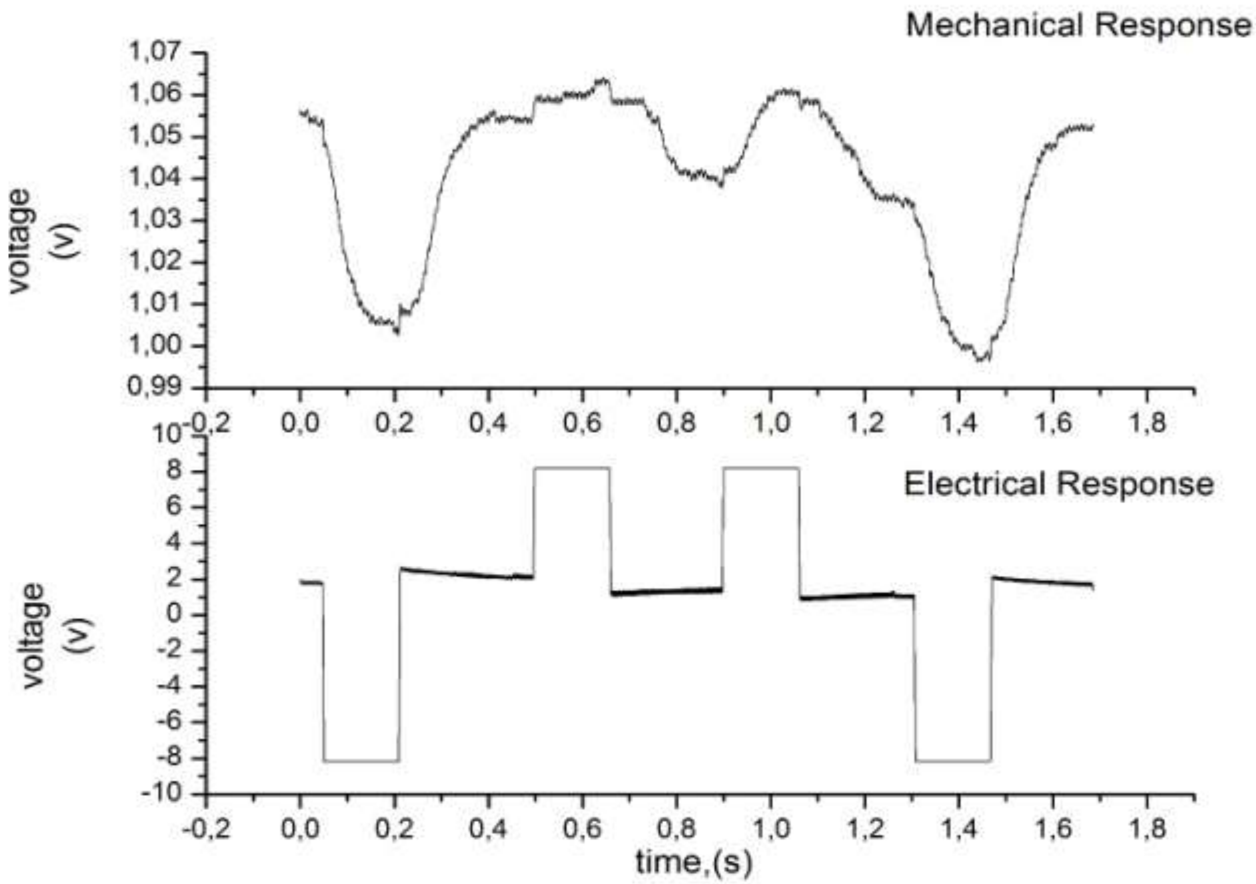


Fig. 31. Output response.

In this graph, by using switch on and off, the anode and cathode stimulus responses were obtained and as shown in the above graph. The possibility of Stimulus responses can be recorded to various seconds like 3sec, 5sec, 8sec, 20sec.

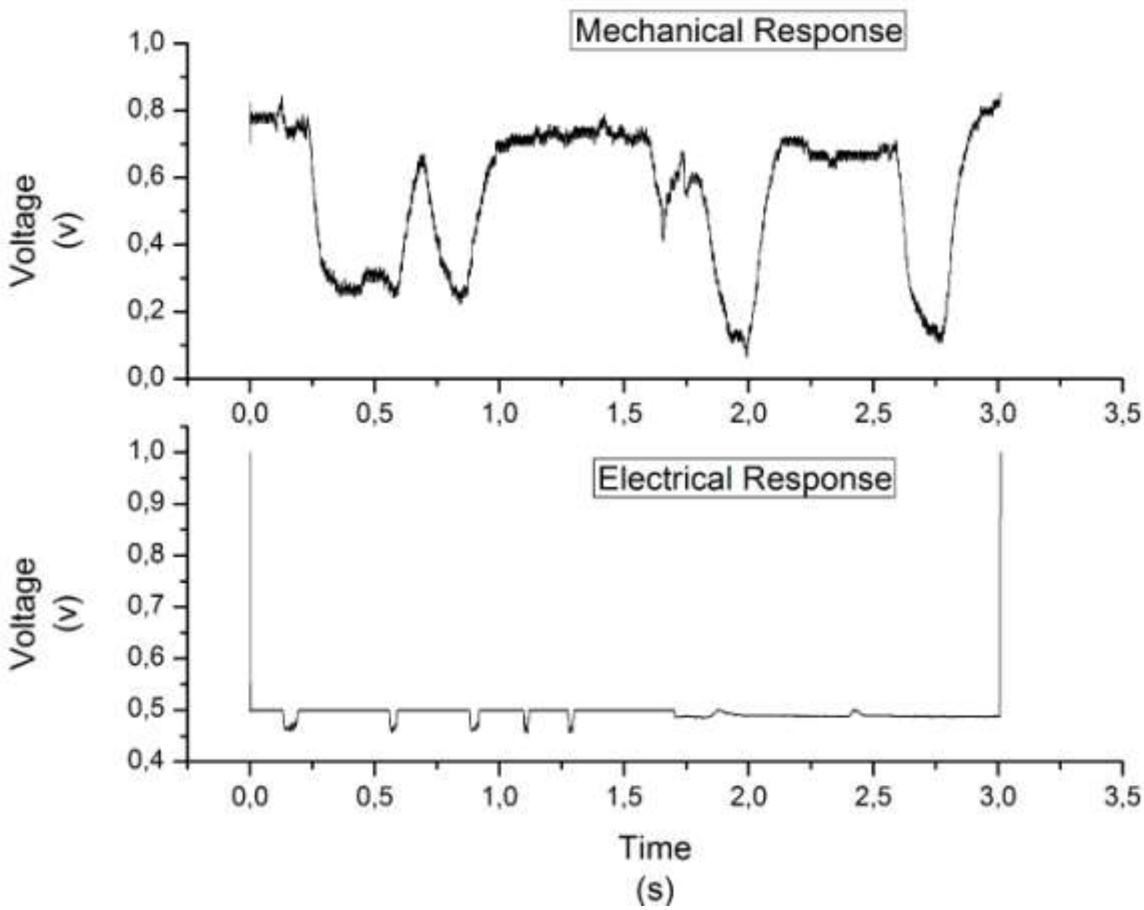


Fig. 32. Output Response.

In this graph we obtained the mechanical response by recording the measurements of voltage corresponding to the time. Some noises can be affect the output so we should use the filter to reduce it. Due to noises may be affect the Electrical response.

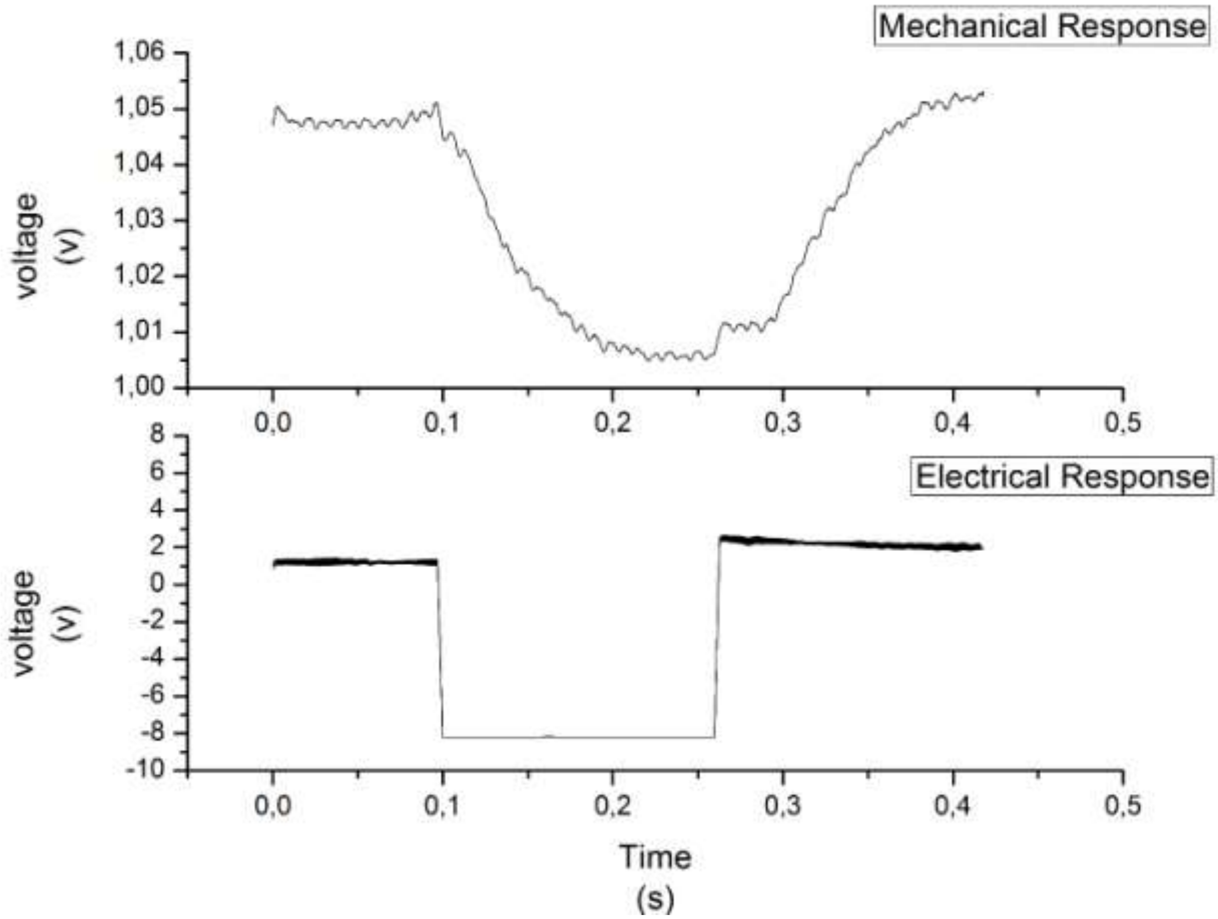


Fig. 33. Output response.

In this graph we can clearly see the anode and cathode muscle contraction by applying stimulus it varies and also shows the relaxation period.

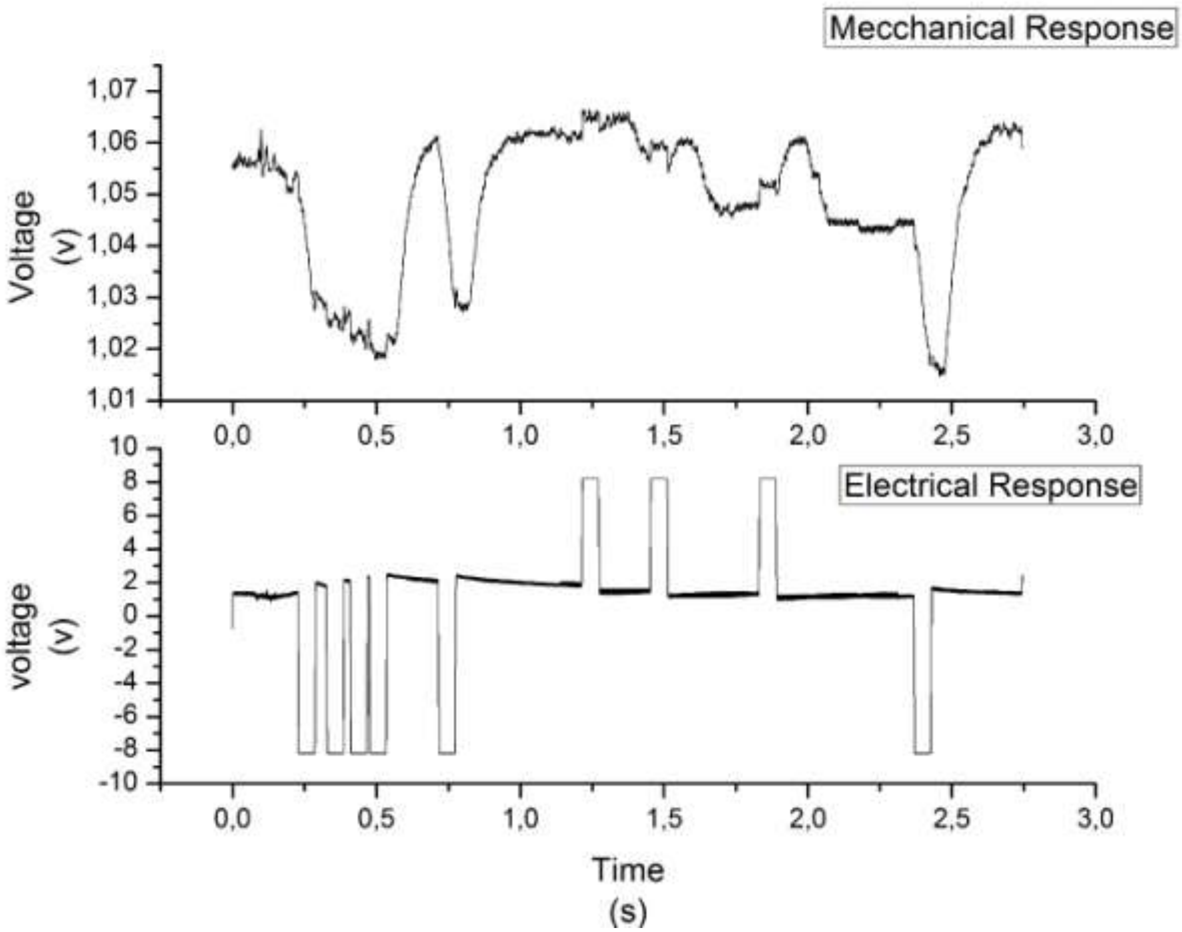


Fig. 34. Output Response.

In this above Graph, we obtained some Mechanical response and Electrical Response when we apply stimulus to the muscle, Muscle should be dissected and placed in the Krebs solution. One end of the muscle is fixed and another end of the muscle is connected to the mass. Optical Source is passed to the target and it reflects back. So that we can analyze muscle contraction and relaxation period also we obtained and see through the computer. It is synchronized by the analog to digital converter. By this way we can obtained this graph. Readings and Graph were recorded and seen through by the LGRAPH software.

4.4 CONCLUSION:

- We developed the electro-optical system to control small movements of muscles during the manipulations. Manipulations like electrical and chemical stimulation are often used for studying physiological parameters.
- We measured an electrical stimulation and mechanical response of the muscle movements using electrical current and optical source.
- Accurate measurements are noted and recorded.
- We believe, this device is very useful in the medical field especially in the detection of muscle contractions and study the mechanisms of contraction.

CHAPTER-5

5.0 FINANCIAL DEPARTMENT:

5.1 THEME OF OUR PROJECT:

This paper presents a detection of elastic movement of an object and measure the contractile activity of the object. An optical sensor is used to detect the Elastic object contraction, which is described. In the initial experiments, we used elastic. Next object will be animal muscle, so that we can determine the muscle contraction. Optical light is passed to the reflective plate fixed on the muscle, the backscattering is observed, and the contraction is detected by measuring the change of the distance, that occurs during muscle contraction and corresponds to muscle activity. The optical sensor converts the distance to voltage, which is recorded by digital oscilloscope. With respect to electromyography and to optical absorption-based sensors, our device has the advantage of lower invasiveness, of lower sensitivity to electromagnetic noise and to movement artifacts, and of being able to distinguish between isometric and isotonic contractions. Here electrical activity and optical activity is used to analyze the wave characteristics and muscle contractile activities.

Optics is the branch of science that deals with the behavior of light and its properties which includes light interactions with matter and the construction of instruments which is used to detect it. Optics describes the behavior of visible, ultraviolet, and infrared light. Light is a electromagnetic radiation such as X-rays, microwaves, and radio waves exhibit similar properties. The science of optic is relevant to many related topics including astronomy, different types of engineering fields, photography and medicines specifically ophthalmology and optometry. The applications of optics are present in various types of technologies.Objects may includes mirrors, lenses, telescopes, microscopes, lasers, and fiber optics. In this experiment we are using object as laser.

In an optical sensor light rays are converted into electronic signals, it measures the physical quantity of light and then translates it into a form that is readable by an instrument. An optical sensor integrates a source of light, a measuring device and the optical sensor which is often connected to an electrical trigger. The trigger reacts to a change in the signal within the light sensor. It can measure the changes from one or several light beams. This optical sensor works as a photoelectric trigger, when a change occurs, therefore electrical output either increases or decreases.

Electromyography (EMG) is an instrument which is used to record the electrical activity of the muscles and to determine whether muscle is contracted or not. This measurement is also important for myoelectric control of prosthetic devices. Finally output is displayed and recorded on Digital storage oscilloscope. It is a type of electronic test instrument which allows observation of constantly varying signal voltages and signals as a function of time. Other signals like sound or vibration can be converted to amplitude and which is displayed.

5.2 RESOURCES REQUIRED:

- Analog To Digital Converter
- Impulse Generator
- Dc Power Supply
- Optical Sensor
- Electrical Sensor
- Muscle
- Kreb Solution
- Electrodes

- Computer
- Soldering Iron and tin
- Lgraph 2 Software
- Origin Pro Software

5.3 SWOT ANALYSIS

Strength

- In this paper, we measured an electrical activity of the elastic object and also animals muscle movements using optical sensor and electrical sensor.
- This device is very useful in the medical field especially in the detection of muscle contractions.
- Accurate measurements are noted and recorded.
- Installation is Easy.
- Optical laser and Electrical sensor is small size and less weight.
- High Precision Measurements.
- Since the hardware required is significantly reduced, manpower required to run the project in a larger environment is also reduced.
- This project is not only targeted at the biomedical field, it can be applied in numerous fields where non-destructive testing is required.

Weakness:

- Optical laser can detect upto 50mm distance.
- Bad Noises of immunity because of sensitivity.
- Currently our project under Scientific trails.
- Avoid direct propagation of light
- Use spectacles and follow to the requirements of laser safety.

Opportunities:

- This is an entirely new field in non-destructive testing, hence there are lots of emerging technologies using software.
- Open source software can use this emerging field by improving certain features in their software which gives an edge over licensed software like Lgraph.
- This will open higher amount of employment for fresher students who are knowledgeable with these projects.
- This also can provide opportunities for cross platform projects for further improved systems.
- It creates numerous employment opportunities in various fields as the project can be applied in various fields.

Threats:

- Compatibility is the main idea behind the project, if the current non-destructive testing companies are able to make their equipment's into a compatible piece then the project will be less efficient when compared to the newer compatible models.
- Avoid direct propagation of light
- Use spectacles and follow to the requirements of laser safety.

5.4 COST OF THE DEVICES

- Analog To Digital Converter- 3000rub
- Impulse Generator- 500rub
- Dc Power Supply-3000rub
- Optical Sensor-12000rub
- Electrical Sensor-3000rub(2 electrodes)

- Muscle-800rub (for single experiments)
- Kreb Solution -200rubles
- Sucrose solution-200rubles
- Computer
- Soldering Iron and tin
- Lgraph 2 Software
- Origin Pro Software
- Electricity -16 hours-500wats/hours
- Electronic components-500rubles

5.5 TIME DURATIONS

The total required to complete this project for students would be 6months and for engineer it will be 3sdays if every components are available.

CHAPTER-6

SOCIAL RESPONSIBILITY

6.1 OCCUPATIONAL SAFETY:

The main occupational safety concerned with the project is electrical shock from the working equipment. Each and every electrical component that is used has to be insulated and secured properly and usage of safety apparatuses is important. The main working component is Optical sensor and some electrical components hence it does not affect much compared to other methods of non-destructive testing.

6.1.1. Identification and analysis of workplace hazards, which the research object can create for people.

The main workplace hazards which arises from this project for people using the system is the electrical shock hazards that may occur due to poor wiring and insulation. Therefore all the connections has to be thoroughly inspected and checked before the operation of the system.

6.1.2. Identification and analysis of workplace hazards, which may influence a researcher during the research process.

Most of the time spent during the research process by the researcher is with LASER and working on a computer, for experimental results working with the optical sensor and electrical sensor is necessary. Care has to be taken while working and safe equipment had to be always worn by the researcher for safety precautions. Also the data which is used for research is important, it has to be safely stored in a secured database.

6.1.3. Protection methods to mitigate the potential damage.

The main precaution taken for this project has to be with the electrical shock hazard that arises from the various electrical components used. Safety checks has to be done periodically to avoid any potential damage from the shock and other electrical factors associated with the system.

Another important factor is the working conditions of the computer used, it has to be equipped with anti-virus and software which protect the necessary data that is used for the analysis and research work. There is no harmful effects of laser if we follow the safety precautions.

6.2. ENVIRONMENTAL SAFETY

This project does not have any kind hazardous emissions or components that affect the environment. Care has to be taken during the disposal of the waste products which includes wiring and other electrical components used during the experimental trails.

6.2.1. Impact analysis of research object on environment.

Electrical wastes are the only problem associated with the project on environment, hence the waste products that arise during the project trails has to be safely disposed. And avoid direct propagation of light.

6.2.2. Impact analysis of research process on environment.

There is not much impact by the research process on the environment as it mostly done by a software on a computer.

6.2.3. Protection methods to mitigate the potential damage.

The electrical wastes had to be disposed accordingly to prevent its potential damage on the environment.

6.3. SAFETY IN EMERGENCY

Emergency cases occur when there is short circuits in the system, the working voltage is about 12V hence there is no risk of shock from electrical leaks in the outer parts of the system. However the power supply part consists of a step down transformer which steps down the voltage from 220V to 12V, this part has to be isolated properly so that there is no short circuits and electrical hazards.

6.3.1. Identification and analysis of emergency situations, which the research object can create.

The main emergency situation that arises is fire due to short circuits and electrical shock by physical contact. Proper isolation of the power supply unit and insulation of the wires can prevent these emergency situations.

6.3.2. Identification and analysis of emergency situations, which may occur during the research process.

During the research process, data loss can occur which is a huge situation as all the collected data is important for the project.

6.3.3. Protection methods to mitigate the potential damage.

Good wiring and isolation units can prevent the potential damage that arises from electrical shocks and fires. Proper backups and antivirus and antimalware software has to be installed to protect the data during the research process. In case of fire accidents it is necessary to install and use fire extinguishers also to have first aid at the lab. Use spectacles and follow to the requirements of laser safety.

6.4. WORKPLACE DESIGN:

The workplace should be neat and dry, as a moist working place can cause problems to the electrical components of the project. Good computers is necessary for smooth data processing of the data which is acquired from the working of the system. The workplace should have soundproof coverings to prevent the intervention of noises which will affect the efficiency of the system

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