Microcontroller Based Mobile Platform with Fiber Optic Sensors

P.B.Buchade

***Abstract:** In the present work a mobile platform with optical fiber sensor was designed, built and tested. The IC 89C51RD2 was used as controller on the platform. The platform was designed with two powered wheels on the back and one free turning wheel on the front. Further the platform was outfitted with proximity, weight and touch plastic fiber sensors. Home position was sensed by touch sensor, the destination by proximity sensor and weight by the load cell sensor. A program was written to move the platform from home position to the destination where after loading the weights in the pan the platform moves back to the destination, unloading the weight the cycle repeats.*

***Keywords:** Fiber optic sensors, load cell, Microcontroller, Mobile platform, Proximity senso , Touch sensor .*

I. INTRODUCTION

A mobile platform is a robotic system, which can move as a whole in a controlled way with some degree of autonomy. The popular image of a robot is normally associated with creatures having forms or behaviors that resemble those of humans. The human like robots (android) in most cases have arms, legs, head etc. A robot is a re-programmable and multifunctional manipulator, devised for the transport of materials, parts, tools, or specialized systems with varied and programmed movements, with the aim of carrying out varied tasks [1]. The basic idea of practical robot is to replace humans in repetitive, dangerous or tiring tasks. A general-purpose useful robot must have controller, arm, drive, end-effector and sensor [2]. However some special purpose robots do exist without arm and end-effector. A practical robot on an industrial production line has an appearance that in most cases does not resemble a human being in any way, but have many arms and mobile platforms that are designed in appropriate forms and sizes for specific tasks.

Robots without sensors are deaf and blind. Sensors provide feedback to the robot and aid in performing job. By virtue of their high accuracy and fast response, intensity based fiber optic proximity sensors have found applications in robot end-effector position control. Robot end-effector orientation control using proximity sensors based on multi-sensor approach is reported [3,4]. Basically a system for measurement of a distance to a target i.e. proximity sensor for robotics [5] contains light emitted from a multimode laser coupled to a sensor assembly. A portion of the light at the sensor assembly is reflected backing to the fiber optic cable from which it came. When the target beam and the reference beam interface with one other, the path length is determined to be equal to the length to the target. A system for measurement of distance to a target [5] and to locate and track a dynamic perimeter for robots [6] is studied. Robotic platform for monitoring underground cable system using infrared and acoustic sensors is reported [7]. The next section describes the developed fiber optic sensors that were used with mobile platform.

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Author name,Dr. Buchade P.B.M.E.S. Abasaheb Garware College, Karve Road , Pune-411004, India.

II. OPTICAL FIBER SENSORS FOR MOBILE PLATFORM

Fiber optic proximity probe: The fiber optic micro displacement probe consisting of T- fiber and R-fiber is used to sense the distance [8]. It is shown to be capable of sensing distance of the object. In the present application the same sensor probe along with some control logic is used as proximity sensor. Figure 1 shows the assembled fiber optic probe.

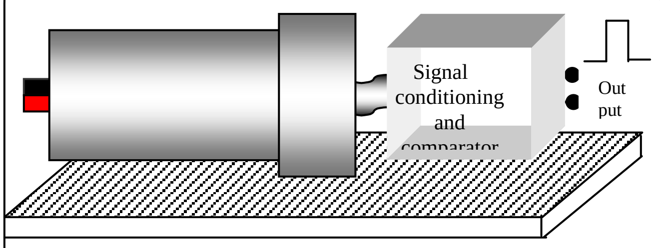

Figure 1: Fiber optic proximity probe

The signal-conditioning circuit of FOP contains electrical to optical converter and optical to electrical converter and amplifier. The probe produces output depending up on the position of the reflecting object in accordance with the characteristics of FODS. It was found that at distance of 4 mm from the target, the voltage output from the probe was 1.4V.

The FODS output is fed to comparator, which has reference of 1.4V corresponding to a distance of 4 mm. So when the platform is approaching the object, output of FODS is less than reference voltage of comparator as long as distance is more than 4 mm, which maintains output of comparator in low state. As soon as the distance between probe and object becomes 4 mm or slightly less the FODS output crosses the reference level of comparator and comparator output goes into high state. This resulting change of state of comparator was used to control the mobility of platform.

Fiber optic weight sensor: The designed and developed optical fiber based load cell described is used to decide the direction of the mobile platform depending up on the weight in the pan. Load cell generates output proportional to the weight in the pan. Figure 2: shows fiber optic weight sensor. Load cell having spring steel diaphragm of 0.1mm thickness with 50g load gives 3.41V.Further it gives 5.9mV per gram up to 100g.

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In order to generate the pulse depending upon the weight in the pan the output from the load cell is fed to the comparator. The reference voltage set to the comparator is 3.41V. If Weight in the pan is less than 50g output of the comparator is in low state where as when it is above 50g output is in high state.

Optical fiber based touch sensor: In the distance or proximity sensors, optical fibers are used for the transmission of light to and from the reflector. The sensor actually measures the amount of light reflected from an object. In the opposed or beam break configuration [1] the object is detected when it actually interrupts the beam of light.

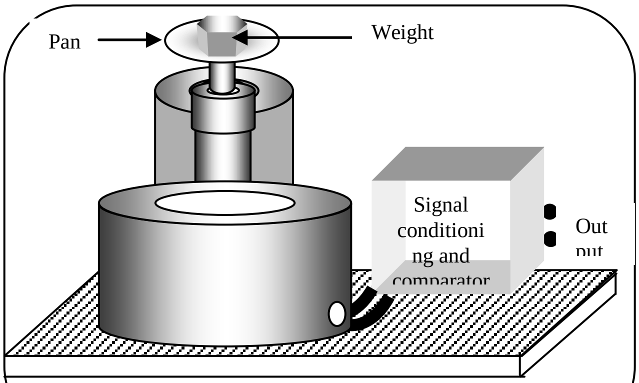

Figure.2: Fiber optic weight sensor

Normally such type of configuration informs the robot that something is or is not present. Such beam break configuration as shown in figure 3 was used to detect the presence of touch. In touch sensor configuration light was launched to one end of the transmitting fiber. The light from the other end of the fiber was coupled with another fiber called as receiving fiber, through a gap of 1mm. Since for a plastic fiber of core radius 0.488mm upto 1mm distance there is sufficient coupling of light observed from T- fiber to R- fiber. A pin attached to pad forms a touch probe.

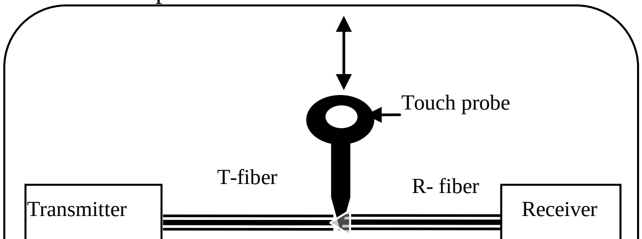

Figure.3: Schematic of touch sensor

In the absence of any touch signal to the probe, the light gets coupled from T- fiber to R- fiber and hence receiver generates some voltage, where as with touch, the pin gets shifted in between the T- and R-fiber and breaks the light coupling between them. The generated signal in the presence and the absence of touch was converted in to a pulse using a comparator with suitable reference voltage.

III. DESIGNING OF THE MOBILE PLATFORM:

The mobile platform was designed with controller and fiber optic sensors. The stepper motors and the sensors were interfaced to the different ports of the controller. The mobile platform operated according to the program stored in the controller and the signals from the sensors. Figure 4 shows the block diagram of mobile platform. The controller is the heart of the mobile platform.

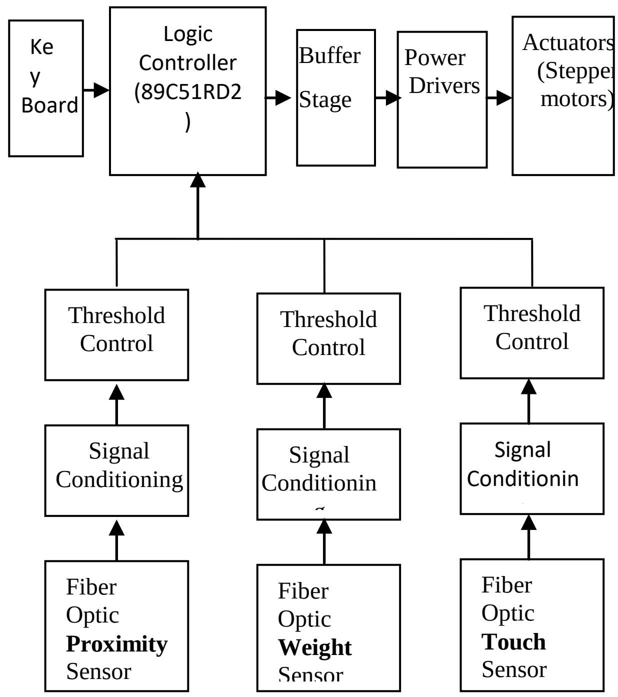

FIGURE 4: BLOCK DIAGRAM OF MOBILE PLATFORM

It controls the mobility of the platform depending upon the outputs from the different sensors interfaced to it. Although any 8 bit controller can be used for this application, the controller from 8051 family was chosen for its wide popularity, easy programming facility, excellent features and availability of other compatible peripheral chips. Mobility to the platform is obtained using stepper motors, since precise control of the speed can be obtained through digital signals. To satisfy the current requirement of motors, power drivers are designed. For interfacing different sensors, the port pins of controller are used. To test the viability of fiber optic sensors in robotic applications proximity, load and touch sensors developed in the present work were interfaced to the controller.

As shown in the block diagram these sensors were linked to the controller after suitable signal conditioning and through threshold control circuit. The signal from the sensor was converted in to a pulse using comparator designed with operational amplifier having appropriate reference voltage.

IC P89C51RD2BN was used as the controller in the circuit of mobile platform. Three ports P0, P1 and P2 of the controller were buffered using three transceivers ICs 74LS245.

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These buffered ports were used for data as well as signal transfer among the peripherals. The power on reset circuit was connected to reset pin. A 12 MHz crystal was connected at external input X1 and X2. Internal oscillator provides clock frequency to controller and synchronizes its operations with clock.

μc 89C51RD2: Due to the immense features the controller **89C51RD2** was chosen in the present design.IC**74LS245** is used as Transceiver.

IV. STEPPER MOTOR INTERFACING:

In order to obtain the mobility to the platform two Srijan [9] make stepper motors, one for driving the platform and other for steering it were used. The required current for driving the stepper motor was obtained by ULN2003,In this design four ULN2003 were used. Out of this two were used to drive driving motor and two for steering motor. The designed platform has thus following specifications:

i) Platform size: 250mm x 200 mm x 35 mm in wooden material
a) Back wheel diameter: 80mm
b) Free rolling front wheel diameter: 35mm
c) Driven System: A micro-controller based drive
d) Motor driving: Through axis, Torque 2Kg-cm, Step angle 1.8^o ,200 steps /revo.
e) Motor steering: Torque 2Kg-cm, Step angle 1.8^o , 200 Steps per revolution.
f) Sensors: Optical fiber based proximity sensor, weight sensor and touch sensor.

Even though 89C51RD2 has in circuit programming feature, in the present study, to program 89C51RD2 a special board was prepared

V. INTERFACING SENSORS TO MOBILE PLATFORM

Figure.5: Micro-controller based fiber optic mobile platform

As soon as power is applied to the controller circuit the platform moves to the home position. It senses the home position by touch sensor attached to the side of the platform. Then the platform moves from home position to the loading station, Upon reaching the loading station, which is sensed by the proximity sensor, it waits for loading the object. After load sensor gives signal, platform moves towards home, Unloading the object at home platform repeats its operation.

VI. RESULTS

The μc89C51RD2 detects the proximity of the object, weight in the pan and the sense of touch through optical fiber sensors. Through buffers these sensors are connected to P0.0, P0.1 and P0.2 pins of the port P0 of the controller respectively. The controller always monitors the state of the pins P0.0, P0.1 and P0.2. Home position is sensed by touch sensor. As soon as platform is in contact with place assumed as home, touch sensor generates the pulse and if signal from P0.1 is low indicating no load in the pan it stars moving towards destination to load the weight. The destination is detected by proximity sensor. When the platform is approaching the destination the output from proximity sensor increases and at 4mm distance it generates pulse that is detected on P0.0 pin. The platform stops at distance of 4 mm till a pulse on P0.1 corresponding to weight sensor is generated. Pulse is generated on P0.1 when load in the pan is more than 50g. After loading the weight in the pan the platform moves towards the home position. Until the pan is unloaded platform stays at the home position, once unloaded it again starts moving towards the destination for loading the weight. The to and fro operation of the platform is controlled by loading the weight at the destination and unloading it at home position.

VII. CONCLUSIONS

The mobile platform was designed with micro-controller. It was found that the three-wheeled design was probably be the best, two powered wheels on the back and one free turning wheel on the front. The online testing of intensity modulated fiber optic sensors was done with mobile platform. It was found that the designed and developed fiber optic sensors interfaced to control the mobile platform functions satisfactorily.

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AUTHORS PROFILE

Dr.P.B. Buchade, is Associate professor and Head of the Department of Electronics at Maharashtra Education Societies Abasaheb Garware College, Pune- 411004. India. His area of interests are Optical fiber sensors and Embedded systems. He is founder member and the secretary of SPEED.

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