A Device Which Extracts the Complete Map of a Labyrinth, Without Using Overhead Vision

Conceptual Design Report

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ABSTRACT

The Clavis Co. will design a device that is capable of extracting the map of a labyrinth without using an overhead vision. The labyrinth is an 80cmx80cm square consisting of 20cmx20cm square cells.
The main constraint of the design is to not to use a camera or any other device that can give the upper vision of the labyrinth. This brings the necessity of the implementation of a device which will find its way through sensor mechanisms and which has the ability of making decision in the roads of the labyrinth. These two main features form the fundamental algorithm that will be used in the design to extract the complete map.
The ability of deciding is the heart of the project. This ability needs a complex algorithm such that the device can extract the whole map even in the most complex wall placements. So, Clavis Co. began the design process with the construction of a powerful decision algorithm whose details are given in the report.
Clavis will construct a car as travelling device. The car will be constructed by considering three main parts;

i. The motion mechanism
ii. The sensors
iii. Communication and control units

The motion mechanism consists of the structure for movement and rotation. The movement will be provided by use of motors controlled by a control mechanism. The control unit will be either a computer or a microcontroller. Rotation will be done via use of two directional vehicle, differential steering, or spherical wheel system,

.Two duties will be performed by sensors. One group of sensors will be used for wall detection and the other is for coordinate identification. There are different kinds of sensors for wall detection which are included in main body of the report. The coordinates are determined by use of distance sensors via the method which is described in detail in report.

The communication between displacement unit and sensors has a structure including a memory unit and a control unit. The memory unit is responsible for collection of data of the coordinates and control unit supplies the necessary directions to the motors.

The Clavis Co. continues its research for the selection of the suitable equipment. According to the results obtained, the selection will be done considering the objectives of the company.

TABLE OF CONTENTS **Page No**

1. PROBLEM ANALYSIS and DESIGN

1.1. INTRODUCTION

1.1.1. Problem Recognition

The design of the device includes four main research parts namely;

A. The decision algorithm,
B. The determination of the coordinates and wall sensing,
C. The displacement unit,
D. The controller unit

1.2. PROBLEM STATEMENT

1.2.1. Goals of the Project

- A car, a labyrinth, and a display unit will be constructed.
- The labyrinth contains 16 cells of 20x20cm squares.
- The car is capable of making decision on route selection in labyrinth.
- A group of sensors will be used for wall detection and distance sensors for coordinate determination.
- The centering of the road will be provided by line following method.
- The exit points of the labyrinth will be identified by specific signs.
- The connection will be made by cabling or as an alternate, wireless.

1.2.2. Constraints of the Project

- Maximum labyrinth size is 80cmx80cm.
- It must be based on an at least 4x4 grid.
- Overhead vision cannot be used.
- The labyrinth should be passive

1.3. SOLUTION

1.3.1. Design Requirements

1.3.1.a Decision Process

This is the vital feature of the car since it is the key to be able to reach every cell in the labyrinth. So, the device should have a powerful decision system to be able to do selection between the routes and to return back to the crossroads. This needs a memory in which the passed cells' coordinates will be recorded.

1.3.1.b Coordinate determination

In order to perform the decision, the device will be provided with the coordinates of the labyrinth floor. This will enable the device to check whether it passed a cell before or not.

1.3.1.c Centering of the road

The car should follow a straight path. This will be provided via the "line following method."

1.3.1.d Memory

The system should have a reliable and high performance memory to keep the data of the coordinates. The memory will be accessed every time to check the coordinates whether a cell was passed or not.

1.3.2. Relevant Alternative Solutions

Clavis Co. has produced many different methods for the main parts of the design. Among these solutions, the ones that are conforming to the objectives of the company will be selected. The alternative solutions exist for decision algorithm, the determination of coordinates and wall sensing, the displacement unit, and the data transfer unit.

A. DECISION ALGORITHM

Requirements and Definitions

1) Every grid is known by its coordinate. ($x_1 y_1$, $x_2 y_2$ etc…)

2) The device moving inside the labyrinth knows which grid it currently occupies, i.e. it measures and determines its exact position.

3) The grids that have been passed, they are recorded in memory and remaining grids are determined.

4) In any position, there are maximum 4 possibilities for the vehicle to move. When the previous grid, which is passed to reach the current position, is taken out of consideration, there are at most 3 possibilities. To decide where to go, we determined such priorities: unexplored grids have higher priority; if there are plural numbers of unexplored grids, vehicle chooses direction as: continuing forward (highest priority) – turning right – turning left (lowest priority).

5) Consider the case where there are two walls at each side of a grid making it look like a corridor. At such a situation, vehicle has no choice but to move forward. That defines the easiest case for the labyrinth solving action. However, when the vehicle reaches a grid and sees plural number of ways connected to it, it assigns the adjective **"node"** to that grid. Nodes constitute the most important part of the algorithm and they are also recorded in memory along ordinary grids.

6) Consider the case when the device is at a node. We plan to build a logic system which is able to carry out the task of recording node position, determining the positions of the grid which **is chosen** for the next step **and also other grids** which **are not** chosen for the next step.

An example is provided below:

There is a node at: $x_3\ y_3$

Possible ways: $x_1\ y_1$, $x_2\ y_2$

Picked way: $x_1\ y_1$

Unpicked way: $x_2\ y_2$

7) When the case above is examined, a fundamental question may arise: How can the vehicle determine the position of a grid without going there? For this problem, we plan to build a suitable device which enables the system with the sense of direction, i.e. north, east, west etc… After implementing such a system, our device can conclude that: if the current position is ($x_1\ y_1$) the grid at (let us say) north corresponds to the grid position ($x_2\ y_2$).

8) Another problem is that the system should realize when the scanning operation is complete. That is required to prevent an infinite loop situation. Here is the technique we propose: Vehicle simply checks the nodes. In other words if all of the possible road combinations a node introduces are explored then the scan process is over. This technique is better than counting all the explored grids and expecting to reach the total grid number because there may be areas totally enclosed by walls so that our vehicle cannot enter.

Algorithm

After stating all those requirements and mentioning some number of important situations that may be encountered, the algorithm has been roughly described. Below is the concrete form:

Move according to the priorities described above.

If a node is encountered, record it and continue moving according to the same priorities.

Let ($x_1\ y_1$) be an unpicked grid which was not chosen as the movement direction. If that point ($x_1\ y_1$) is later passed along the way, record that one more possibility the node introduces is checked.

We did theoretical simulations of that algorithm and saw that above steps may complete the process for some labyrinth structures such that there are no walls or there are very less number of walls. In many other situations (which we tried to draw a complicated labyrinth), after the above three steps, vehicle finds itself in a blocked position or there are no unpicked grid nearby. For these situations, algorithm continues with the steps below:

When the situation described above arises, return to the last node and check other unpicked grids.

Repeat the above step.

When all possibilities of all nodes are checked, process is over.

B. THE DETERMINATION OF COORDINATES and WALL SENSING

It is obvious that we need sensors to detect the presence of walls and determine the coordinate of the travelling vehicle. During our research for the most efficient way to overcome the problem, it has come to our attention that most of the companies throughout the world who are interested in robotics and do similar projects choose Sharp sensors for distance measurement and detection. The advantages of Sharp sensors are their high reliability, availability in the market and good operation characteristics given at the datasheets.

Theory of Operation:

The basic idea is this: a pulse of IR light is emitted by the emitter. This light travels out in the field of view and either hits an object or just keeps on going. In the case of no object, the light is never reflected and the reading shows no object. If the light reflects off an object, it returns to the detector and creates a triangle between the point of reflection, the emitter, and the detector.

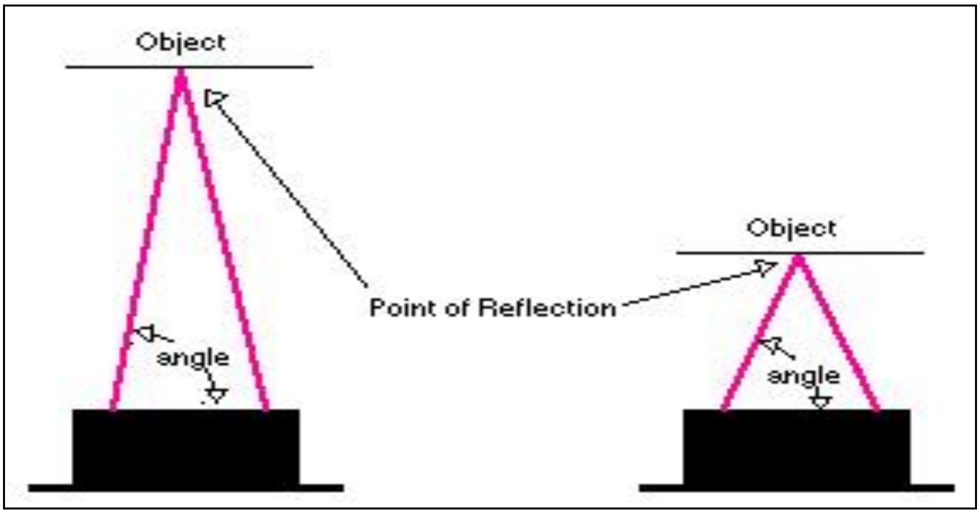


Figure-1 The operation of distance sensor

The angles in this triangle vary based on the distance to the object. The receiver portion of these new detectors is actually a precision lens that transmits the reflected light onto various portions of the enclosed linear CCD array based on the angle of the triangle described above. The CCD array can then determine what angle the reflected light came back at and therefore, it can calculate the distance to the object.

This new method of ranging is almost immune to interference from ambient light and offers amazing indifference to the color of object being detected. Detecting a black wall in full sunlight is now possible.

B.1. The determination of the coordinates

B.1.1. Use of distance sensors

The coordinates of the cells can be defined via use of distance sensors which will measure the distance between the device and outside walls of the labyrinth. By this way, the 16 cells will be assigned unique coordinates according to the relevant distances.

B.1.2. Counting the steps of step motor

If the motor type is selected as step motor which makes the movement at definite distances, starting from the initial place of the car and counting the forward, backward, rightward, and leftward steps of the motor, the path followed can be drawn.

B.2. Wall Sensing

B.2.1. Use of distance sensors

The distance between the outermost side of the device and the nearest wall can be measured by distance sensors so that, if the distance is above a pre-defined range it will mean that there is no wall. If the distance is in the range, it will imply the existence of a wall.

B.2.2 Use of light sensors

Most of the light sensitive sensors are made of IR diodes which work on the principle of emission and the detection of the reflected light. So, if the walls of the labyrinth are made of a material that can reflect the light, the sensors will detect them.

Which Detector to Use

We are planning to use GP2D12 for coordinate determination and GP2D120 for wall detection. Datasheets of these sensors are added at the appendix.

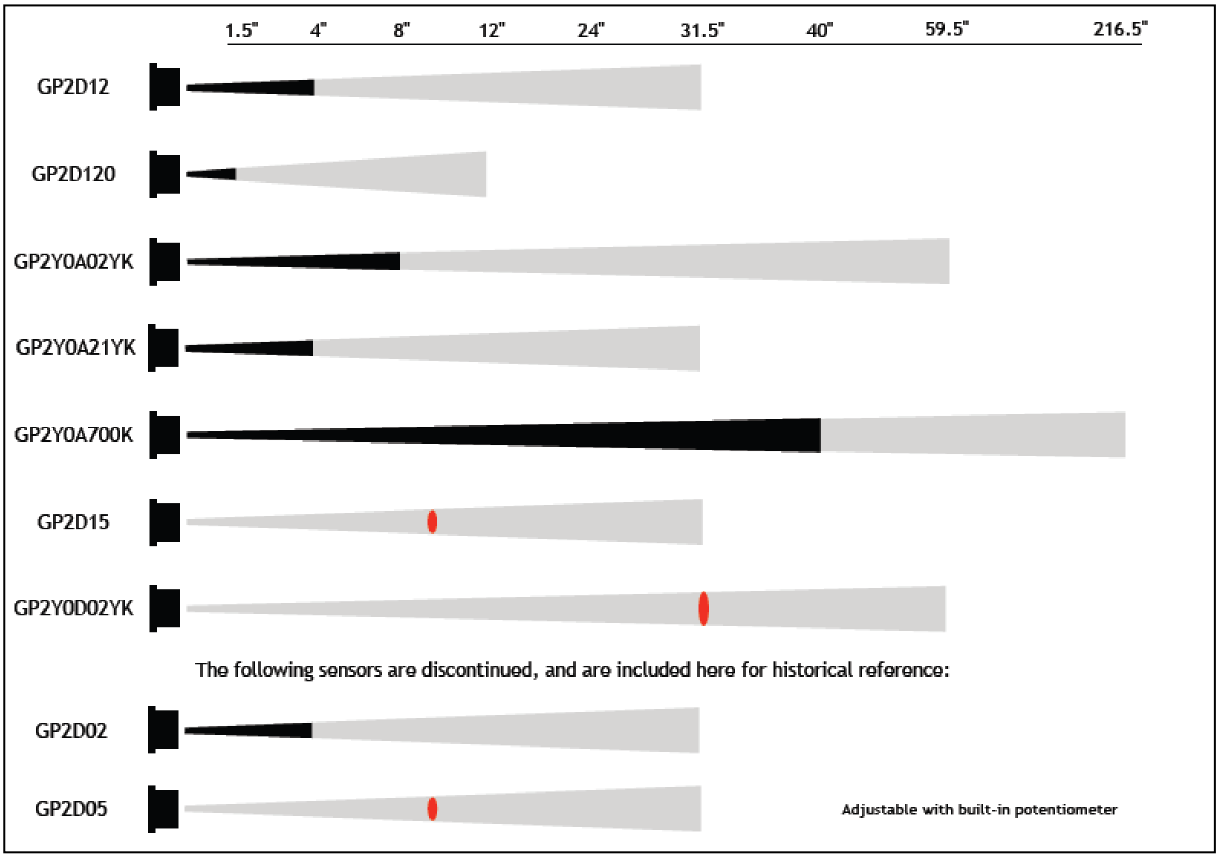


Figure-2 Ranges of measurable distances for different sensor models

Although Sharp sensors are high quality products, we still have an alternative set of sensors for wall detection. At the operation of wall detection, the system must conclude if there is a wall or not; i.e. the precise distance is not important as long as it is for sure that scanning is done in the range of our interest. Therefore, much simpler thus cheaper sensors can be used for wall detection instead of Sharp distance sensors which are unnecessarily sophisticated for this job.

CNY70 Sensor

The CNY70 sensor is one of the most popular devices among the line following robot designers. The sensor has the sensitivity of detection on 0.3 mm which is not sufficient for our design purpose. But the research we conducted showed that by adjusting the resistance values on the collector and IR diode, the distance of measurement can be increased up to 4-5 cm. However we will conduct an additional experiment till the presentations start. The data sheet for CNY70 is given in the appendix. The circuit in Figure-3 is used generally for test of the device.

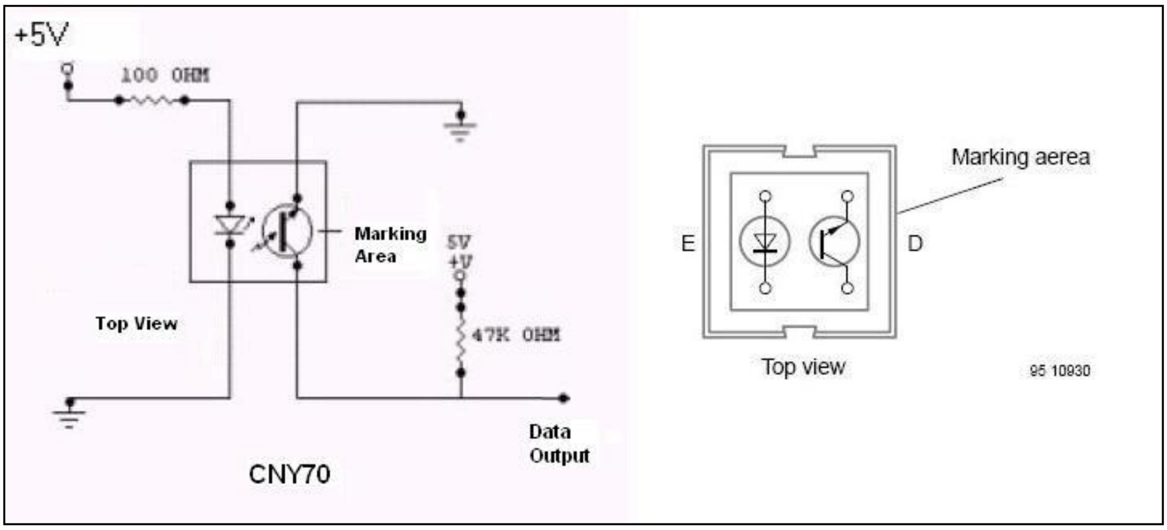


Figure-3 General Test Circuit of CNY70

C. THE DISPLACEMENT UNIT

C.1. Motors

C.1.1 DC Motor

The movement of the car can be provided via DC motor. The car, every time, will move the pre-defined distances and stop to check for the walls, so, a motion like go-stop, go-stop,…will be performed. To achieve this, the DC motor can be controlled by PWM structures, which will keep the time variation of the current of the DC motor under control and supply the desired motion.

C.1.2 Step Motor

Step motors are also possible for the stated motion characteristics above but they have a different control mechanism from the DC motor. A step motor is digitally controlled through its pins, thus, unlike the DC motor; a logic circuit is needed for obtaining the desired motion.

C.2. Displacement Mechanisms

Displacement unit is in contact with the deciding mechanism and applies the commands of decision making system. In our system we need 2 directional movement mechanism and these 2 directions are perpendicular to each other. In other words; we need to implement a movement mechanism that makes the displacement in 0, 90, 180 and 270 degrees in a Cartesian coordinate system. The main problem is to decide the system at the turning point. At the beginning, we discussed 5 alternates for the movement mechanism, namely; 2 directional vehicle, turning with differential steering, turning by aligning directions of wheels on a circle, turning with the help of a separate mechanism and turning with 2 wheels. We, as a company, made the necessary research and thought about the advantages and disadvantages of all movement mechanisms. We made the necessary brainstorming to anticipate the gain and the possible problems of these systems and made one main and one alternative systems.

C.2.1. Two Directional Vehicle

We decided to use 2 directional vehicle after the brainstorming sessions about the movement mechanisms by looking the whole picture. By this movement system, the main body of our system would not be turning by the change of the movement direction. We anticipate that this situation would ease the mapping process-each of the wall sensors will be responsible for a wall at constant direction, i.e. third sensor will check whether there is a wall or not on only the south direction at each cell on the labyrinth-. However, we had some problems about the implementation of the 2 directional system caused by the wheels. We create two mechanisms that overcome this problem.

C.2.1.a Transwheel System

On the research sessions, we had discovered the existence of the transwheel system which should solve the main problem of the two directional vehicle. At this point, we must give some information about the transwheel to make the customers familiar with the system that we will try to implement.

Figure-4 Transwheel

The Transwheel’s unique design contains eight free-turning rollers perpendicular to the axle arranged around the Transwheel periphery. This distinct design combined with the rotation of the wheel body provides the ability to move loads in any direction without “freezing.” Its enclosed, light-weight body is self cleaning and keeps out foreign material.

Transwheels are constructed with a standard ABS body, Nylon rollers, a Polyethylene center axle, Delrin sprockets, and stainless steel roller axles with low friction coatings. The combination of these materials creates a corrosion-resistant wheel that allows steam cleaning, water immersion, and outdoor use. Self-lubricating properties eliminate the need for oil or grease.

Transwheels are available with a 2” or 4” outer diameter. The Series 2000 Transwheels have a 2” outer diameter and a 25 pound/wheel load rating. The Series 4000 Transwheels have a 4” outer diameter and a 100 pound/wheel load rating. Center bore diameters vary according to the particular Transwheel model. The Transwheel is available in a variety of styles for standard and special applications.

- Standard Transwheel Models: Plain Bore, Bushed, Axled, Keyway, Sprocketed, Multiple Row, and Hex Bore.
- Transwheel Assemblies: Idler Transrail and Transection.

The Transwheel is an indispensable component for any application that requires multidirectional movement. The Transwheel’s unique features create an all-purpose wheel that can be used in numerous industries ranging from material handling to robotics. The Bushed Transwheel has the same basic dimensions as a standard skatewheel, and can easily convert any section conveyor into a multi-directional “ball table” or work station using the same axle rods and spacers. The keyway and the sprocket models allow the Transwheel to be used as a powered conveyor wheel. The Cat-Trak Transwheels offer resilient, non-marring surfaces for use with robots, and by glass and window manufacturers. The Transwheel’s exceptional light weight is an important advantage for portable or aircraft equipment. Other applications include: conveyor discharge or loading stations, packaging tables, appliance casters, transfers between angled conveyors, powered turns and powered multi-directional tables.

Cat-Trak Transwheel: The Cat-Trak Transwheel has been specially designed with traction in mind when power is applied. The Cat-Trak Transwheel has the ability to provide the ultimate in gripping power to operate on slick surfaces. Unlike the standard Transwheel rollers that are made from nylon, the Cat-Trak Transwheels are produced with either Synthetic Rubber Coated Polypropylene Rollers or Polyurethane Rollers. The Cat-Trak Transwheels are highly popular for use with robots, glass and window manufacturers, and in other similar circumstances where wheels need traction to grip the surface. The Polyurethane Rollers provide a stronger gripping force than the Rubber Coated Rollers; however both wheels provide remarkable traction. The Series 4000 Transwheels are available with both types of Cat-Trak rollers, and the Series 2000 Transwheels are available only with the Synthetic Rubber Coated Polypropylene Rollers.

High-Impact Plastic: Transwheels are also available in a high-impact plastic that provides resistance to extreme vibration. These Transwheels are ideal for 90 degree transfers using gravity or power, and are widely used by automotive tire manufacturers for conveying and in-process storage of rubber ply stock.

Customers can find more about the models of transwheels at the appendices part. We did not yet decided the model of the transwheel that we will use because the weight and size of the machine is not well defined yet. As you can see the model is not much important because idea is fixed and the prices of the models are close to each other.

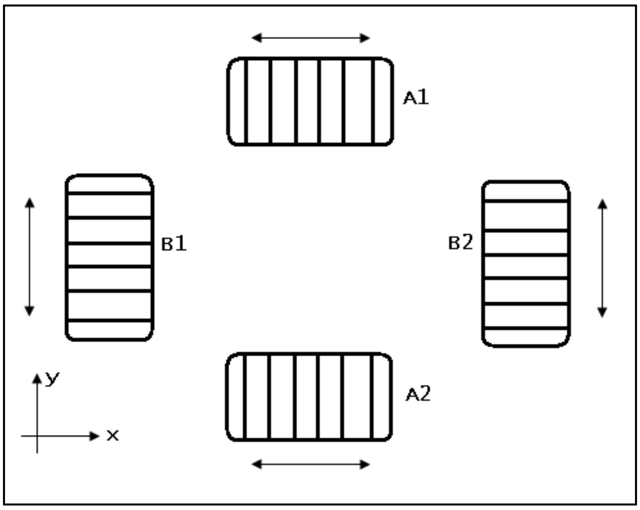


Figure-5 Transwheel placement on the vehicle

As it is seen in Figure 5, there will be four transwheels, each connected to a different motor. Parallel transwheels will move on the same axis. While going on one axis, the architecture of the transwheel will help the movement, passive wheels will not interrupt it.

C.2.1.b Spherical Wheel System

As an alternate solution (before we had discovered the transwheel), we thought about implementing one spherical wheel at the bottom of the robot. The movement of the old computer mouse inspired us during the thinking process.

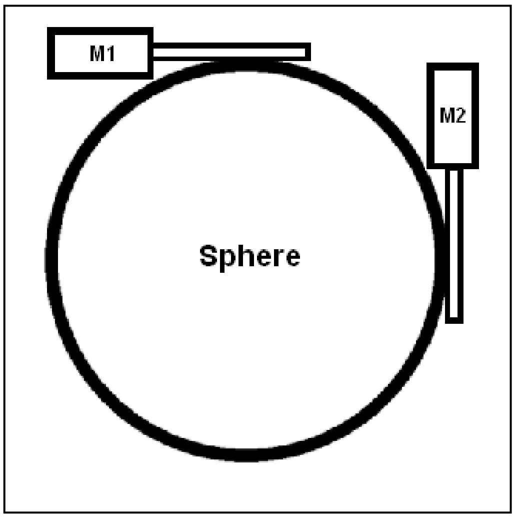


Figure-6 Spherical Wheel System

This structure includes a sphere which works as a wheel for both movement in forward and backward direction and rotation to the right or left. Figure above shows the schematics of this structure. In this model, two motors directly touch the surface of the sphere at two points. M1 provides the sphere with the movement in forward and backward direction and M2 will enable the sphere to turn to right or left. By this model, the need for a separate rotation mechanism will be eliminated since a single sphere will both make the movement in forward direction and rotation possible. The challenging way of the model is that, it needs care to place the motors suitably to touch the sphere in a healthy way, that is, the friction between the shaft and sphere should be sufficient to turn the sphere.

Our company will make the necessary tests about the spherical system and if we confirm the feasibility of the system, we can choose to apply it because it works with 2 motors, so it will decrease the cost.

C.2.2. Differential Steering

In this method, we control the speeds of right and left motors separately. Because while turning, the wheel close to the turning direction will travel shorter distance than the wheel far from the turning direction and their speed and turning angles will behave in the same manner, because they will travel their paths in the same time period. It can be seen easily on Figure-7.

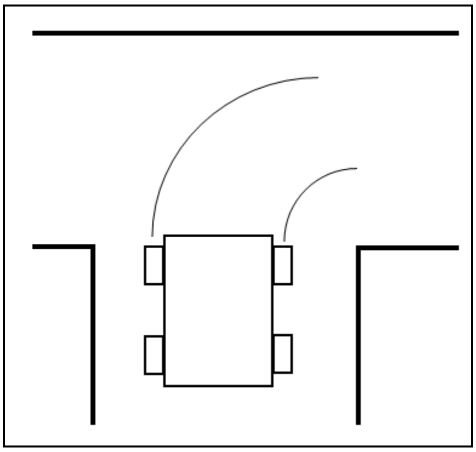


Figure-7 Differential Steering Geometry

Advantage of this method is we can use less number of motors. This saves space and decreases the cost. On the other hand it needs more space to turn with respect to turning on the axis of vehicle. In addition to this vehicle have to know that it will begin to turn before the turning point. Another problem occurs when our vehicle have four wheels. The same system should be applied to rear wheels in order not to face the same problems at the corners when the vehicle moves to backward. Furthermore its front direction will change, i.e. backward will be forward and forward direction will be backward in the dead ends of labyrinth. Using only one wheel on front side of the vehicle can be a solution to differential steering problem. However, backward movement cannot be complete easily with this method.

D. THE CONTROL UNIT

A microcontroller that is interfaced with other circuit elements will be used to control the whole system. It can be thought as the brain of the device. According to the data taken from the environment with the help of some sensors etc, it makes the decision and drives some motors to make the device maintain its position. Microcontroller is chosen as the controller units among the many controller choices since microcontrollers are programmable, inexpensive, small, require almost zero power and there are so many varieties to suit every need.

PIC 16F877A is a high performance capability, full-static, 8-bit microcontroller. It has

specific properties which decrease the number of circuit elements in the design and provide a drop in both the cost and energy consumption significantly. Moreover, this microcontroller includes 4 different oscillator types. Among these RC (4 MHz) oscillator has low cost price, LP (40 KHz) oscillator minimize the energy consumption, XT crystal and resonator oscillator has standard speed and HS crystal oscillator has very high speed (20 MHz).

One of the most important properties of PIC microcontrollers is sleep mode property.

When no operation is being performed, microcontroller passes to sleep mode and so pulls very low current, so energy consumption decreases. User or system can take microcontroller out from sleep mode by some internal and external interrupts.

EEPROM memory of PIC16F877A makes it possible to change the program again and again. By this property, it is possible to update the code involved when necessary.

This microcontroller is preferred due to the fact that it has high performance on high speed, decreases the energy consumption and cost price significantly and can be programmed by C programming language. Detailed information can be found in appendices.

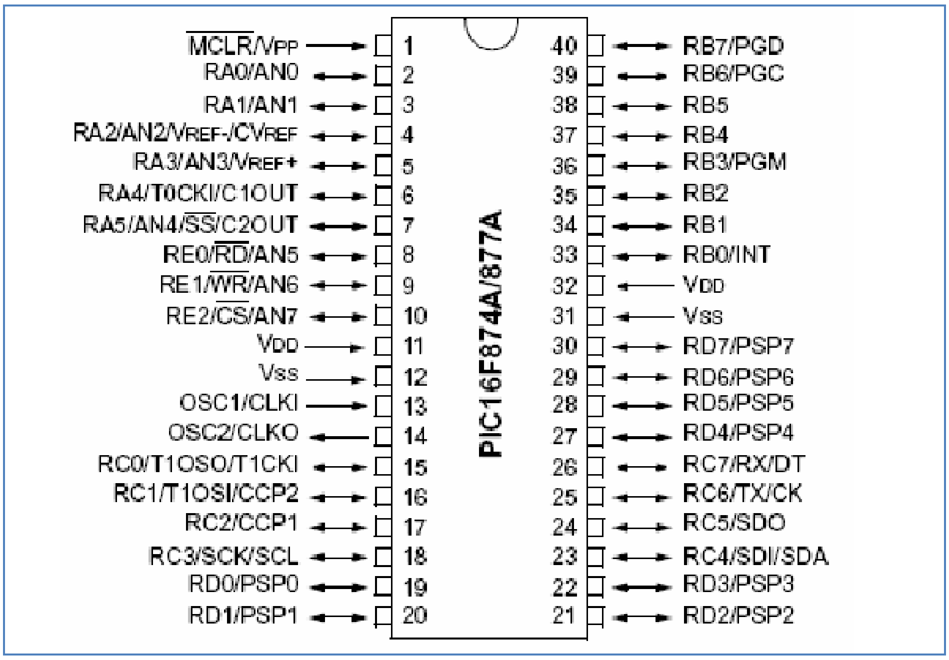


Figure-8 PIC16F877A

Ports of PIC16F877A

Port A

It is 6 bit port located between RA0 and RA5. whole pins can be used for A/D conversion by using RA2 and RA3 pins as reference voltage inputs.

Port B

It is 8 bit port that can utilized as I/O located between RB0 and RB7. RB3, RB6 and RB7 pins are allocated for debugging.

Port C

It is the most employed port of PIC16F877A and has 8 bit digital I/O. Schmidt trigger input is used for all legs.

Port D & Port E

Port D and Port E are employed together usually and on duty for parallel connection. Port D constitutes 8 bit address and data bus, while Port E is used for controlling. Furthermore, Port E can be utilized for analog input alike Port A.

Serial Data Transfer

During the mapping process we need to send our data to a display device which we will show our findings to outer world. In order to do this we must send our data from the labyrinth robot to a specific program in computer. Data can be transferred to the computer in various ways. One and most common way is using serial port of the computer. This process is known as serial port communication.

Serial port communication uses a transmitter to send data, one bit at a time, over a single communication line to a receiver. You can use this method when data transfer rates are low or you must transfer data over long distances. Serial communication is popular because most computers have one or more serial ports, so no extra hardware is needed other than a cable to connect the instrument to the computer or two computers together.

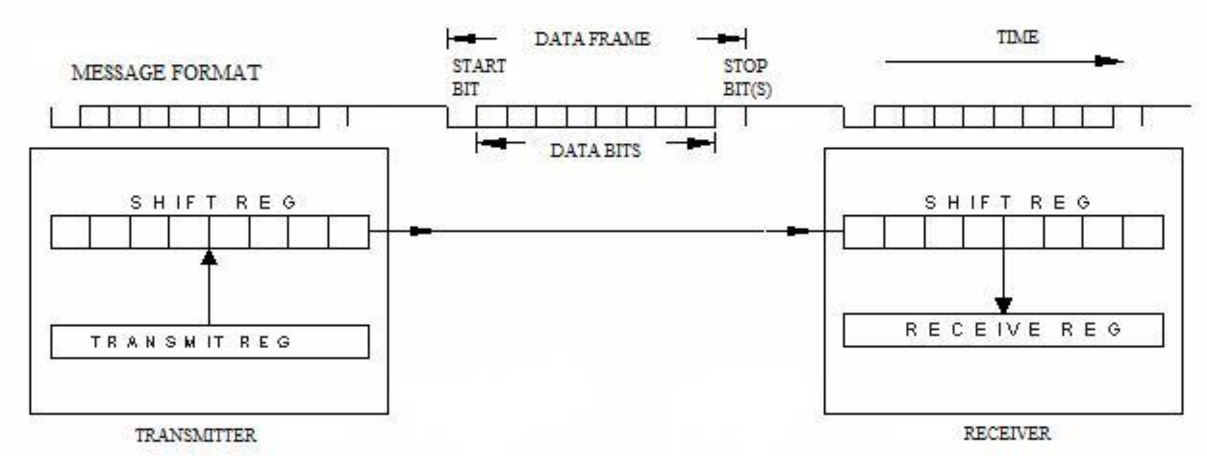


Figure - 9 A serial transfer operation

Serial communication requires that you specify the following four parameters:

- The baud rate of the transmission
- The number of data bits encoding a character (eg. 1 byte)
- The sense of the parity bit (optional)
- The number of stop bits

Baud rate is the measure how fast is the data signal is transferred between the transmitter and the receiver. Generally it is measured in number of bits transmitted per second (bps).

The character is generally the actual data bits to be transmitted. It will be a word of 8 bits in our serial communication process.

Parity bit is needed sometimes in order to detect the transmitted signal is correct or not.

Lastly a stop bit indicates that all data is sent in the character frame.

Figure 10, shows a typical data sequence which also we call it as character frame.

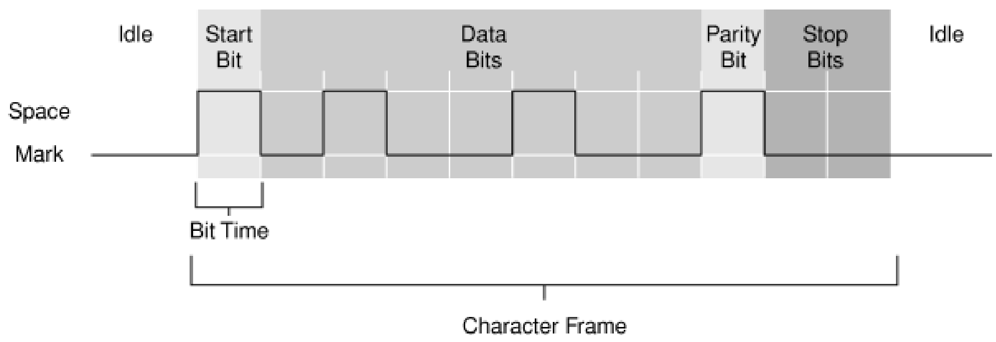


Figure - 10 A typical character frame

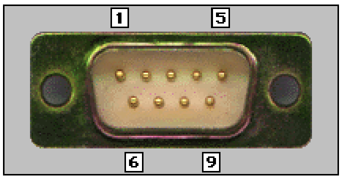
We will use RS-232 (RS-485) standard for serial data transfer.

RS-232 Interface Standard

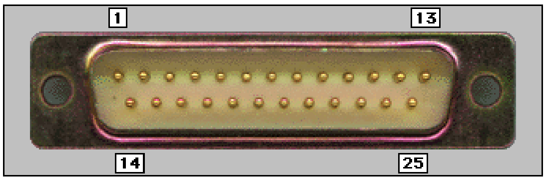
Most equipments communicating in asynchronous serial mode use the RS-232 standard. This standard defines the signal levels, connectors and pin assignments, among other things. A serial port is the serial interface connector plus all the electronics required to make the interface fully functional.

The standard defines 25 different signals, although in practice few of these are used. Most RS-232 interfaces use a mechanical connector with 25 pins known as DB-25. Since few of the 25 signals are ever used, many serial ports also use a DB-9 connector. It only uses 9 plug pins. Only 3 signals are required for a connection: transmit data, receive data and signal ground.

Typical RS-232 serial ports come in two sizes. 9-pinned port (DB-9) and 25-pinned port (DB-25). These are shown in the Figure 11..



RS-232 DB-9



RS-232 DB-25

Figure-11 Serial Port pins

For DB-9, which we can find easily rather than DB-25, pin function table is:

Function	Signal	PIN	DTE	DCE
Data	TxD	3	Output	Input
	RxD	2	Input	Output
Handshake	RTS	7	Output	Input
	CTS	8	Input	Output
	DSR	6	Input	Output
	DCD	1	Input	Output
	STR	4	Output	Input
Common	Com	5	--	--
Other	RI	9	Output	Input

Figure 12 DB-9 Function/pin table

Here we will use pin use pin 2 and 3 for data transfer and pin5 for signal grounding.

1.4. DESCRIPTION OF THE SOLUTION METHOD

1.4.1 Implementation Steps

1. The device will determine its coordinate at the initial place and this coordinate will be recorded on memory.

2. It will check the walls around and the wall knowledge will be recorded again.

3. The initial movement will be defined according to the wall knowledge around under the control of the control unit.

4. When the device moves to the other cell, the same coordinate determination and wall checking operations will be performed.

5. As the device comes to the crossroads called as "node", these will be recorded and the device will return back to these points to travel all the roads.

6. Along these steps, the device always accesses the memory to check for the recorded coordinate data where the device passed before, and choose a different path, so, the decision will be conducted.

7. When all nodes are checked the map will be completed.

Note: The wall sensors on the vehicle will be given numbers, so, the manipulation of the data will be easier.

Among the stated solution alternatives, Clavis Co. will choose the most feasible ones considering the objectives of the company.

- Transwheel will be used at the moving vehicle part because of its advantages like fixed direction, low cost and high reliability.
- CNY70 sensors will be used for wall detection if we manage to modify its range to 4-5 cm. If that requirement is not met then we will use Sharp sensors models GP2D12 and GP2D120, for position determining and wall detection respectively.
- For coordinate determination, the idea of counting the steps of the step motor is eliminated due to its unreliable nature. We will depend on sensors.

- Creating the image of map on an LCD screen is the primary goal but we will try to write a suitable program and use the computer screen for display purposes.

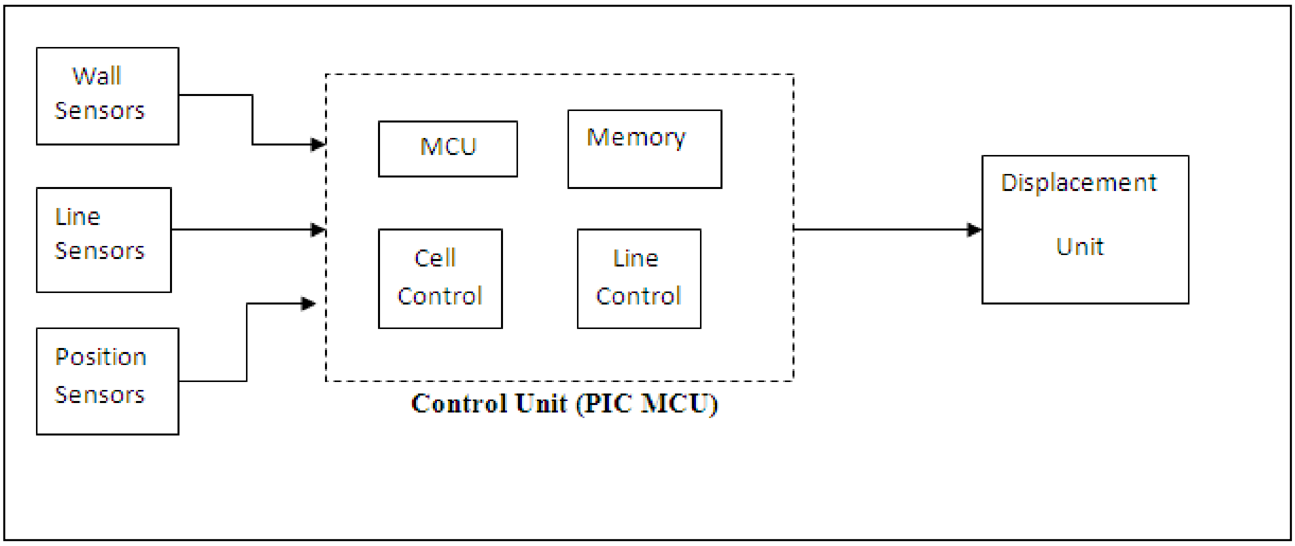


Figure-13 The flow of implementation steps

2. ORGANIZATIONAL STRUCTURE

2.1 Company Organization

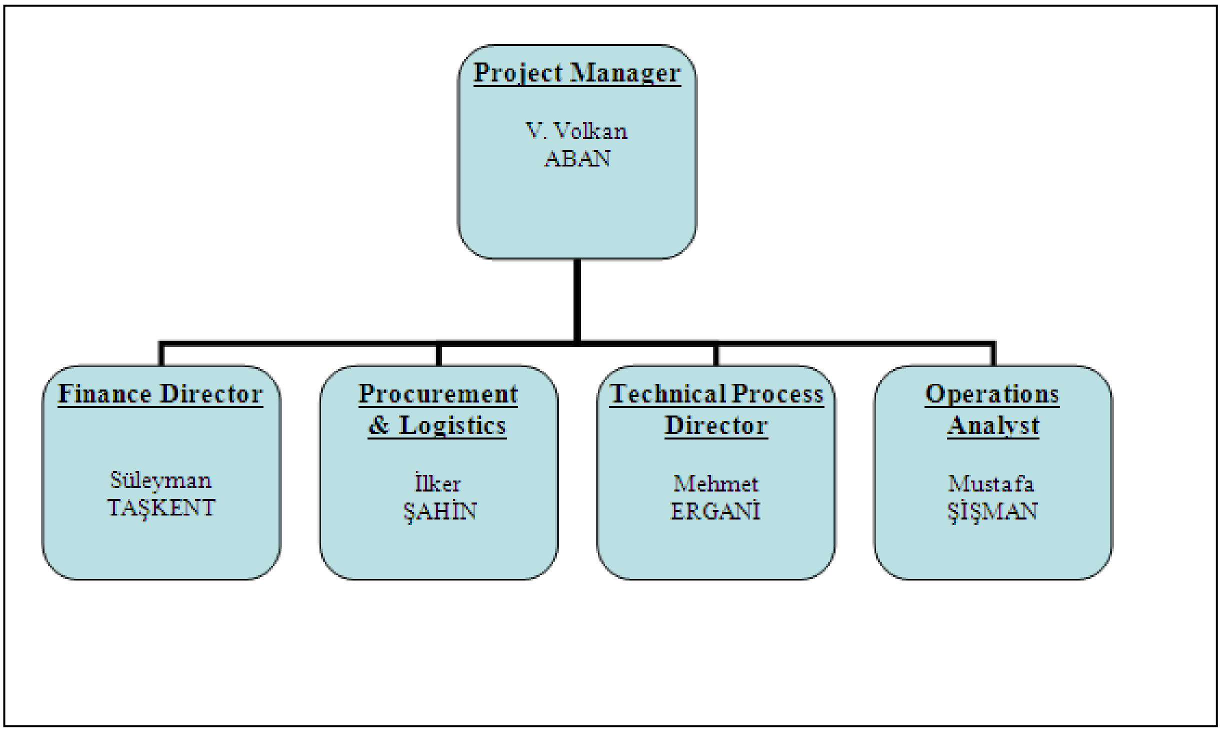


Figure-14 Clavis Organization

2.2. Detailed Information About the Shareholders

Mustafa ŞİŞMAN

He is specialized in communication area in his senior year. Currently enrolled courses are; Digital Signal Processing, Telecommunications I, Nonlinear Electronics for Communications. He will also be familiar to software and mechanical implementations during the design of the project.

Mehmet ERGANİ

He is specialized in power electronics area in his senior year. Currently enrolled courses are; Power System Analysis I, High Voltage Techniques I, Data Structures, Static Power Conversion I. Besides the mechanical and power design, he will help the software designs.

İlker ŞAHİN

He is specialized in both waves and communications areas in his senior year. Currently enrolled courses are; Nonlinear Electronics for Communications, Microwaves I, Digital Signal Processing, Telecommunications I. His conceptual and mechanical genius will be critical during the design.

Vahap Volkan ABAN

He is specialized in power electronics area in his senior year. Currently enrolled courses are; Power System Analysis I, High Voltage Techniques I, Static Power Conversion I. Besides the mechanical and power design, he will help the software designs.

Süleyman TAŞKENT

He is specialized in computers area in his senior year. Currently enrolled courses are; Digital Signal Processing, Data Structures, Computer Architecture I, Introduction to Microprocessors.

He will be the main software genius of the company, besides he will help in conceptual and mechanical designs.

3. GANTT CHART and EXPECTED USE of TIME

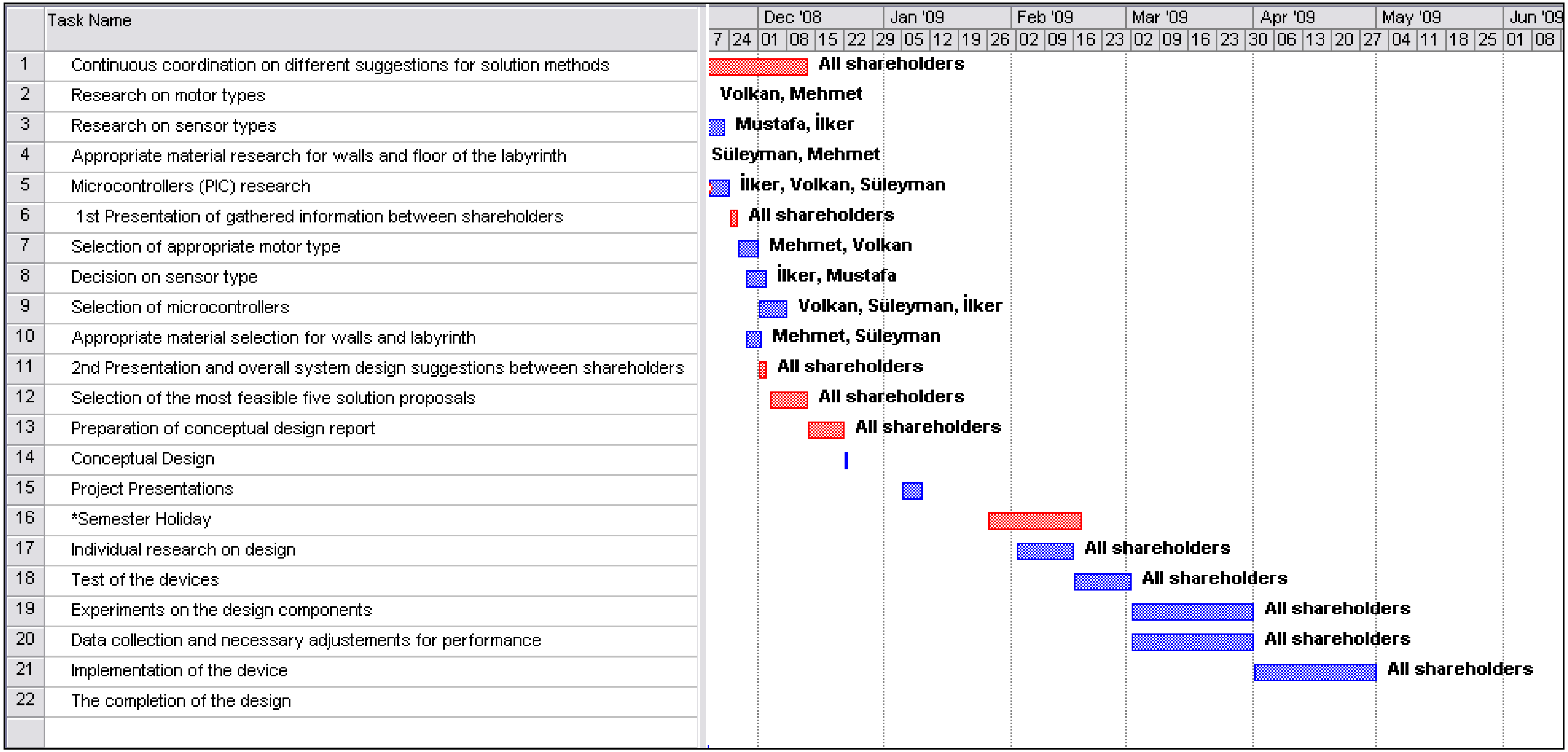


Figure 15- Gantt Chart

4. COST ANALYSIS

Items	**Fee**
Wheels and wall material	$25
Motors	$40
Power System Components (batteries, converters, regulators etc.)	$15
Microcontrollers	$15
Electronic components (resistors, wires, capacitors, inductors, etc…)	$5
Sensors (CNY70 and Sharp Sensors)	$45
PCB Fabrication	$5
TOTAL	***$150***

5. CONCLUSION

Clavis Co. has represented the conceptual design steps of the device which extracts the complete map of a labyrinth without using overhead vision with the expected completion time and cost.

Through the end of the first and in second semester, the company shareholders will be mainly dealing with the test of the system and software development for the algorithm. The selection of the sensor type and motors will be clear as the test procedures begin.

As Clavis Co., the shareholders are planning to be in contact with each other during the semester holiday as often as possible. Through the meetings, possible to do online, all shareholders will share the results of their research on the main parts of the system.

6. APPENDICES

APPENDIX-A SHARP GP2D120 DATA SHEET

SHARP | GP2D120

GP2D120

General Purpose Type Distance Measuring Sensors

■ Features

1. Less influence on the color of reflective objects, reflectivity
2. Line-up of distance output/distance judgement type
   Distance output type (analog voltage) : **GP2D120**
   Detecting distance : 4 to 30cm
3. External control circuit is unnecessary

■ Applications

1. TVs
2. Personal computers
3. Amusement equipment
4. Copiers

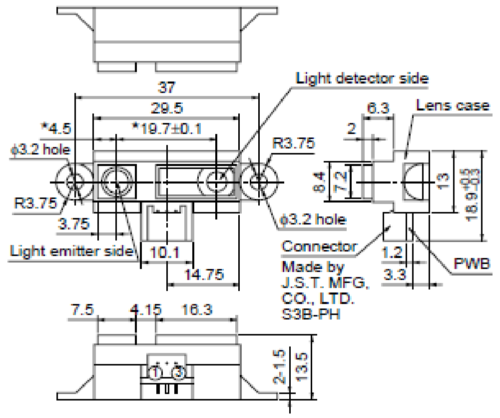
■ Absolute Maximum Ratings

(Ta=25°C, Vcc=5V)

Parameter	Symbol	Rating	Unit
Supply voltage	V_{CC}	−0.3 to +7	V
Output terminal voltage	V_O	−0.3 to V_{CC} +0.3	V
Operating temperature	T_{opr}	−10 to +60	°C
Storage temperature	T_{stg}	−40 to +70	°C

■ Outline Dimensions

(Unit : mm)



Terminal connection
① V_O
② GND
③ V_{CC}

✱ The dimensions marked * are described the dimensions of lens center position.
✱ Unspecified tolerance : ±0.3mm

Fig.3 Analog Output Voltage vs. Surface Illuminance of Reflective Object

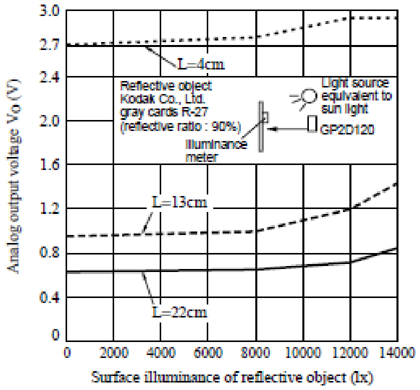


Fig.4 Analog Output Voltage vs.Distance to Reflective Object

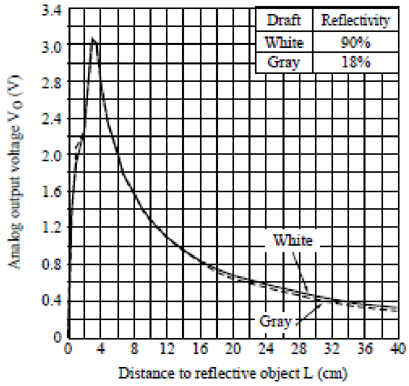


Fig.5 Analog Output Voltage vs.Ambient Temperature

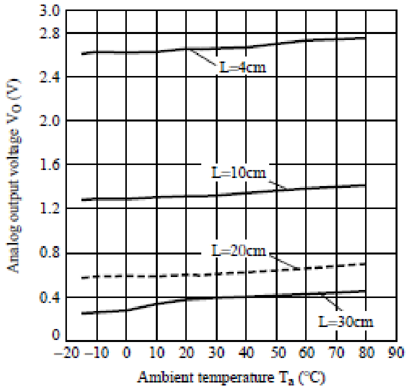
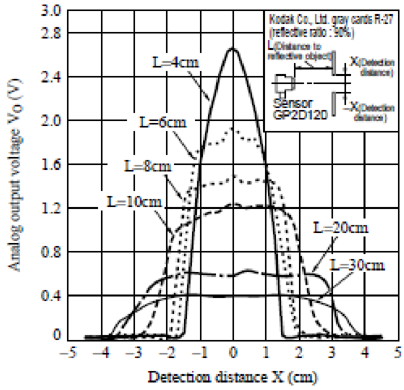


Fig.6 Analog Output Voltage vs.Detection Distance



APPENDIX- B VISHAY CNY70 DATA SHEET

VISHAY

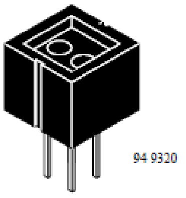
CNY70

Vishay Semiconductors

Reflective Optical Sensor with Transistor Output

Description

The CNY70 has a compact construction where the emitting light source and the detector are arranged in the same direction to sense the presence of an object by using the reflective IR beam from the object.
The operating wavelength is 950 nm. The detector consists of a phototransistor.

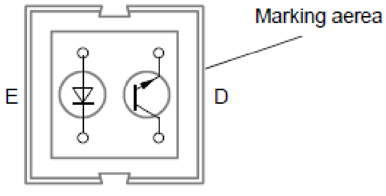


Applications

- Optoelectronic scanning and switching devices i.e., index sensing, coded disk scanning etc. (optoelectronic encoder assemblies for transmission sensing).

Features

- Compact construction in center-to-center spacing of 0.1'
- No setting required
- High signal output
- Low temperature coefficient
- Detector provided with optical filter
- **C**urrent **T**ransfer **R**atio (CTR) of typical 5%



Order Instruction

Ordering Code	Sensing Distance	Remarks
CNY70	0.3 mm	

Absolute Maximum Ratings

Input (Emitter)

Parameter	Test Conditions	Symbol	Value	Unit
Reverse voltage		V_R	5	V
Forward current		I_F	50	mA
Forward surge current	$t_p \leq 10\ \mu s$	I_{FSM}	3	A
Power dissipation	$T_{amb} \leq 25^\circ C$	P_V	100	mW
Junction temperature		T_j	100	°C

Output (Detector)

Parameter	Test Conditions	Symbol	Value	Unit
Collector emitter voltage		V_{CEO}	32	V
Emitter collector voltage		V_{ECO}	7	V
Collector current		I_C	50	mA
Power dissipation	$T_{amb} \leq 25^\circ C$	P_V	100	mW
Junction temperature		T_j	100	°C

Coupler

Parameter	Test Conditions	Symbol	Value	Unit
Total power dissipation	$T_{amb} \leq 25^\circ C$	P_{tot}	200	mW
Ambient temperature range		T_{amb}	–55 to +85	°C
Storage temperature range		T_{stg}	–55 to +100	°C
Soldering temperature	2 mm from case, $t \leq 5$ s	T_{sd}	260	°C

Typical Characteristics (T_{amb} = 25°C, unless otherwise specified)

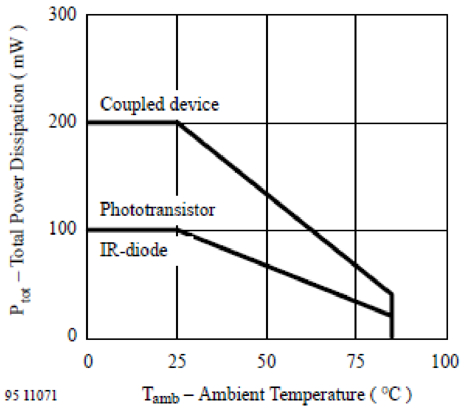


Figure 2. Total Power Dissipation vs. Ambient Temperature

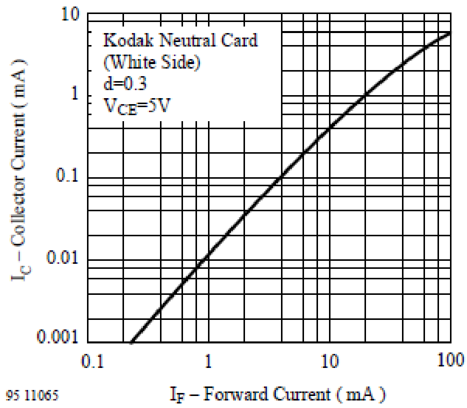


Figure 5. Collector Current vs. Forward Current

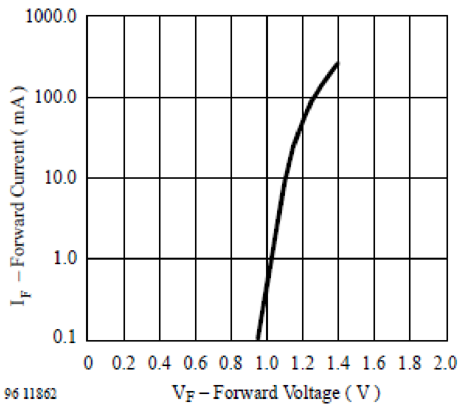


Figure 3. Forward Current vs. Forward Voltage

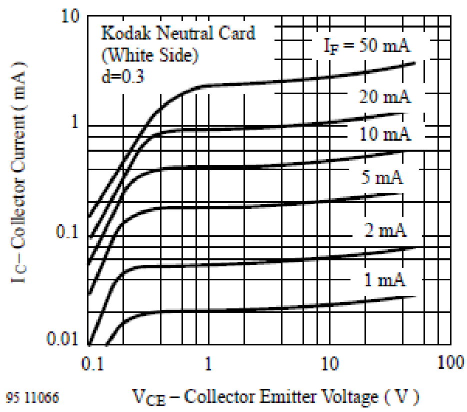


Figure 6. Collector Current vs. Collector Emitter Voltage

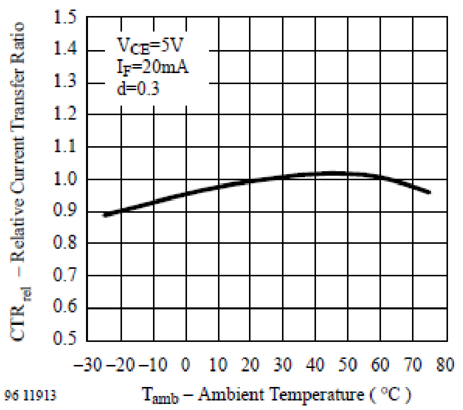


Figure 4. Relative Current Transfer Ratio vs. Ambient Temperature

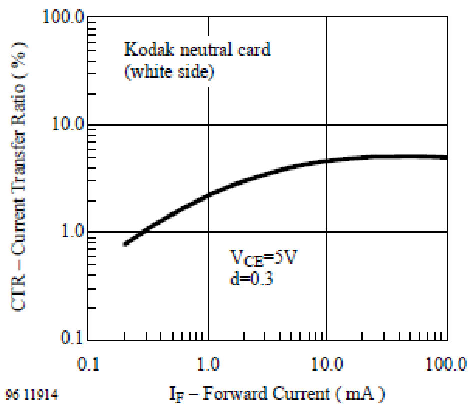


Figure 7. Current Transfer Ratio vs. Forward Current

APPENDIX-C PIC 16F87XA DATA SHEET

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input
  DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

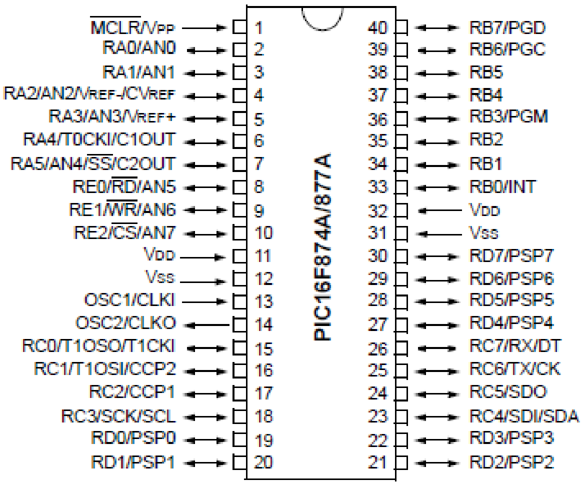
CMOS Technology:

- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

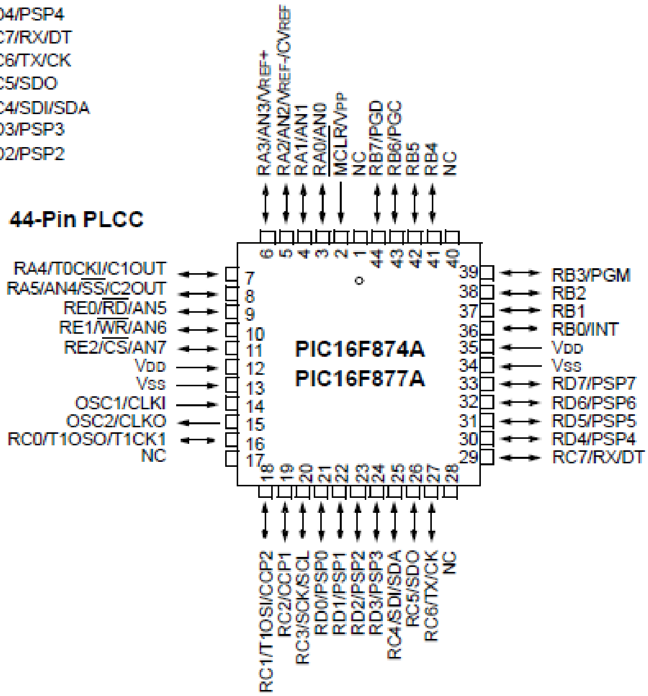
Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^2C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

Pin Diagrams (Continued)

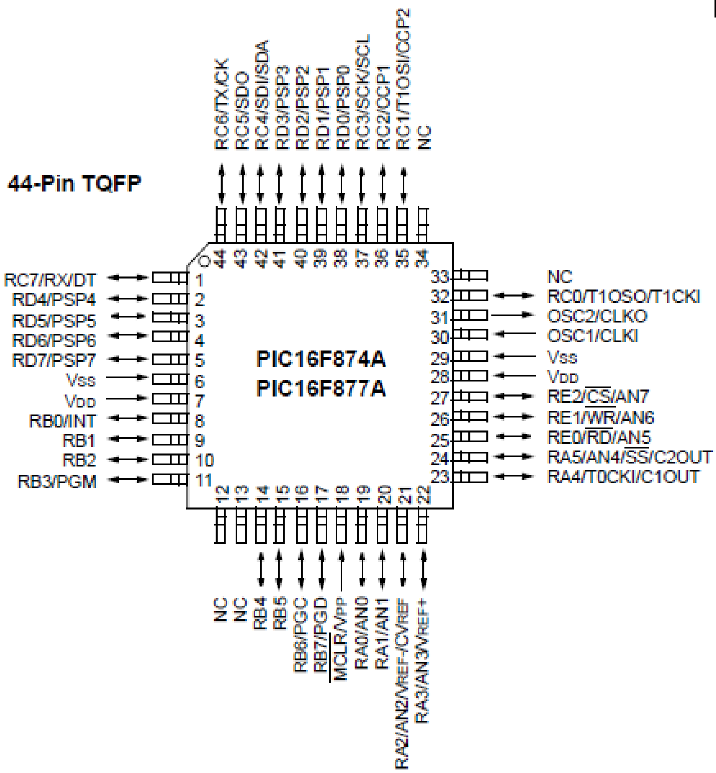
40-Pin PDIP



44-Pin PLCC



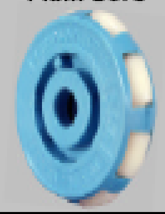
44-Pin TQFP

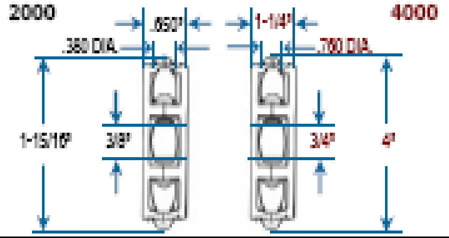


APPENDIX-D TRANSWHEEL DATA SHEET

Standard Transwheel Models

Plain Bore



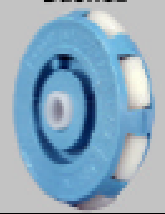


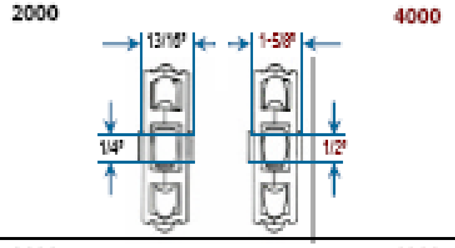
PLAIN BORE: Models 2051, 4201

- For applications where side clearance is assured to allow the wheel to rotate freely without a bushing

Also Available In:
2": 1/4" ID, 1/2" ID, 10mm, HI, X
4": 3/4" ID, HI, X, XU

Bushed



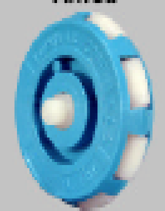


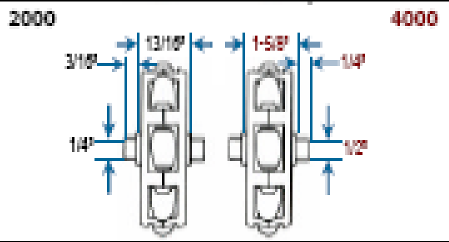
BUSHED: Models 2051B, 4201B

- Guarantees wheel side clearance in applications where wheel is clamped between rails or spacers
- Has exact diameter, width, and bore as skatewheels
- Converts any portion of existing skatewheel conveyor into ball table equivalent

Also Available In:
2": HI, X
4": HI, X, XU

Axled



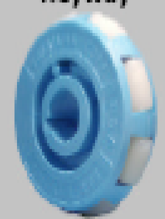


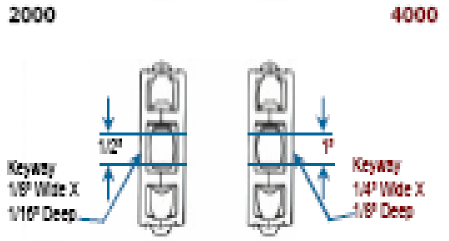
AXLED: Models 2051A, 4201A

- Can conveniently be dropped into a slotted channel without the need for an axle
- Shoulders on the built-in axle maintain wheel side clearance

Also Available In:
2": HI, X
4": HI, X, XU

Keyway



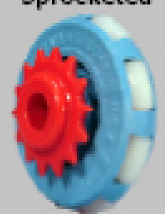


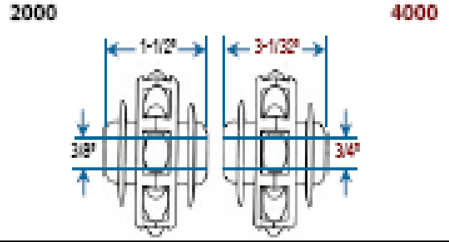
KEYWAY: Models 2051K, 4201K

- Mounts on a keyed shaft to provide powered movement of load in wheel direction

Also Available In:
2": HI, X
4": HI, X, XU

Sprocketed



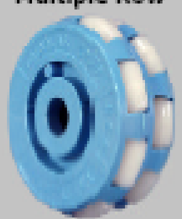


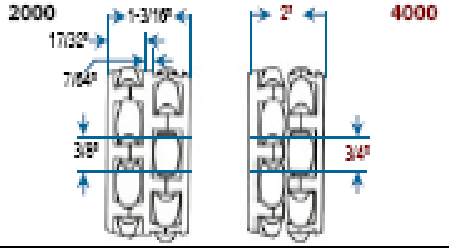
SPROCKETED: Models 2051S, 4201S

- Turns on plain shaft when chain driven to provide powered movement in wheel direction
- Sprocket on each side permits chain engagement on either or both sides
- Sprockets are welded or available separately

Also Available In:
2": HI, X
4": HI, X, XU

Multiple Row



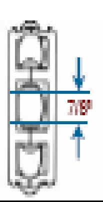


MULTIPLE ROW: Models 2052, 4202

- Provides smoother rolling in single wheel applications
- Available in three styles: plain bore, bushing, axle

Also Available In:
2": 1/4" ID & Bushing, 1/2" ID & Keyway, HI, X
4": 1/2" ID & Bushing, 1" ID & Keyway, HI, X, XU

Hex Bore



HEX BORE: Model 4201HB

- Mounts on hex shaft to provide powered movement of load in wheel direction

Also Available In:
2": Available Upon Request
4": HI, X, XU

NOTE: HI: High-Impact Plastic, X: Synthetic Rubber Coated Polypropylene Rollers, XU: Polyurethane Rollers

Maximum Load Capacity for Each Model Based on Bottom Surface Indentation Per Wheel

	Model 2051	Model 2052	Model 4201	Model 4202
Steel	25 lbs.	25 lbs.	100 lbs.	100 lbs.
Plywood	7.5 lbs.	15 lbs.	40 lbs.	80 lbs.
200 lbs. Test Corrugated	5 lbs.	10 lbs.	20 lbs.	40 lbs.

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[4] Information and prices about motors

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[5] Datasheet of CNY70, Sharp GP2D120, and PIC 16F87XA

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[6] Information for serial port
EE447 Introduction to Microprocessors Lecture Notes, METU 2006
http://cnx.org/content/m12293/latest/ , Serial Port Communication