iBEAM

Line Tracing Robot Kit for everyone

This is the simplest line tracking robot with BEAM robotics. Learn about the basic electronics and the operation of simple automatic control system.

When talking about the autonomous robot is almost 100% think of robots that require programming. It may be forgetting that robot may occur from the very basic electronic circuit. The concept of a simple system is receiving an input signal from the sensor to process and control to the motor outputs.

The operation similar as programmable robots is very easy to make it happen without using microcontroller or programmable controller. The device used is the Operation Amplifier or Op-Amp. It is created a voltage comparator circuit between the voltage from the sensor with the reference voltage of the circuit. The results were compared to control the motors used to drive the robot works or does not work. Sometime call the OpAmp as "Analog computer".

Operation Diagram

iBEAM robot is the simple autonomous robot that using this concept. iBEAM use the key component Op-Amp integrated circuit to work with line tracking sensors and simple mechanical parts. The robot moves along the black line automatically without any microcontroller and no programming. iBEAM is a Non-programmable robot. Figure 1 shows the operation diagram of iBEAM robot.

Figure 2 is a schematic diagram of the iBEAM controller board. Heart of the circuit is IC1 the power Op-Amp ICs; L272M. It is constructed to the voltage comparator circuit that compared voltage between the sensor voltage and the reference voltage. IC1 has 2 Op-Amp circuits. Output of each circuit is connected to drive the DC motor.

Figure 1: iBEAM robot operation diagram

iBEAM controller board circuit description
Non-inverting input (+) of each Op-Amp is connected to the IR reflector sensor, ZX-03, which was used as a black line detector. While the inverting input (-) is connected with VR1 or VR2 variable resistor that used as the voltage reference for comparison with voltage from ZX-03 sensor in each Op-Amp.

When the apply voltage at the non-inverting input is greater than the inverting input. The output voltage of the Op-Amp is high nearby the supply voltage. It can drive the DC motor that connected at the output terminal. In the other hands, in case the sensor voltage is lower than reference voltage that set by VR1 or VR2. Output of the Op-Amp is 0V. The DC motor at the output will stop.

This controller board takes the voltage comparator operation to control the DC motor working by using the operation of line tracking sensors to set the condition of movement.

This circuit drives 2 of 3 to 6V DC motors. In iBEAM kit choose the DC motor gearbox model BO1 with 87:1 gear ratio.

The supply voltage is wide range from +3 to +9V. Use 4 pieces of AA Battery. The alkaline type or rechargeable battery also is recommended. iBEAM controller board also works with 2 cells of Li-Po batteries (7.4V) and 1000mAH or higher.

### Part list of iBEAM robot

- **iBEAM controller board**
- **80x80mm. grid plate**
- **Battery holder box**
- **Wheel and tire set (x2)**
- **25mm. standoff (x2)**
- **IR reflect sensor (x2)**
- **Obtuse joiner (x2)**
- **5-hole strip joiner (x2)**
- **3mm. Nut (x16)**
- **Metal bracket 2x3.5 (x2)**
- **3 x 8mm. Flat head screw (x4)**
- **3 x 10mm. screw (x4)**
- **3 x 15mm. screw (x2)**
- **3 x 25mm. screw (x4)**
- **3 x 35mm. screw (x2)**
- **DC motor gear box 87:1 (x2)**

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**iBEAM controller board specification**

- 2 of DC motor outputs. Drives 3 to 6V motor
- 2 of analog sensor inputs suitable for any analog sensor. Line tracking sensor is recommended for iBEAM robot.
- 2 of sensitivity knobs. It is used to adjust the reference voltage.
- Use L272M; the power Op-Amp for driving DC motor.
- 2 of motor LED status
- On-board power switch
- Power LED indicator
- No require any programming skill and knowledge.
- Wide range supply voltage +3 to +9V. Require 500mA current consumption for driving DC motors. Battery AA 4 pieces are required (not included in the kit). Alkaline battery is recommended.
Construct the iBEAM robot

(1) Attach the metal brackets with the grid plate by using 3 x 6 mm. flat head screws and 3mm. nuts as shown in the photo below.

(2) Attach another side of metal bracket with BO-1 DC motor gearbox by using 3 x 25mm. screws and 3mm. nuts. Turn the motor shaft to outside following the photo.

(3) Attach the obtuse joiner 2 pieces with the grid plate that is used as robot chasis by inserting the 3 x 10mm. screw through hole of grid plate and obtuse joiner. Tighten with 3mm. nut following the photo.

(4) Fix the 5-hole strip joiner with ZX-03 line tracking sensor by using 3 x 15mm. screw and 3mm. nut. Do 2 sets.

(5) Attach the ZX-03 sensors with the robot chasis by using 3 x 10mm. screws and 3mm. nuts.

(6) Insert 3 x 35 mm. screw through battery holder box and 25mm. standoff. Do the same for 2 sets then attach them to the robot chasis.

(7) Insert the plastic wheel with motor shaft and fix them together by using 2mm. tab screw. Do the same for both DC motor gearboxes.

(8) Put 4 of AA batteries into battery holder at the back of controller board. Place the controller board in the battery holder box following the photo below.

(9) Connect both ZX-03 sensor boars to LEFT and RIGHT sensor input of iBEAM controller board following the sensor position.

(10) Next, connect the motor wires to the controller board. Do not worry about the polarity for the motors. Try to turn the wheel each side and observe the motor's LED status. If LED is on, it means connection is correct. If not, change the connection to opposite and try again.
Testing

(1) Turn on. The green LED on the iBEAM robot is on. If not, check the battery connection to make sure tightened and correct pole.

(2) Place robot on the white floor. Turn the Sensitivity Knob in clockwise direction to end. If motor on, it will stop and red LED of motor status must off.

(3) Lift the robot and adjust the the Sensitivity Knob in anti-clockwise direction to end. Both motors must be turned on and the red LEDs of motor status must on. If not, check the sensor connection and installation.

Make the demonstration field

The demonstration field for iBEAM robot is easy to make. It includes white surface with black line. User can make their own field using the items below (not provided in this kit):

1. Polypropylene board or PP board white sheet. Size is 90 x 60 cm. However, the size can change depending on your applications and resources.
2. Black electrical tape 1 inches width 2 rolls. 3M brand is recommended.
3. Scissors or a Cutter Making is easy. Attach the black tape on the PP board with any shape. The black line must continue and no crossing.

Calibration iBEAM robot to move along the black line

(1) Place the iBEAM robot on the white floor. Lift the robot 3 cm. above the floor. Adjust the Sensitivity Knob until all motor stop.

(2) Place the iBEAM robot over the black line. iBEAM robot will move along the black line following the figure 5.

How to iBEAM move?

Refer the figure 6, the first scenario is the left and right line tracking sensors detect the white floor. It means the iBEAM robot is over the black line. The sensors apply voltage high level (near the supply voltage) to the voltage comparator circuit that used the power Op-Amp ICs. This case the sensor voltage is greater. The Op-Amp drives the high voltage to both DC motors at the output. Robot will move forward.

Whenever the left sensor detects the black line and the right sensor detects the white surface, the left sensor gives low voltage that lower than the reference voltage. It causes one comparator circuit apply the zero voltage to output. The output DC motor will be stop immediately while another one motor still operate continue because the right sensor also detects the white surface. The robot will turn left slowly following the figure 7.

On the other hands, the left sensor detects the white surface and right sensor detects the black line. The right sensor send a low voltage to the output. The output motor at right side will be stop immediately while another one motor still operate continue because the left sensor also detects the white surface. The robot will turn right slowly following the figure 8.

Final scenario, the iBEAM robot does not move if both line tracking sensors detect the black line.

Summary

The simple autonomous robot is built upon the BEAM concept of basic electronic circuits. It is easy to understand and can be further extend to the next stage of circuit controls.

The iBEAM robot is also fun when used in the line tracking competitions. The robot that can move from start to finish fastest and without moving out of the line is the winner.