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The Robot for Education in Fields Including Structure, Sensory and Brain Function

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Abstract

The robot has spread remarkably, is used not only in manufacturing but also in various other fields, and is becoming more popular in everyday life. At the same time, the functional demands for all manner of robots have been diversified.

Education regarding robots has been developing in the computer, mechanism, sensor and artificial intelligence fields. Technical education which integrates all of the above is necessary and in great demand.

We have developed an educational robot so that it can be used in education in fields including structure, sensory and brain function and can also organically integrate those.

1. Introduction

The robot we developed comprises structure, sensors, interface, character display, speech synthesis, control parts and their software. This system can move on a designated route, stop at a designated point on the route and provide information through character display, TV screen display and speech synthesis. Furthermore, the flexibility is high enough to execute handling and supply work pieces. The structure of each part will be explained. Its possibilities will be also stated from an educational point of view.

2. Outline of the Robot System

Its structure of the robot system is shown in Fig.1. There are 6 kinds of input sensors; a magnetic sensor which detects a line stop point, a contactless switch which detects a turning position, a photoelectric switch which detects obstacles on the route, a limit switch which detects items touching the bumper, a rotary encoder which detects traveling speed and a pyroelectrical infrared detecting sensor which detects human body heat.

Although the controller is a control computer (Z80 cpu) built into the robot, it can transfer data and programs using a host computer.

Screen display is executed by receiving the video and sound signals from the VTR via antenna.

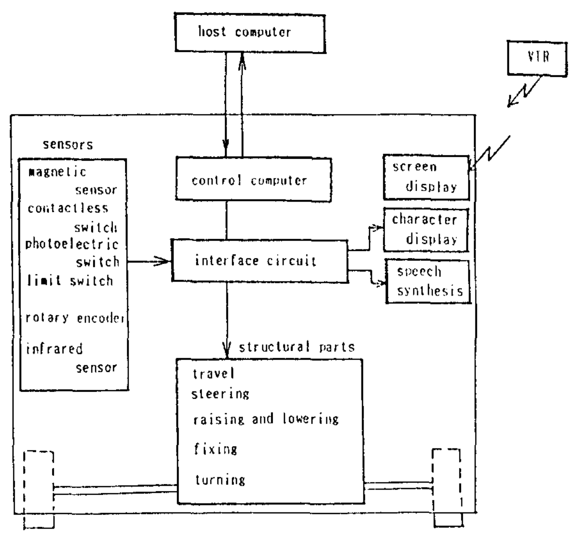


Fig.1. General configuration of this system

3. Frame and Structural Parts

The frame consists of two parts, the body and upper turning parts. The body part is of welded construction using 10(mm) × 10(mm) and 10(mm) ×20(mm) square bars. A 1.2 (mm) iron plate is bent, processed and installed on the 3.2(mm) turn-table on the upper turning part. The surface of the body part is covered with a 5(mm) transparent vinyl chloride plate so that the structural part, sensors, interface circuits and control computer can be easily seen. The structural part can be classified into the following 5 parts depending on 6 DC motors.

①. Travel, stop and speed control on the route.
②. Steering on the route.
③. Fixing the robot at a stop position.
④. Raising and lowering the upper turning part.
⑤. Turning the picture and character display parts to the right and left.

2 DC motors are used in ③, as motors are needed both on the right and left, while only one motor is used in the others. An outline of the frame and structure are shown in Fig.2.

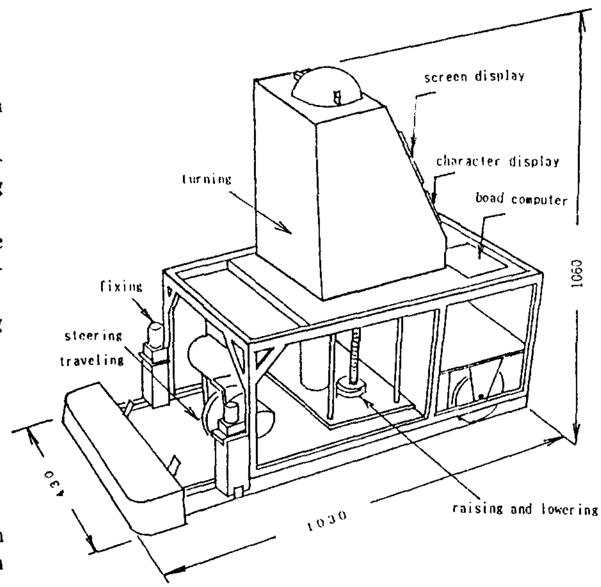


Fig.2. Outline of the frame

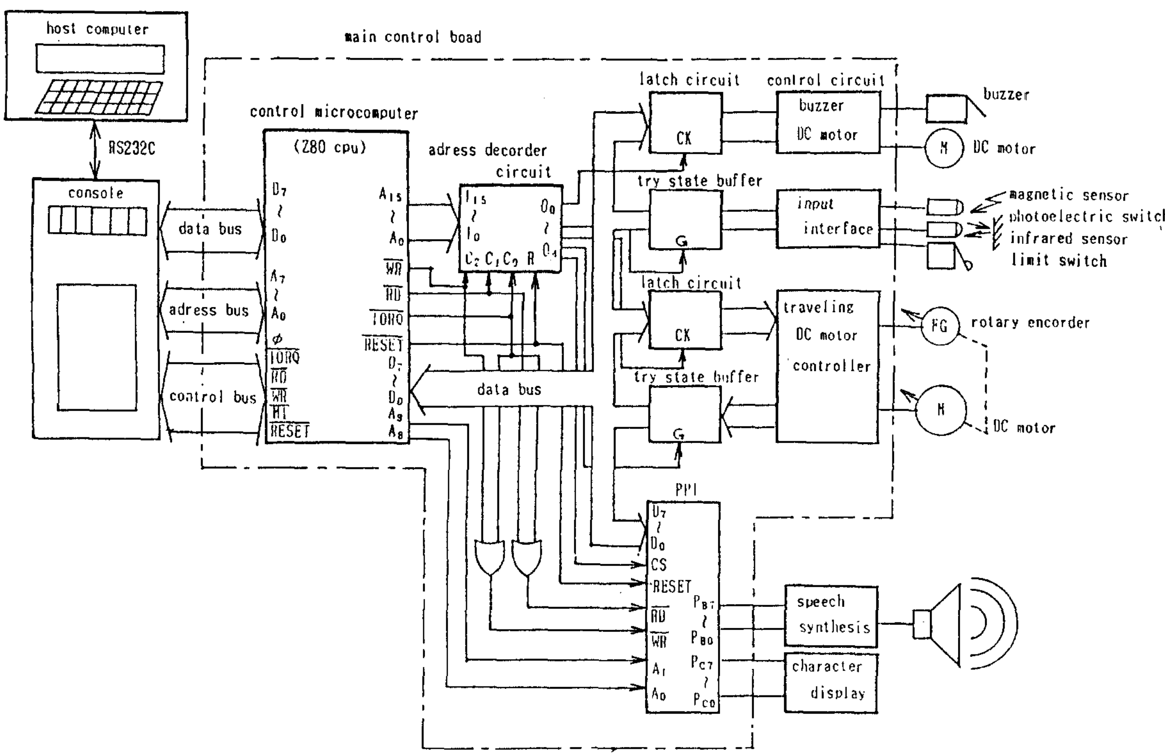


Fig.3. Outline of the control part

4. Hardware

4.1 Control part

An outline of the control part is shown in Fig.3. A Z80CPU is used as a micro-processor. The memory structure is as follows:

ROM 32KB 0000 - 7FFFH
RAM 16KB A000 - DFFFH

RAM saves the memory using a 1.0 (F) super capacitor which is active even when the power is off.

The input interface is used to input the sensor signals and key switch signals into micro-computer. As the logical level of the input signal differs depending on the kind of sensor, +12(V) and +5(V) are provided. The former is used for the magnetic sensor to detect a line and for the photoelectric switch to detect objects. The latter is used for the pyroelectrical human body detecting sensor, the key switch, etc.

The output interface consists of a motion related output part and a character and voice related output part.

The latch circuit is used in the former, and LSI PPI8255A for parallel input in the latter.

Data can be input by pressing the key on the console and memory content can be checked by inputting a 7 digit LED segment. The console can be also removed from the main control board and can transmit and receive data using the RS232C interface of the host computer. As programs can be created in the host computer and transmitted to the main control board, programs can be developed without a developing support tool such as ICE.

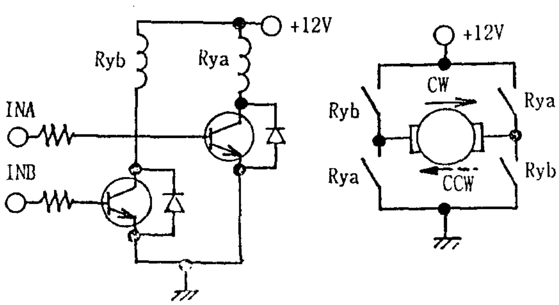
4.2 DC Motor Driving Part

4.2.1 Driving circuit using a relay

The motor for ascending and descending the display part and fixing a robot's stop position is used to contorl the direction of the robot using a relay.

The relay is driven by signals from a micro-computer which are held in a latch circuit via a transistor. A Darlington type transistor is used and the grade (maximum rating Ic=7(A)) is high enough to fully drive the relay.

A driving circuit using relay is shown in Fig.4.

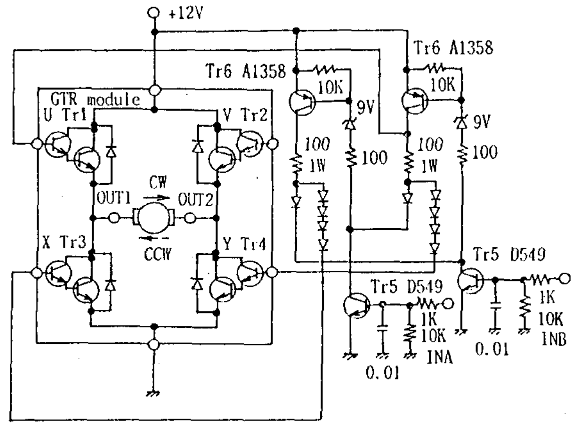


INA	INB	Motor
0	0	Stop
0	1	CW
1	0	CCW
1	1	

Fig.4. Driving circuit using relay

4.2.2 Driving circuit using transistor

A driving circuit using transistor is shown in Fig.5.



INA	INB	Motor
0	0	Stop
0	1	CW
1	0	CCW
1	1	brake

Fig.5. Driving circuit using transistor

The module (MG20G4GL1) where GTR is built in an H-shaped bridge circuit is used to drive the motors for turning, traveling and controlling the display part. An externally installed circuit is used to control the motor with a combination of INA, INB. Positioning control using the contactless and limit switches can be fully carried out by controlling reversal, braking and stopping of the motor. However, this will not work when the motor rotating speed is changed and certain rotating speed is maintained against a fluctuating load. Therefore, we changed the ON/OFF ratio of the bridge element and controlled power supplied to the motor (PWM control).

Although there is another motor output control method, called the linear control method, which uses the active area of the element, we adopted the PWM control method for motor drive travel motion parts, since the linear control method leads to power losses and the form of the element becomes bigger.

Though the higher the PWM switching frequency becomes, the smaller the motor vibration and noise become, the switching loss of the element becomes larger and electric changing efficiency decreases. Therefore, we set the frequency of this robot at 1(KHz). PWM is controlled by the motor controller and also can be controlled from the microcomputer side only by controlling reversal and speed signals to the I/O port. The motor controller controls the speed by detecting the rotating speed using the rotary encoder and automatically adjusting the duty ratio of the pulse. Data from the encoder is automatically counted and can be read from the I/O port as positioning data.

4.3 Sensors

The following 6 sensors are built in the robot and used for automatic traveling.

①. Pyroelectrical infrared sensor: detects a moving human body.

This sensor detects a moving object which has a heat source. The visibility of the robot is 3(m) in the forward direction and 40° to the right and left in the moving direction. When objects come within range of the sensor's view, the sensor detects and reports a change in infrared energy based on the temperature difference between the object and the background, replacing it with a voltage change.

Two sensors are installed in the upper part of the robot in the forward direction.

②. Magnetic sensor: detects the orbit and stop position.

Magnetic tape is attached in advance to the surface of a passage on which the robot travels. The traveling passage is removable. The width of the tape is 25(mm) and two magnetic sensors always detect the tape while the robot is traveling.

The 80(mm) - wide and 150(mm) - long mark plate which is placed on the left side in the moving direction is a position at which the robot can stop.

③. Photoelectric switch: detects obstacles in the moving direction.

The role of this sensor is to detect obstacles on the robot's traveling passage and to stop the robot before it touches the obstacles.

One sensor has light projecting and receiving parts which are installed on the right and left of the front part of the robot. They are adjusted so that they detect obstacles before they touch the bumper.

④. Contactless switch: detects positions such as a turning position, and ascending and descending positions.

This sensor detects the ascending and descending position of the display part; turning position and limit of the front wheels on the right and left. 14 of them are used in this robot.

⑤. Limit switch: Detects obstacles by contact.

Two limit switches are built into the bumper and deal with obstacles and contact.

⑥. Rotary encoder: detects the motor revolving speed. Its accuracy is 300 (pulse /rev) and it accurately detects the revolving speed.

5. External Output Device

5.1 Character display

The robot program was designed so that it uses a message unit and carries a power unit.

5.1.1 Outline of the message unit

①. 22 characters can be displayed on the screen (11 characters × 2 lines)

②. Fluorescent character display tube...blue green

③. Characters which can be displayed....Kanji, Hiragana, Katakana, numbers and roman alphabet

④. Scroll display type. Flashing and reverse image can be displayed. Pages can be displayed in succession.

⑤. As a counter is built in, the results of addition can be displayed.

⑥. Data can be written and stored on EEPROM.

5.1.2 Directions

①. Decide on a sentence which you wish to display.

②. Input the sentence in a personal computer.

③. Transfer the sentence using RS232C or centronics interface.

④. Set a page in the page selection input terminal.

⑤. The entered sentence is displayed.

5.1.3 Power circuit

As the unit is designed to start using a commercial power source, it cannot start using a battery (DC+12(V)). Therefore, we created a power circuit (switching method) to obtain required power DC+5(V), +24(V) from the battery.

The circuit is shown in Fig. 6.

TL1451 is used as the IC for PWM control and consists of two switching regulators. It is designed so that the maximum output current is 1 (A) when +5(V) power is used and 500(mA) when +24(V) is used. PWM frequency is set at 60(KHz), avoiding the audio frequency range.

5.2 Speech synthesis

The speech synthesis circuit is installed in the robot so that speech can be audible. The speech reproducing LSI is used to deal with sound signals. The speech synthesis circuit has the following advantages as it digitizes and records the sound signals in IC memory.

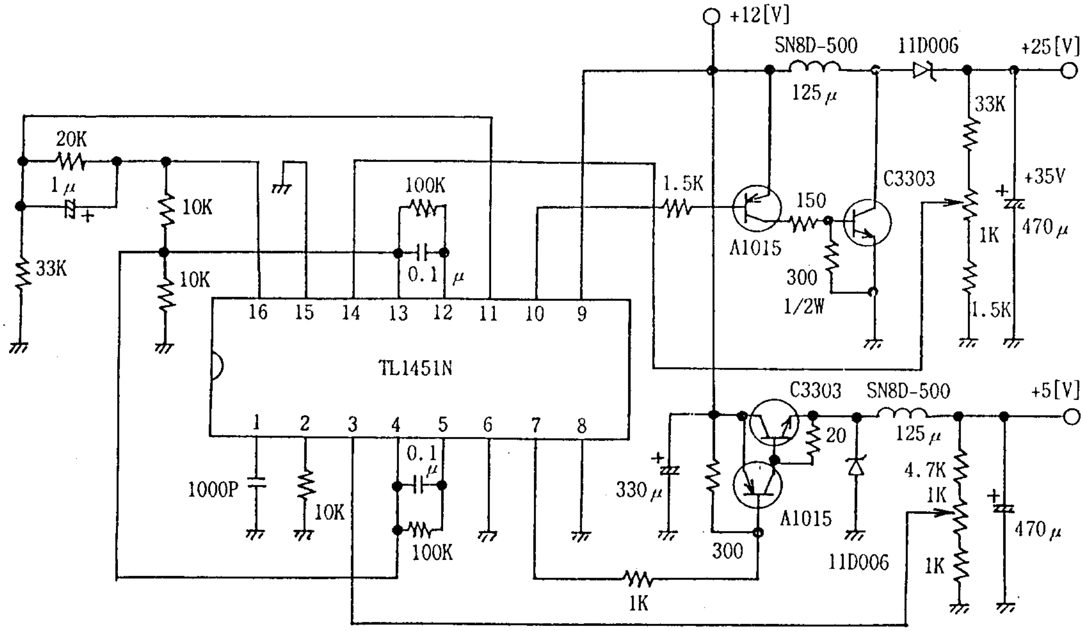


Fig.6. Power circuit

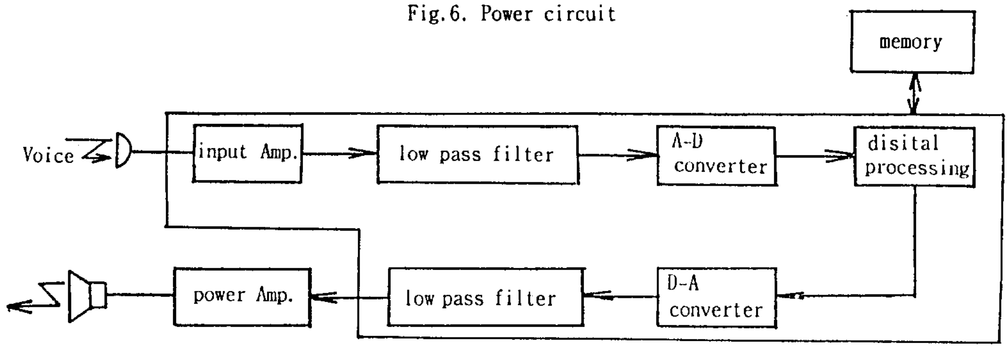


Fig.7. The block diagram of the speech synthesis circuit

①. Mechanical parts are not required and therefore it is not easily broken.
②. It can be miniaturized.
③. As the tape does not have to be rewound and sound can be reproduced immediately, the sound quality will not deteriorate even if the sound is reproduced repeatedly.

The block diagram of the speech synthesis circuit is shown in Fig. 7.

On the same principle as a CD, it stores digitally recorded data (PCM: Pulse Code Modulation) in memory and amplifies it as a voice following D-A conversion. The recording time is 32-128 seconds and four kinds of the recording time can be chosen by changing a bit rate. The range of the recording time can be divided up to 16 and the sound can be randomly reproduced by a signal from the interface. The sound is stored in memory in a recording phrase. The phrase can be freely selected by inputting a 4 bit-phrase select signal from the interface.

The bit rate is 8kbps (when the recording time is 128 seconds) to 32kbps (when the recording time is 32 seconds). Although the sound quality becomes higher when bit rate is larger, the recording time becomes shorter.

Music continuously sounds while the robot is traveling to inform the environment in which it is traveling. The melody IC in which music data is built in is used for the melody circuit.

The analog switch receives control signals from the interface and selects either the speech synthesis circuit or the melody circuit; the melody circuit functions while the robot is traveling or the speech synthesis circuit functions while the robot stops. A phrase is selected using the phrase select signals and a combination of words come out from the speaker. An outline is shown in Fig. 8.

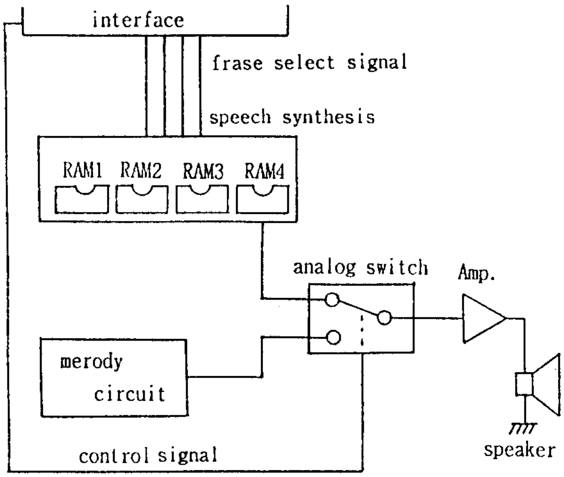


Fig.8. The outline of this circuit

5.3 Image display

A television is built in the upper character display part of the robot. Images are displayed via the television and the content of the displayed image is sent from a video deck. The television receives electric waves sent from the video deck and the transmitting circuit which are installed near the robot's traveling passage and displays an image. The UHF band TV transmitter kit is used for the transmitting circuit. Its transmitting distance is approx.10(m) and it can receive clear image.

6. Conclusions

This system was developed to contribute to robot technical education, giving consideration to the following points:

①. It is covered with a transparent plate so that the usage of structures and elements can be seen.
②. As many sensors and output as possible are used to facilitate education.
③. The structure is divided into a frame and upper turning part and the upper turning part can be replaced to answer various purposes.
④. The PWM switching frequency was raised to decrease vibration and noise.
⑤. The number of parts was reduced at the stage of circuit creation to miniaturize the system.

It can be presumed that the system can be used not only for education in fields such as structure, technology for using sensors, methods of motor control, interface circuitry and software, but also for technical education which integrates those fields, which is the purpose of our research.

The system has the following possibilities:

(A) Image can be controlled by synchronizing VTR, as shown in Fig. 1, and the control computer.
(B) If the computer is on-line via a radio and the robot is always supervised by the host computer;
- the current position of the robot can be known.
- more than one robot can travel at the same time.
- The course of the traveling robots can be changed.
- Robot abnormalities can be immediately detected.
(C) Vocal orders can be executed, combined with a speech acknowledging device.
Adapting these in the educational environment can diversify technical education.

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