

Start Up

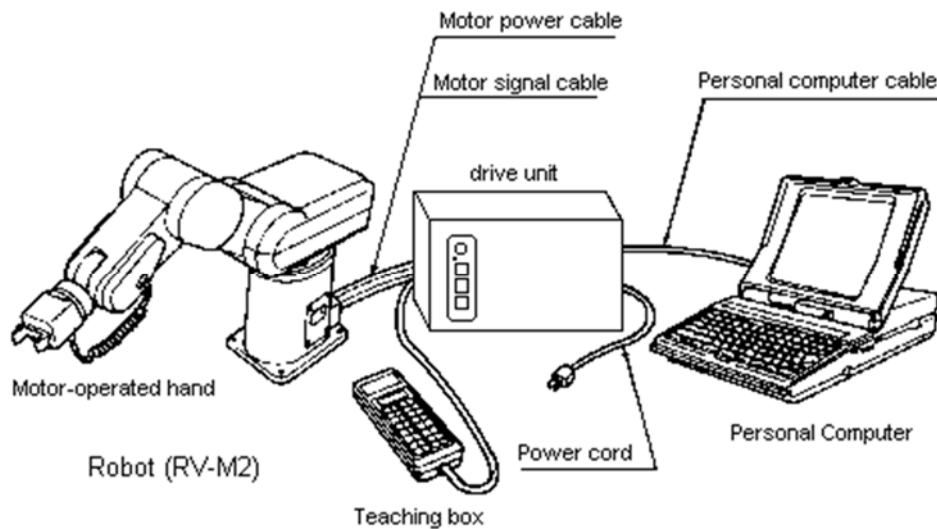


Figure 1: Overall

Configuration of the Robot

This chapter applies to students who will be working with the robot in the lab. When you want to access the robot via the WEB, somebody must do the start-up (steps 1, 2, and 3) for you and enable remote operation. When you enter the interactive control module of this tutorial you will receive a warning if the robot is not currently ready to operate in remote mode.

To start the robot in the lab do the following steps in order:

1. Plug the Teach Box (Pendent) for the robot into the drive unit, if not already plugged in.
2. Turn on the power to the robot and its computer from the main switch on the power strip between the computer and the drive unit. If the drive unit does not power up, turn on the power switch on the back of the unit.
3. Turn on the Teach Pendent and press the <NST> & <ENT> keys to home the robot arm.
4. At this point you can move the robot arm from the Teach Pendent, teach new points, or execute (in single step only) a program contained in the drive unit's RAM.
5. By this time the computer will have completed its boot sequence and be ready to accept inputs. The computer runs Windows 98 which offers the user the option to control the robot directly via a terminal emulation program called ProComm or for more complex tasks via programs written in QBASIC.

Movements

Robot Arm Articulation

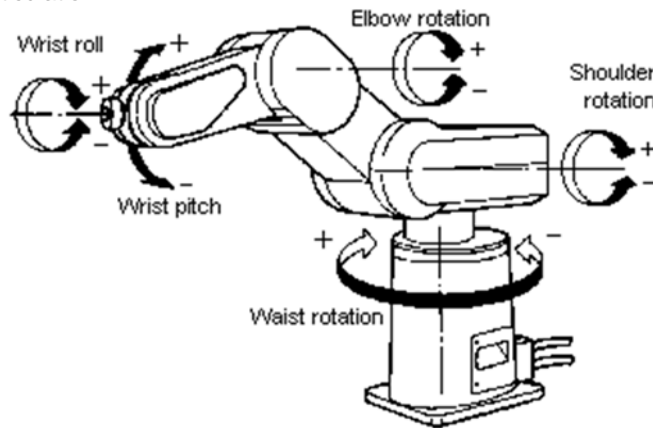


Figure 2: Arm Configuration

The Move master RV-M2 is a jointed arm with five (5) degrees of freedom. That means the arm has five joints connecting the rigid links of the arm. Starting from the base, the joints are:

1. Waist - connecting base and body. This is a rotary joint allowing 300° rotation in the horizontal plane.
2. Shoulder - connecting body and upper arm. This is a rotary joint with a range of 130° in the vertical plane.
3. Elbow - connecting upper and fore arms. This is a rotary joint with a range of 120° in the vertical plane.
4. Wrist Pitch - connecting fore arm and wrist. This is a rotary joint in the vertical plane allowing rotation of $\pm 110^\circ$.
5. Wrist Roll - connecting the wrist to the tool adapter. This is a twisting joint allowing $\pm 180^\circ$ of rotation.

The arm is powered with electric motors giving it a maximum pay load capacity of 2 kg (4.4 lb). The maximum reach of the arm defines its work space. This is shown in Figure 3.

Coordinate System

1) Joint Coordinate System

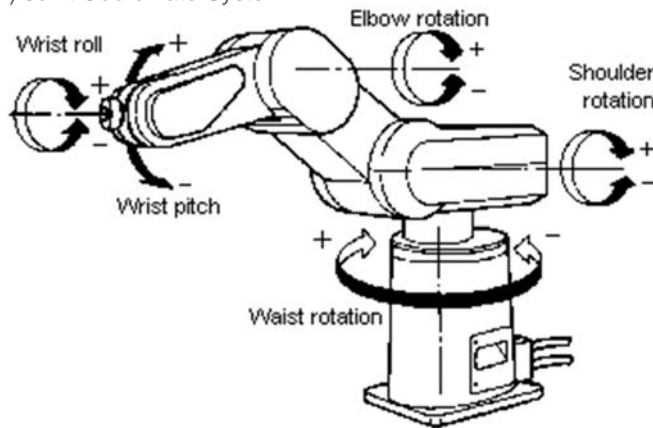


Figure 5: Joint Coordinate System (Articulated Motion)

In the Joint Coordinate System a position of the robot hand in space is defined by the angles of rotation of the five joints of the arm. Because of the design of the arm, positions can be reached through different combinations of these angles, albeit with different orientations of the hand.

Specifying a new coordinate for one of the joints results in motion of only that one joint; the endeffector (hand, tool) moves on an arc. Movement from some point A to another point B using linear interpolation in these joint coordinates does not result in straight line motion but rather follows a complex curve in three space. This makes precise positioning of the hand very difficult in manual mode since the tool axis vector changes with each move of a joint.

This is the coordinate system used by the servo-loops of the robot controller. It allows for independent control of each joint.

2) World Coordinate System

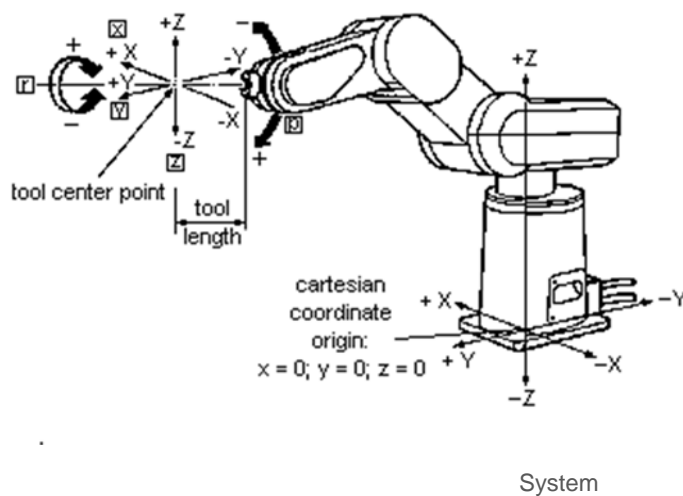
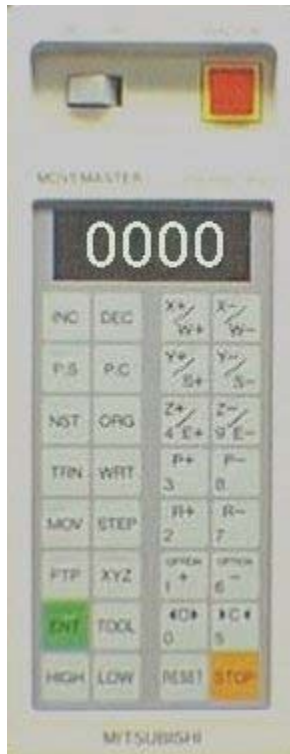


Figure 6: Cartesian (World) Coordinate

System

Teach Pendant



Using the Teach Pendant:

- From the teach pendant you can control the robot arm for setup and teaching of locations.
- With the pendant you can move the arm in any direction, you can open and close the hand, and move to defined locations.
- Using the pendant you can also define (teach) locations for the robot to remember for later recall from the pendant or in a program.
- You will not be able to create programs with the pendant nor will you be able to execute an existing program.
- In this tutorial all the buttons on the pendant will be explained. Click on any button and its function will be described in this window.

Keys

Inc Button

Pressing this key followed by **ENT**, moves the robot to the predefined (taught) position whose position number is greater than the current one using joint (articulated) interpolation.

Define Location

Pressing this key followed by a three (3) digit numeral and ENT, defines the coordinates of the current position of the robot into the position of the specified number - Teaching.

Hard Origin (Nesting)

This instruction is used to move the robot arm to a predefined position called the nested position or hard origin. This instruction must be given immediately after power-up of the robot arm to initialize the sensors in the robot joints. This key can also be used to move the robot to a safe position out of harms way.

Instruction Set

The instruction set for the RV-M2 robot can be divided into several subsets depending on the general function an instruction executes. In the following table only those instructions are listed which are deemed necessary for the student to successfully understand this tutorial.

1) Position Definitions:

HERE	HE a
	Defines the coordinates of the current position by assigning position number (a) to it. Range: $0 < a < 1000$
NEST	NT
	Returns the robot arm to its mechanical origin and resets the joint coordinates. Must be executed every time the robot is turned on.
Position	PD a, x, y, z, p, r[,O/C]
Define	Defines the coordinates (x, y, z, p, r) of position (a). range: $0 < a < 1000$
Position	PL a, b
Load	Assigns the coordinates of position (b) to position (a). range: $0 < a, b < 1000$
Position	PX a, b
Exchange	Exchanges the coordinates of position (b) with those of position (a). range: $0 < a, b < 1000$

2) Motion Control:

Decrement	DP
Position	Moves the robot to a predefined position number smaller than the current one. Uses articulated interpolation.
DRAW	DS x, y, z
straight	Moves the hand the specified distances in the x, y, and z direction from the current position. Uses linear interpolation.
DRAW	DW x, y, z
	Moves the hand the specified distances in the x, y, and z direction from the current position. Uses articulated interpolation.
Increment	IP
Position	Moves the robot to a predefined position number greater than the current one. Uses articulated interpolation.

Binary I/O

Connection to Digital I/O Circuits

The following diagrams show brief examples of the connections between the I/O connector and an external peripheral device.

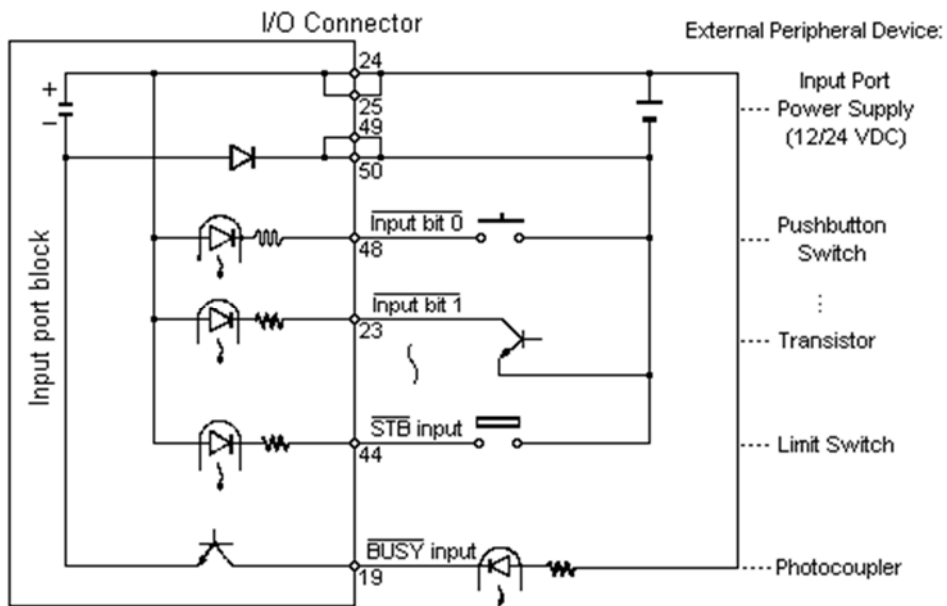


Figure 8: Connections for

digital input devices

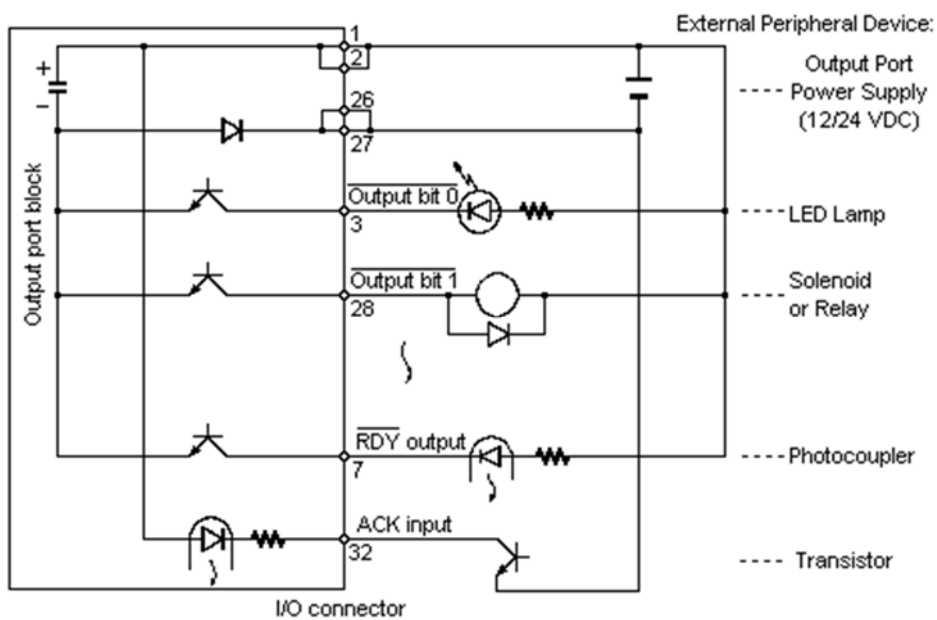


Figure 9: Connections for

digital output devices

Shut Down

This chapter applies to students who will be working with the robot in the lab. When you have accessed the robot via the WEB the remote control program for the robot will remain active after you terminate your session.

At the end of your lab session the computer and robot system must be shut down properly to avoid damage to the equipment.

1. Using the teach pendent, ProComm, or QBASIC issue one last command, the <ORG> & <ENT> keys or the OG command, to return the robot arm to its HOME position.
2. When the arm reaches that position, turn off the drive unit (switch at back);
3. Terminate which ever program you are running on the computer:
 1. press: <ALT>X, <ENTER> to exit from ProComm or
 2. select Exit from the File menu to exit from QBASIC.
4. Shut down Windows using established procedures.
5. Turn off power to the computer and drive unit on the power strip.