Squarebot 3.0
(from Protobot kit)
Building Instructions
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The Squarebot 3.0 (from Protobot kit) instructions enable construction of a Squarebot including an arm and all necessary sensors for use in Teaching ROBOTC for Innovation First VEX Robots.

Note that this robot can replace both the original Squarebot 2.0 in Setup/Build and the Upgrade Squarebot to v.3.0 building show in Radio Control/Buttons.

The Squarebot in this guide requires the following kits:
VEX Protobot Robot Kit (1)
VEX Power Pack Kit (1)
VEX Optical Shaft Encoder Kit (1)
VEX Ultrasonic Range Finder Kit (1)
VEX Limit Switch Kit (1)
VEX Transmitter and Receiver Kit (1)
VEX Microcontroller (1)

Please note also that you may use this building show as a guide to constructing Squarebot from the Protobot Kit alone, if you do not follow any of the steps involving the accessory kits.
### Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

1. Collect and identify the parts from the list of materials below:

<table>
<thead>
<tr>
<th>materials</th>
<th>qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis rails</td>
<td>4</td>
</tr>
<tr>
<td>Bearing flats</td>
<td>14</td>
</tr>
<tr>
<td>Pop rivets</td>
<td>10</td>
</tr>
<tr>
<td>Motors</td>
<td>3</td>
</tr>
<tr>
<td>8-32 x ½ “ long screws</td>
<td>10</td>
</tr>
<tr>
<td>8-32 x ¼ “ long screws</td>
<td>32</td>
</tr>
<tr>
<td>8-32 x 3/8” long screws</td>
<td>5</td>
</tr>
<tr>
<td>6-32 x ½ “ long screws</td>
<td>6</td>
</tr>
<tr>
<td>2” shafts</td>
<td>2</td>
</tr>
<tr>
<td>3” shafts</td>
<td>4</td>
</tr>
<tr>
<td>4” shaft</td>
<td>1</td>
</tr>
<tr>
<td>Shaft collars</td>
<td>12</td>
</tr>
<tr>
<td>60-tooth gear</td>
<td>3</td>
</tr>
<tr>
<td>36-tooth gear</td>
<td>4</td>
</tr>
<tr>
<td>Chassis bumpers</td>
<td>2</td>
</tr>
<tr>
<td>Keps nuts</td>
<td>34</td>
</tr>
<tr>
<td>Clutches</td>
<td>2</td>
</tr>
<tr>
<td>C-channel 1 x 2 x 1 x 25</td>
<td>1</td>
</tr>
<tr>
<td>C-channel 1 x 2 x 1 x 15</td>
<td>2</td>
</tr>
<tr>
<td>¼ “ spacer</td>
<td>11</td>
</tr>
<tr>
<td>Small green wheels (tires + hubs)</td>
<td>4</td>
</tr>
<tr>
<td>2” standoffs</td>
<td>4</td>
</tr>
<tr>
<td>1” standoffs</td>
<td>4</td>
</tr>
<tr>
<td>5 x 15 plate</td>
<td>1</td>
</tr>
<tr>
<td>25 hole bars</td>
<td>2</td>
</tr>
</tbody>
</table>

*Please note: Parts below the line are NOT in the Protobot kit. They are in separate accessory kits.*

| Battery holder  | 1 |
| Receiver        | 1 |
| Antenna         | 1 |
| Blue rechargeable VEX battery | 1 |
| VEX microcontroller | 1 |
| Ultrasonic Range Finder | 1 |
| Limit switches  | 2 |
| Encoders        | 2 |
| 8-32 x 3/8” long screws | 10 |
| Keps nuts       | 5 |
Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

chassis rail x 4

chassis bumper x 2

2" standoffs x 4

pop rivets x 10

8-32 x ¼" long screw x 32

keps nut x 34

8-32 x ½" long screw x 10

8-32 x ¾/s" long screw x 15

6-32 x ½" long screw x 6

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Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

- **5 x 15 plate x 1**
- **motor x 3**
- **2.75" removable tire x 4**
- **1.895" detachable hub x 4**
Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

- 36 tooth gear x 4
- 60 tooth gear x 3
- Shaft collar w/threaded set screw x 12
- 2” shaft x 2
- 3” shaft x 4
- 4” shaft x 1
- Bearing flat x 14
- 25 hole bars x 2
PLEASE NOTE: Parts below are NOT in the Protobot kit, but are in accessory kits. Please note also that these accessory kits have additional parts (screws, nuts, etc.) which are used in steps in which they are added.
2 Inner chassis rails

Face two chassis rails towards each other.

Add six bearing flats to the chassis rails (three per rail, on the outward-facing sides). Position the bearing flats so that their middle holes align with the 4th, 7th and 12th (middle row) holes of the chassis rail.
2 Inner chassis rails (cont.)
Secure the OUTSIDE holes of the OUTSIDE BEARING FLATS ONLY to the chassis rails by pushing pop rivets from the inside. Note that the pop rivets come assembled, but are in two pieces. To use pop rivets:

1. Push the pop rivets all the way through the bearing flat hole
2. Continue to push the head, and it will lock the pop rivet in place.

Your completed inner chassis rails should look like this when you’re done:
3 Drive Train
Position two motors between the rails as shown.

Parts needed in this step:
- x 2

Attach the motors with four 6-32 x 1/2" long screws in the sixth and seventh holes of the chassis rails, which will also pass through the two leftmost holes of the bearing flats.

Parts needed in this step:
- 1/2"
- x 4
3 Drive Train (cont.)
Insert two 2” shafts into the motors.

Parts needed in this step:
- 2” x 2

Insert two 3” shafts into the center holes of each of the outside bearing flats.

Parts needed in this step:
- 3” x 4

Snug 6 shaft collars over the six shafts. Tighten their set screws with the small Allen wrench.

Parts needed in this step:
- x 6
Drive Train (cont.)
Slide two 60-tooth gears over the center shafts, and four 36-tooth gears over the other shafts.

Snug six shaft collars against the gears. Tighten their set screws.
Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

4 Outer chassis rails
Arrange two chassis rails and six bearing flats.

Parts needed in this step:
- x 2
- x 6

Attach the bearing flats with 12 pop rivets through the third, fifth, seventh, ninth, eleventh and thirteenth middle row holes in the rails. The HEADS of the pop rivets should be on the OUTSIDE of the rails.

Parts needed in this step:
- x 12
5 Outer chassis rails (cont.)
Slide the outside rails fourth, eighth and 12th middle holes over the shafts.

Slide two chassis bumpers over the outside chassis rails.

Parts needed in this step:

- [Diagram of parts needed]
Bumper assembly
Prepare eight 8-32 x 1/4” long screws and eight kep nuts.

Parts needed in this step:

\[ \frac{1}{4}'' \times 8 \]

Insert the screws into the first and fourth holes from both sides of both chassis bumpers, in the holes nearest the edge. Use the large Allen wrench to tighten them into the nuts.
6 Bumper assembly (cont.)
Prepare eight 8-32 x 1/4” long screws and eight keps nuts.

Insert the screws into the first and fourth holes from both sides of both chassis bumpers, in the outermost line of holes in the other bumper edge. Use the Allen wrench to tighten them into the nuts.

Parts needed in this step:

- ¼" x 8
- x 8
6 Bumper assembly (cont.)
Attach two clutches to the inner ends of the shafts on the wire side of the motors.

Parts needed in this step:

![Clutch x 2]
Encoder mount assembly
Use an appropriate cutting tool to cut the C-channel, 1x2x1x25 hole in two places, so that two five hole long sections are left, along with a central, 15 hole long section.

Using a hacksaw or other appropriate tool, cut the 12” axle into the measured segments. File down all cut ends afterward to remove any sharp or rough edges.

IF YOU ARE UNSURE ABOUT HOW TO USE THE TOOLS OR PERFORM THIS PROCEDURE SAFELY, DO NOT ATTEMPT THIS STEP ALONE. SEEK QUALIFIED ASSISTANCE BEFORE PROCEEDING.

Parts needed in this step:
1x2x1x25 (1)
Encoder mount assembly (cont.)
Place 4 1/4” spacers over the first and fifth visible holes of each innermost chassis rail on the side nearest to the motor wires.

Parts needed in this step:
1/4”
x 4
Encoder mount assembly (cont.)

Line the outside holes of the two shorter cut pieces of C-channel (see above) over the spacers so that the ‘U’s face outward. Slide four 8-32 x 1/2” long screws through the spacers and cut pieces. Secure them with four keps nuts.

Parts needed in this step:

![Diagram of Screw](Image)

1/2” x 4 x 4

Parts needed in this step:
Encoder mount assembly (cont.)

Slide an encoder over the shaft end nearest to the encoder mounts. Angle the encoder so that the central hole of the encoder aligns with the central hole of the encoder mounts. Slide a 3/8” screw through both holes, then fix with keps nuts.

Parts needed in this step:

- Encoder x 2
- 3/8” screw x 2
- Keps nuts x 2
8 Chassis assembly
Slide four 1/4" spacers and four small green wheels (2.75” Removable Tire and 1.895” Hub) over the four corner shafts.

Parts needed in this step:
- 4 x 1/4" spacers
- 4 x 2.75" Removable Tires
- 4 x 1.895" Hubs
8 Chassis assembly (cont.)
Snug four collars against the wheels. Tighten their set screws.

8 Chassis assembly (cont.)
Place the VEX microcontroller just behind the encoder mount assemblies with the ports nearer to the center. Attach it with two 8-32 1/2” screws and two keps nuts at each of its outside corners.
Chassis assembly (cont.)

Use two 8-32 x 3/8” long screws and two keps nuts to attach the ultrasonic rangefinder to the front chassis bumper so that there are four exposed holes to the right and five exposed holes to the left.

Parts needed in this step:

- 3/8” x 2
- 2

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Chassis assembly (cont.)

Bend the arms of two limit switches in the center to form approximately 45 degree angles. Push two 8-32 1/4” screws through the two upper row holes in the chassis bumper nearest to the ultrasonic rangefinder on the left. Screw in two 1” standoffs. Use two 8-32 3/8” screws to attach one limit switch by its lower slot to the two standoffs.

Parts needed in this step:

- 1/4” x 2
- 1” x 2
- 3/8” x 2
9 Left side subassembly
Attach two 2” standoffs to one C-channel, 1x2x1x15 and one 5 x 15 plate with two 8-32 1/4” screws at either end.
9 Left side subassembly (cont.)
Attach the battery holder to the 15 hole plate with two 8-32 x 3/8" screws and two keps nuts through the outermost seventh and ninth holes of the 15 hole plate.
Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

10 Left side subassembly (cont.)
Push two 8-32 1/4” screws through the fourth upper row hole and fifth lower row hole in the vertical side of the C-channel. Screw in two one inch standoffs. Use two 8-32 3/8” screws to attach the second limit switch by its lower slot to the two standoffs with the switch pointing downward.

Parts needed in this step:

- 1/4” x 2
- 3/8” x 2
- 1” x 2

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10 Left side subassembly (cont.)
Attach one bearing flat on the inside left edge of the C-channel with two pop rivets in the second and third holes of the middle row of the C-channel’s vertical side.

Parts needed in this step:
- x 2
- x 1
Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)

11 Right side subassembly
Attach two two inch standoffs to one C-channel, 1x2x1x15 with two 8-32 1/4” screws at each end.

Parts needed in this step:
- 2” x 2 x 1
- 1/4” x 2
11 Right side subassembly (cont.)
Attach the receiver to one end of the C section with two 8-32 3/8” screws and two keps nuts through the top slot of the receiver.

Parts needed in this step:
- Receiver x 1
- 3/8” screws x 2
- Keps nuts x 2
Right side subassembly
Attach the receiver antenna holder and antenna with one 8-32 3/8” screw and one keps nut to one end of the C-channel.

Parts needed in this step:

|x 1 | 3/8” x 1 x 1 |
11 Right side subassembly (cont.)
Attach a motor with two 6-32 x 1/2” long screws and a bearing flat to the end of the C-channel. Insert the screws into the second and third holes of both the C-channel and the bearing flat.

Parts needed in this step:
- Motor x 1
- 1/2” screws x 2
- Bearing flat x 1
12 Arm assembly
Attach a 60-tooth gear to the center of a 15 hole C-channel with two 8/32 1/2” inch screws, two 1/4” spacers and two keps nuts in the seventh and ninth holes.

Parts needed in this step:
- 60 x 1
- 1/2” x 2
- x 2

Bend two 25 hole bars into a U by bending once between the tenth and eleventh holes, and a second time between the fifteenth and sixteenth holes.

Parts needed in this step:
- x2
12 Arm assembly (cont.)
Attach one of the bars you bent above to the end of the 15 hole C-channel with two 8-32 1/4” screws and two keps nuts.

Parts needed in this step:
- 1/4” x 2
- x 2
Arm assembly (cont.)

Attach the second bent 25 hole bar to the first with two 8-32 1/4” screws and keps nuts through the THIRD holes from the bend of the VERTICAL (first) bar and the SECOND holes from the bend of the HORIZONTAL (second) bar.

Parts needed in this step:
- 1/4” x 2
- x 2
Final assembly
Attach the left assembly to the main assembly with two 8-32 1/4" screws holding the two three inch standoffs in the FIFTH hole from the LEFT of the REARMOST ROW of both the FRONT and REAR chassis bumpers.

Parts needed in this step:

- 1/4” x 2
13 **Final assembly (cont.)**

Attach the right assembly to the main assembly with two 8-32 1/4” screws holding the two two inch standoffs in the FIFTH hole from the RIGHT of the REARMOST ROW of both the FRONT and REAR chassis bumpers.

**Parts needed in this step:**

- 1/4” x 2
13 Final assembly (cont.)
Put a four inch shaft through the second hole in the middle row of the C-channel in the left assembly, a 1/4” standoff and a shaft collar, WITHOUT TIGHTENING THE SHAFT COLLAR.

Parts needed in this step:

- 4” x 1
- 1/4” x 1
- x 1
13 Final assembly (cont.)
Position the arm assembly so the 4” shaft positioned above can slide through the center of the arm assembly’s 60-tooth gear. Slide a collar over the shaft, then slide the shaft into the right assembly’s motor as far as possible. Tighten the set screws on each of the collars. Mechanical assembly of the robot is now finished.

Parts needed in this step:

- Collar x 1
14 Wire Assembly
Take the wire coming out of the battery and plug it into the matching white port on the back of the microcontroller.

NOTE: Motor platform and arm not shown.
14 Wire Assembly (cont.)

Take the 9” RJ-10 wire (yellow phone cable) and plug one end into the yellow receiver module and the other end into the port marked “Rx1” on the back of the microcontroller.

NOTE: Battery platform and arm not shown.
14 Wire Assembly (cont.)
Plug the arm motor wire into “MOTORS” port 6 on the microcontroller.

NOTE: Battery platform and arm not shown.
14 Wire Assembly (cont.)
Plug the wire coming from the right motor into “MOTORS” port 2. Right refers to the robot’s right. The side of the microcontroller with the LEDs is the front.

NOTE: Platforms and arm not shown.
**Squarebot 3.0 (from Protobot kit) Building Instructions (cont.)**

14 Wire Assembly (cont.)
Plug the wire that is attached to the left motor into “MOTORS” port 3 on the microcontroller.

NOTE: Platforms and arm not shown.
14 Wire Assembly (cont.)
Plug the right encoder wire into “ANALOG / DIGITAL” port 2 on the microcontroller.

NOTE: Platforms and arm not shown.
14 Wire Assembly (cont.)
Plug the left encoder wire into “ANALOG / DIGITAL” port 3 on the microcontroller.

NOTE: Platforms and arm not shown.
14 Wire Assembly (cont.)
Plug the rear limit switch wire into “ANALOG / DIGITAL” port 4 on the microcontroller.

NOTE: Platforms and arm not shown.
14 Wire Assembly (cont.)
Plug the front limit switch wire into “ANALOG / DIGITAL” port 1 on the microcontroller.

NOTE: Platforms and arm not shown.

Congratulations! Squarebot 3.0 is now complete!