SERVICE MANUAL

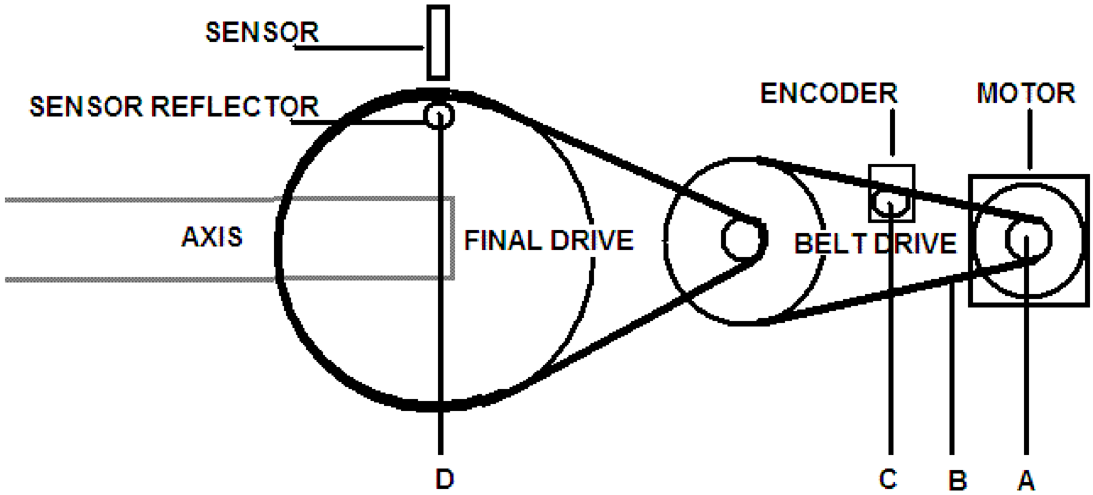
Contents:

Separate pdfs:
Exploded diagrams
- Waist axis (B set)
- Shoulder (S set)
- Fore-arm (elbow) and hand/wrist (E set)

Wiring diagram

Diagnosing Mechanical Errors using software

In normal use the system is in closed loop and there is little difference between the motor counts and the encoder counts. The controller moves the motors by a software generated count. The encoders feed back into hardware counters which are compared to the motor counts by the CPU.



Above is a simplified diagram of the drive train.
Movement of the motor is exactly matched by movement of the axis.
The encoder is in loose mesh against the very first drive belt.
The calibration sensor is as far down the train as possible, located on the axis itself so is absolute in it's effect.

“ENCODER-STEPPER MISMATCH”
If your get this error then there is either something wrong with the motor drive OR something wrong with the encoder. To find out which run the robot open loop:

CALIBRATE
Reports errors since the last calibration. This should always be zero or within a few counts of zero. A number of, say 10 or more means that the linkage between axis and motor is faulty – a loose pulley, or pulley-to-pulley fixing, or keyway etc.
If you type START when the robot is NOT at HOME then the first CALIBRATE will always produce spurious errors. Subsequent CALIBRATEs should be near zero. Therefore as soon as you get a failure including ENCODER STEPPER MISMATCH do a CALIBRATE immediately and note the errors.

A – motor drive pulley. If this is loose you should get an encoder mismatch (providing the error is more than the threshold in ENCTOLS)
Since the axis has now not synchronized to the motor you will also see an error reported after CALIBRATE

B – drive belt. Occasionally these can stretch in one place. If so this will produce a calibrate error though not necessarily an encoder error. Use the teach pad to drive one complete rev and watch the belt teeth run over the pulleys. A stretched part will cause the belt to lift or jump.

C – encoder and pulley. A problem here will cause an encoder error but a subsequent CALIBRATE will not show an error because there is no loss of linkage between motor and final drive.
There is no torque on the encoder so a loose pulley is unlikely to be a culprit. Check that the pulley is in loose mesh with the belt. If under high torque conditions the belt is able to go slack and move away from the pulley you may have to move the pulley closer to the belt.
At HOME enter ENCTEST to continuously display the encoders. They should all be zero except the suspect one. Force the encoder one tooth one way or the other to see if it corrects the error. If the error is one or more exact teeth then mesh is the problem.
Also check that the encoder itself is not loose and able to move – tighten the fixing nut if necessary.

D – final calibration sensor. If you are getting positional errors which are confirmed by CALIBRATE yet you had no encoder error then the problem must be in the drive **after** the first belt. Check to see if the dual pulley is able to move i.e. if one of its pulleys can move relative to the other. You would need to have the robot energized and use hand force.

Drive train health check

Step 1
Enter
START
CALIBRATE
ENCOFF
HOME
CALIBRATE

What errors are reported from CALIBRATE? If there is a substantial error on an axis then it means there is a problem mechanically with that axis, for example: broken belt, loose pulley on a motor or other shaft etc.

If there are no substantial errors (less than, say 5 counts) then
Step 2
Enter:
ENCOFF
HOME
START
CALIBRATE
ENCOFF
HOME
WHERE

After this sequence of operations the counts under WHERE should show all the motor counts as zero. The second line displays the actual encoders, ignore these. The third line displays the converted encoder count i.e. what the motor should be according to the encoders. Ideally these should also be zero or else just a few counts out. Any substantial error means there is a fault with the encoder.

Diagnosing mismatch in an application

Note: the test program is an application in this sense.

It might be that it takes a while for ENCODER STEPPER MISMATCH to appear. As soon as ENCODER STEPPER MISMATCH comes up immediately type
ENCOFF
HOME
If there are any errors on the bottom line make a note of size and axis.
Then enter
CALIBRATE
If there are any errors reported then compare them to the numbers in step 2.
If they are similar and same axis then the problem is the motor.
Possible problems:
Slipping pulley
Pulley rubbing on motor or on casing or on another pulley.
Damaged belt.
If the CALIBRATE errors are zero then the motor and transmission were fine and the error lies with the encoders.
Possible problems:
Bad mesh of encoder pulley into the belt.
Faulty encoder (rare)

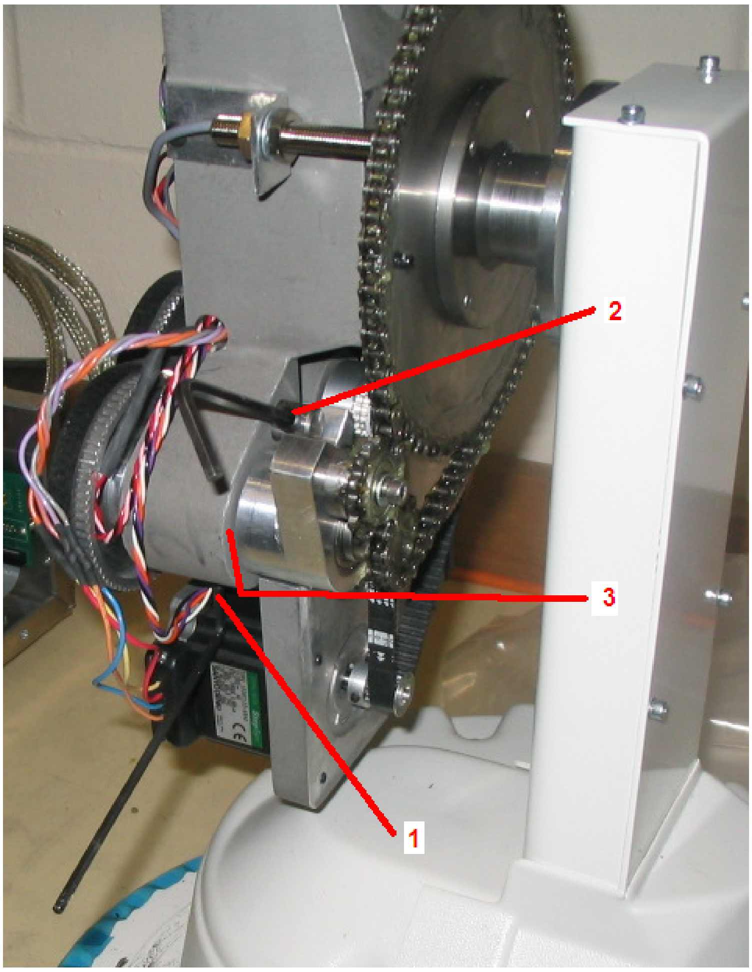
Backlash (free motion in joints)

Backlash can be due to 3 possible causes:

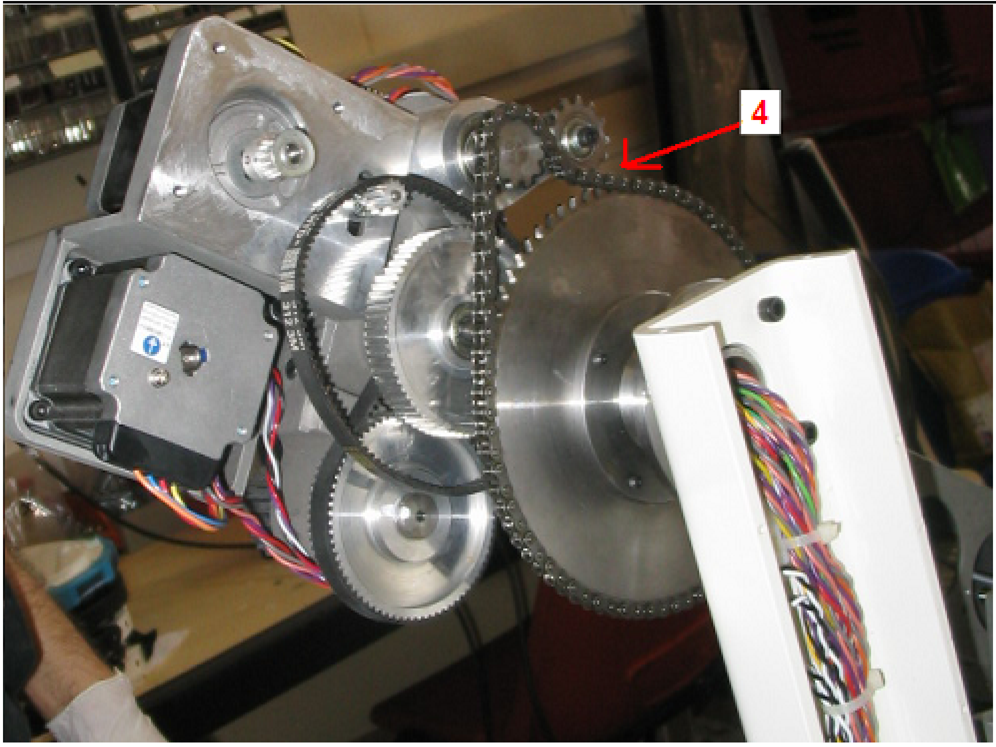
1. Slack toothed drive belt.
This is unlikely to be the cause because even when a belt is slack the effect on the final axis motion is small. This is especially true for the first belt from the motor. Since the belt ought to have been set up correctly when the robot was built then a slack belt is probably damaged. Replace the belt by reference to the exploded parts diagram.
2. Slack drive chain.
Check the chain for damage. If one link appears to be slightly longer than the others then it is damaged. In this case replace the chain.
If the chain looks ok but is simply slack then it has probably just worn. It can be retensioned using the instructions below.
3. Loose joint.
Major axis joints have keyways to transmit the torque. However keyways are not positive for bi-directional positioning. We therefore rely on the ring nuts on each axis. They can be tightened using a two pronged ring nut wrench.

Chain adjustment

Shoulder drive:
With the arm energized rock the upper arm (that's the limb nearest the shoulder) back and forth to check for backlash. There will always be a little backlash because of the chain drive but if you think it might be excessive remove the covers and investigate. As you move the arm back and forth does the chain appear to relax and tighten just below the tensioner?



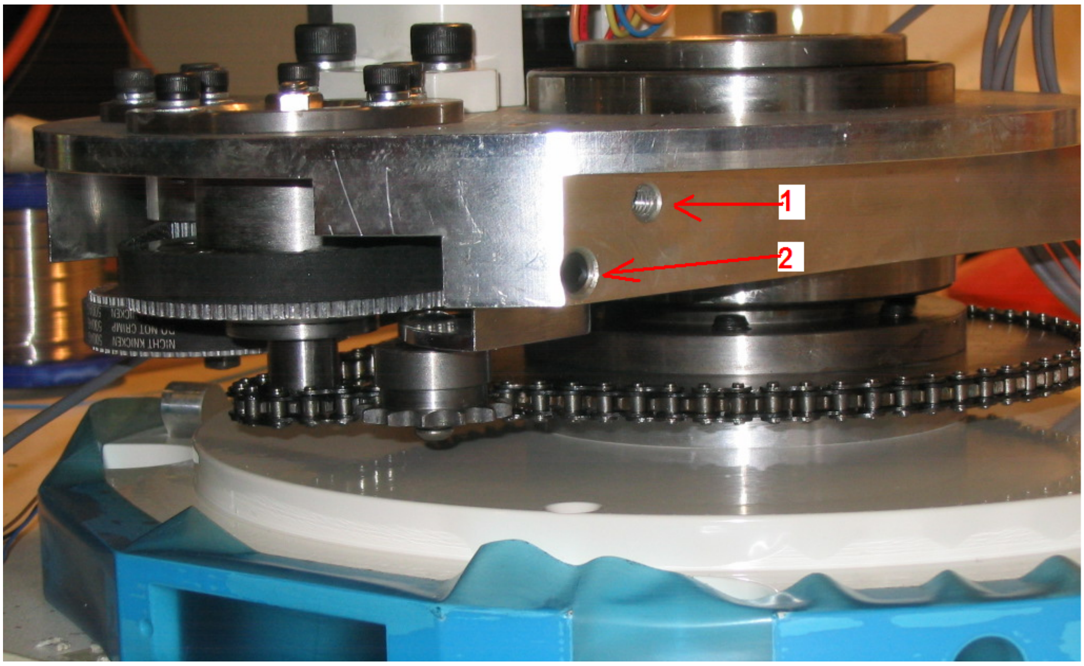
To adjust the tensioner proceed as follows:
1. untighten the lock screw (1)
2. tighten the adjustment screw (2) while rocking the shoulder joint to check for backlash. If it is loose then as you rock the shoulder you will see the chain drop from being straight to hanging a little. The screw should be tightened until this is no longer the case but NO FURTHER. Over-tightening the chain can cause excessive drag on the motor, wear on the sprocket wheels or even break the chain.
3. make sure the chain adjuster is pushed fully in and the gap at (3) is minimum.



4. Make sure you do not allow the chain tensioner to run against the main sprocket wheel. There should be a small gap as in (4).
5. re-righten the lock screw (1)
6. While you have the covers off make sure there is grease on the inside of the chain, especially all round the small drive sprocket and the tensioner. There does not need to be much grease, just a small coating on the sprocket teeth will suffice.

Waist drive

With the arm energized rotate waist back and forth to check for backlash. There will always be a little backlash because of the chain drive but if you think it might be excessive remove the covers and investigate. Looking at the straight part of the chain between the small drive sprocket and the large sprocket wheel, as you move the waist back and forth does the chain appear to relax and tighten?



If so remove the covers and proceed as follows:

1. untighten the lock screw (1)
2. tighten the adjustment screw (2) while rocking the waist drive to check for backlash. If you make it too tight it will cause excessive drag on the motor, excessive wear on the sprocket wheels or even break the chain.
3. re-righten the lock screw (1)

warning: the shaft that carries the tensioner can move up and down. Make sure by sight that the tensioner wheel is central on the chain before locking the shaft with the lock screw (1)

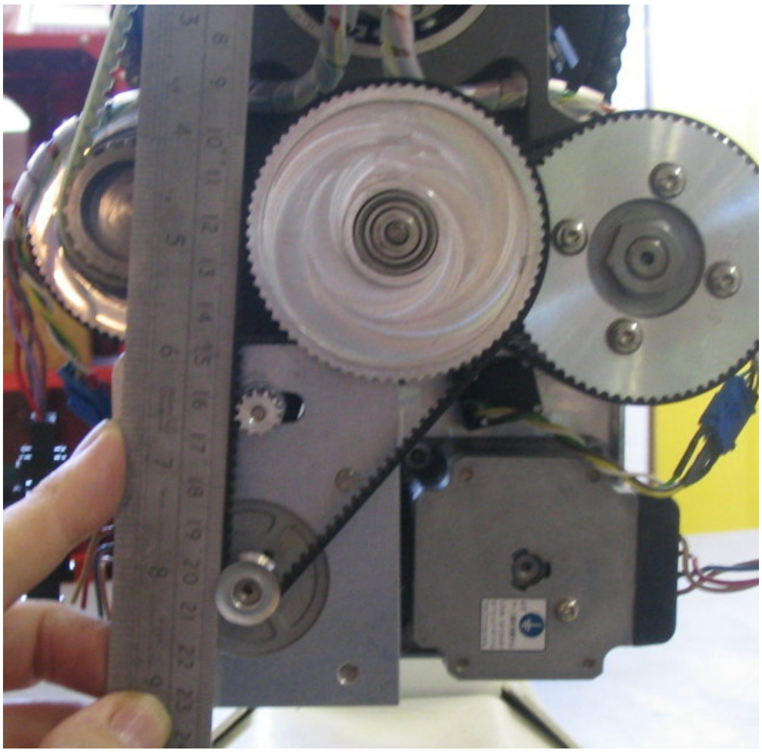
4. While you have the covers off make sure there is grease on the inside of the chain, especially all round the small drive sprocket and the tensioner.

How to fit and adjust encoders

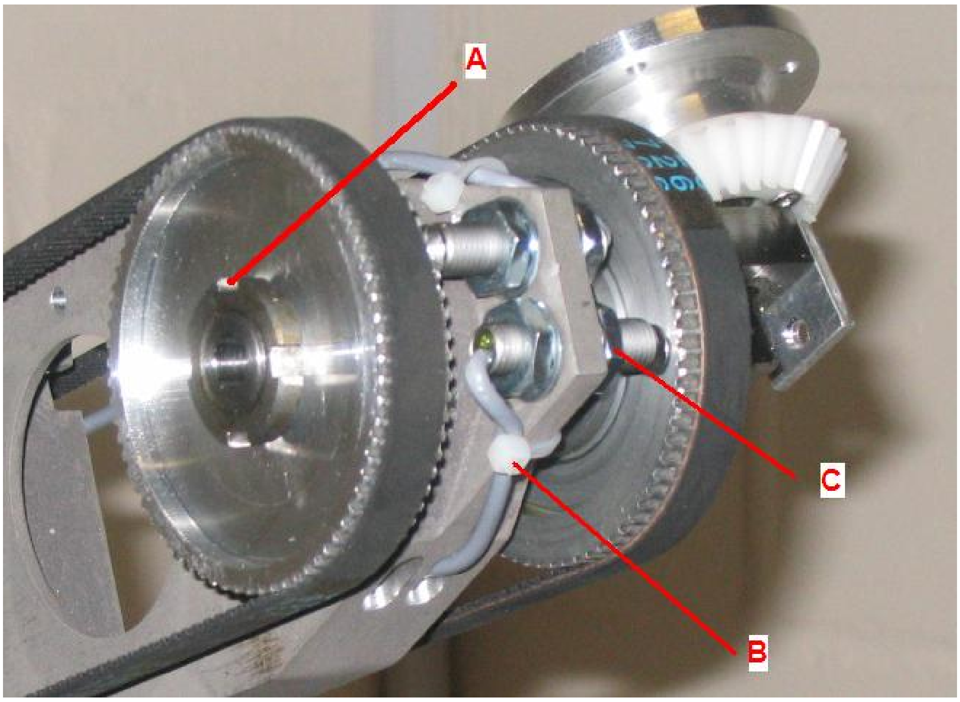
First remove the faulty encoder and cut the wires. A replacement encoder might have short wires already attached. If so join and solder the wires end to end first sliding the heatshrink sleeve on to one side then shrink the sleeve with a heatgun or failing that a gas lighter. Be sure to keep the heat away from the encoder. If the encoder has no wires attached then cut an strip the robot wires and solder them to the encoder quickly using minimum heat, first sliding on silicon sleeves (notheatshrink). Then fit the encoder to the robot.

When fitting a new encoder make sure there is none of the plastic body in contact with any metal part of the robot. A locking washer around the bush will ensure that the plastic pip on the body will not touch metalwork.

Take care not to put any side loads on the encoder shaft. This is a very small shaft with tiny bearings and the shaft will bend or the bearings fail if too much side load is applied. Do not try to use the encoder as a belt tensioner. This applies serious side loads which will increase substantially when the motor runs against a load. The encoder pulley should be loosely meshed with the belt such that it follows the belt motion but as there is no torque required to turn the encoder a firm mesh is not required. The belt alongside the encoder pulley should be straight. Check with a rule as shown in the picture. In some circumstances, if the belt is too slack then the belt may come away from the encoder pulley when the robot moves, resulting in an encoder mismatch. In this case a small side load is permissible.



How to fit and adjust calibration sensors

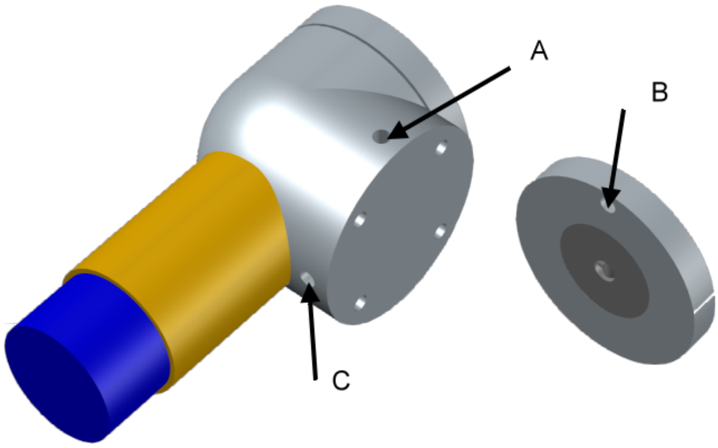


1. A this is a nut with 4 notches. In the absense of a special tool simply put a screwdriver in the notch at the direction of the red line and tap with a hammer.

2. The pulley then pulls off - it has a keyway, do not lose the key.
3. Cut the tie-wrap **B;** cut the wires at the end of the grey lead first, then pull through the arm. Then it is easier to twist the sensor.
4. Loosen nut **C** and remove the sensor by twisting the wire and loosening the nut simultaneously.
5. Replace the sensor and tighten the nuts with a credit card between the sensor and the reflector screw head on the pulley. This ensures correct sensing distance.
6. Finally re-connect the wires using same colours as before.
Do this as follows:
a. push 2 or 3 cm of the heat-shrink sleeve supplied over the free wire and push it away from the join.
b. bare the wires and twist together in a line.
c. solder the wires.
d. slide the sleeve over the connection and hold a heat gun, or lighter, or match back and forth across the sleeve until it shrinks tight over the join.
7. Rotate the pulley so that the c/s screw is adjacent to the sensor then adjust the sensor position so that the gap is about 1mm. Sliding a credit card in the gap is ideal. Test with PP e.g. for wrist rotate 11111111 goes to 11101111.

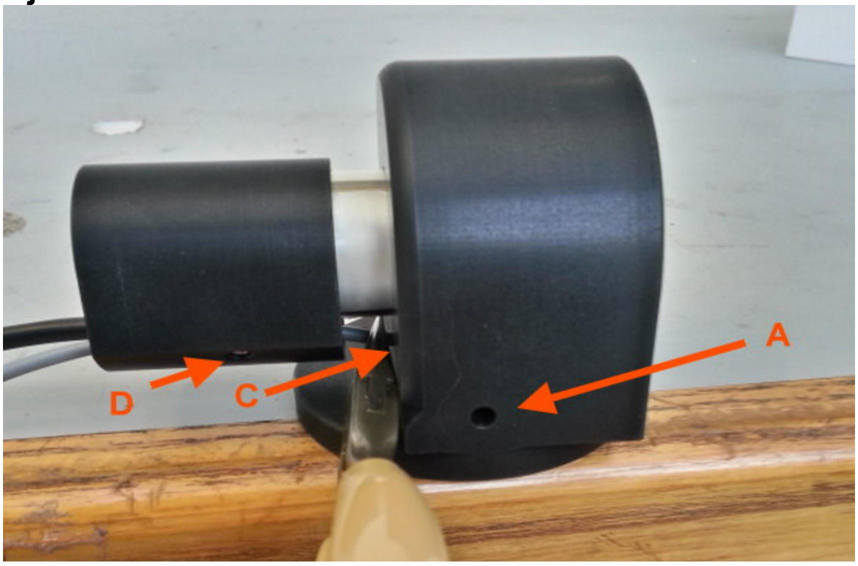
Sixth Axis sensor adjustment

IMPORTANT: do not back-drive the 6th axis wrist roll.
See diagrams below:



The diagram shows: left the complete assembly, right the mounting plate. Calibration works as follows: most of the time the sensor (mounted at C) is sensing the mounting plate and reads '1'. During CALIBRATE or DATUM the plate rotates until the hole B lines up with the sensor then it changes to '0'.

How to adjust



The sensor is attached to the grey wire at C inside the black housing on the right. It is held in place by a set screw at A. Loosen the set screw so you can move the sensor in or out by moving the wire. You may need small pointed pliers. It may also help to move the cap back by slackening the screw at D; move the cap back to give more space.

Enter `PP`. You should see
11111111
If you see
11011111
then the wrist roll is on the sensor. It should be possible to clear the sensor by moving the wrist roll motor with a command:
`TELL WRIST 1000 MOVE`
you should now see
11111111
If, no matter where you send the wrist you always see 11011110 then the wrist sensor is too far from the plate. Slacken the sensor set screw at A and push the sensor in using the wire at C until it contacts the plate. The PP should change to 11111111. Now pull the sensor back, estimating 0.5mm. The read should stay at 11111111. If it goes to 0 then push back in a little. Tighten the set screw a VERY SMALL AMOUNT: just enough to hold the sensor. If you tighten too much you will crush the sensor.
Finally restore the cap to it's original position and tighten the screw at D

Now test with
`TELL WRIST DATUM`
You may get a “too far message”, repeat the command a few times until the sensor hole is reached. Of course if you have gone 360 degrees then you may need to check adjustment again. Be sure about adjustment before replacement of sensor.

Setting up entire robot from scratch

After adjusting the chain or tightening an axis joint you may wish to check that calibration has not changed. Perform steps 1 to 9 to check. If the robot is not level then perform the steps 10 to 13 to correct the calibration.

1. Set the robot up to as near a HOME position as you can, visually. Robot must be bolted down to a level bench.
2. Enter TELL SHOULDER S-RATIO MOVE – shoulder moves so arm is horizontal.
3. Click the T (teach) button, select a low speed e.g. 2
4. Place a spirit level on the upper arm and use J2 to make it level.
5. Place the spirit level on the forearm and use J3 to make it level.
6. Place the spirit level on the hand flange and use J4 to make it vertical.
7. Place the spirit level on the gripper or tool and use J5 to make it level.
8. Use J1 to center the waist. The peg which stops the robot exceeding 360 degrees should be exactly opposite the stop toggle.
9. Enter TELL SHOULDER REVERSE S-RATIO MOVE – robot is now in HOME position.
10. Enter SETHOME
11. Enter CHECK – the robot seeks out the sensors.
12. Enter SETLIMITS which over-writes the old parameters

Now try the calibration by typing START CALIBRATE HOME (or click the 3 Robwin buttons). Does the HOME position look right? If so then save the calibration on disk and also into the flash ROM in the controller as follows:

13. Click file – save binary. Change parameters to:
(**V11**) Bank 0, start 9C00 length 100,
(**V13 up**) Bank 0, start A200 length 200
14. Save as serial number .SIG e.g. R17C123.SIG (actual filename will be R17C123.SIG.ram).
15. Enter (**V11**) PSAVE (**V13 up**) USAVE to save to the flash ROM.