This Procedure explains how to set resistor values for a stick (sensor) type.

Preliminary Setup: (Steps 1-4)

1. Install appropriate Y, Z axis invert jumpers in TrackPoint circuit as appropriate for the stick/sensor type you have. Presently, Bokam needs INVERTZ and INVERTY pins connected to ground (usually already installed). For others, leave jumpers open.

2. Build simulated pointing stick so that its resistor network and sensitivity matches those of the real stick. See separate instructions of how to build a ***Simulated Sensor.***

3. Get software to provide test data, ***Potfind.exe*** and ***Joytest.exe*** and ***Potmap.exe***.

4. Note that the following capacitors and resistors are fixed for all TrackPoint circuits:
   - **C2**=0.01uF ;Ramp capacitor (should have 1% tolerance)
   - **C6, C7, C8**=0.01uF ;RF bypass caps
   - **R11, R19, R20**=68.1K
   - **R4, R5, R16, R17**=10K

A thorough completion of the Preliminary setup is essential in calibrating for a type of sensor (or for a single TrackPoint unit). The setup involves the proper application of the forces in the x, y, z directions. Using the simulated sensor to apply the electrical load, instead of mechanically applying the appropriate forces, results to a more effectively calibrated TrackPoint circuit. This is because the implemented switches simulate a constant amount of load in the X, Y, and Z axes. Since its design is based on the average value measurements, which should also meet the manufacturer's specifications, the center of the resulting overall system sensitivities for the X, Y,Z axes (or the TP circuit resistor values) is easier to obtain.

The non-changing parts should be correctly populated in order to effectively calibrate for the TP circuit. (See explanation for non-changing parts below.)

Explanation of parts

*(Refer to TP schematic: **http://wwwcssrv.almaden.ibm.com/trackpoint/circuit.html**:)*

***C2**;	*the ramp capacitor is the most sensitive component since it is connected to the XYZRamp which provides a low impedance pulldown to the circuit ground potential, Vss, under Software control.*
***C6, C7, C8**;	*Rf bypass caps*
***R19, R20**;	*Closely-matched reference voltage dividers for W*
***R4, R5**;	*Closely-matched reference voltage dividers for X,Y*
***R16, R17**;	*Closely-matched reference voltage dividers for Z*
	*Note: **R4, R5, R16, R17** are set resistors which determine the centering of the low-order calibration (DAC setting). **R4, R5, R11, R16, R17 R19, R20** are dependent on fixed timing parameters necessary for proper micro controller operation.*

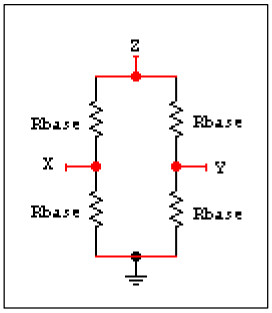
TrackPoint Resistor Values

The main purpose of this section is to obtain an overall precision of sensitivity of approximately +/- 2%, for the individual unit, or more importantly, for the center of the production distribution.

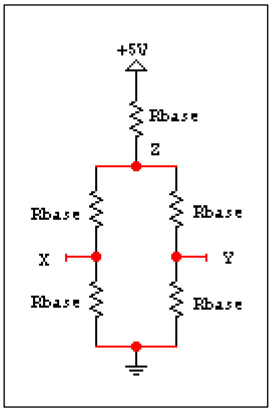
1. Install potentiometers for the following resistors that change according to the different

stick/sensor types:
R1, R6, R7, R9, R12, R13, R15, R18, R23, and R24. **(Usually, R12, R13 are open.)**
Suggested potentiometer values:
R1 = 50K potentiometer
R6, R7, R15, R23, R24 = 200K potentiometers
R9, R18 = 500K potentiometers

2. Calculate and preset R1 pot accordingly.
For a stick <u>without an on-board series resistor</u>, the initial value for
R1 = (Stick resistance) || (R19 + R20) || (R4 + R5) || [(Vz/Vx)R23] || [(Vz /Vy)R24]
= (Stick resistance) || (68.1K+ 68.1K) || (10K + 10K) || [(2) 100K] || [(2) 100K].
Where, **"Stick resistance = R_{ZX} ~ R_{ZG}"**



For a stick <u>with an on-board series resistor</u>, the initial value for
R1 = (R19 + R20) || (R4 + R5) || [(Vz/Vx)R23] || [(Vz /Vy)R24]
= (68.1K+ 68.1K) || (10K + 10K) || [(2) 100K] || [(2) 100K].
Where, **"Stick resistance = R_{VZ} ~ R_{ZG}"**



R1 *mainly controls Z centering. It forms the upper half of the Z divider, either alone or in parallel with the on-stick Z series resistor. Since the <u>lower half of the divider</u> consists of the Rs, sensor's (nominal) resistance, in parallel with the X,Y reference divider (R4, R5) and the W divider (R19, R20), this will have a value such that:* ***R1|| Rs =Rs||(R19+R20)||(R4+R5).*** *Rs is present only when there is an on-stick series resistor dividers (like R4, R5 and R16, R17) since these determine the centering of the low-order calibration (DAC setting) and are not changed during the calibration procedure.*
If possible, these should be +/-0.1% thin-film resistors.

3. Preset **R18=402K** and **R23=R24=100K** as starting values.
NOTE: Remember to reset after every adjustment of a resistor pot.

R18 *(Z ramp resistor) controls Z sensitivity and has effect on Z DAC stepsize. It connects to the ramp and to the positive terminal of the Z comparator. Therefore, adjusting R18 adjusts the amount of current which is added to the current through the main Z DAC stepsize resistor,* ***R6****. The sum of the currents determine the voltage that is inputted to the Z comparator.*
(See Calibration Step# 5 for R23, R24.)

4. **Connect fake stick to TrackPoint circuit.**
   Run *Joytest*.
   In the graphics portion, **switch X on**.
   Check the amount of **voltage change, dVx = |Vx,$_{original}$ - Vx, $_{max}$|.**
   Adjust **R9** and turn switch X off.
   Reset and restart Joytest until **dVx = 1 [v]**.
   *Increasing R9 increases dVx output.

   NOTE: **1 [V] ~ 50 counts**.

For X-axis:	**For Z-Axis**:
count/32 g * **170g** = 50 counts	count/10 g * **500 g** = 50 counts

The applications of the 170g and 500g forces are simulated with the two switches on the fake stick.

R9 *(X,Y ramp resistor) controls X , Y sensitivity and has effect on X, Y DAC stepsize. R9 is supplied by the X,Y Source through the R11 which affects the ramping of C2. Based on this network, the X,Y sensitivity is affected when R9 is adjusted. When R9 is higher, the threshold voltage is crossed by the ramp at a shorter time, which is related to sensitivity. This means that if two points were designated on the screen, it would take less time for the cursor to travel from one point to another with the higher value of R9, compared to a lower value for R9 (relating to a less steep ramp, taking a longer time to cross the threshold voltage). The Joytest is the tool that is used to gauge the 1V change when a set amount of force (170g) is applied in the X, Y direction.*

5. Run ***Potfind*** .
   Adjust **R7 until 18 counts** per XYDac step **(Step Size) is reached.**
   *Increasing R7 decreases Step Size**.**
   Adjust **R23**, **R24** (stick pulldown resistors) **to center** the POTS **(Pot Value) at 80 hex.**
   *Increasing R23, R24 increases Pot Value.
   A passing circuit should look something like the following:

   Response to reset command was AA 00 **PASSED**
   X: POT VALUE 80, SAMPLE 80, STEP SIZE 18 (DECIMAL)
   Y: POT VALUE 80, SAMPLE 80, STEP SIZE 18 (DECIMAL)
   Z: POT VALUE 80, SAMPLE 80, STEP SIZE 100 (DECIMAL)

   Calibration results in Potfind should be within 5% error.

R7 *controls X, Y DAC stepsize, as well as X, Y sensitivity. It is connected to the non-switchable output from the internal DAC, and is also fed into the positive terminal of the X, Y comparators. When R7 is increased, the stepsize decreases as a result of less current being added to the current through the R9 which is connected to the ramp. The sum of the currents determine the voltage which is compared with* *the Vx, Vy threshold voltages of the X, Y comparators.*

R23, ***R24*** *are the pulldown resistors placed in parallel to the bypass capacitors, C7 and C8. The pulldown resistors and bypass capacitors filter high frequencies and allow the slowly varying voltage sensor signals through to the Y, X comparators, therefore, controlling Y, X centering.*

6. Run ***Joytest*** (Same as #8).
   In the graphics portion, **switch Z on**.
   Check the amount of **voltage change,** $dVx = |Vx_{original} - Vx_{max}|$.
   Adjust **R15** and turn switch Z off.
   Reset then restart Joytest until **dVz = 1[v].**
   (If R15 needs to be <0, install R15=0 and reduce R18 until target is reached.)

Supplied by Vreg, ***R15****, along with R11, determines the rate at which the ramp rises when the Z is being measured. The current through these resistors goes through R18 which controls Z sensitivity.*

7. Run ***Potfind*** .
   Adjust **R6** until 100 counts per ZDac step **(Step Size)** is reached.
   Verify final ZDac step with ***Potmap.exe***. (Redirect the standard console output from POTMAP to a file. Find the in range steps for the Z axis and verify that the pot step(s) that are valid are correct. Potfind may have displayed incorrect step sizes when adjacent steps are at their limits.)

R6 *controls Z DAC stepsize, as well as Z sensitivity. It is connected to the switchable output from the internal DAC, and to the positive terminal of the Z comparator. The current through R6 adds to the current through the Z ramp resistor, R18. The sum of the currents determines the voltage that is to be inputted in the Z comparator. (Also, refer to Calibration step #3.)*

8. Run ***Potfind*** .
   Adjust **R1** to center Zdac (Pot Value) at 80 hex.
   *Decreasing R1 increases Pot Value.

9. Run ***Joytest*** and ***Potfind*** to recheck the test results. Iterate from step 4 as necessary.

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11/97
(Revised 08/98)