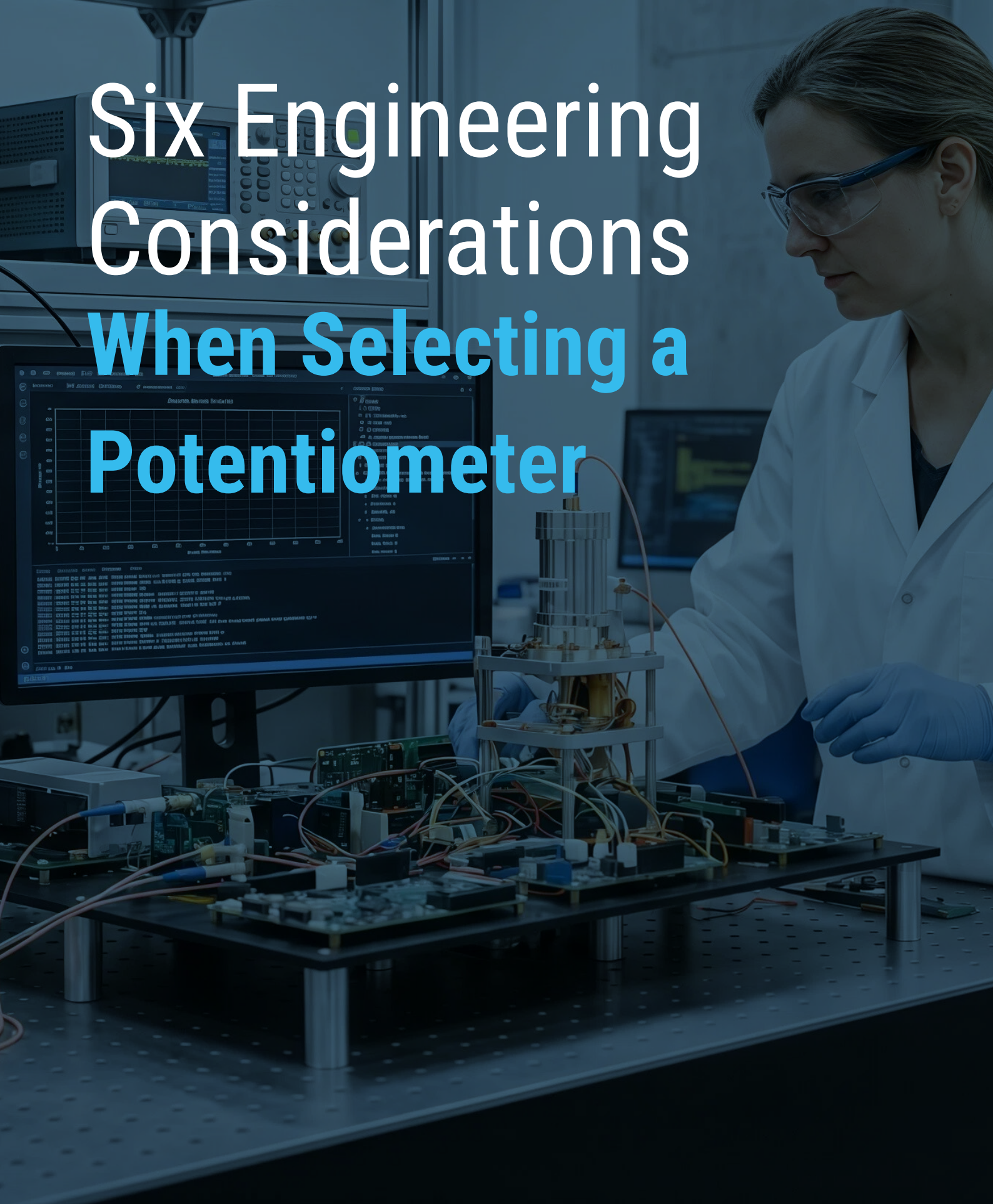




Six Engineering Considerations When Selecting a Potentiometer



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Selecting a potentiometer can look straightforward: determine the required resistance, choose a package and shaft, and check the power rating.

For a simple adjustment function, that may be enough. For position feedback, frequent operator adjustment, calibration or operation in a demanding environment, it usually is not.

The electrical output of a potentiometer depends on a mechanical contact moving across a resistive element. That makes electrical performance, mechanical design and operating conditions closely linked. Independent linearity, contact resistance variation, rotational life, power dissipation, electrical travel and environmental exposure can all influence whether the component continues to perform as expected over the life of the equipment.

A useful starting point is therefore not the resistance value, but the job the potentiometer is expected to perform.



1. Define the Function and Duty Cycle First

A front-panel control, a production calibration adjustment and a position-feedback sensor may all use a potentiometer, but they place very different demands on it.

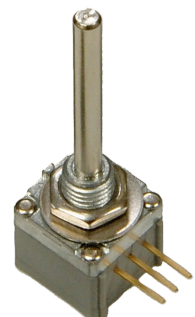
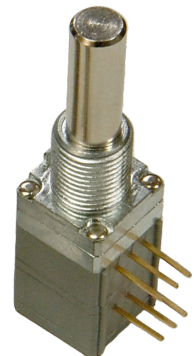
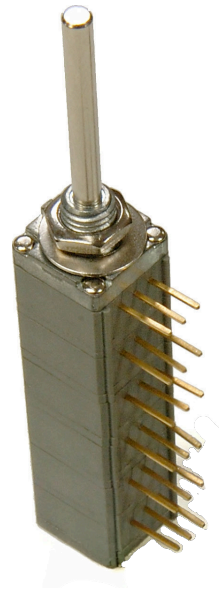
An operator control may be adjusted thousands or millions of times and needs appropriate rotational life, torque and mechanical construction. For a calibration function that is set during production and rarely adjusted afterwards, stability and adjustment resolution may matter more than high cycle life. A position-feedback device introduces another set of priorities, including independent linearity, output smoothness and repeatability.

The differences can be significant even within one manufacturer's portfolio.

BI Technologies [P260/P261 panel potentiometers](#), for example, are 12.7 mm rotary conductive-plastic devices available in configurations with up to six gangs. The family covers resistance values from 500 Ω to 1 M Ω and includes sealed/dust-proof construction, linear and audio tapers, switch, detent and wire-lead options. Selected configurations are specified for a one-million-cycle life.

For precision position sensing, the requirements can be considerably different. The BI Technologies [6180 Series](#) is a single-turn conductive-plastic precision potentiometer with resistance values from 1 k Ω to 100 k Ω . Depending on model and configuration, minimum cycle-life ratings extend to a minimum of five million.

The intended function and expected number of operations should therefore be established before comparing nominal resistance values.



2. Match the Resistive Technology to the Requirement

The resistive element has a direct influence on electrical behaviour, power capability, resolution and operating life.

Wirewound potentiometers use resistance wire wound around an insulating former. They are well established in precision measurement and control applications where stability, power handling and tight linearity are important. One trade-off is that the discrete turns of resistance wire inherently limit resolution compared with a continuous resistive track.

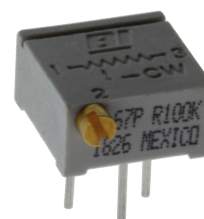
As an example, BI Technologies [7280 Series](#) is a 10-turn wirewound precision potentiometer offering resistance values from 100 Ω to 100 k Ω , a 2 W power rating and $\pm 0.25\%$ standard independent linearity. Depending on the model, minimum cycle-life ratings extend to 300,000 rotations.

Conductive-plastic potentiometers use a continuous resistive element and are particularly useful where smooth output and high operational life are required. The [6180 Series](#), for comparison, is rated at 1 W at 70°C, provides $\pm 1\%$ standard independent linearity with $\pm 0.5\%$ listed as the minimum practical value, and specifies output smoothness of 0.1% maximum.

Carbon elements continue to provide an economical solution for less demanding adjustment and control functions, particularly where precision and very high cycle life are not primary design requirements.

For PCB calibration, cermet is another important option. The [67 Series trimmers](#), for example, uses cermet elements and includes 20-turn configurations for fine adjustments. Selected versions are sealed for compatibility with aqueous PCB-cleaning processes.

The choice is therefore not a question of one technology being better than another. It is a trade-off between the electrical, mechanical and cost requirements of the application.



3. Look Beyond Resistance Value and Tolerance

Nominal resistance and tolerance are necessary specifications, but they do not describe how accurately shaft position will be represented at the wiper.

For a potentiometer used as a voltage divider or position sensor, independent linearity is often more directly related to positional accuracy. It describes how closely the actual output follows a specified straight-line relationship over the electrical travel.

Consider two BI Technologies precision products:

The [single-turn wirewound 5100 Series](#) has a standard independent linearity of $\pm 0.5\%$, with $\pm 0.25\%$ listed as the minimum practical value. The 10-turn wirewound 7280 Series specifies $\pm 0.25\%$ standard independent linearity.

By contrast, the conductive-plastic 6180 Series specifies $\pm 1\%$ standard independent linearity, with $\pm 0.5\%$ available as a minimum practical value. It also specifies 0.1% maximum output smoothness.



Those differences illustrate why the selection cannot be based on resistance alone. The designer should consider which error mechanisms matter to the circuit and how the potentiometer is being used.

Other parameters worth checking include:

- Contact resistance variation or output smoothness
- Repeatability
- Effective electrical travel
- End voltage
- Rotational torque
- Insulation resistance
- Dielectric strength
- Maximum operating voltage

Loading should also be considered. A potentiometer used as a voltage divider produces its most predictable transfer characteristic when the load connected to the wiper is high relative to the potentiometer resistance. A low-impedance load changes the effective divider ratio and introduces non-linearity even if the potentiometer itself has excellent independent linearity.

The component specification and the surrounding circuit therefore have to be considered together.



4. Match Mechanical Life to the Actual Duty Cycle

Cycle-life figures only become useful when the expected duty cycle of the application.

Suppose an operator control is moved 500 times per working day. At 250 working days per year, that represents 125,000 cycles annually. A product intended to remain in service for eight years could therefore approach one million operations.

A calibration control adjusted during manufacture may accumulate only a fraction of that number.

BI Technologies portfolio illustrates the range. The 7280 wirewound precision family includes models with minimum life ratings to one million rotations. Standard 6180 conductive-plastic configurations are available with five-million-cycle ratings. P260/P261 panel-control configurations are available with ratings up to one million cycles.

These figures should not be compared in isolation because the products serve different purposes and their ratings are based on specified test conditions. They do, however, demonstrate why expected movement should be quantified early.



Specifying far more endurance than the application requires can add unnecessary cost. Specifying too little may turn an inexpensive component into a field-reliability problem.

5. Design for the Operating Environment

A potentiometer can meet every required electrical parameter at room temperature and still be unsuitable for the equipment in which it is installed.

Temperature affects both power capability and electrical performance. Power ratings are therefore normally accompanied by a derating curve rather than remaining constant across the full operating-temperature range.

For example, the BI Technologies 6180 Series is rated at 1 W at 70°C and derates to zero power at 125°C. A designer cannot assume that the 1 W headline rating applies at every operating temperature.

Shock and vibration can also matter when the potentiometer is mechanically coupled to a moving assembly. The BI Technologies 5100 Series, for example, is specified for 100 g, 6 ms sawtooth shock and 10 g vibration from 10 to 500 Hz. Its environmental data also includes temperature cycling and humidity testing, while rotational load life is specified as 500,000 shaft revolutions plus 900 hours at rated power at 40°C.

Contamination presents a different problem. Dust or moisture reaching the resistive track and wiper can affect electrical contact and long-term performance, making sealing and housing construction important selection criteria.

Instead of treating environmental specifications as a final qualification check, they should be part of initial component selection alongside the electrical requirements.

6. Treat Mechanical Integration as Part of the Electrical Design

A potentiometer may satisfy the electrical requirements and still create integration problems if the mechanical interface is considered too late.

Shaft diameter and length, bushing dimensions, mounting method, rotational travel, available panel depth and termination style all constrain the design.

Electrical and mechanical travel also need to be distinguished. The full physical rotation of the shaft is not necessarily the

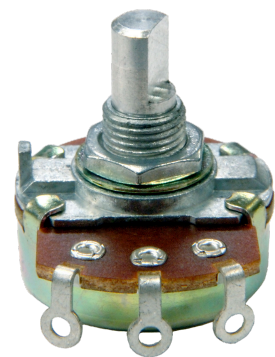


portion over which the specified electrical transfer characteristic applies. The P260/P261 Series, for example, specifies a nominal electrical travel of 265°, while the 6180 precision series specifies nominal actual electrical travel of 340° in its standard configuration.

The required taper is another application-dependent choice. A linear taper is appropriate where resistance or output voltage should vary approximately in proportion to position. Other response characteristics are useful where the required output is intentionally non-linear. The P260/P261 family, for example, is offered with both linear and audio taper options.

Mechanical configuration can also affect assembly complexity. The same P260/P261 platform supports PCB pins, solder lugs, wire leads, ribbon cable, detents, rotary switches and multiple-gang configurations. Selecting the appropriate interface at component level can remove the need for additional mechanical or wiring components elsewhere in the assembly.

Where a standard configuration does not fit, shaft geometry, electrical characteristics, terminations and other parameters may also be candidates for customisation.



A Practical Selection Check

Before releasing a potentiometer into a design, it is useful to be able to answer six questions:

Design Question	Parameter to Check
What is the potentiometer doing?	Adjustment, calibration or position feedback.
How accurately must position or adjustment be represented?	Independent linearity, output smoothness/CRV, repeat-ability, electrical travel.
How often will it move?	Rated cycle life, torque and duty cycle.
What electrical stress will it see?	Resistance, power rating, maximum voltage and derating.
Where will it operate?	Temperature, sealing, shock, vibration and contamination
How will it fit into the equipment?	Shaft, bushing, mounting, terminations, taper, gangs and available space

These questions narrow the available choices much more effectively than resistance value alone.

Bringing the Design Together

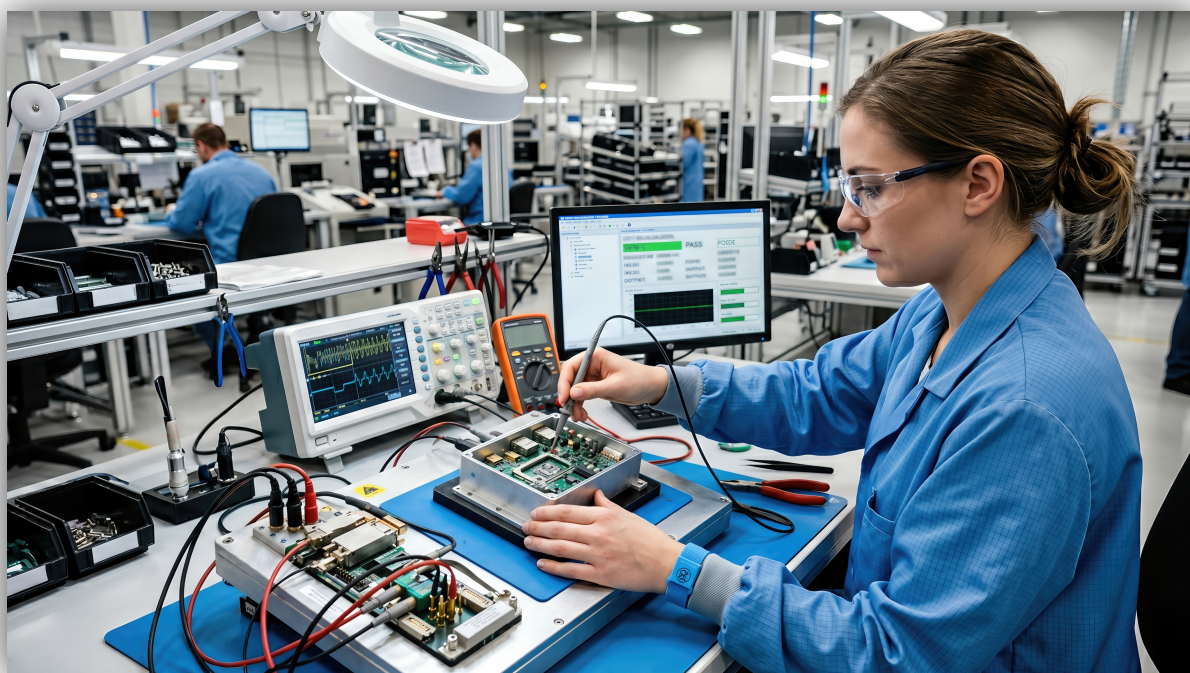
There is no single specification that determines whether a potentiometer is right for an application. A conductive-plastic device is not automatically preferable to a wirewound device, just as tighter resistance tolerance does not automatically produce more accurate position feedback.

The correct choice depends on what the component is being asked to do.

BI Technologies portfolio includes panel and precision potentiometers as well as trimmers across conductive-plastic, wirewound, carbon and cermet technologies. The range covers applications from operator adjustment and PCB calibration to precision position feedback, with multiple mechanical configurations and custom options available for OEM designs.

When specifying a potentiometer, begin with function, accuracy, duty cycle and operating environment. Once those requirements are defined, resistance value becomes one part of a much clearer engineering decision.

Explore the TT Electronics [BI Technologies](#) potentiometer portfolio to compare product options and technical data, or discuss the electrical and mechanical requirements of your application with a [TTI representative](#).



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