

## Trimming Potentiometer Application Note *Effects of Setting the Wiper at End Set on Cermet Resistors*

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### Introduction

Bourns® trimming potentiometers are designed and tested to operate under extreme conditions. However, the performance of a trimmer is dependent on its proper use in application.

Problems during the customer's production stage, or fabrication, may go undetected into the processing stage. Instead, these reported failure modes are detected in process, burn-in test, final testing, or in the field. Failures can lead to huge setbacks in the production line and overall costs in time and money spent on a failure analysis by the customer and the manufacturer.

The good news is that there are some easy solutions. To help ensure quality performance of the trimmer, application notes and datasheets are provided to specify the range of operation for each model. By following the manufacturer's recommendations, costly failures caused by the improper use of a trimmer can be eliminated.

This note serves to illustrate the issues dealing with the potential problems of setting the wiper at or near the end set.

### Key Terms

This section reviews the terms that will be referenced throughout this document.

**Electrical parameters** are those characteristics that describe the function and performance of a trimming potentiometer.

**Total resistance**, or TR, is a parameter defined as the resistance between the end terminals of the trimmer, pins 1 and 3, and is always specified as a nominal value in ohms.

**Absolute Minimum Resistance**, or MR, is the lowest value of resistance obtainable between the wiper and either end terminal. It is always specified as a maximum because the specification is a level of resistance at or *below* which the wiper can be set.

**End resistance**, or ER, is the resistance measured between the wiper and a reference end terminal when the movable contact is positioned against the adjacent end stop. End resistance is expressed in terms of a maximum ohmic value or maximum percentage of the unit's TR.

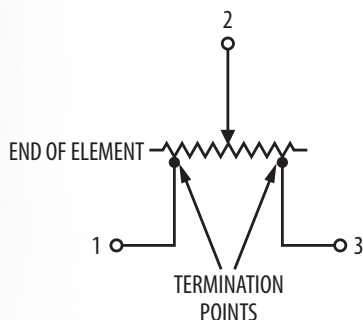


Figure 1 illustrates termination position relative to element end

**Minimum voltage ratio** and/or **end voltage ratio** is specified for applications that require the trimmer to operate as a voltage divider. It is often referred to as end setting, with typical values ranging from 0.1 % to 3.0 %.

**Contact Resistance Variation**, or CRV, is the maximum instantaneous change in contact resistance that will be encountered as the result of moving the wiper from one position to the other. The limit of CRV is expressed as a percentage of the unit's total resistance in ohms. When the wiper is actuated, the resistance at the wiper terminal, with respect to either end terminal, is apt to increase or decrease by a value within the CRV specification.

## **Design Problem: Setting The Wiper At End Set**

**Objective:** To eliminate costly failures caused by the improper use of a trimmer.

Potentiometers normally have a small region at the extreme ends of the adjustment range where the output is irregular. This can be seen when there is a sudden drop to essentially zero resistance. Alternatively, the change in output will stop at some small residual value of resistance, depending on the design of the trimmer.

Although this unstable region is usually less than 1 % or 2 % of the total range of adjustment, it is important to remember to make allowances for avoiding it in your applications.

Various application errors contribute to failures caused by setting the wiper at end set. Here are some examples:

- Setting the wiper at extreme ends
- Exceeding power ratings
- Derating rheostat applications
- Not limiting current through the wiper
- Using an ohmmeter

### **Setting the wiper at extreme ends**

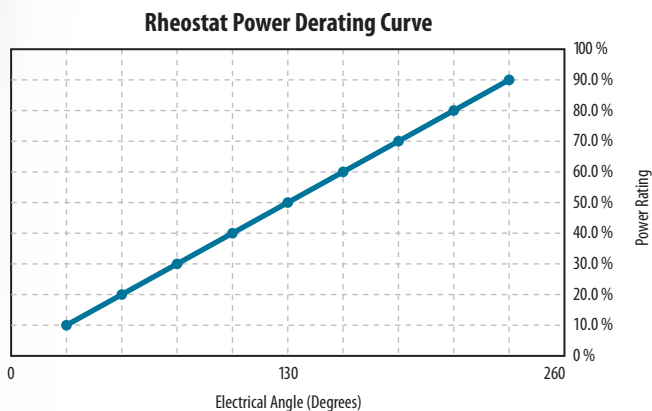
End-set is a region of instability inherent to all cermet trimming potentiometers. In the end-set region, there is termination material that meets the resistance material. Because the two materials have different expansion coefficients, the resistance will have a chance to become erratic. Bourns does not recommend the use of any trimmer at or near the end-set. It is recommended that the application be designed to have the trimmer operate between 10 % and 90 % of the total resistance.

### **Exceeding power ratings**

Power rating is the maximum heat that can be dissipated by a trimmer when a voltage is applied to the end terminals. It is typically determined by the temperature-rise method. This prevents any portion of the trimmer from exceeding the maximum operating temperature at full rated power. Exceeding the specified power rating produces an over-powered contact spring and resistance element. High current through the contact spring may reduce the spring back properties and damage the contact spring and resistance element. For this reason, we recommend the customer review its process and avoid exceeding the recommended power ratings provided in the datasheet.

## Derating rheostat applications

A common overlooked design parameter in rheostat applications is the derating factor necessary to achieve a reliable and efficient design. The power rating in rheostat applications must be de-rated depending on the portion of the resistance element used. For example, if a 10K ohm total resistance trimmer is set at 50 % of the total resistance, i.e. 5 K, then the trimmers' power rating must be derated by 50 %. Figure 2 helps illustrate this point.



Note: There are no values specified between 0 % and 10 % and between 90 % and 100 %. Bourns does not recommend the wiper be set in these regions as described in the section "Setting the wiper at extreme ends."

Figure 2: Rheostat Derating Curve

## Not limiting current through the wiper

Fortunately, power dissipation and wiper current usually only become problems when trimmers are used in the rheostat mode. In this mode, the current through the trimmer element and the wiper contact is limited only by external circuit conditions.

This is where you, the designer, must make sure you limit the wiper current to the maximum value stated in the trimmer specifications. Exceeding the maximum wiper current has caused more trimmer problems than any other design error. If the maximum wiper current specification is not available, you can safely assume that it is the current that would produce maximum power dissipation in the trimmer, if applied through the element only, if it does not exceed 100 mA. Table 1 outlines the recommended maximum wiper currents for multiple resistance values in voltage divider applications.

Total Resistance (Ohms)	0.25 Watt	0.5 Watt	0.75 Watt	1.0 Watt
10	100.0	100.0	100.0	100.0
20	100.0	100.0	100.0	100.0
50	70.7	100.0	100.0	100.0
100	50.0	70.7	86.6	100.0
200	35.4	50.0	61.2	70.7
500	22.4	31.6	38.7	44.7
1,000	15.8	22.4	27.4	31.6
2,000	11.2	15.8	19.4	22.4
5,000	7.1	10.0	12.2	14.1
10,000	5.0	7.1	8.7	10.0
20,000	3.5	5.0	6.1	7.1
50,000	2.2	3.2	3.9	4.5
100,000	1.6	2.2	2.7	3.2
200,000	1.1	1.6	1.9	2.2
500,000	0.7	1.0	1.2	1.4
1,000,000	0.5	0.7	0.9	1.0
2,000,000	0.4	0.5	0.6	0.7

Table 1: Maximum Wiper Current vs Power Rating

## Using an ohmmeter

An important feature of hand-held ohmmeters must be taken into consideration. Hand-held ohmmeters do not employ current regulators. When a trimmer is set at the end-set and a hand-held ohmmeter is used, the battery in the ohmmeter will discharge completely through the wiper. This will cause a high current condition, which will damage the trimmer.

Any of the above application errors have the potential to cause failures experienced by the customer. Associated failure modes may be any of the following:

- Linearity, Settability, or CRV out of specification
- Unstable output
- Circuit is susceptible to failures
- Electrical failures such as short circuit or burn-out
- Limited resistance range and performance
- Erratic circuit behavior
- Internally damaged units

The effects can become very costly. This application issue will continue to produce problems if the trimmer is not used properly. Such implications include:

- Costs of production line down
- Costs and time taken to conduct a failure analysis
- Replacement parts
- Field failures
- Documentation
- Increase of failure rates

Be cautious of application errors associated with setting the wiper at end set. They can be easily avoided at no cost by following Bourns' recommendations. The easiest way to prevent improper use is by setting the wiper within the optimum operating range of 10 %-90 % TR. Choose the correct resistance value for the circuit. While it is always easier to work with standard parts inventories, you still have to keep in mind that to reach optimum stability and adjustability, you need to use the smallest value of trimmer resistance your application allows.

When you are working with critical applications, try to avoid the extremes of resistance range when you are selecting a trimmer. Although the entire range will meet the stated specifications, mid-range values tend to perform better than low and high values. The goal is to prevent the improper use of a trimmer and avoid costs of production line downtime by recognizing this application issue right away. Save yourself the trouble of replacement parts as well as reducing failure rates. Ultimately, this will help to optimize electrical performance and extend the life of a trimmer.

## Conclusion

By explaining the causes and effects of setting the wiper at end set, we hope to provide a better understanding of how a trimmer functions. Simple precautions can be effective tools that will ultimately save your company unnecessary production costs. Bourns' Trimpot® Division strives continuously to improve our technical support. Visit the Bourns library for other application notes and reference materials.

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