



Designation: F 1811 – 97

Standard Practice for Estimating the Power Spectral Density Function and Related Finish Parameters from Surface Profile Data¹

This standard is issued under the fixed designation F 1811; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice defines the methodology for calculating a set of commonly used statistical parameters and functions of surface roughness from a set of measured surface profile data. Its purposes are to provide fundamental procedures and notation for processing and presenting data, to alert the reader to related issues that may arise in user-specific applications, and to provide literature references where further details can be found.

1.2 The present practice is limited to the analysis of one-dimensional or profile data taken at uniform intervals along straight lines across the surface under test, although reference is made to the more general case of two-dimensional measurements made over a rectangular array of data points.

1.3 The data analysis procedures described in this practice are generic and are not limited to specific surfaces, surface-generation techniques, degrees of roughness, or measuring techniques. Examples of measuring techniques that can be used to generate profile data for analysis are mechanical profiling instruments using a rigid contacting probe, optical profiling instruments that sample over a line or an array over an area of the surface, optical interferometry, and scanning-microscopy techniques such as atomic-force microscopy. The distinctions between different measuring techniques enter the present practice through various parameters and functions that are defined in Sections 3 and 5, such as their sampling intervals, bandwidths, and measurement transfer functions.

1.4 The primary interest here is the characterization of random or periodic aspects of surface finish rather than isolated surface defects such as pits, protrusions, scratches or ridges. Although the methods of data analysis described here can be equally well applied to profile data of isolated surface features, the parameters and functions that are derived using the procedures described in this practice may have a different physical significance than those derived from random or periodic surfaces.

1.5 The statistical parameters and functions that are discussed in this practice are, in fact, mathematical abstractions that are generally defined in terms of an infinitely-long linear

profile across the surface, or the “ensemble” average of an infinite number of finite-length profiles. In contrast, real profile data are available in the form of one or more sets of digitized height data measured at a finite number of discrete positions on the surface under test. This practice gives both the abstract definitions of the statistical quantities of interest, and numerical procedures for determining values of these abstract quantities from sets of measured data. In the notation of this practice these numerical procedures are called “estimators” and the results that they produce are called “estimates”.

1.6 This practice gives “periodogram” estimators for determining the root-mean-square (rms) roughness, rms slope, and power spectral density (PSD) of the surface directly from profile height or slope measurements. The statistical literature uses a circumflex to distinguish an estimator or estimate from its abstract or ensemble-average value. For example, $\hat{A}$ denotes an estimate of the quality A. However, some word-processors cannot place a circumflex over consonants in text. Any symbolic or verbal device may be used instead.

1.7 The quality of estimators of surface statistics are, in turn, characterized by higher-order statistical properties that describe their “bias” and “fluctuation” properties with respect to their abstract or ensemble-average versions. This practice does not discuss the higher-order statistical properties of the estimators given here since their practical significance and use are application-specific and beyond the scope of this document. Details of these and related subjects can be found in References (1–10)² at the end of this practice.

1.8 Raw measured profile data generally contain trending components that are independent of the microtopography of the surface being measured. These components must be subtracted before the difference or residual errors are subjected to the statistical-estimation routines given here. These trending components originate from both extrinsic and intrinsic sources. Extrinsic trends arise from the rigid-body positioning of the part under test in the measuring apparatus. In optics these displacement and rotation contributions are called “piston” and “tilt” errors. In contrast, intrinsic trends arise from deliberate or accidental shape errors inherent in the surface under test, such as a circular or parabolic curvature. In the absence of a-priori information about the true surface shape, the intrinsic shape

¹ This practice is under the jurisdiction of ASTM Committee F-1 on Electronics and is the direct responsibility of Subcommittee F01.06 on Silicon Materials and Process Control.

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² The boldface numbers in parentheses refer to the list of references at the end of this practice.