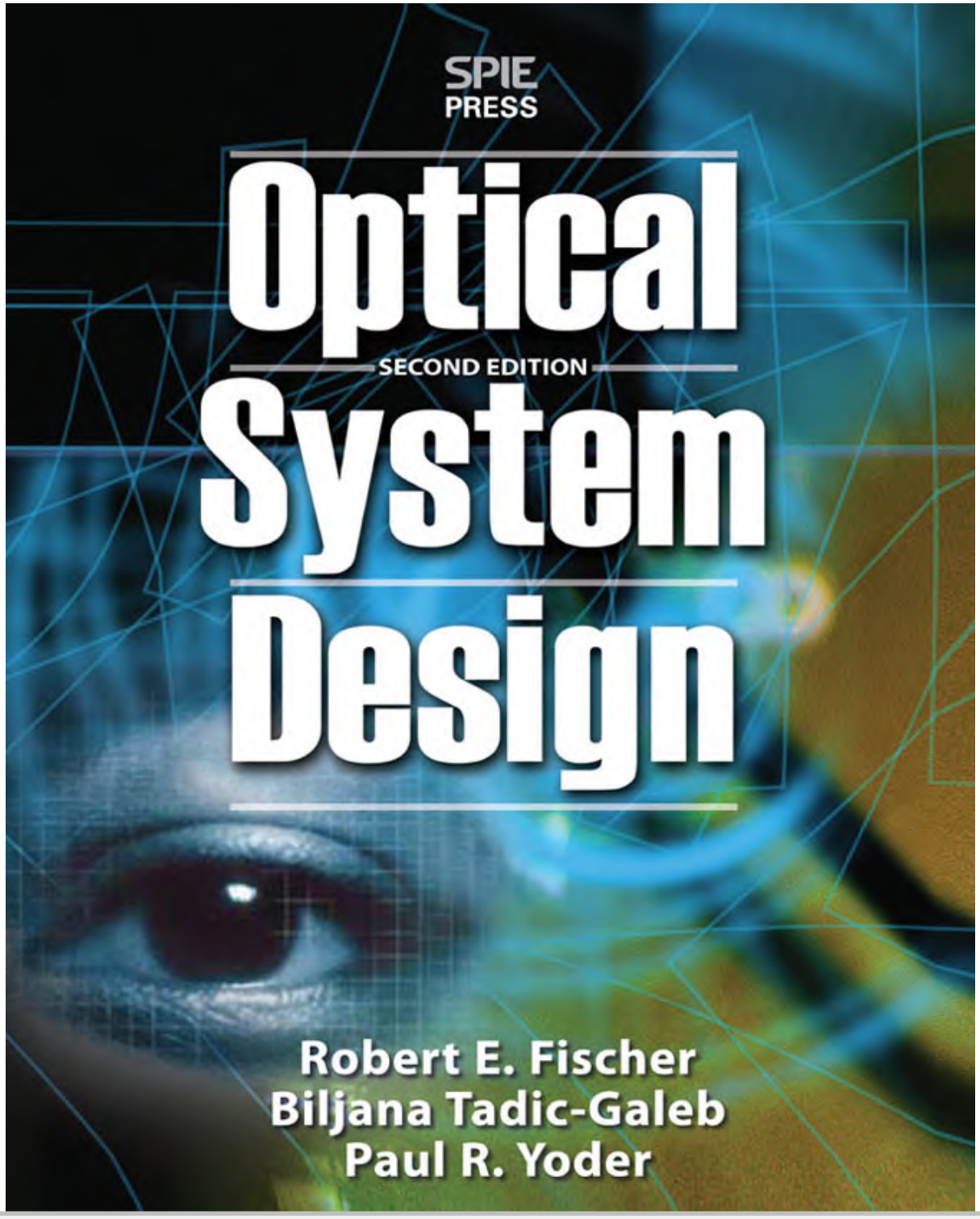

OPTICAL SYSTEM DESIGN

0-07-159358-6

The material in this eBook also appears in the print version of this title: 0-07-147248-7.

DOI: 10.1036/0071472487

CHAPTER 9

The Optical Design Process

The optical design process includes a myriad of tasks that the designer must perform and consider in the process of optimizing the performance of an imaging optical system. While we often think primarily of the robustness of the optimization algorithm, reduction of aberrations, and the like, there is much more to do. The designer must be at what we sometimes call "mental and technical equilibrium with the task at hand." This means that he or she needs to be fully confident that all of the following are understood and under control:

- All first-order parameters and specifications such as magnification, focal length, f/number, full field of view, spectral band and relative weightings, and others.
- Assure that the optical performance is being met, including image quality, distortion, vignetting, and others.
- Assure that the packaging and other physical requirements, including the thermal environment, is being taken into account.
- Assure that the design is manufacturable at a reasonable cost based on a fabrication, assembly, and alignment tolerance analysis and performance error budget.
- Consider all possible problems such as polarization effects, including birefringence, coating feasibility, ghost images and stray light, and any other possible problems.

Once every one of these items has been addressed and is at least recognized and understood, we start with the sketch of the system. First, the system is divided into subsystems if possible, and the first-order parameters are determined for each subsystem. For example, if we are to design a telescope with a given magnification, the entrance pupil diameter should be chosen such that the exit pupil size matches the eye pupil. A focal length of the objective and the eyepiece should be chosen such that the eyepiece can have a sufficiently large eye relief. Now, when the specs for each subsystem are defined, it is time to use the computer-aided design algorithms and associated software to optimize the system, which will be discussed in the rest of this chapter. Each subsystem can be designed and optimized individually, and the modules joined together or, more often, some subsystems are optimized separately and some as an integral part of the whole system.

What Do We Do When We Optimize a Lens System?

Present-day computer hardware and software have significantly changed the process of lens design. A simple lens with several elements has nearly an infinite number of possible solutions. Each surface can take on an infinite number of specific radii, ranging from steeply curved concave, through flat, and on to steeply curved convex. There are a near infinite number of possible design permutations for even the simplest lenses. How does one optimize the performance with so many possible permutations? Computers have made what was once a tedious and time-consuming task at least manageable.

The essence of most lens design computer programs is as follows:

- First, the designer has to enter in the program the starting optical system. Then, each variable is changed a small amount, called an *increment*, and the effect to performance is then computed. For example, the first thickness may be changed by 0.05 mm as its increment. Once this increment in thickness is made, the overall performance, including image quality as well as physical constraints, are computed. The results are stored, and the second thickness is now changed by 0.05 mm and so on for all variables that the user has designated. Variables include radii, airspaces,

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.