Course Description

Course name	**#013 - Digital Imaging: Image Capturing, Image Sensors – Technologies and Applications**
Duration	**4 days**
Format	**Public Classroom or Inhouse Event. Not suitable Online**

Overview

Professor Albert J.P Theuwissen, Harvest Imaging, Belgium, is the instructor for this 4-days course in how to get familiar with **Solid-State Imaging** and relevant related topics.

If "A picture tells more than a thousand words", then imaging was and still is the language of the future. In today's emerging markets of electronic equipment, imaging plays a very important role. The art of imaging and image processing is working its way into the automotive scenes, wearables, IoT, AR/VR and taking on environmental challenges. Solid-state image sensors are present in diverse professional application areas.

The major objective of this course is to make the participants familiar with solid-state imaging and the relevant related topics. It will give an in-depth view of the possibilities and limitations of the Image Capturing Technology of today and tomorrow.

Technical Focus

New developments in **CMOS Semiconductor Technology**, next to the outstanding imaging performance of solid-state imagers, open up new applications.

Automotive camera systems, improving image quality, and post-capture image processing techniques for digital video signals are important areas where extensive development progress is being made. It is just a matter of time before we will detect single photons with solid-state image sensors, enabling photon counting applications which enable quality images in extremely low light conditions.

In the medical world, new surgery techniques become possible thanks to the powerful characteristics of the image sensors. Also in the mobile world, the image sensor technology went to a revolution over the last two decades. For instance, in today's smart phone, there are more mm^2 of imaging silicon than in a professional broadcast camera.

Course Content

The major objective of this course is to make the participants familiar with **Solid-State Imaging** and the relevant related topics. It will give an in-depth view of the possibilities and limitations of the image capturing technology of today and tomorrow.

Participants will receive a comprehensive set of course notes. These notes are for participants only and are not for sale.

Who should attend?

This course is aimed at engineers, scientists and managers with basic knowledge, either theoretical or hands-on, in engineering or physics.

No detailed knowledge of device physics is assumed.

The course is developed to give an in-depth understanding of image capturing to engineers and technicians who are active in the field, and to give those with a theoretical knowledge the opportunity to learn more about the practical issues of the subject.

Much of the course will be of interest also to camera designers through its practical approach.

The course will provide managers and research workers having related experience in industrial, governmental or academic institutions with a valuable update on the latest developments in these fast-moving imaging topics.

More experienced engineers should instead choose our course **#020 - Advanced Course on Imaging Sensor Technology.**

Course Daily Schedule

Day 1

During the first day of the course, we will focus on the overall image sensor architecture and the various pixels used in CMOS image sensors. Pixels with 1 transistor, 3 transistors and eventually 4 transistors will be explained. The pixel discussion will be concluded with the shared pixel concept.

Without any further introduction it should be clear that light sensitivity is an important characteristic of the devices. In the course, the light sensitivity of the sensors will be explained, and (new) technologies will be introduced on how to further increase the light sensitivity.

Day 2

The second day of the class will be a very “noisy” day. The full day will be devoted to noise. Special attention will be paid to temporal noise sources and to fixed-pattern or spatial noise sources. Once the various noise issues are understood, the focus will shift to how to mitigate (most of) the noise generated by all the various sources.

The second day will conclude with the perception of noise in images by the human visual system and with an in-depth discussion about signal-to-noise ratio and how manipulation of images will change the signal-to-noise ratio.

Day 3

Once the basics of the image sensors are clear, as well as sensitivity and noise is explained, the time will come to characterize all those parameters. Characterization of the following parameters will be discussed: temporal noise (total, column, row, pixel), fixed-pattern noise (total, column, row, pixel), dark current, light sensitivity, quantum efficiency, photo-response non-uniformity, image lag.

A very special performance characteristic of an image sensor is the modulation transfer function (MTF). Why is MTF important, and how is it measured?

Day 4

The last day of the class will be devoted to special architectures that is used to improve the characteristics of the devices. Examples of these architectures are colour image sensors, devices for wide dynamic range, imagers with global shutter pixels, time-of-flight devices, phase-detection auto-focus pixels, …

The training will be concluded with a quick look at datasheets. What is specified in a data sheet and what is not specified? What are the traps that are present in a data sheet?

Instructor Biography

Professor Albert J.P Theuwissen, CEO of Harvest Imaging, Belgium**.**

Dr. Theuwissen received his M.Sc. (1977) and his Ph.D. (1983) degree in electrical engineering from the Catholic University of Leuven, Belgium.

In the ESAT laboratory he focused on semiconductor technology for linear CCD image sensors. From 1983 till 2002 he was involved in research in the field of solid-state image sensing, SDTV- and HDTV-imagers, CCD as well as CMOS solid-state image activities at Philips Research Laboratories in Eindhoven, the Netherlands. From 2001 till 2023 Dr. Albert Theuwissen joined the Delft University of Technology as part-time professor and in 2002 he joined DALSA Corp. to act first as the company's Chief Technology Officer and later as the Chief Scientist of DALSA Semiconductors.

In 2007 Dr. Theuwissen founded Harvest Imaging and since then he has been fully focusing on training, coaching and consulting in the field of solid-state imaging technology.

Dr. Theuwissen is the author or co-author of many technical papers in the solid-state imaging field, has issued several patents, authored a textbook "Solid-State Imaging with Charge-Coupled Devices" in 1995, and been appointed an IEEE distinguished lecturer. He is the founder of the Walter Kosonocky Award, which highlights the best technical paper in the field of solid-state image sensors. He was general chair of the International Image Sensor Workshop in 1997, 2003, 2009 and 2015. Since 1998 he has served as a member of the Technical Program Committee of ISSCC, and in 2010 he was Chair of the International Technical Program Committee of ISSCC. Dr. Theuwissen is an IEEE Fellow. In 2008 he also received the Fuji Gold Medal for his research, development and education work in the field of solid-state imaging. Furthermore, Dr. Theuwissen was elected Electronic Imaging Scientist 2011 at the Electronic Imaging conference held in San Francisco, USA. In 2013 he received the Exceptional Service Award of IISS and in 2014 the SEMI Award. From 2017 till 2021 he was the president of the International Image Sensor Society, which is a non-profit organization that he founded in 2007 together with his peer Nobukazu Teranishi and Prof. Eric Fossum.

Dr. Theuwissen has been a member of the CEI-Europe Faculty since 1999 and completed over 120 courses for CEI-Europe.