What you see is what you get !?

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Outline

• Introduction : Figure of Merit
• Dynamic Range
• Number of Pixels
• Summary
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Introduction

Figure of Merit (FoM)\(^{(1)}\) =

\[
\log_2(\text{dynamic range}) + \\
\log_2(\text{total number of pixels})
\]

(information content a sensor can deliver)

dynamic range \(\neq\) true linear dynamic range

total number of pixels \(\neq\) effective number of pixels

\(^{(1)}\) see : T.Noguchi, Fuji Photo Film, PICS Conf. 1998.

What you see is what you get !?

What you see in the leaflets or in the brochures, is that what you really get out of the sensor ?

Answer : not always !

Example : dynamic range
True linear dynamic range (1)

\[
= \frac{\text{linear output swing}}{\text{total amount of noise}}
\]

linear output swing = maximum \text{ linear charge content} - \text{dark current}

total amount of noise = \text{amplifier noise} + \text{dark current noise}

True linear dynamic range (2)

- some competitors include the non-linear part of the output swing!
- some competitors do not specify the temperature!
- all competitors do exclude the dark current!
True linear dynamic range (3)

![Graph showing dynamic range vs. pixel rate](image)

What you see is what you get !?

What the pixels see, is that what you get on the monitor or on the hard copy?

Answer: not always!

Reasons: transport inefficiency, electrical and optical cross-talk, non-ideal color filter characteristics.
Transport efficiency (2)

- Transport inefficiency unsharpens the image (B/W) or mixes colors.
- Transport inefficiency effects are NOT correctable!
- Optimised technology, optimised lay-out + design: 4 phase transport.

Seybold Seminar, Boston, 2001 © Albert Theuwissen
Electrical cross talk (1)
Electrical cross talk (2)

![Graph showing normalized amplitude against spatial frequency for 600 nm and 710 nm wavelengths.]

Electrical cross talk (3)

- optimised lay-out + design: vertical anti-blooming (VAB),
- VAB acts as:
  - internal IR filter,
  - dark current reducer,
  - eye curve matcher.
Effect of VAB in Philips’ 6M CCD

Optical cross talk (1)
Optical cross talk (2)

• depends strongly on F number!
• introduction of an optical grid.

Optical grid in Philips’ 6M CCD
Color filter characteristics (1)

Color filter characteristics (2)

- cross color effects are correctable,
- S/N loss (up to 3 dB),
- optimise filter characteristics.
Summary (1)

True linear dynamic range ≠

dynamic range,

In the calculation of dynamic range, the
effect of dark current (noise) needs to
be included!

Summary (2)

Effective number of pixels ≠

total number of pixels,

Philips’ 6M CCD comes pretty close:

• very high transport efficiency (4 phase),
• internal IR cut-off filter to reduce electrical
cross talk,
• optical grid to reduce optical cross talk,
• optimized filter technology for color rendering.
Conclusion

F.o.M.(FTF3020C) = 14 + 22.58 = 36.58

Challenge everybody to do this exercise with every competing sensor!