Light flicker: A reasonable measurement method in view

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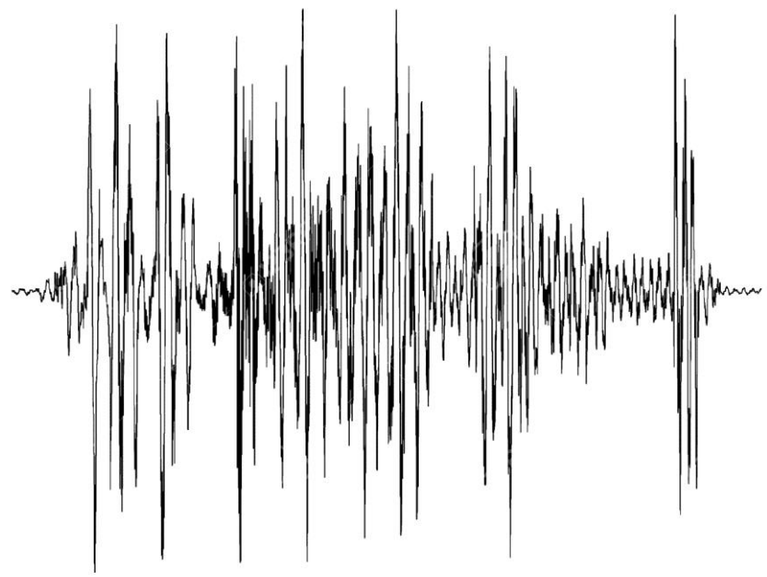
- Light: Classification

- Measurement of modulation
  - Current measuring methods,
  - Their limitations
  - Stroboscope- and phantom array effect
  - Analysis examples



- Goal
  - One single measuring value for all influences according to HCL
  - → CFD, PstLM∞ SVM

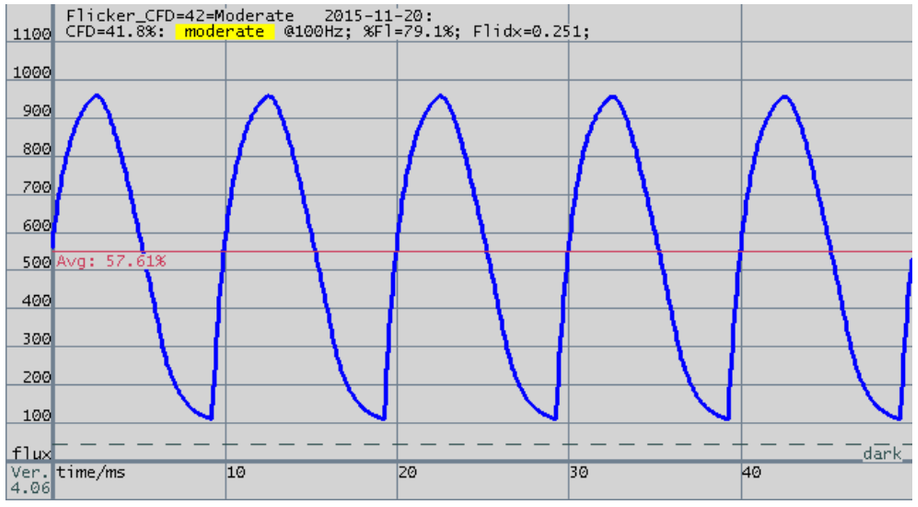
Light: Classification

- Ideal *illuminating* (artificial) light…
  - … w/o modulation (like the sun)...
  - ... requires capacitors

- Contrary: *Informative* light…
  - ... has the information modulated:
  - - Any kind of screens
  - - Special-effect lighting
  - ... wants effects on humans
  - ... may exceed humans compatibleness

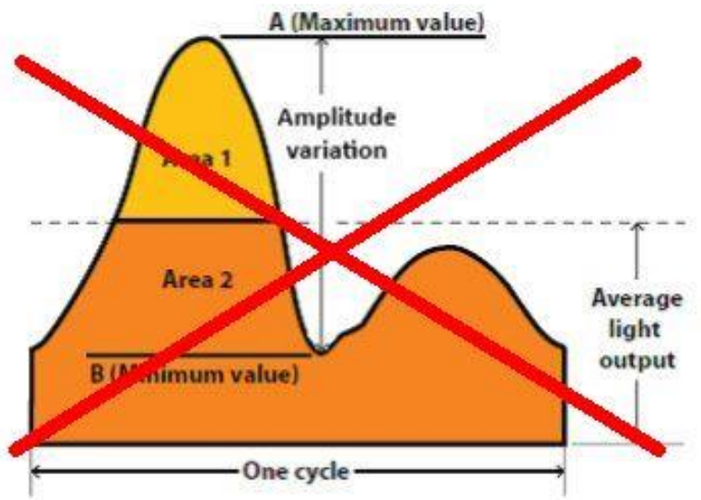
Light: Modulation

- Non-ideal artificial light…
  - … contains modulation...
  - ... with effects on humans

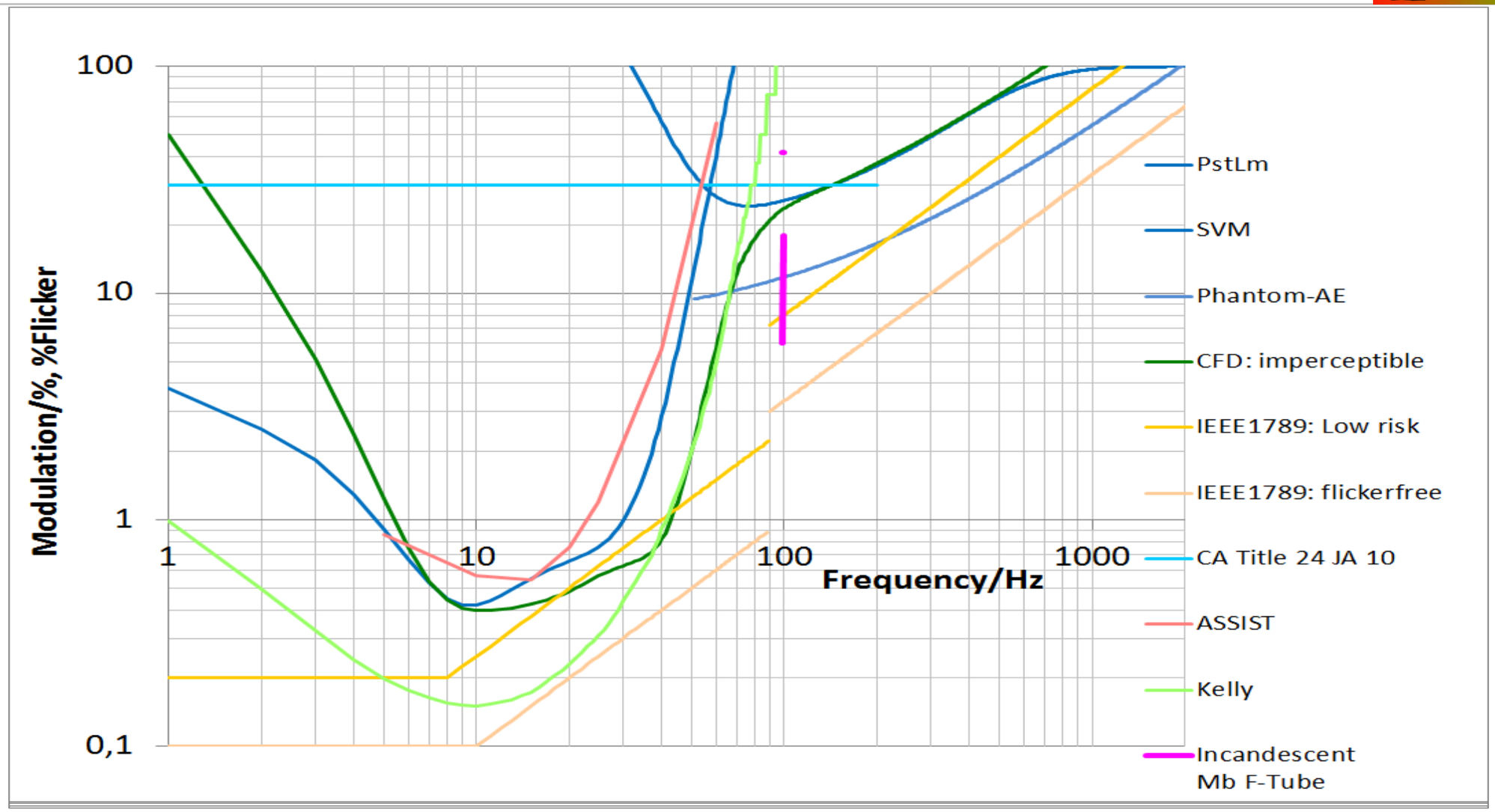


- Perception: different
  - - Directly visible flicker (flicker < 70 Hz)
  - - Non-directly Visible (stroboscopic) flicker (> 70 Hz)
  - - Phantom array effect
  - → CIE : Temporal Light Artefact (TLA)

- Measurement
  - - Only reasonable in frequency domain
  - - So not %Flicker und Flicker index

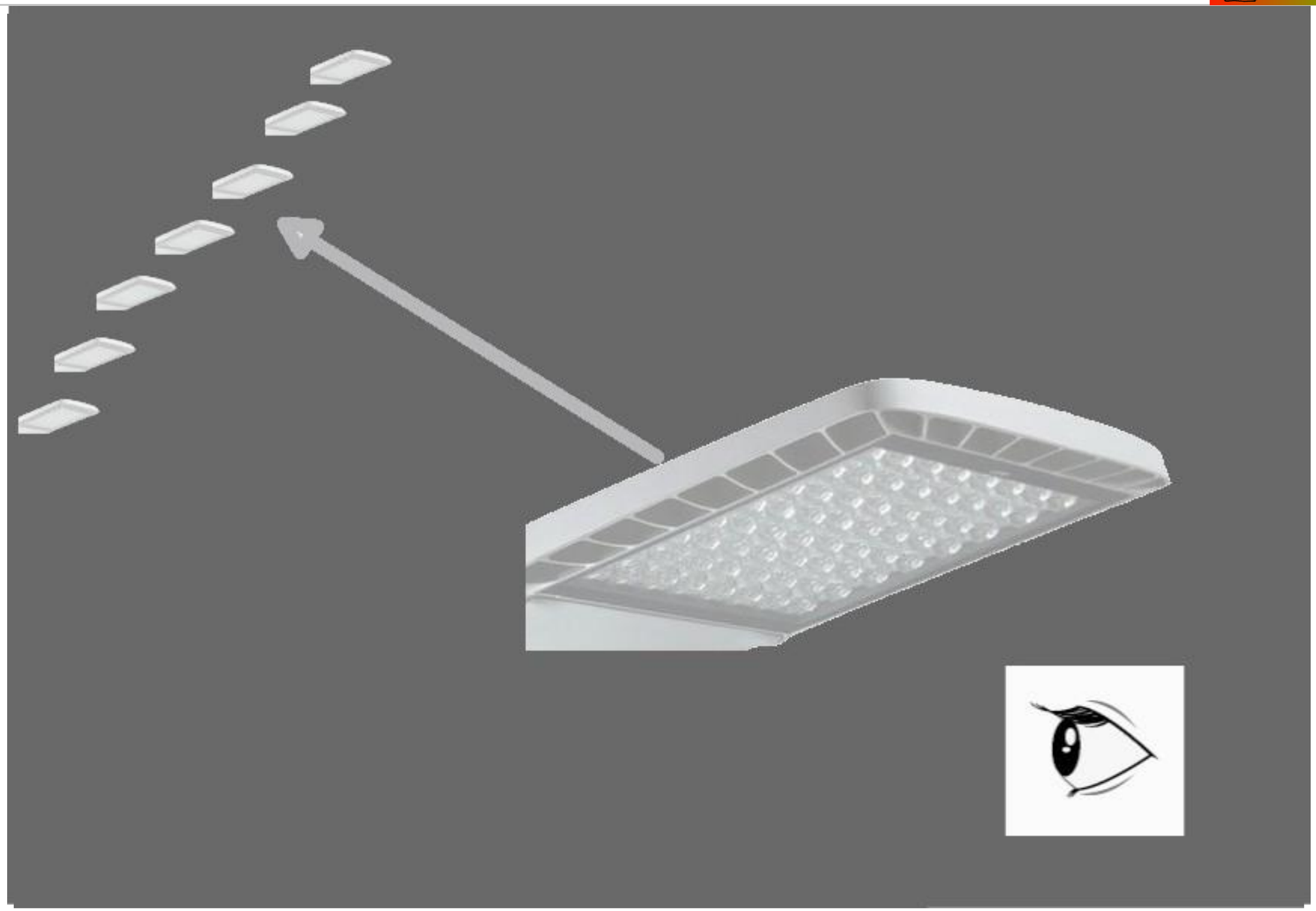


Measurement frequency based



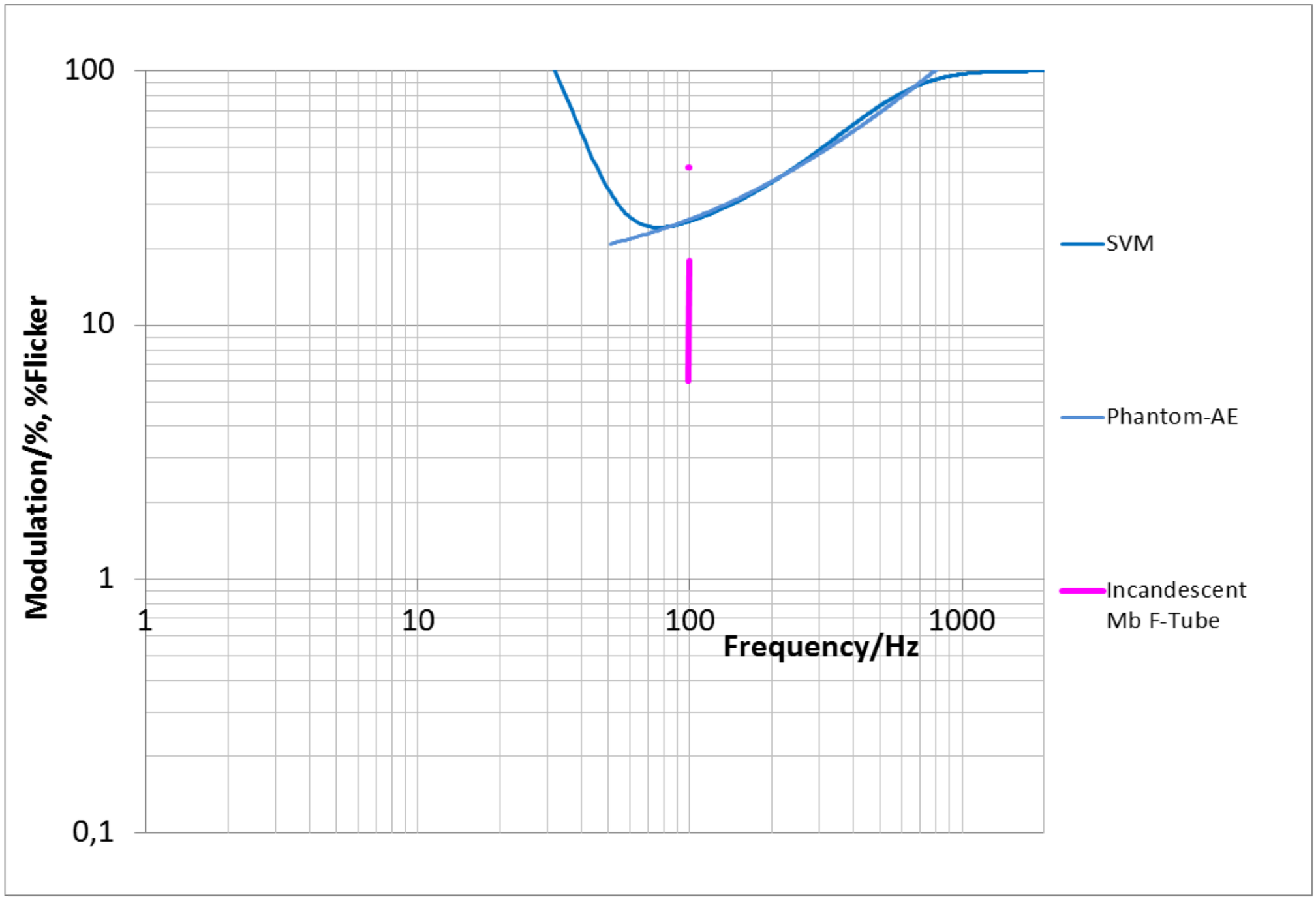
- Perceptibility thresholds
  - CFD (2017): $f_{25\%}$ = 110Hz
  - CIE TN 006:2016
  - - Flicker (PstLM based on IEC/TR 61547-1): $f_{25\%}$ = 55 Hz;
  - - Stroboscopic light (SVM) $f_{25\%}$ = 95 Hz;
  - - Phantom array effect

Stroboscopic and phantom array effect



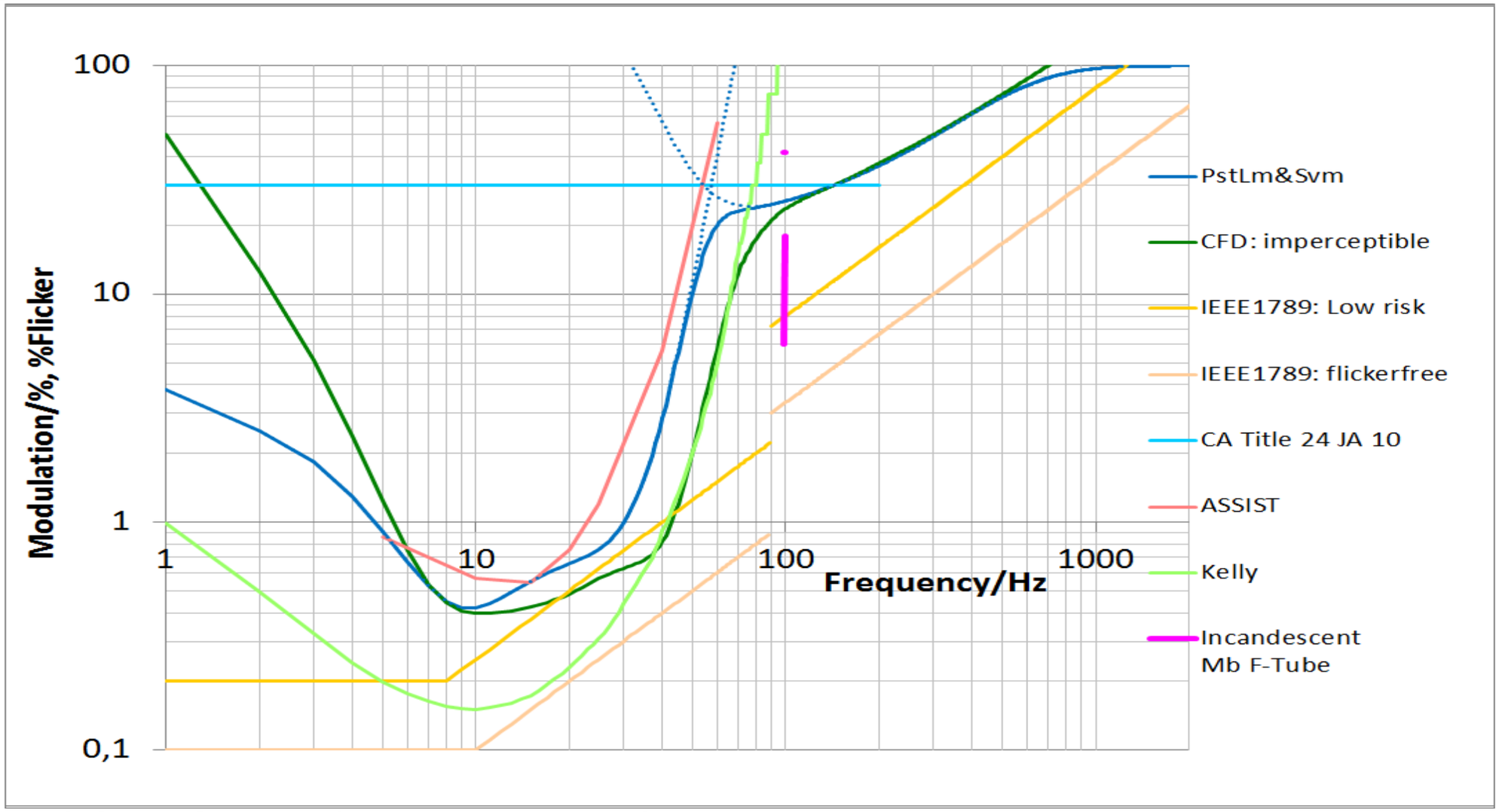
- Phantom array effect

Stroboscopic and phantom array effect



- Phantom array effect ➔ Stroboscopic effect

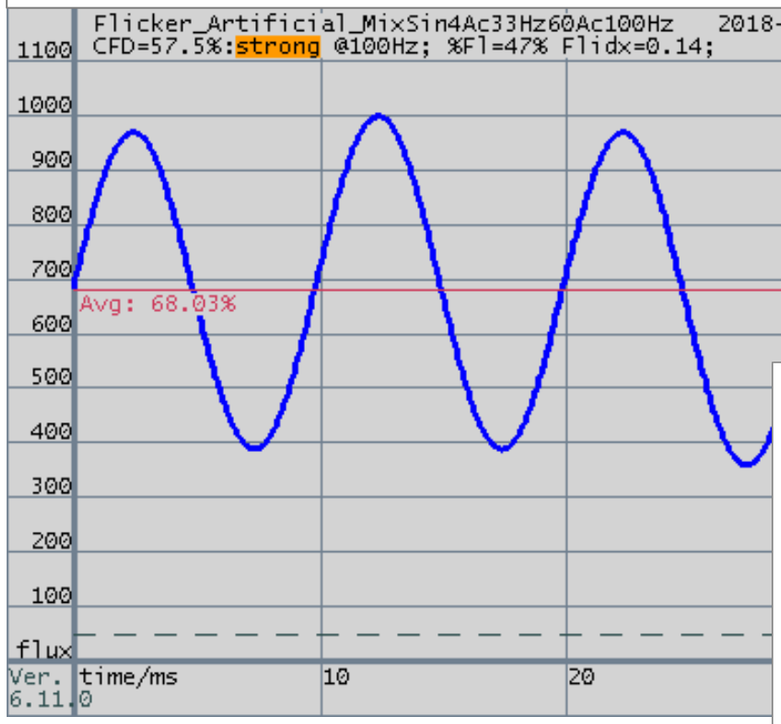
PstLM and SVM

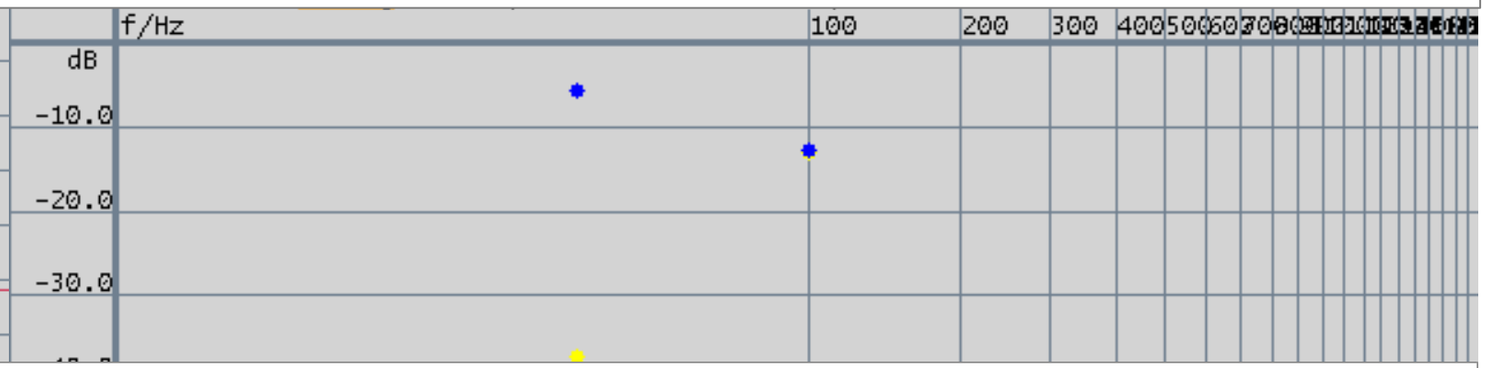


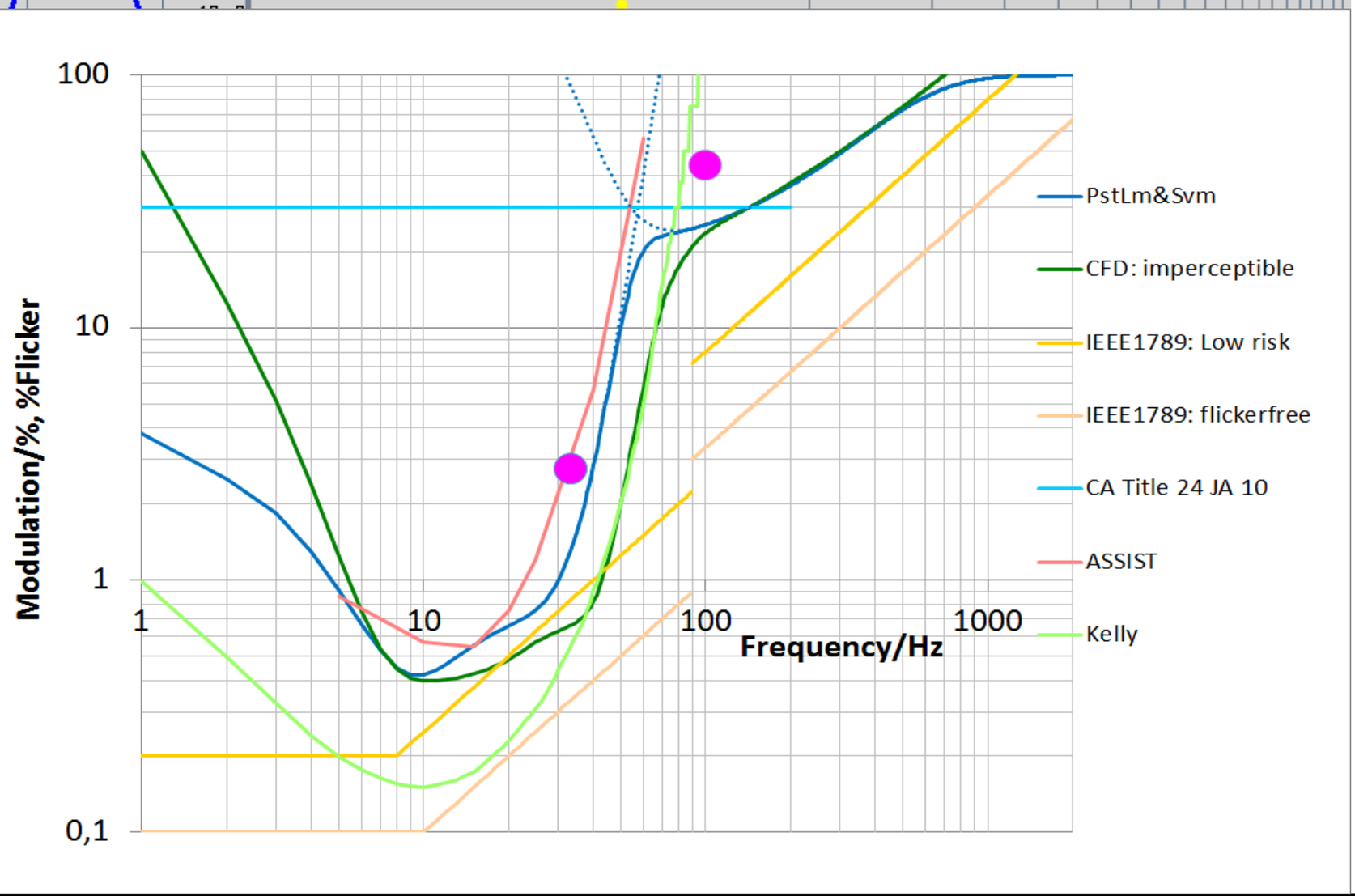
- Combination of PstLM and SVM
  - After merging SVM and phantom array effect:
  - Goal: Merging of PstLM and SVM: Removing the discontinuity at 60..70 Hz.
  - Replacing IEC Pst method into PstLM using SVM formula with new weighting curve.
  - Merge each weighting factor $W(f_{PstLM})$ and $W(f_{SVM})$ via vector-p-norm with p = -1.5.
  - ➔ PstLM & SVM: Frequency range from 1 Hz to 2 kHz in a **single measuring value**.

Examples… No. 1

Sin 33 Hz, MD=2,8% added with Sin 100 Hz, MD=44%



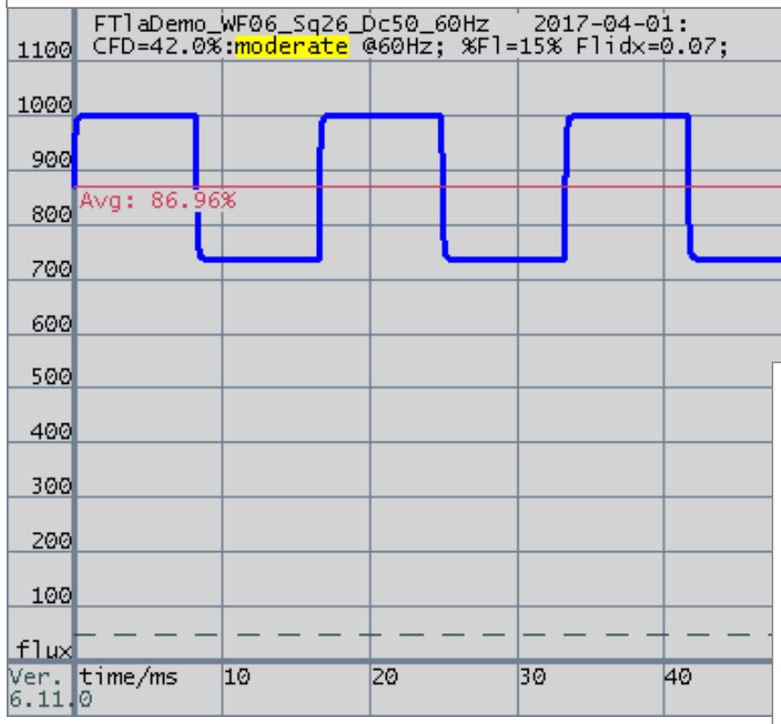


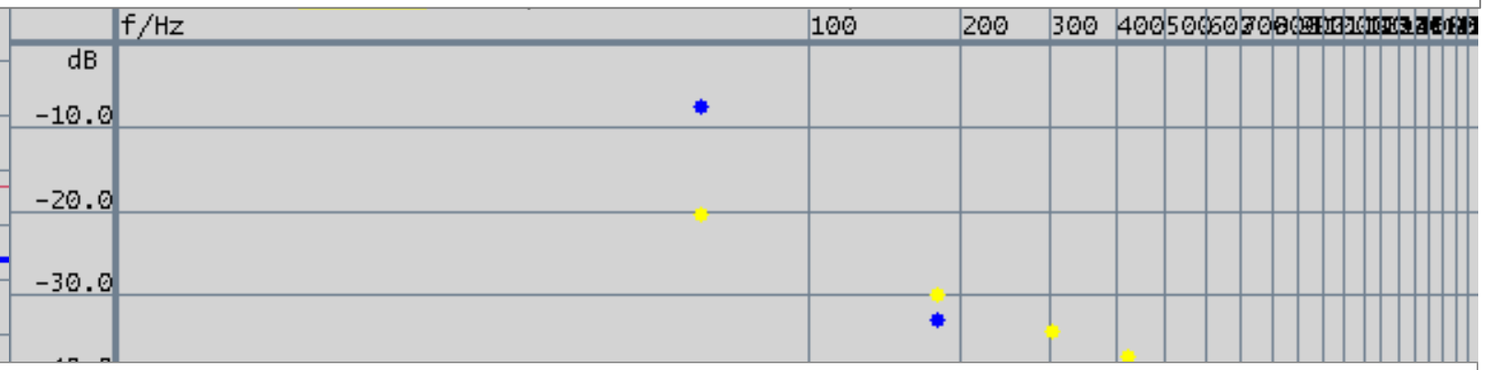


CFD = 57 %
PstLM = 2.18;
SVM = 1.72;
PstLM & SVM = 2.40

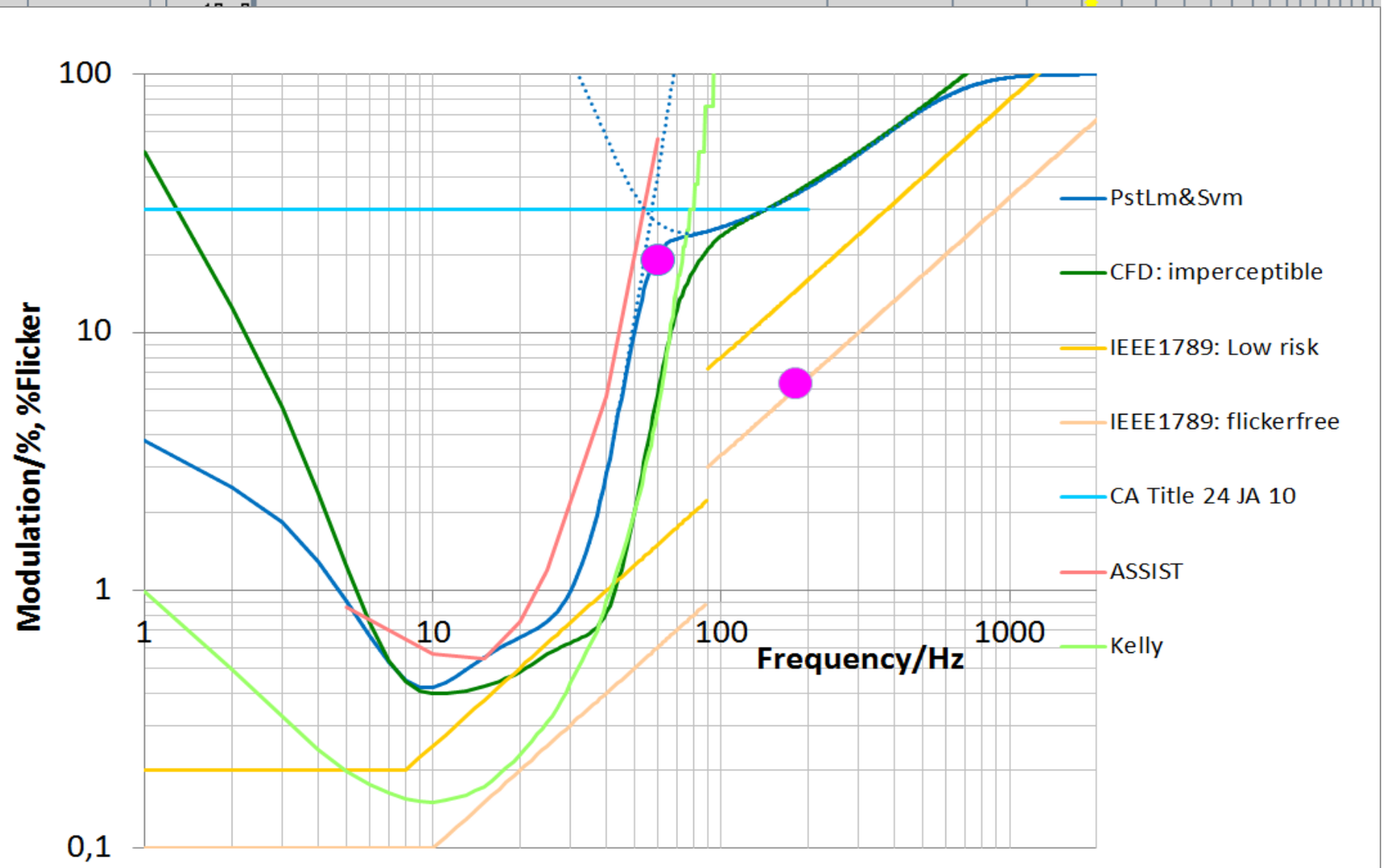
Examples… No. 2

Square, 60 Hz, DC=50%, MD=15%



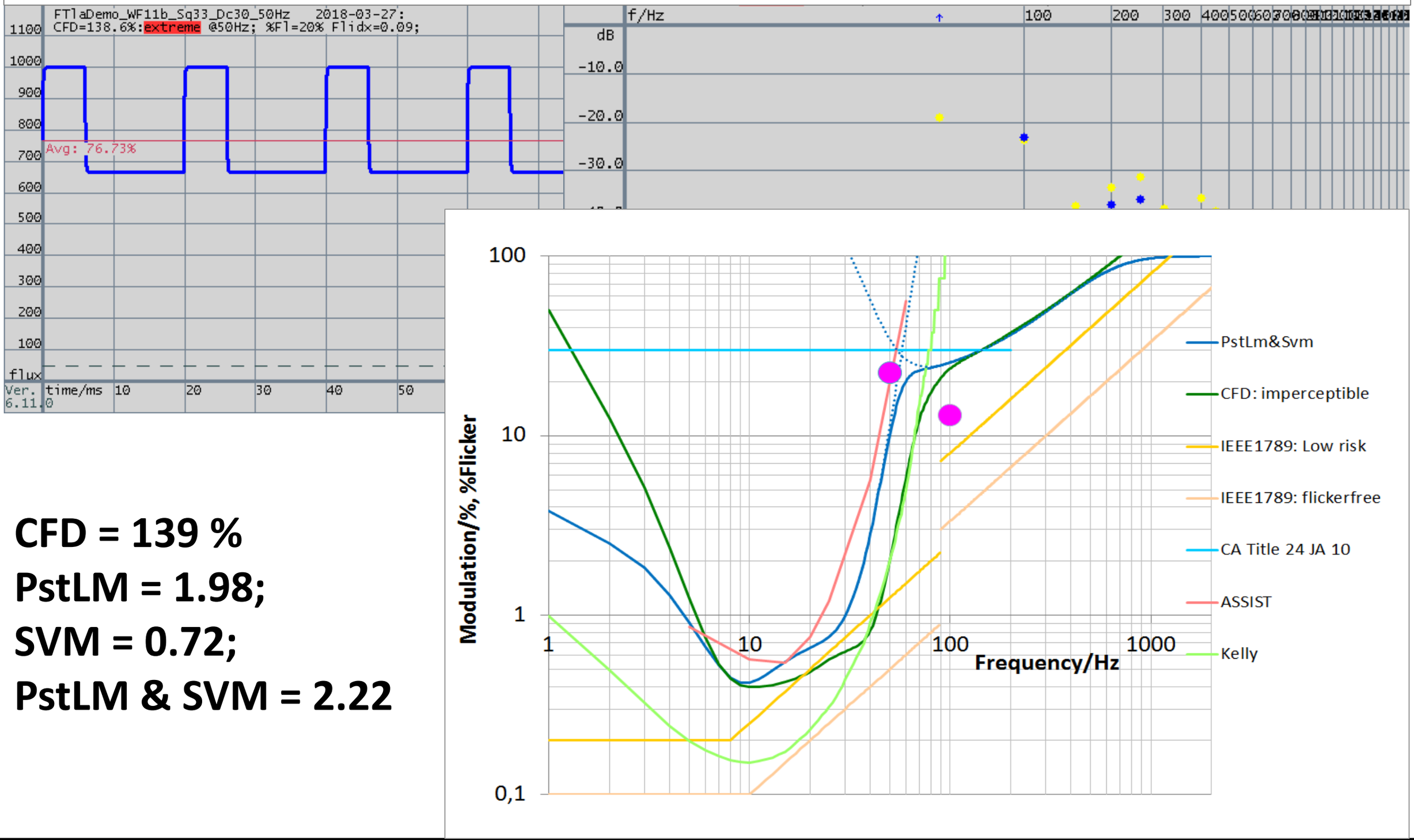


CFD = 42 %
PstLM = 0.48;
SVM = 0.72;
PstLM & SVM = 0.96



Examples… No. 3

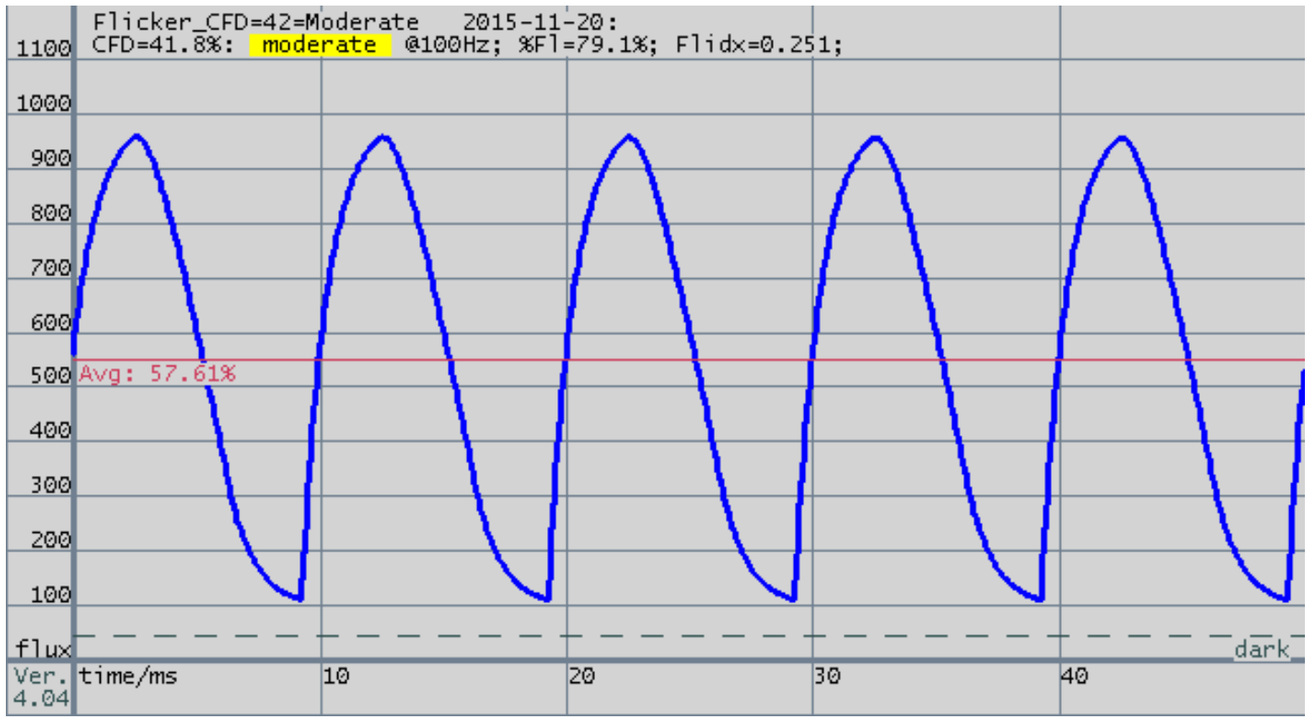
Square, 50 Hz, DC=30%, MD=20%



CFD = 139 %
PstLM = 1.98;
SVM = 0.72;
PstLM & SVM = 2.22

Assessment

- **Signal at 100 Hz**



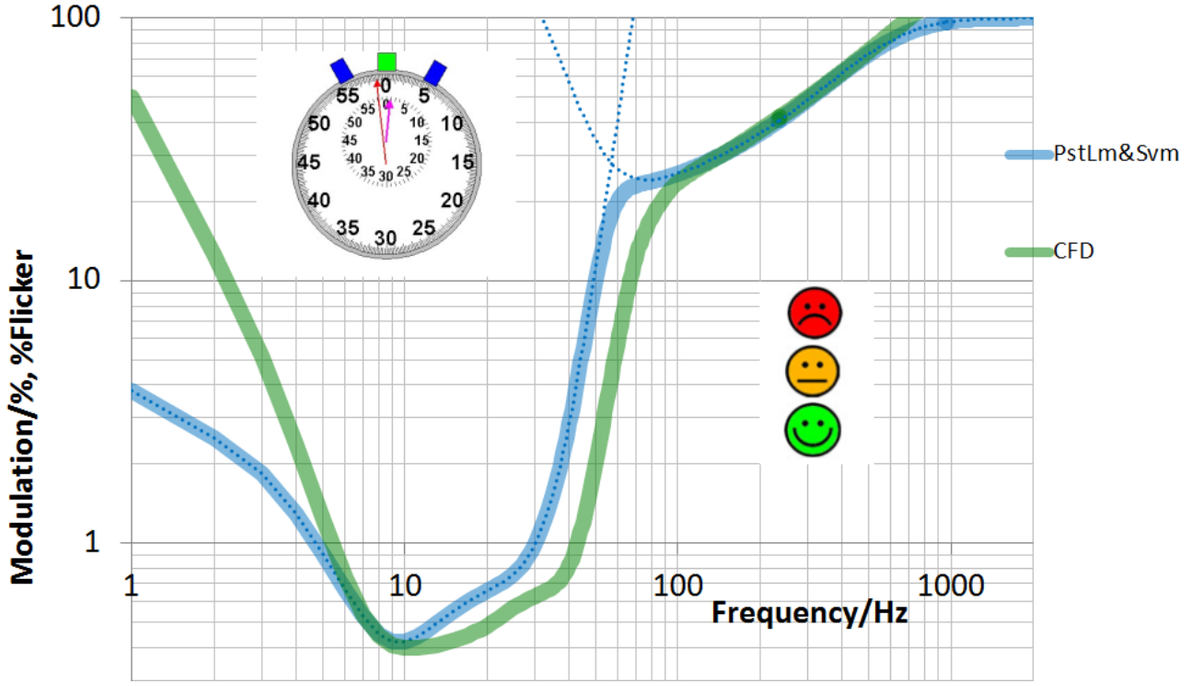
	CFD	PstLM&**SVM** (graph)		**Effect**
❑	0 … 1%	0 … 0,1	(0.0)	None
❑	1% … 12%	0.1 … 1	(0.4)	Not perceptible
❑	12% … 25%	1 … 2	(1.5)	Acceptable (i. e. MB-FLT)
❑	25% … 50%	2 … 4	(3.1)	Moderate
❑	50% … 75%	4 … 6	(4.8)	Strong (Strobe effect)
❑	> 75%	> 6	(8.0)	Extreme (Strobe effect)

Other aspects

- Dimming
  - Whether leading edge, trailing edge, PWM (also spread spectrum):
    Multiple measurement dimmed: worst value → Final value
- Control gears
  - Testing in conjunction with specified load
- Mains flicker
  - Stimulation on the DUT, reference: 60W incandescent bulb
- Camera applications, barcode scanners
  - … and other technical cross influences: special aspect
- Other beings
  - … like birds, nocturnal animals: MD<50%, TLA<1.5, CFD<25%

Consequence

- Light modulation measurement requires…
  - Sampling **>20 kHz** & capt. for **1s**.
  - FFT with 1 Hz resolution.
  - Frequency weighting @ 1 Hz .. ≥ 2 kHz.
  - Summation to single result, allowing easy assessment.



- 2 possible measuring methods…
  - … - CFD.
  - … - PstLM combined with SVM → TLA.
  - … → communicable in the technical data.
  - … → eligible for standard limits.

We have listened to:

Light flicker:
A reasonable measurement method in view

Thank you for your attention.

→ Discussion

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https://www.derlichtpeter.de/

Literature (EuP-Proposal for the new EU Eco-Design Directive):
http://www.eup-network.de/fileadmin/user_upload/Lichtquellen_Flimmern_Erwin_2017_10_EN.pdf