# $P_{st}$ and $P_{lt}$ Concepts
## IEEE 1453 and IEC 61000
### P = Perception of Flicker

Voltage changes on the grid could result in observable "Flicker" from lighting equipment.
If the voltage changes are sudden, frequent or have large amplitude ... it is irritating to humans.

IEEE and IEC are converging on standards to quantify this Perception of Flicker

IEEE and IEC standards specify measuring the Perception of Flicker with a qualifying "Flicker Meter".
the standards specify:
- $P_{st}$ = short term perception
- $P_{lt}$ = long term perception

Real time $P_{st}$ must be measured and "statistically evaluated" with an IEEE or IEC compliant flicker meter.

a purely analytical calculation of $P_{st}$ is likely impossible ... it requires memory of past events.

$P_{st}$ is based upon an observation or measurement period of ten (10) minutes.
$P_{lt}$ is then calculated from twelve (12) consecutive $P_{st}$ values.
the max of these measured values over a few weeks would determine flicker severity.

a $P_{st}$ measurement >= 1.0 indicates an "irritating" flicker level.

### Recommended Max Levels

|          | MV  | HV - EHV |
|----------|-----|----------|
| $P_{st}$ | 0.9 | 0.8      |
| $P_{lt}$ | 0.7 | 0.6      |

$1\,kV < MV < 35\,kV$
$35\,kV < HV < 230\,kV$
$230\,kV < EHV$

the $P_{st}$ short-term evaluation of flicker severity is based upon an observation period of 10 minutes.
after all the measurements over the 10 minute period have been collected...
$P_{st}$ is evaluated with:

$$P_{st} = \sqrt{0.0314P_{0.1} + 0.0525P_{1s} + 0.0657P_{3s} + 0.28P_{10s} + 0.08P_{50s}}$$

*no smoothing*

*where:*
$P_{0.1}$ $P_{1s}$ $P_{3s}$ $P_{10s}$ *and* $P_{50s}$
*are the %flicker levels that are exceeded for*
*0.1  1  3  10  and  50 % of the time.*
*the subscript "s" represents smoothed or averaged values using :*

$$P_{1s} = \frac{P_{0.7} + P_1 + P_{1.5}}{3}$$

$$P_{3s} = \frac{P_{2.2} + P_3 + P_4}{3}$$

$$P_{10s} = \frac{P_6 + P_8 + P_{10} + P_{13} + P_{17}}{5}$$

$$P_{50s} = \frac{P_{30} + P_{50} + P_{80}}{3}$$

*the "P" terms on the right side of these equations represent the flicker levels*
*that are exceeded a percent of the time specified by the subscript.*
*for example:*
$P_{1.5}$ *represents the flicker level that is exceeded 1.5% of the time.*

# $P_{st}$ and $P_{lt}$ Concepts (cont.)

The $P_{lt}$ long-term evaluation of flicker severity is calculated from 12 successive $P_{st}$ values.
(12 - 10 minute periods or a two hour evaluation)
$P_{lt}$ is calculated with:

$$P_{lt} = \sqrt[3]{\frac{1}{12} \sum_{i=1}^{12} P_{st_i}^3}$$

this equation shows that the 2 hour $P_{lt}$ value will be less than the largest 10 minute $P_{st}$ value.
it also shows that if all $P_{st}$ values are equal, then $P_{lt} = P_{st}$
(which is true for voltage changing wave forms that are periodic and rectangular)

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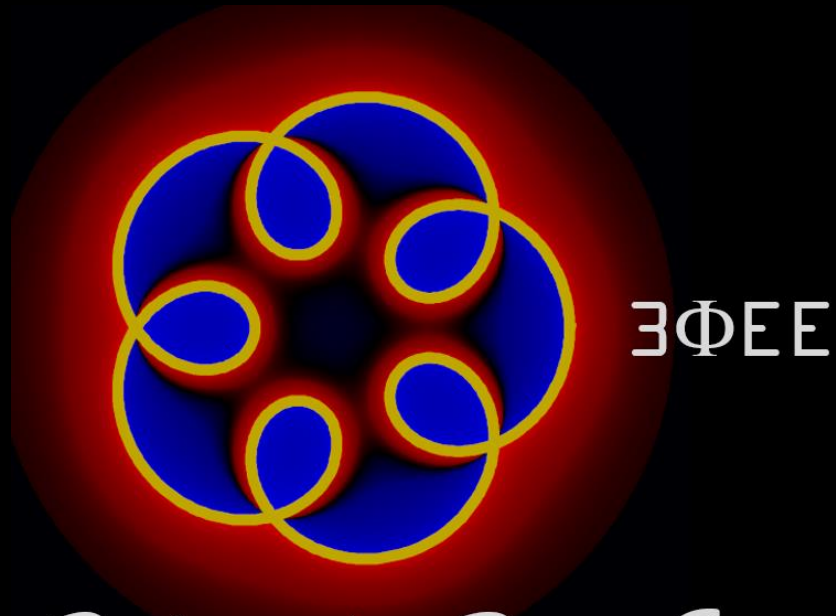
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Questions or Comments …