CONTROL SIGNAL VS. PHASE ANGLE IN AC RECTIFIERS

APPLICATION NOTE

BACKGROUND INFORMATION.

There are lots of inquiries about the phase angle regulation systems, especially regarding to the control signals and to the output voltage.

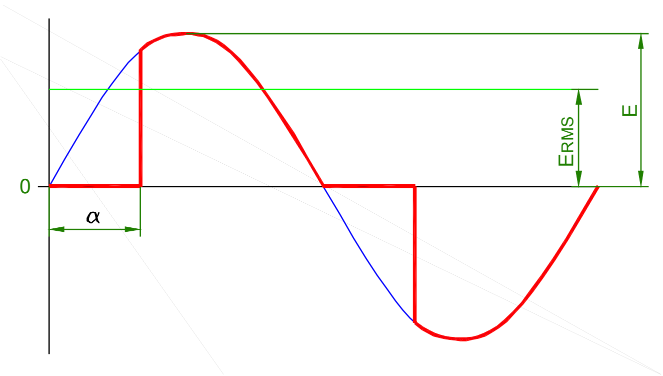
PHASE ANGLE REGULATION.

Phase angle regulation, it’s based on the possibility to realize the connection to the mains power supply at any point of the half wave and in a synchronous way. Thus, sinusoidal voltage can be cut in little sectors, so, in this way regulating the load power.

Considering that each sinusoidal half wave corresponds to a conduction of 180º (360º for the full wave), using a delay from 180º to 0º it’s possible to regulate the load power from 0 to 100%. This delay value it’s called «angle of delay» and it’s symbolized with α letter. Also, there’s the «conduction angle» which is 180-α.

E_{RMS} VS ANGLE OF DELAY.

Analyzing the obtained waveform by regulating the angle, we can appreciate that E_{RMS} vs angle of delay is nonlinear, due to the variation of the waveform which ceases to be sinusoidal. It is important to emphasize that in this applications, the measures must be done by a true RMS instrument.



Use the formula below to calculate the E_{RMS} output value versus the angle of delay:

$$E_{RMS}(\alpha)=\frac{E}{\sqrt{2\Pi}}\sqrt{\Pi-\alpha+\frac{1}{2}\sin 2\alpha}$$

NOTE: α in radians

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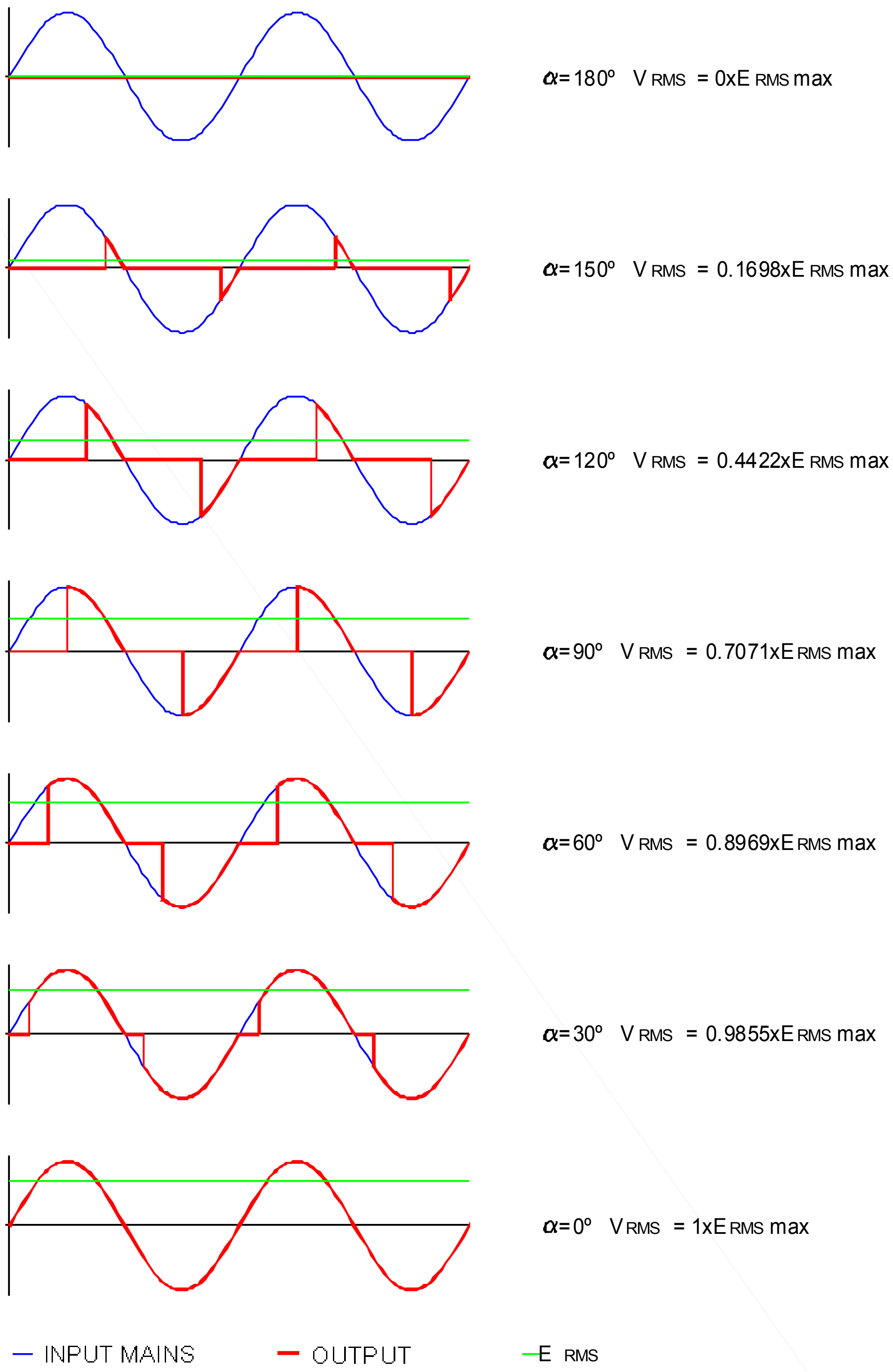
APPLICATION NOTE

Below we can appreciate the waveform and the E_{RMS} values regarding different angle delays.



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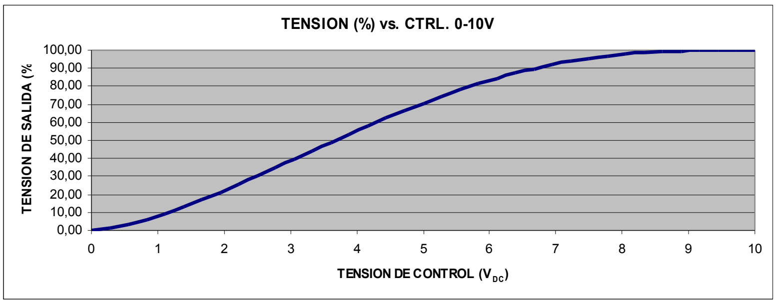
CONTROL SIGNAL VS ANGLE OF DELAY

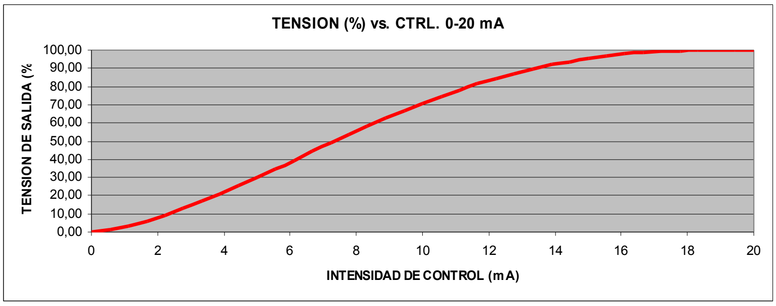
Common control systems (specially the analogical), uses the control signal to adjust linearly the thyristors angle of conduction, like the relation between the conduction angle (remember that conduction angle is 180-α) and the E_{RMS} voltage which it's not linear. We will always have a nonlinear relationship between the control signal and the output voltage.

Below the graphics for a common control signals.



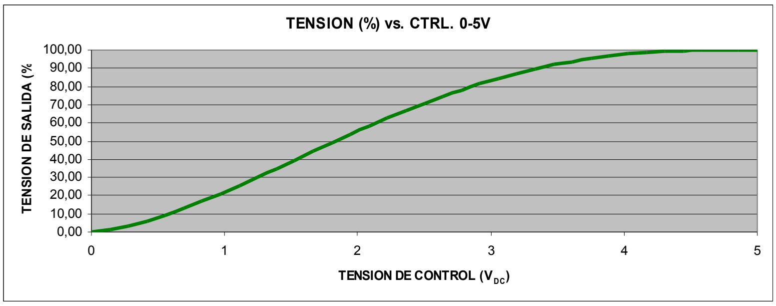
Polynomical approach (valid between 0 and 10)

$y = 0{,}0241x^4 - 0{,}645x^3 + 4{,}614x^2 + 4{,}2201x - 0{,}167$



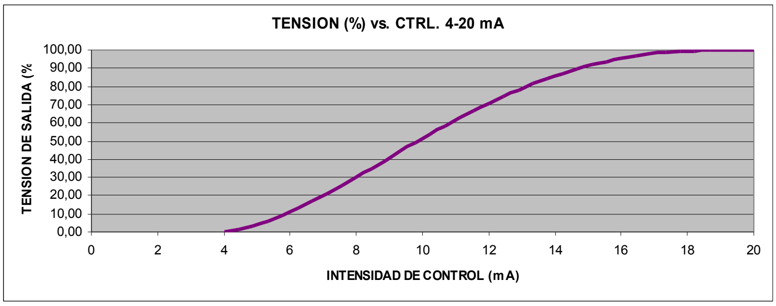
Polynomical approach (valid between 0 and 20)

$y = 0{,}0015x^4 - 0{,}0806x^3 + 1{,}1535x^2 + 2{,}1101x - 0{,}167$



Polynomical approach (valid between 0 and 5)

$y = 0{,}3863x^4 - 5{,}16x^3 + 18{,}456x^2 + 8{,}4403x - 0{,}167$



Polynomical approach (valid between 0 and 20)

$y = 0{,}0037x^4 - 0{,}2164x^3 + 4{,}0457x^2 - 20{,}283x + 29{,}141$

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