6-pulse controlled rectifier (ideal operation)

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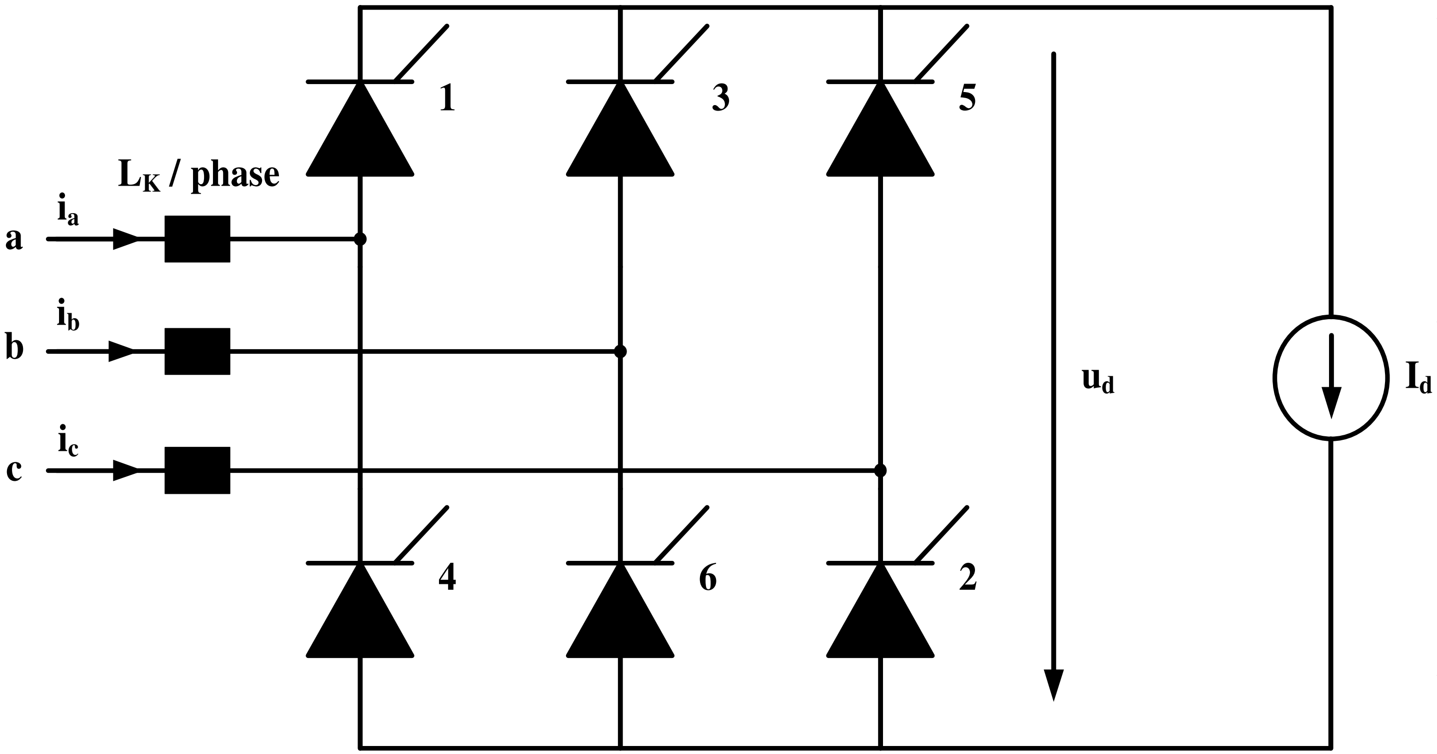
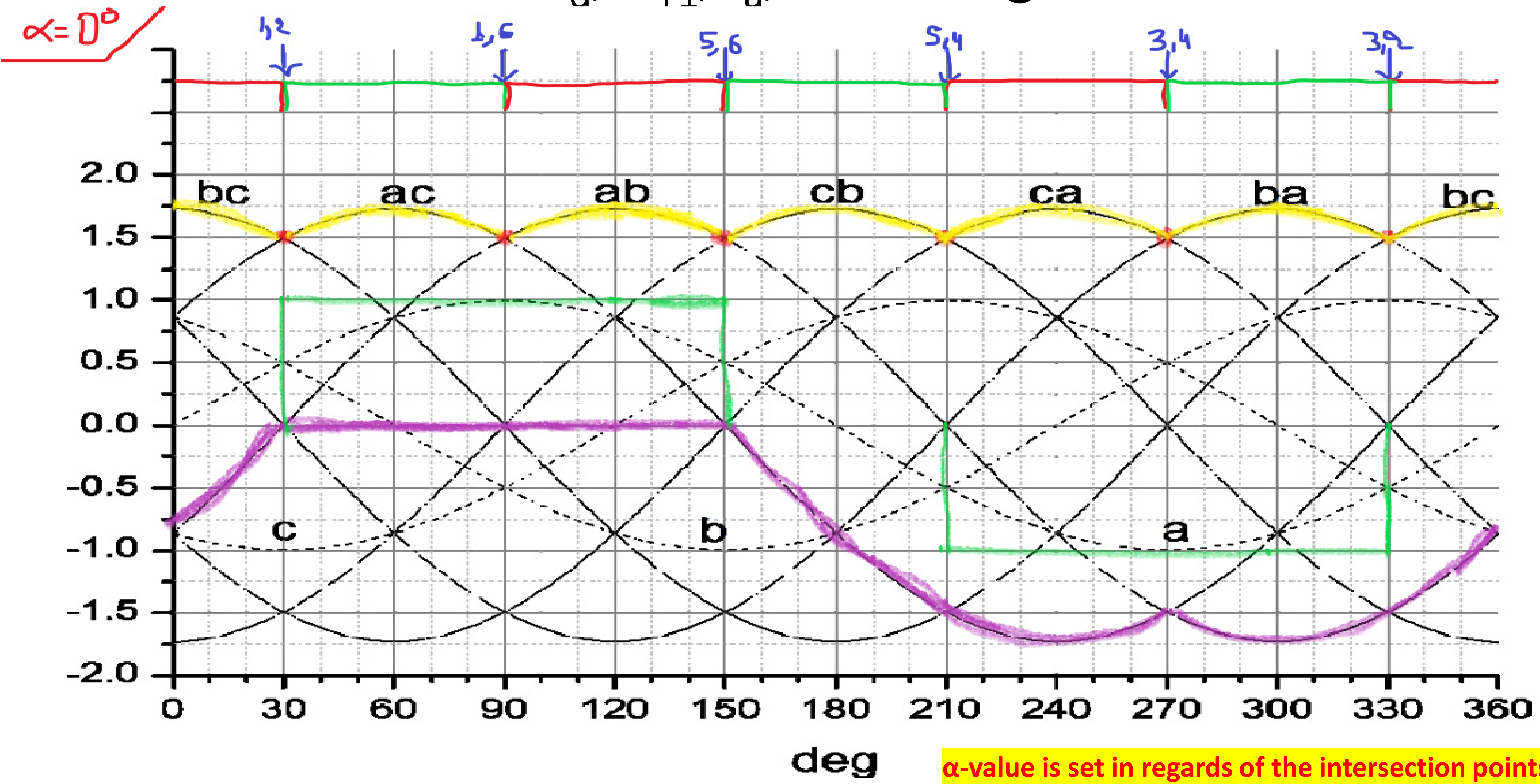
Principles of Operation



- Symmetrical operation under maximum possible dc voltage gain is achieved by the simultaneous operation of 2-SCRs per 60 degrees (6-pulses per line period).
- Every voltage pulse is driven by the operation of the common cathode SCR with the highest (most positive) Anode voltage and the common anode SCR with the lowest (most negative) Anode voltage.
- The above mentioned voltages refer to the operation as diode-bridge rectifier (α = 0 deg)

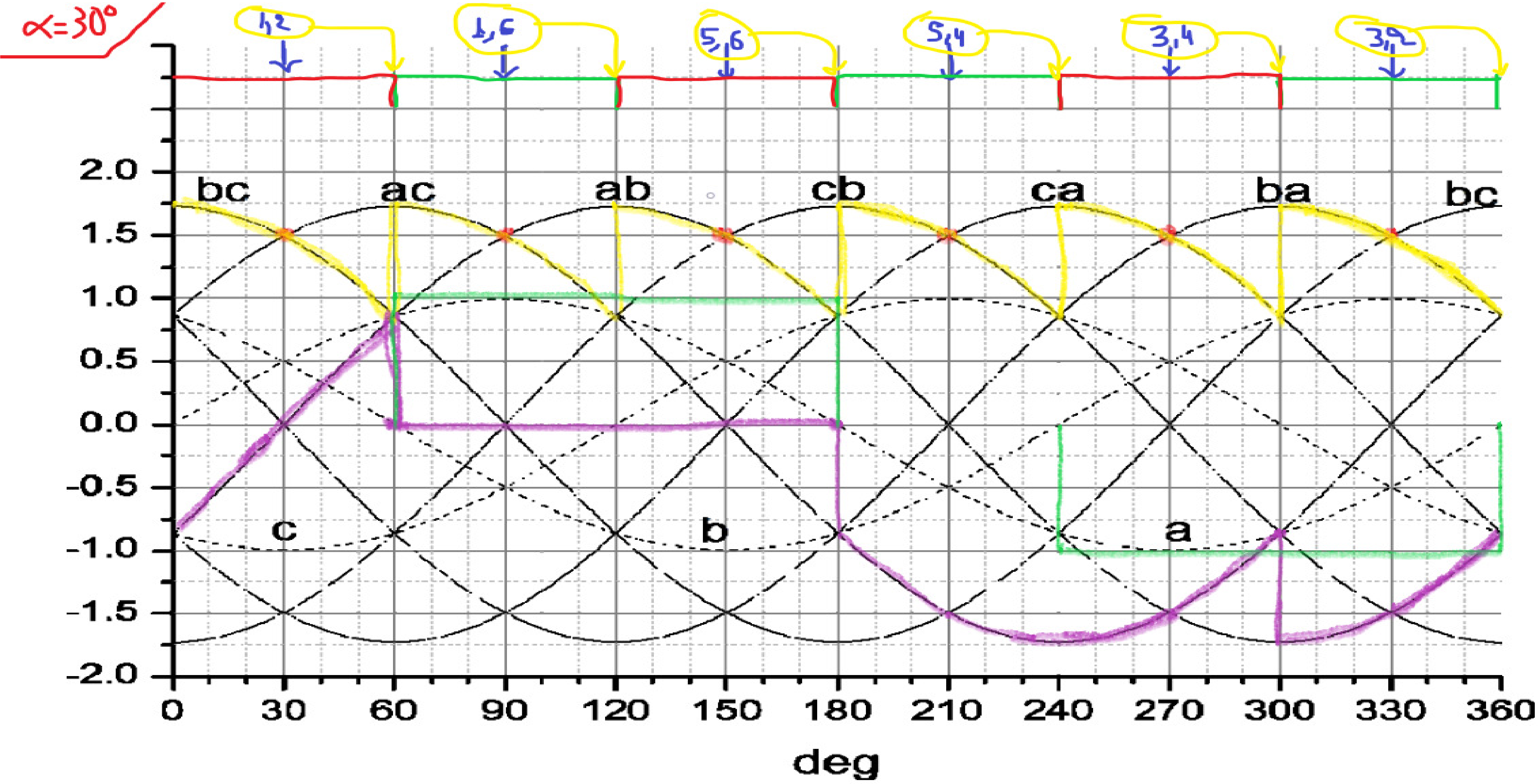
Pulses sequence: 2,1 (ac) → 1,6 (ab) → 6,5 (cb) → 5,4 (ca) → 4,3 (ba) → 3,2 (bc)

u_d, u_{T1}, i_a, α = 0 deg

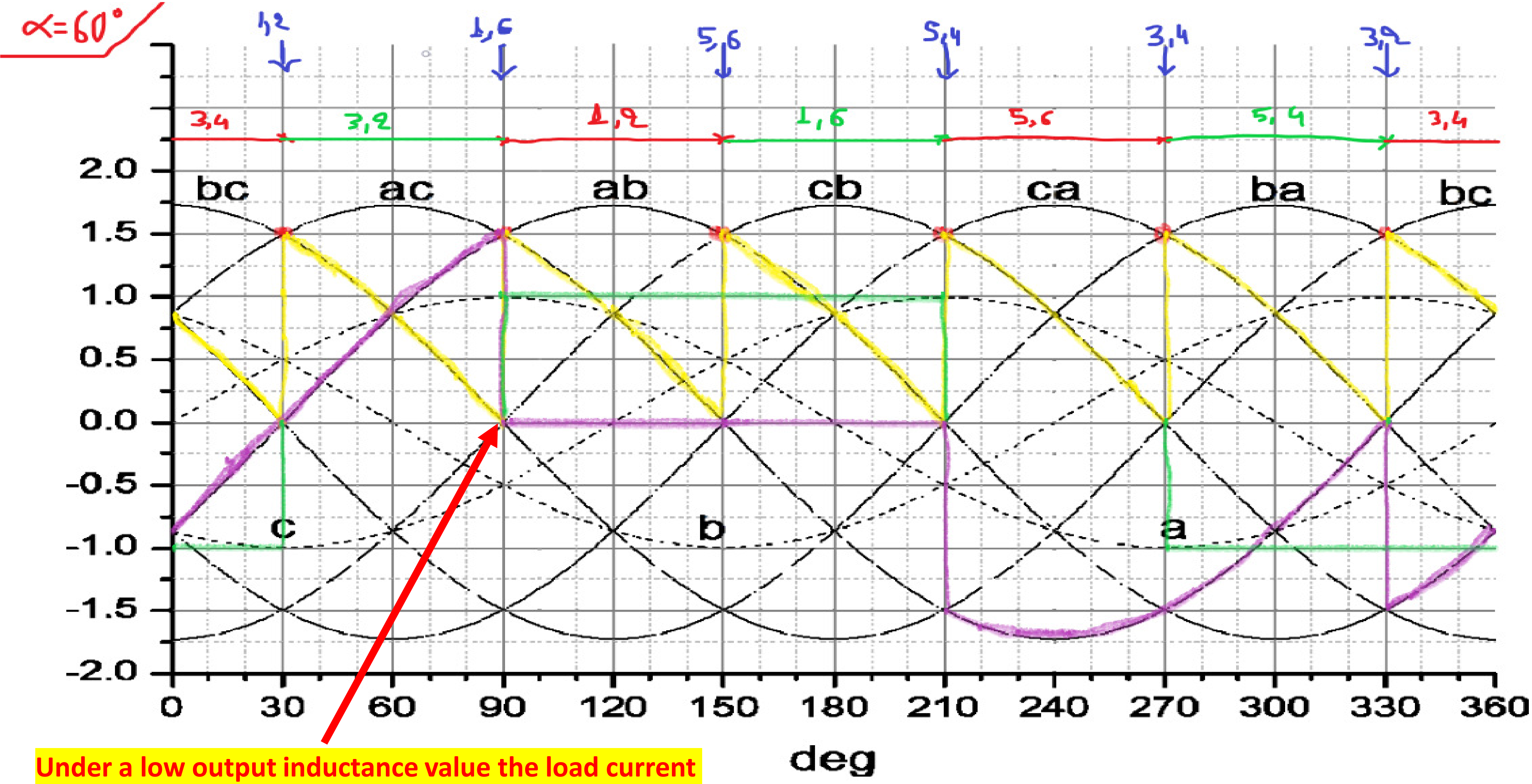


α-value is set in regards of the intersection points of line-to-line voltage waveforms

u_d, u_{T1}, i_a, α = 30 deg

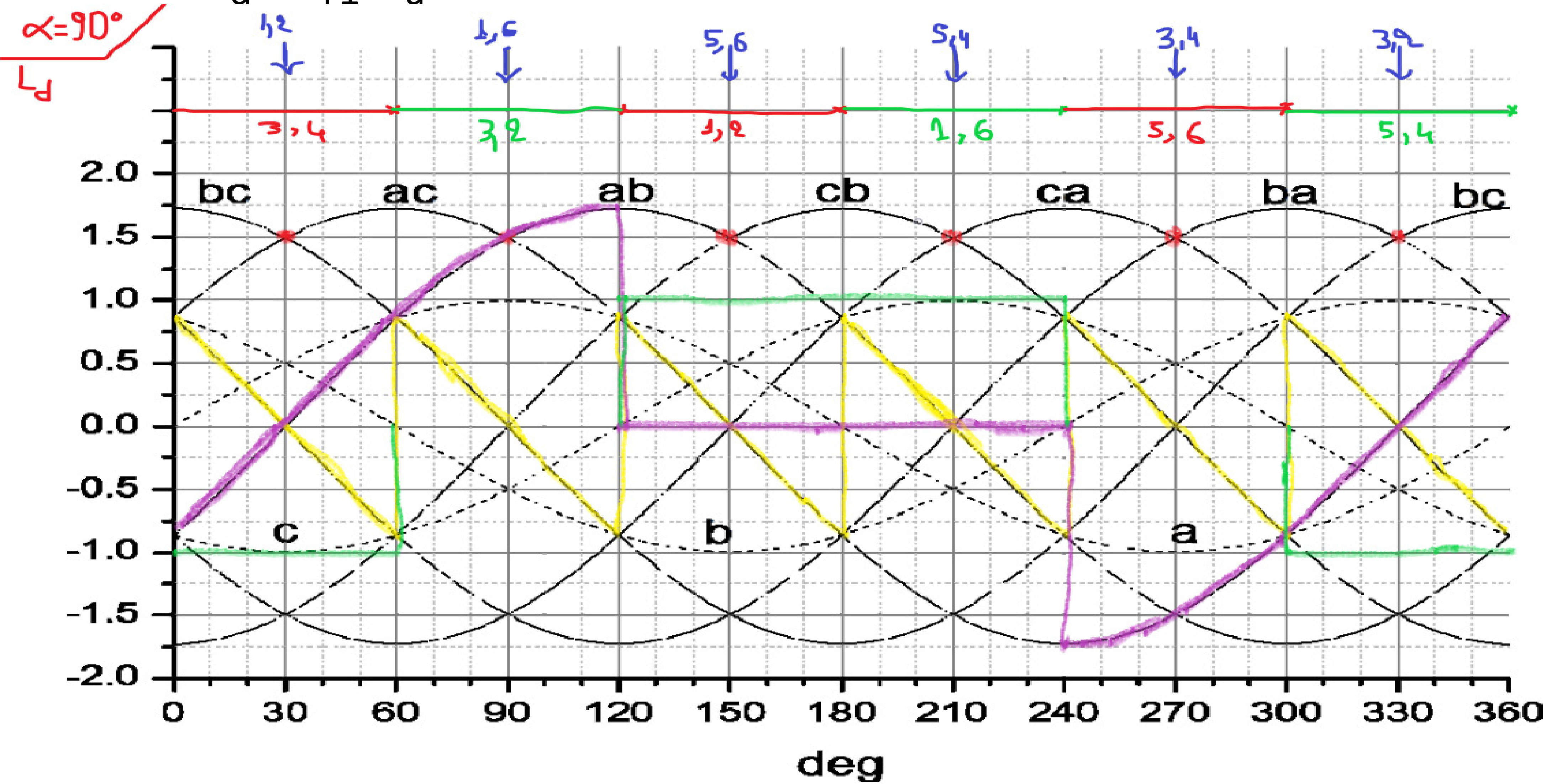


u_d, u_{T1}, i_a, α = 60 deg



Under a low output inductance value the load current becomes zero; need for double pulses (α ≥ 60 deg)

u_d, u_{T1}, i_a, α = 90 deg (continuous conduction)



Average dc-voltage output

- Output dc-voltage (U_d) depends on the firing angle value
- At α = 90deg, $U_d = 0$
- U_d can be calculated by the surface of u_d-waveform over a line cycle
- Ideal continuous conduction operation (zero losses and commutation angle):

$$U_d = \frac{3\sqrt{2}}{\pi} V_{LL} \cos a \rightarrow \begin{cases} 0\,\text{deg} \le \alpha < 90\,\text{deg},\ \text{Rectifying Mode } (\text{U}_d > 0) \\ \alpha = 90\,\text{deg},\ \text{U}_d = 0 \\ 90\,\text{deg} < \alpha \le 180\,\text{deg},\ \text{Line Commutated Inverting Mode } (\text{U}_d < 0) \end{cases}$$

Current-values calculations (Continuous Conduction Mode)

- Output dc-current (I_d) depends on torque load
- Average SCR current value:

$$I_T = \frac{120\deg}{360\deg} I_d = \frac{1}{3} I_d$$

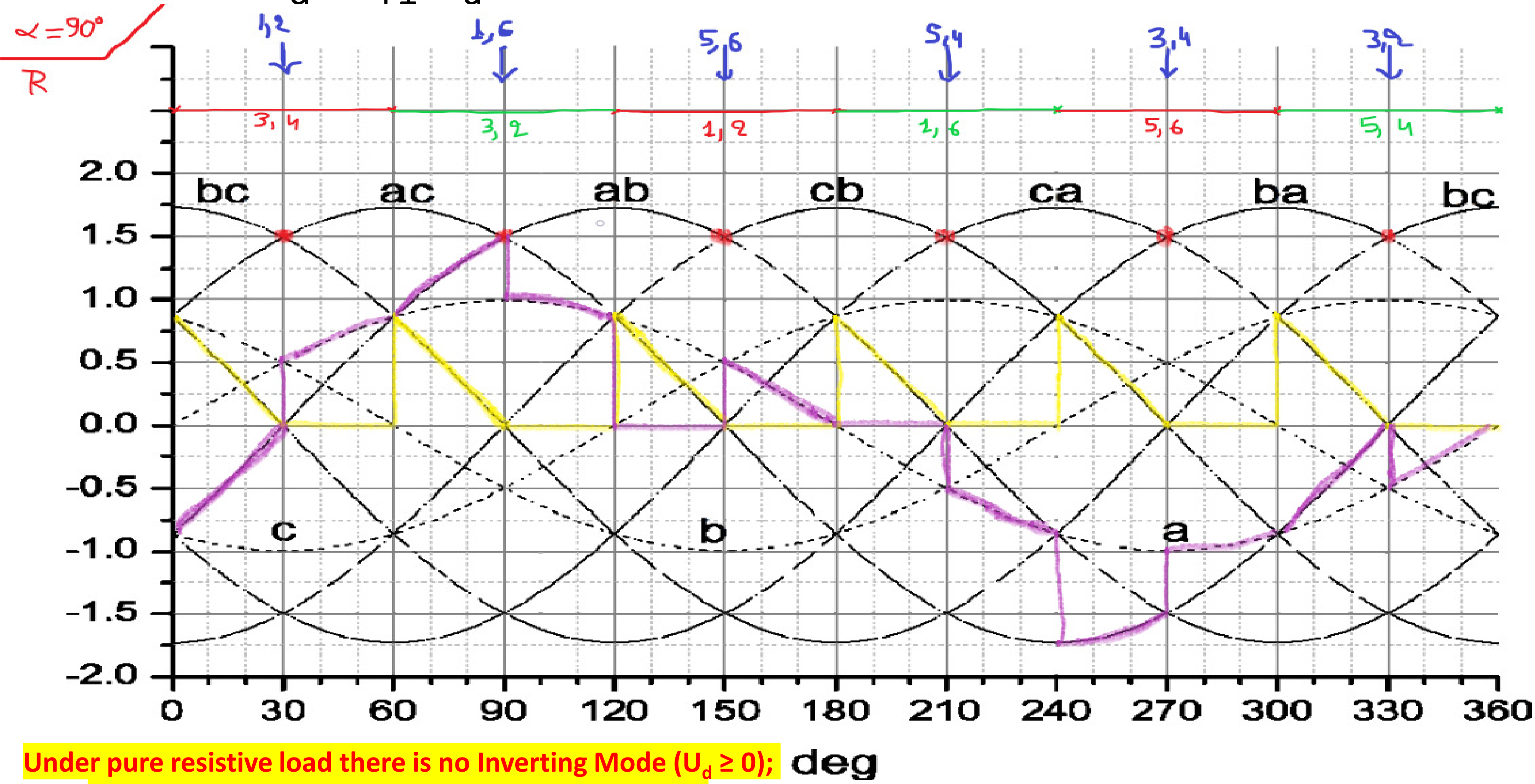
- rms SCR current value:

$$I_{T,rms} = \left[\frac{1}{2\pi} \int_{\alpha}^{\alpha+\frac{2\pi}{3}} I_d^2 d\varphi \right]^{1/2} = \frac{1}{\sqrt{3}} I_d$$

- rms Phase current value:

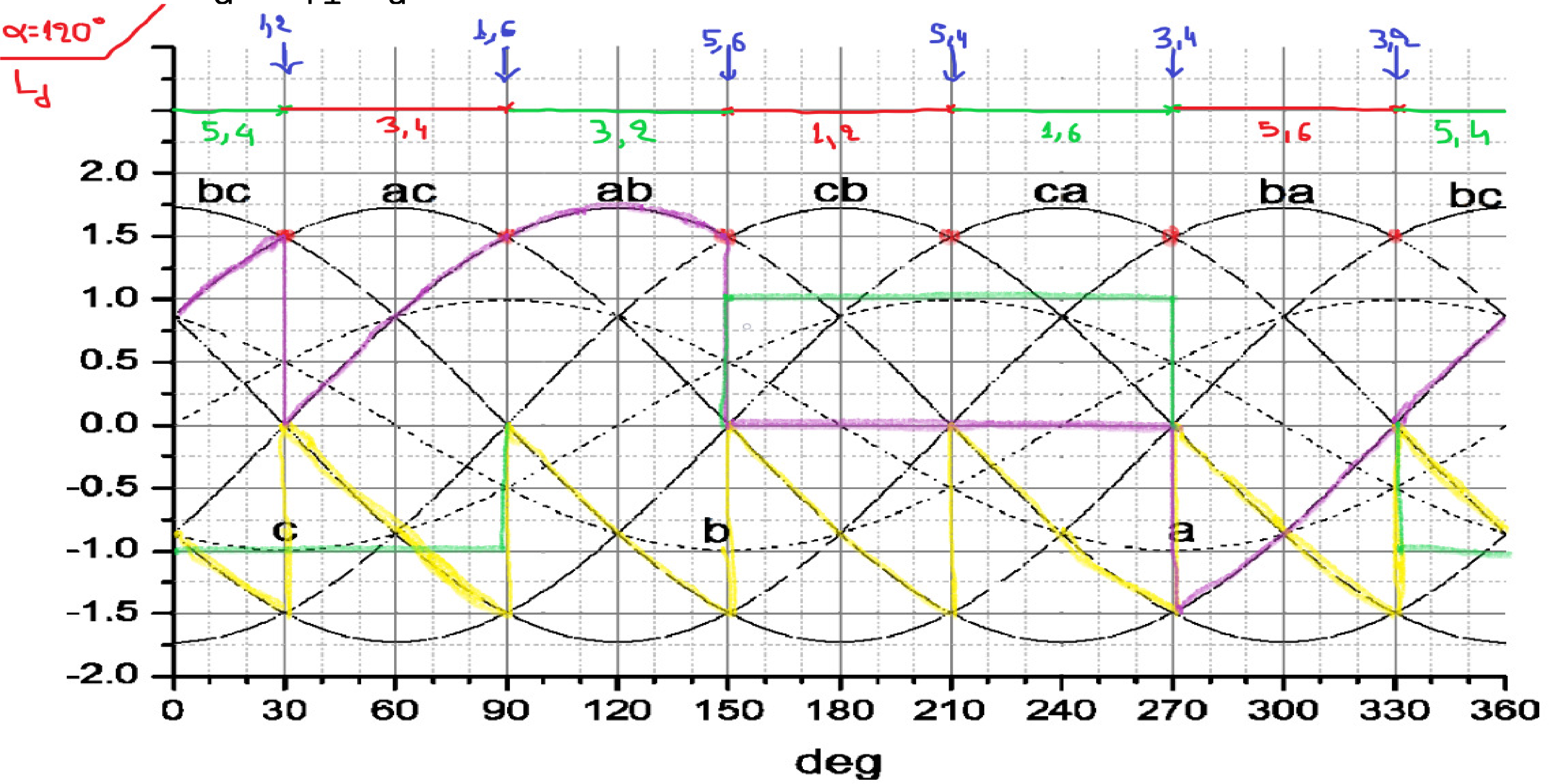
$$I_{ac} = \left[\frac{1}{2\pi} \left\{ \int_{\alpha}^{\alpha+\frac{2\pi}{3}} I_d^2 d\varphi + \int_{\pi+\alpha}^{\pi+\alpha+\frac{2\pi}{3}} \left(-I_d\right)^2 d\varphi \right\} \right]^{1/2} = \sqrt{\frac{2}{3}} I_d$$

u_d, u_{T1}, i_a, α = 90 deg (pure resistive load)

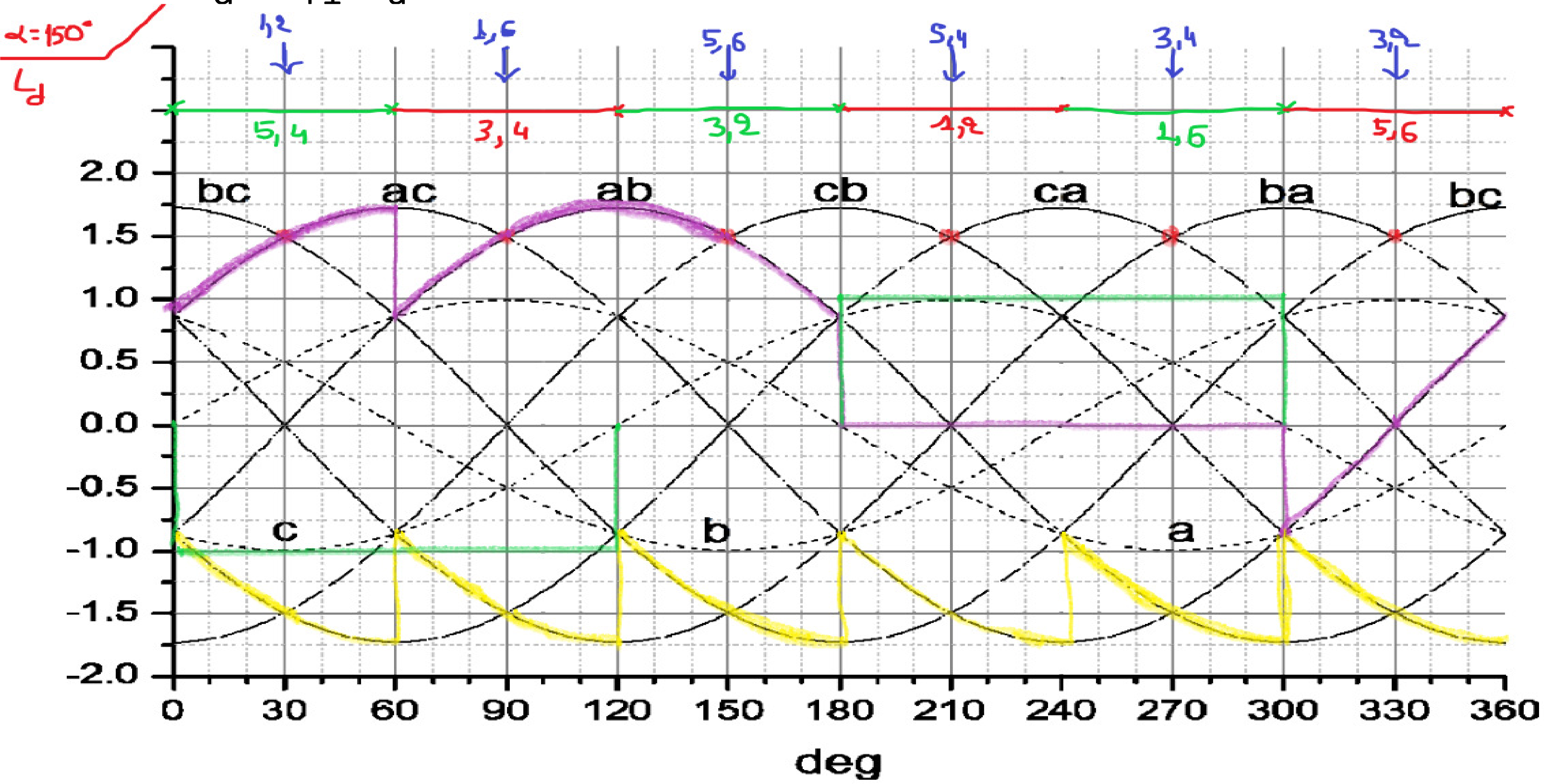


Under pure resistive load there is no Inverting Mode ($U_d \geq 0$); at α = 120 deg the bridge stops conducting ($U_d = 0$)

u_d, u_{T1}, i_a, α = 120 deg (continuous conduction)



u_d, u_{T1}, i_a, α = 150 deg (continuous conduction)



u_d, u_{T1}, i_a, α = 180 deg (continuous conduction)