Consulting Electrical Engineering

How Your Engineering Education Applies to the Real World

CalPoly - IEEE, EPI, PES

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San Luis Obispo, CA

Agenda

- Describe consulting engineer's role in the design of power distribution and lighting systems for buildings
- (How your engineering education applies to the real world)
- Demonstrate a digital lighting control system

Useful Engineering Stuff

- Ohm's Law
- Fourier Analysis
- Three Phase
- $\sqrt{3}$
- Boolean Logic
- Manchester Coding
- Inverse Square

Ohm's Law - Wire Sizing

- What is the load current?
- E = I R I = E / R
- I = E / Z (for AC)
- Z = Impedance of Load
- P = E I pf
- I = P / (E pf)
- Lookup wire gauge in National Electrical Code (NEC)

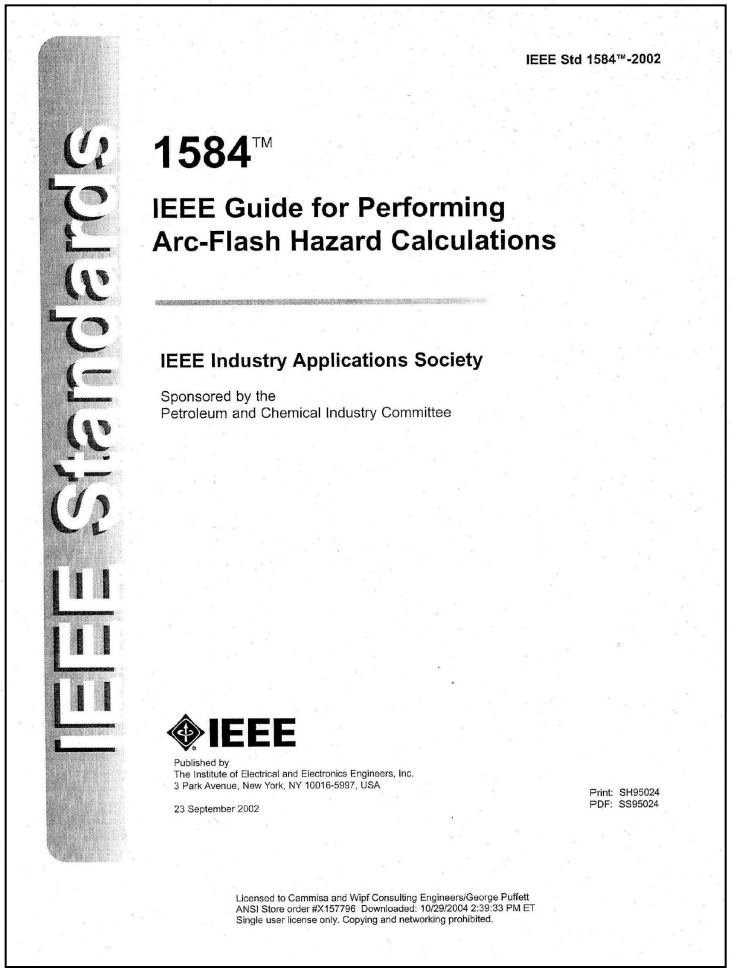
Allowable Ampacity			
SIZE	Temperature Rating of Conductor		
AWG	60°C	75°C	90°C
14	20 †	20 †	25 †
12	25 †	25 †	30 †
10	30	35 †	40 †
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

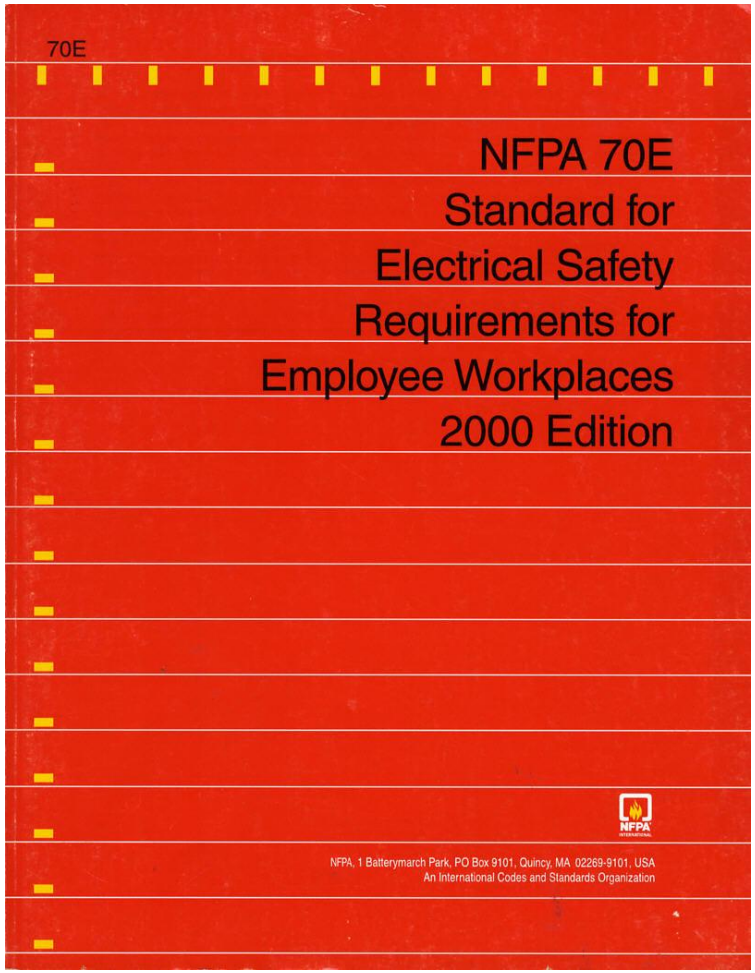
Ohm’s Law - Withstand Rating

- How much current during a short circuit?
- I = E / Z
- Z = Impedance of Source

Results of Arc Flash

Codes and Standards





Software

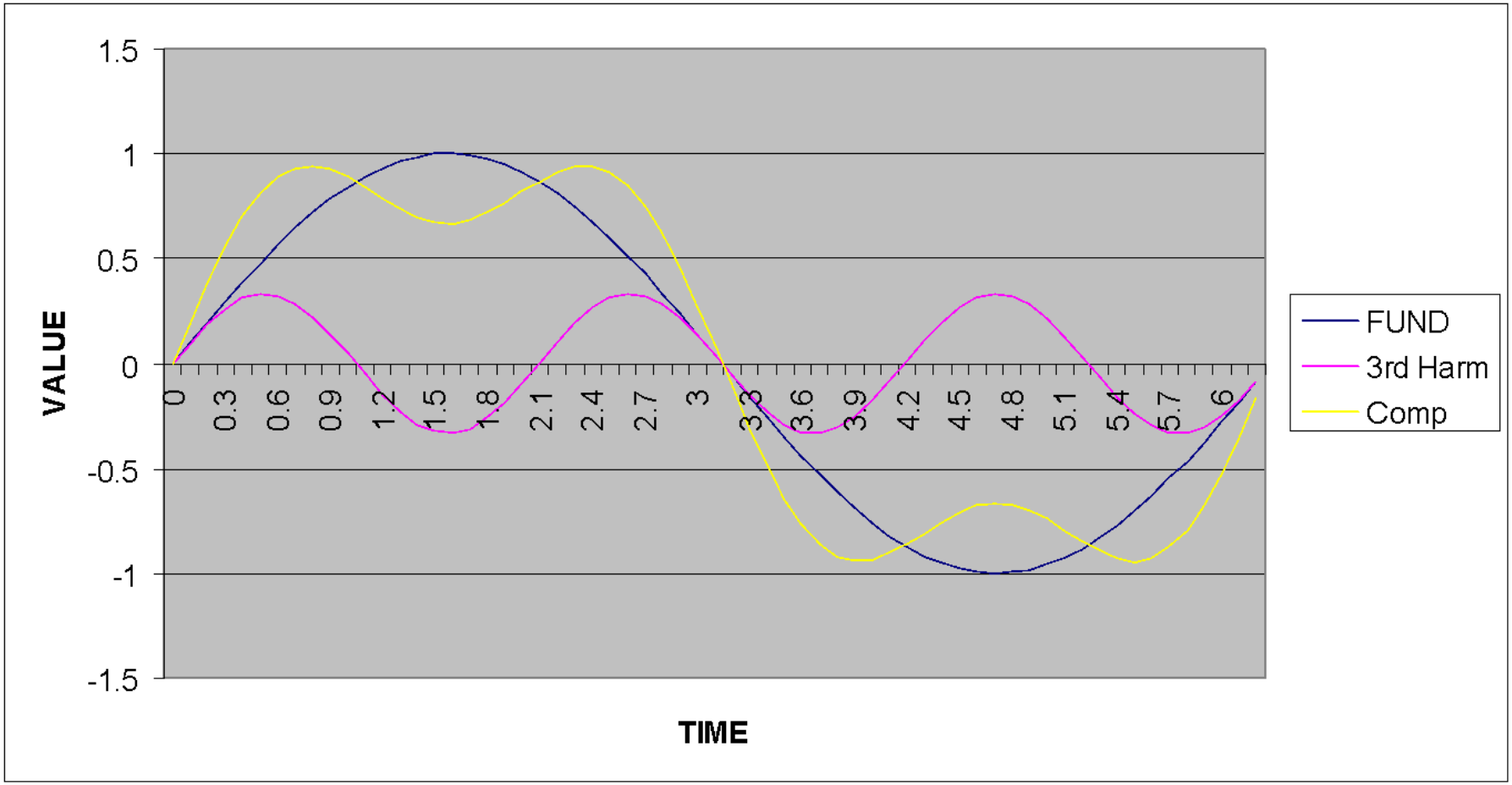
- DAPPER
- EasyPower
- EDSA
- ETAP

Fourier Analysis

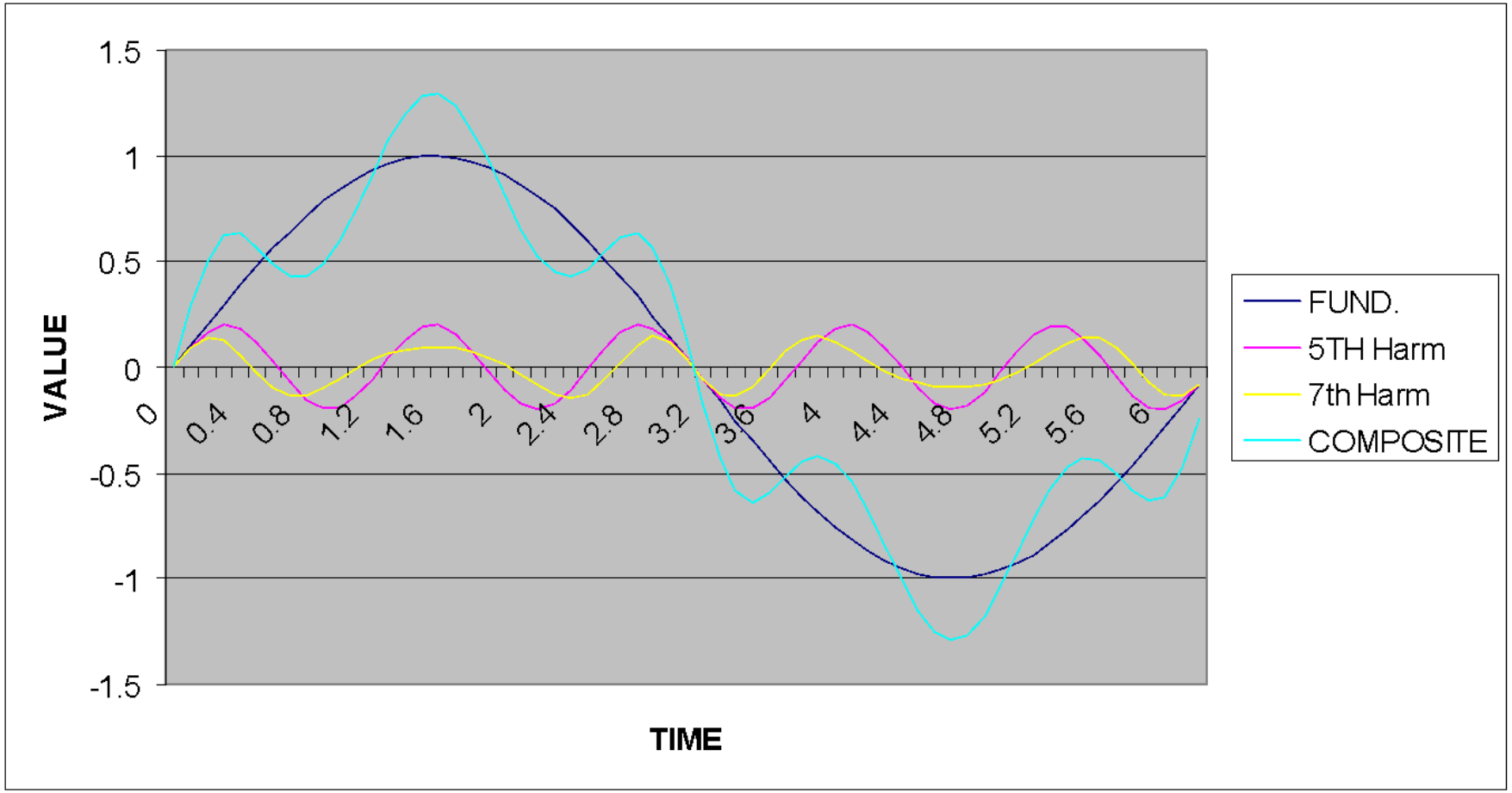
- Total equals the sum of the parts

$$F(\nu) = \int_{-\infty}^{\infty} f(t) \cdot e^{-2\pi \cdot i \cdot \nu \cdot t} dt.$$

Graph of Fund. & 3rd Harm.



Graph of Fund, 5th & 7th Harm.



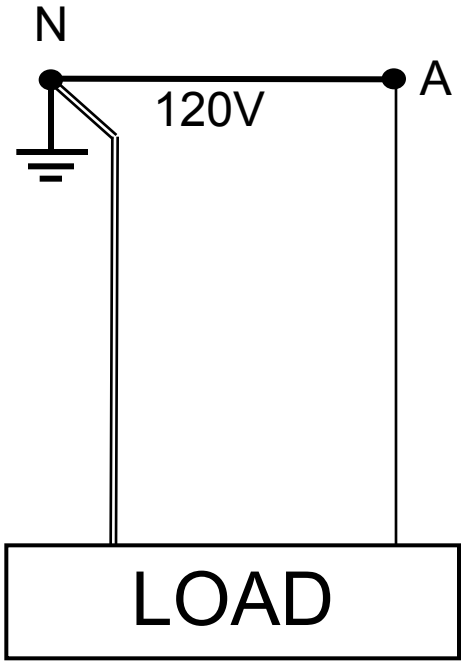
Voltage Configurations

- Single phase, two wire
- Single phase, three wire, center tap
- Three phase, three wire, delta, ungrounded
- Three phase, three wire, delta, grounded
- Three phase, four wire, delta, center tap
- Three phase, four wire, wye

Single Phase – 2 Wire

120V-1∅-2W

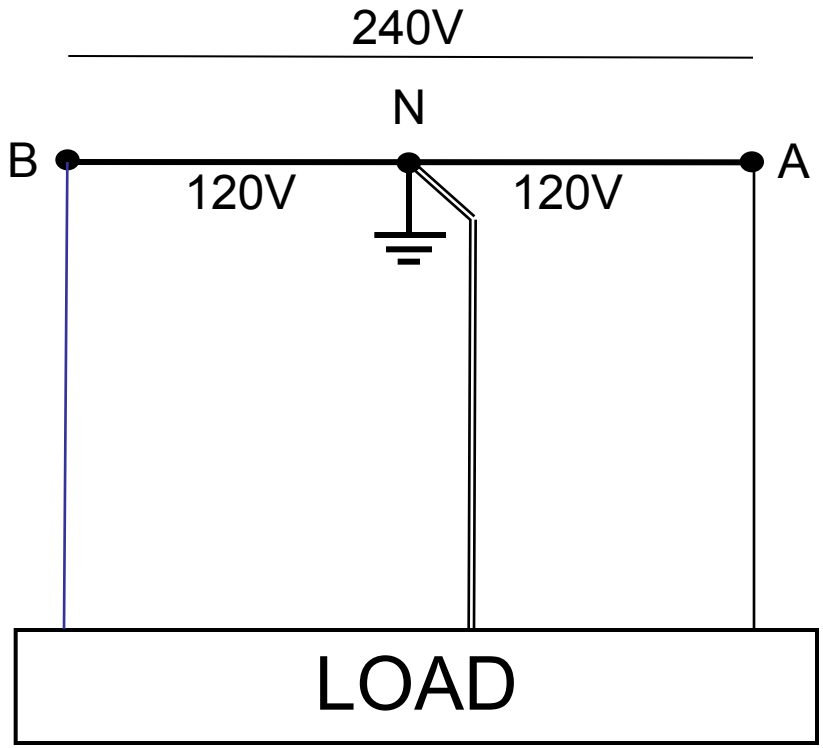
240V-1∅-2W



Single Phase – 3 Wire

240/120V-1∅-3W

480/240V-1∅-3W



Three Phase – 3 Wire Delta

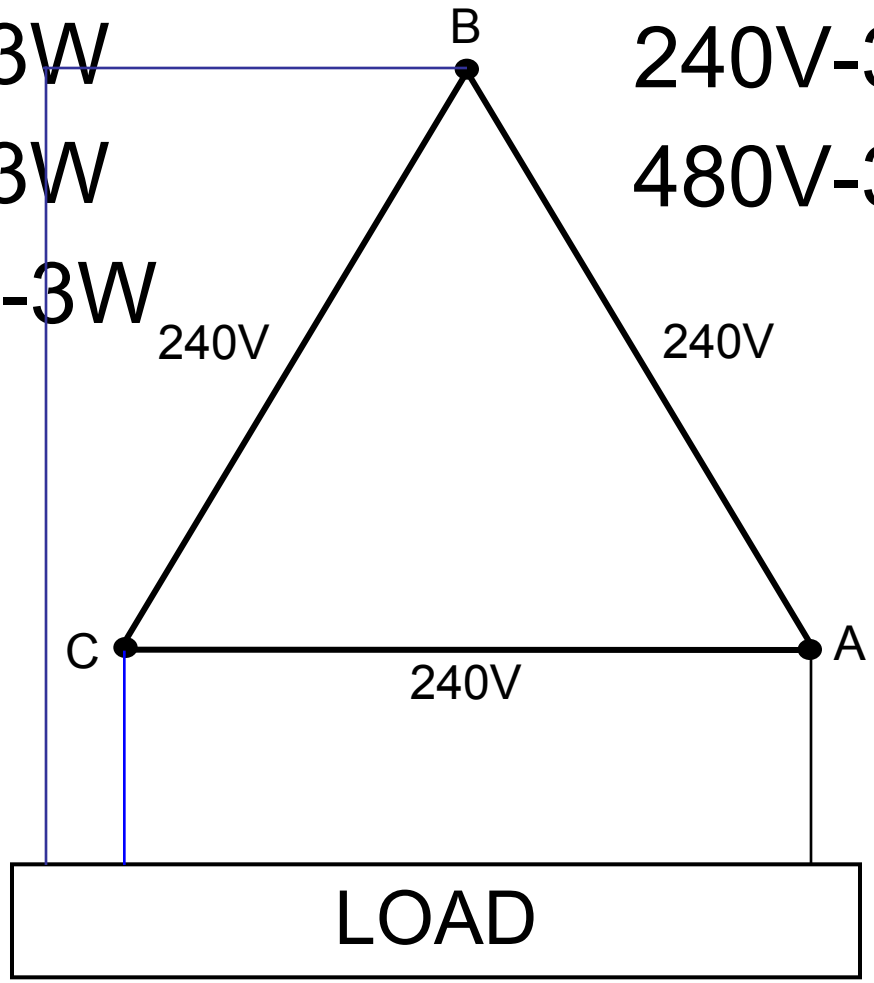
2400V-3∅-3W

4160V-3∅-3W

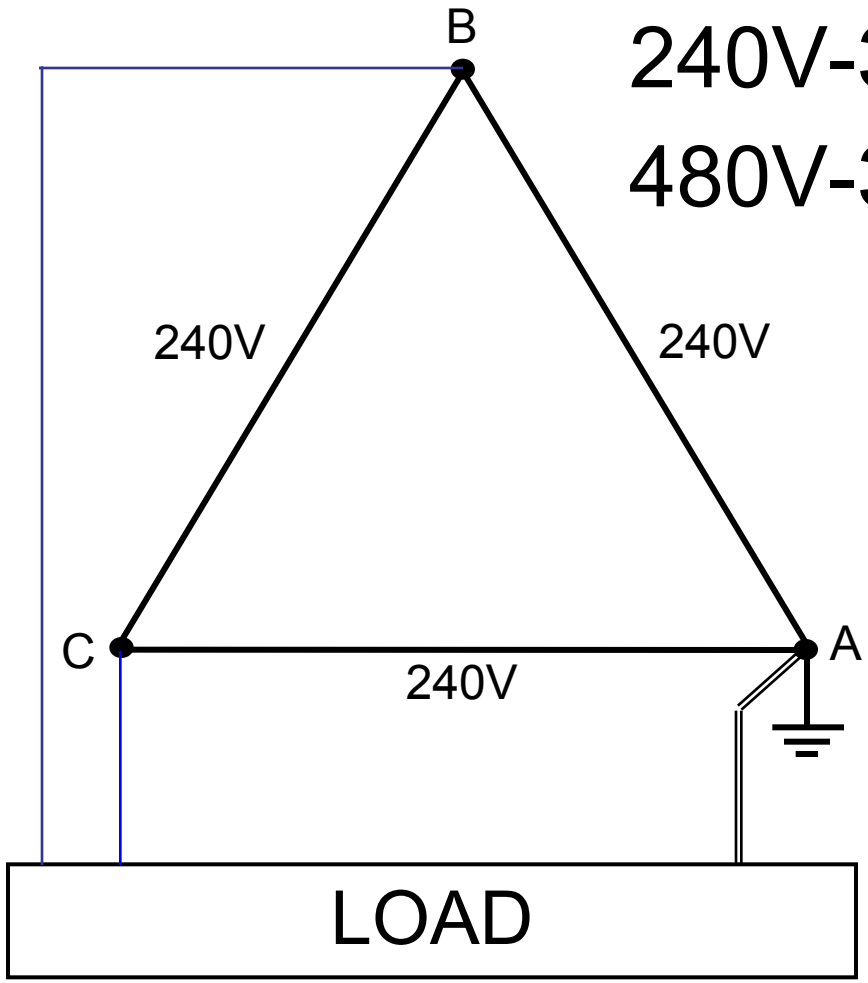
12470V-3∅-3W

240V-3∅-3W

480V-3∅-3W

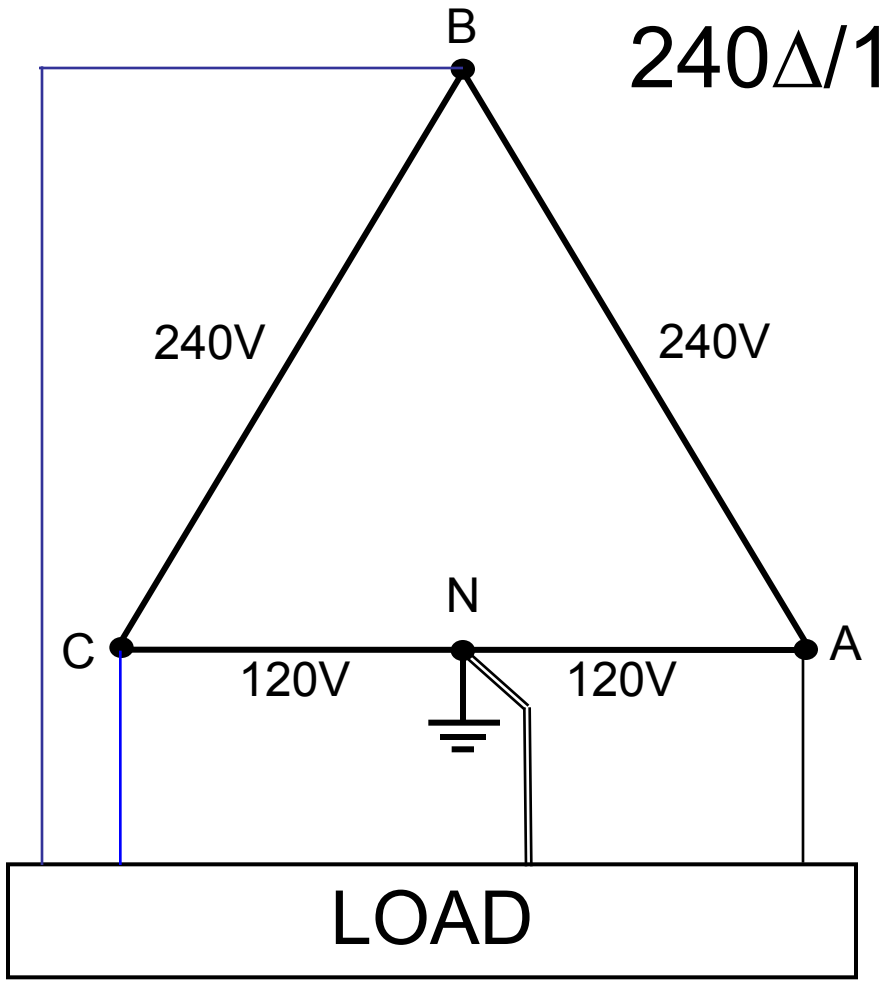


Three Phase – 3 Wire Delta

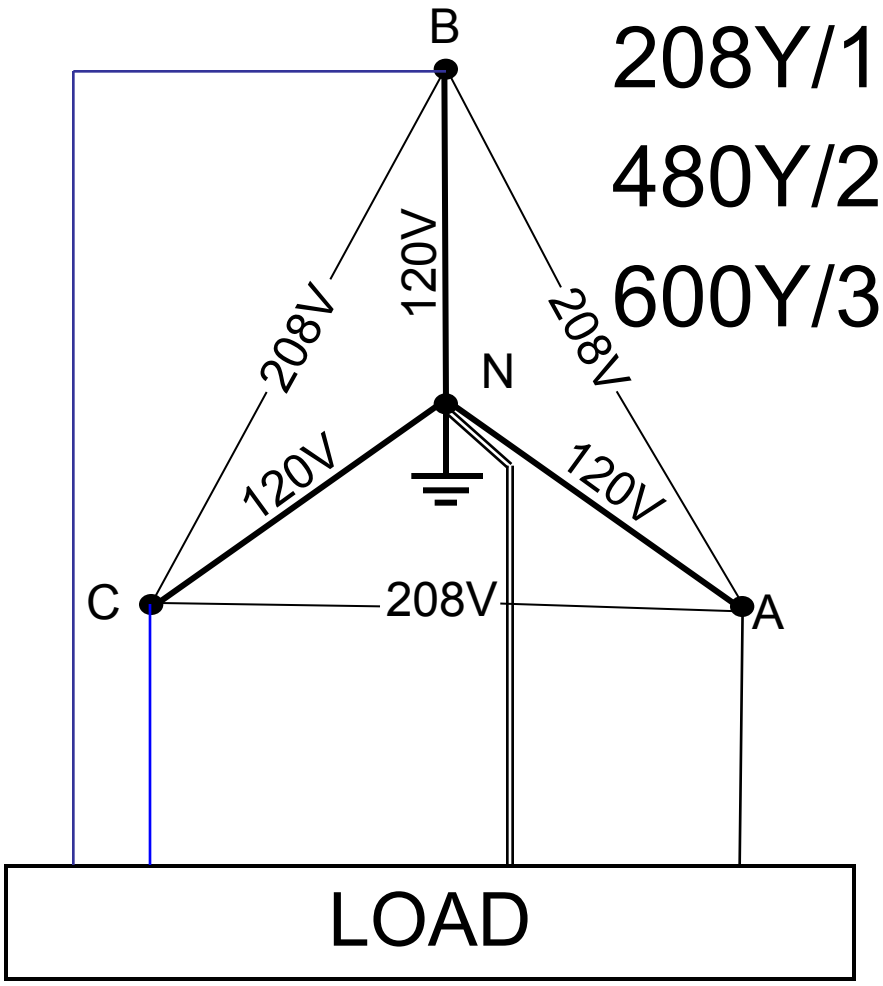


Three Phase – 4 Wire Delta

240Δ/120V-3∅-4W



Three Phase – 4 Wire Wye



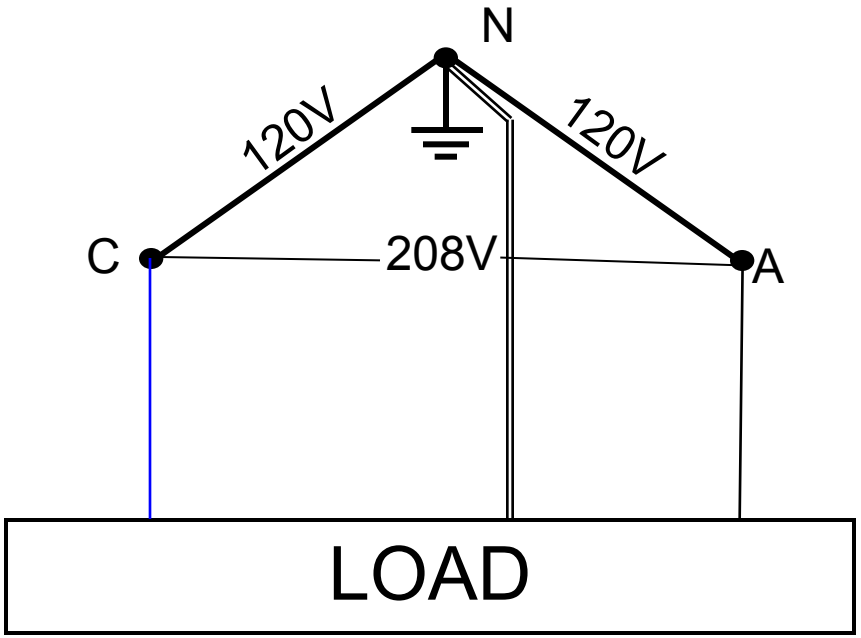
208Y/120V-3∅-4W

480Y/277V-3∅-4W

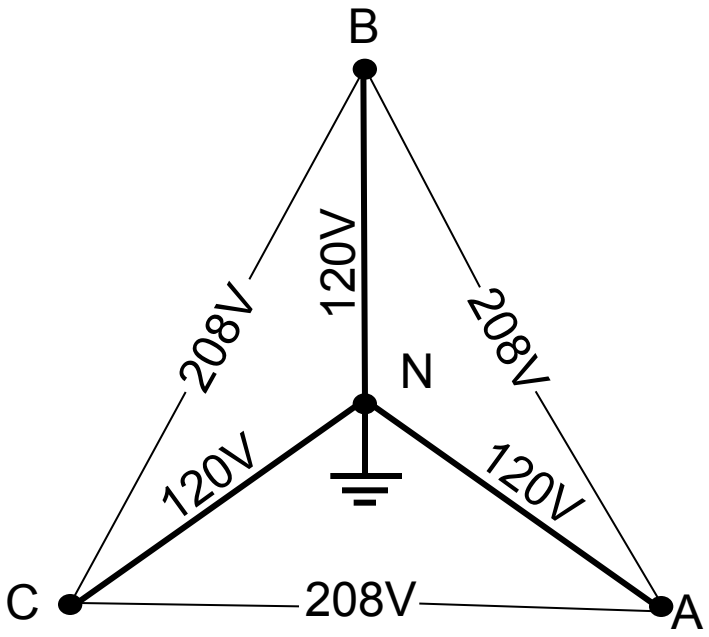
600Y/347V-3∅-4W

Single Phase – 3 Wire Wye

208Y/120V-3∅-3W



Three Phase – 4 Wire Wye



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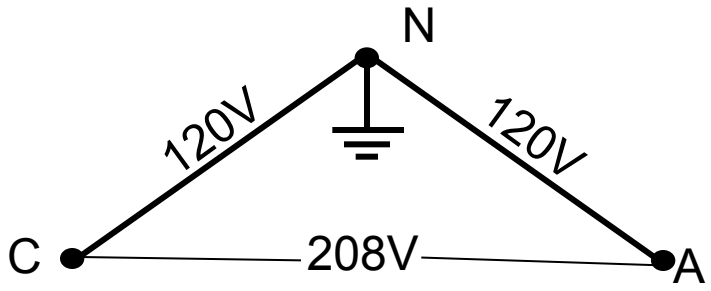

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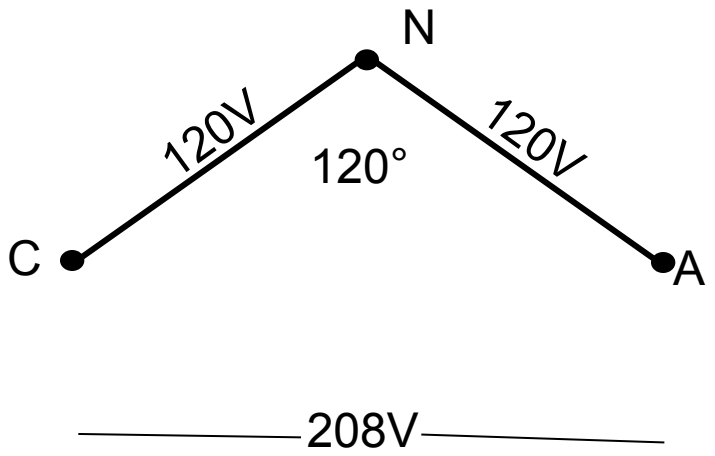

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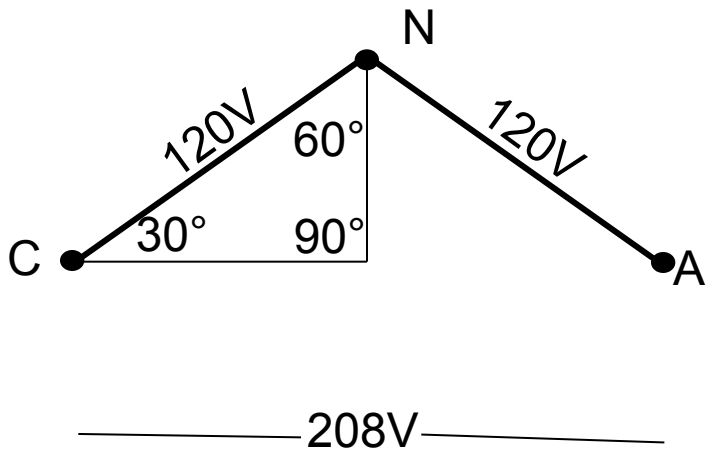
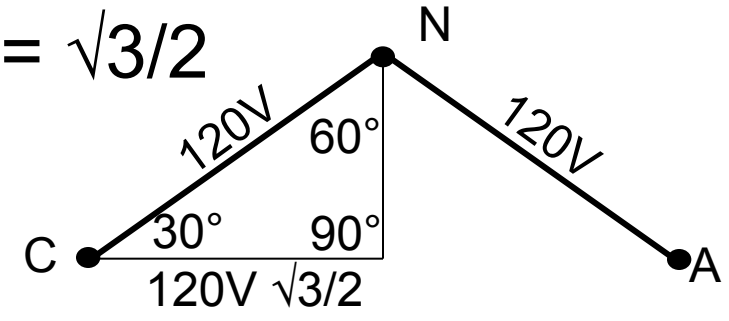


High School Geometry

- 30-60-90 triangle
  - Hypotenuse =1
  - Short leg = 1/2
  - Long leg = $\sqrt{3}/2$

High School Geometry

- 30-60-90 triangle
  - Hypotenuse =1
  - Short leg = 1/2
  - Long leg = √3/2



2x120V √3/2

120V √3

120V x 1.73

208V

$\sqrt{3}$

- Three phase wye
- $P = I_A V_{AN} + I_B V_{BN} + I_C V_{CN} = 3 I V_{LN} = I 3 V_{LN} = I \sqrt{3} V_{LL}$
- P = I 3 * 120v = I $\sqrt{3}$ * 208v
- P = I 3 * 277v = I $\sqrt{3}$ * 480v
- P = I 3 * 7200v = I $\sqrt{3}$ * 12470v
- 30-60-90 triangle
- Hypotenuse to long leg: 1 to ½ $\sqrt{3}$

How to Calculate Power

- Power = Volts x Amps [DC]
- Power = Volts x Amps x PF [AC]
- Power = VA x PF
- VA = V x A [single phase]
- VA = $\sqrt{3}$ x V_{LL} x A [three phase]

- P = $\int VA/dt$

Graph of Volts, Amps, Watts

Three Phase Power

- 3 phase = phase A + phase B + phase C
- $VA = V_{AN} \times A_A + V_{BN} \times A_B + V_{CN} \times A_C$
- If $V_{AN}=V_{BN}=V_{CN}$ and $A_A=A_B=A_C$
- Then $VA = 3 \times V_{LN} \times A$
- $VA = \sqrt{3} \times V_{LL} \times A$ [three phase]

How to Calculate Energy

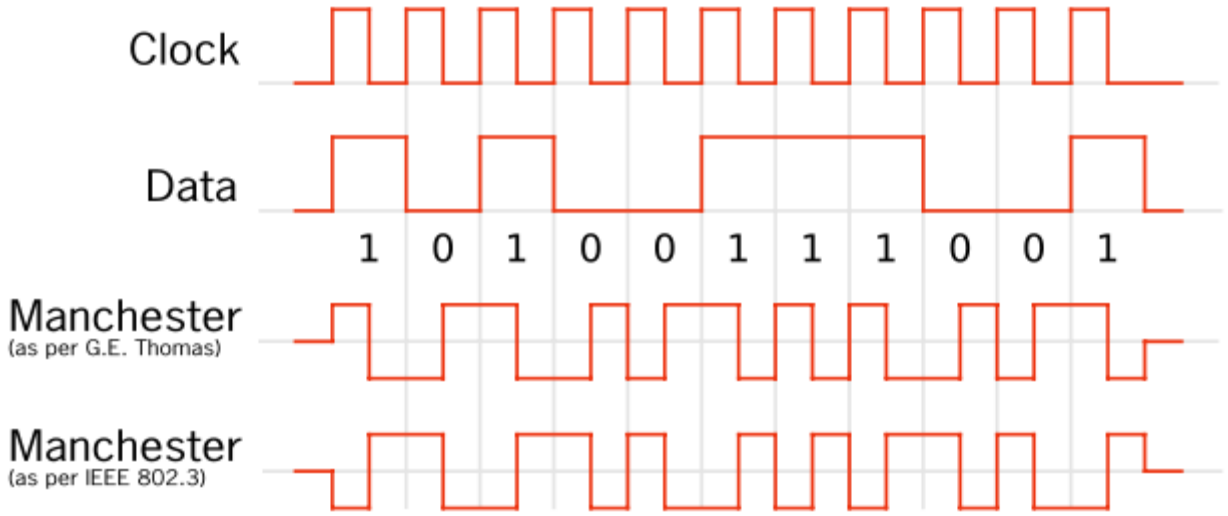
- Energy = Power X Time
- WH = W x Hr [for a constant load]
- WH = $\int Wt/dt$ [for a time variant load]

Boolean Logic

- And
- Or
- Nor
- Xor
- Not
- If, then, otherwise

Manchester Coding

- No DC component
- Direction of the mid-bit transition
- Used in Ethernet and DALI

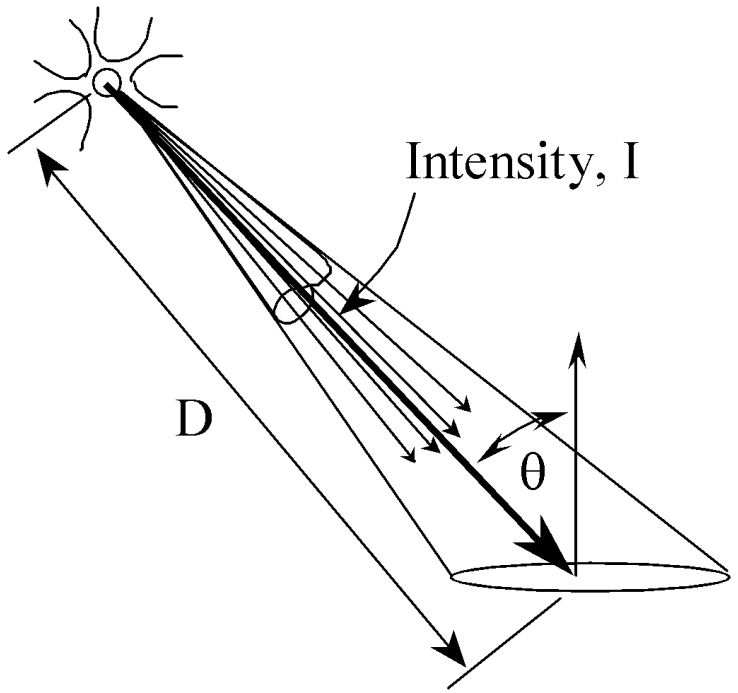


Cosine Inverse Square

- E_p and Intensity can be related

$$E_p = \frac{I\cos(\theta)}{DxD}$$

$$E_p = \frac{I\cos(\theta)}{D^2}$$



Let the Computer to it

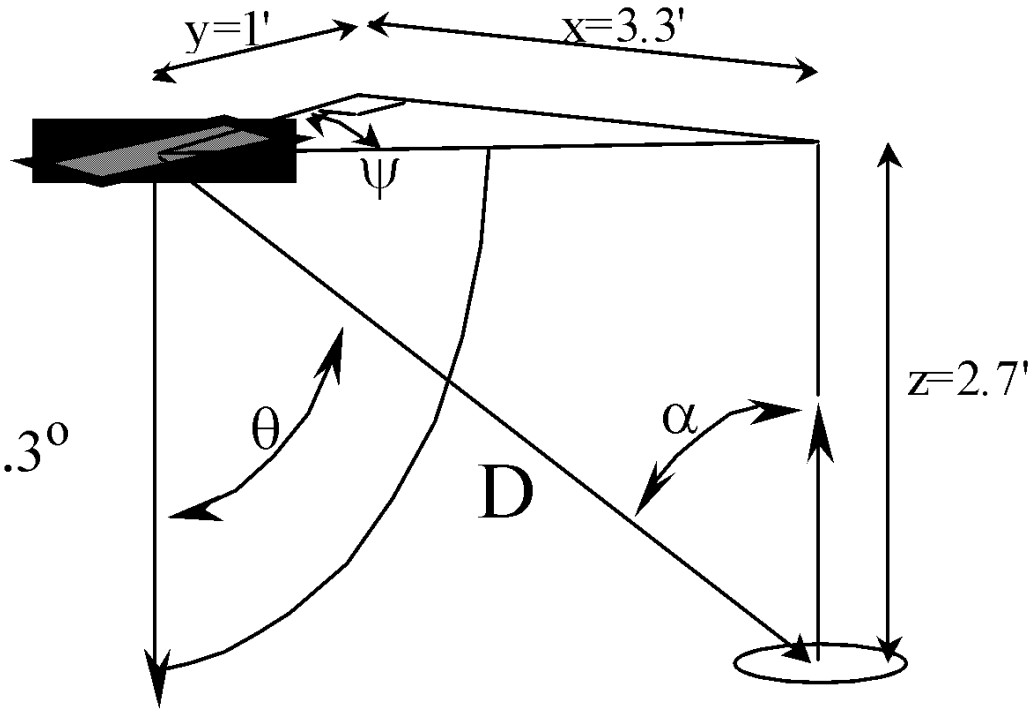
- The angles (θ,ψ) are from distances x, y, and z

$$\theta = \text{Arc}\tan[\frac{z}{(x^2 + y^2)^{1/2}}]$$

$$\theta = \text{Arc}\tan[\frac{2.7}{(3.3^2 + 1^2)^{1/2}}]$$

$$\theta = 37.5^o$$

$$\psi = \text{Arc}\tan[\frac{x}{y}] = \text{Arc}\tan[\frac{3.3}{1}] = 73.3^o$$



AND
DON’T
FORGET

And Don’t Forget

- Communication Skills
- Law
- Politics
- Economics
- Environment
- Continuing Education

Communication Skills

- Verbal
- Written
- Graphic

Law

- License - PE
- Codes
- Standards
- Insurance - professional E and O

Politics

- History
- People
- Objective
- Point of View

Economics

- Cost of development
- Cost to manufacture
- Life cycle
- Margin, mark up, profit
- ROI
- Payback

Environment

- Pollution – spill containment, air quality, carbon footprint
- Energy saving = Power reduction **X** Time reduction

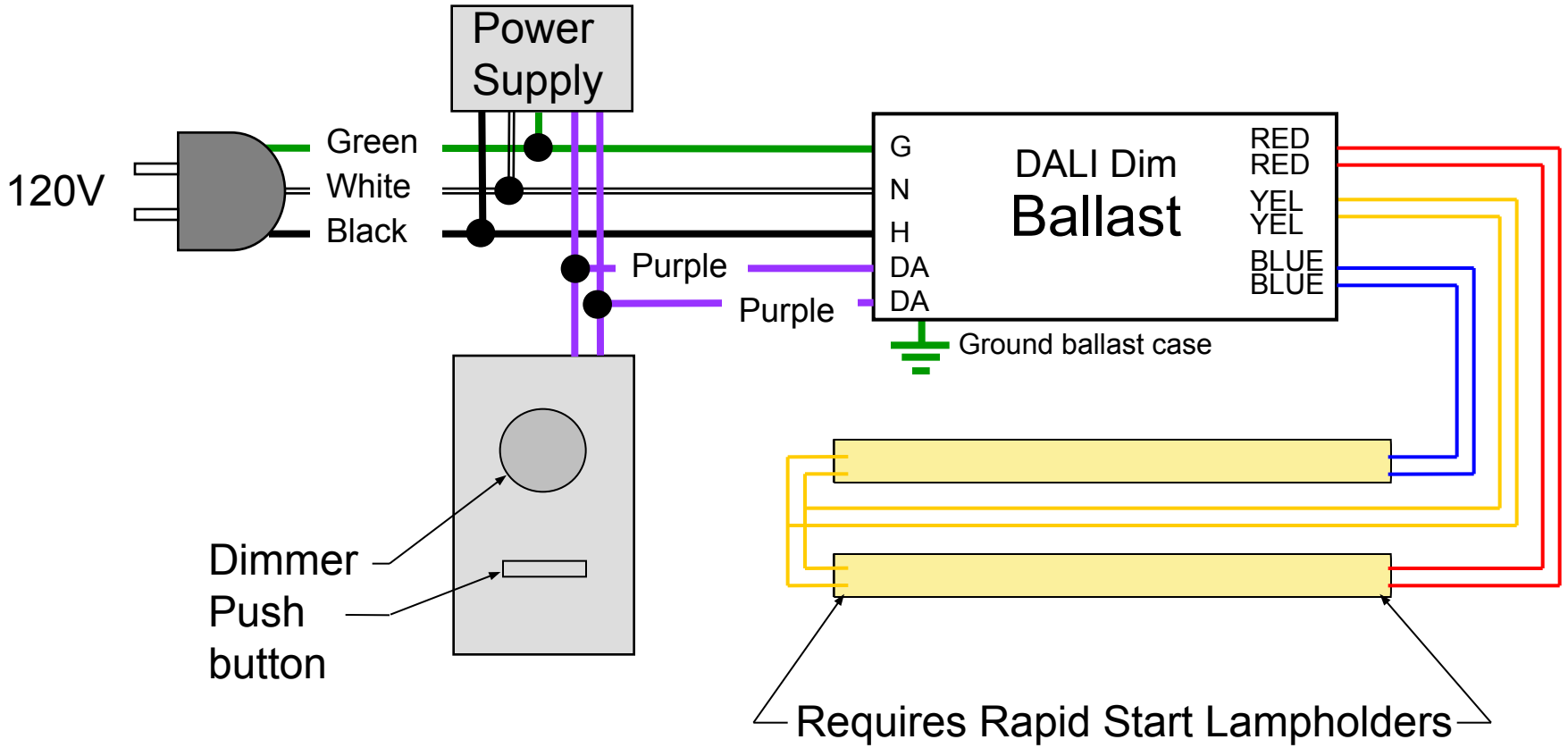
Continuing Education

- Magazines
- Journals
- Seminars
- Webinars
- Trade Shows
- Professional Societies

DALI Demonstration

- DALI:
- Digital Addressable Lighting Interface
- a digital lighting control system

DALI Demonstration



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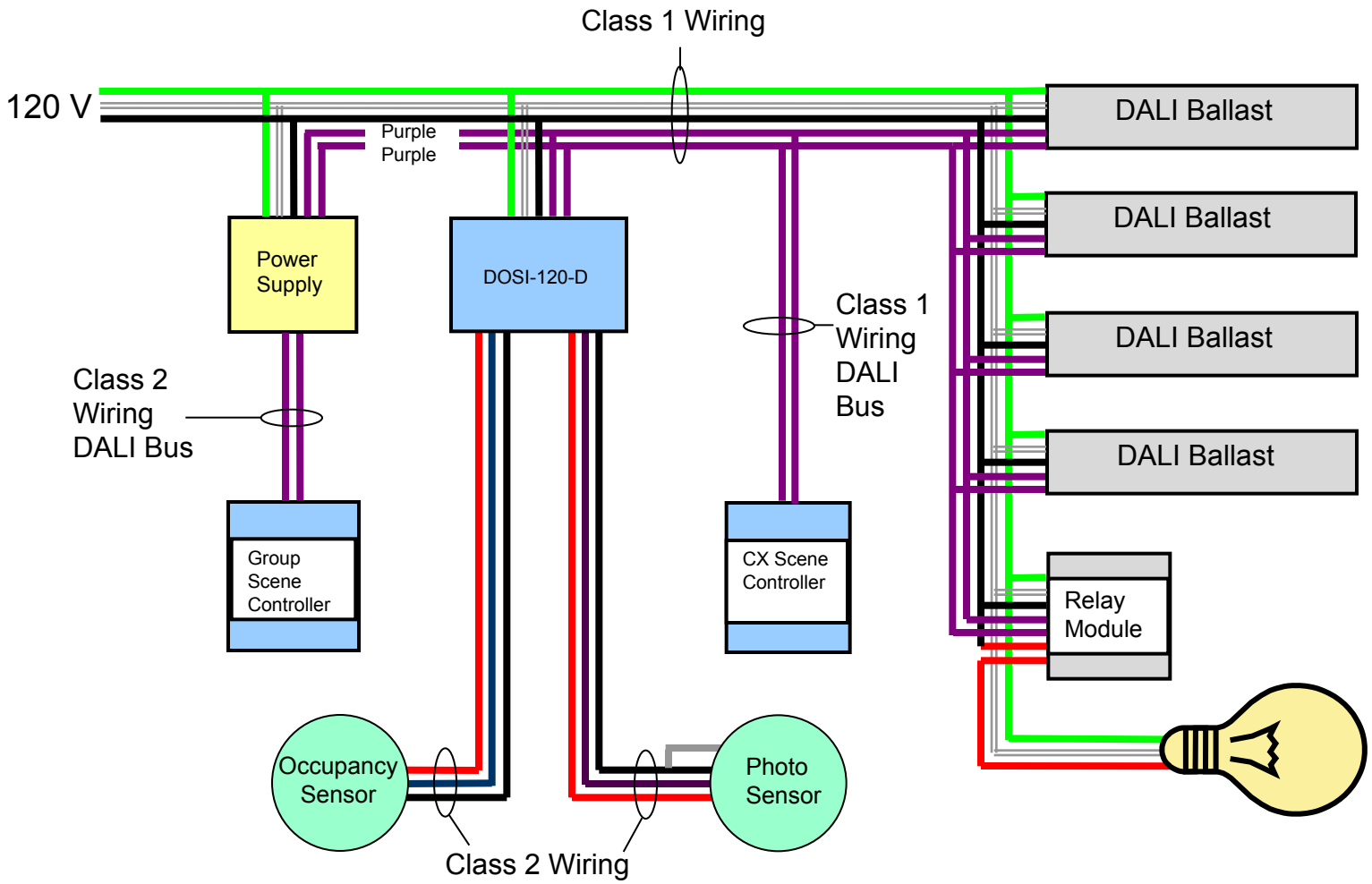

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