

ECE 215/S – Principles of Electronic Cyber Warfare

Block 1: Resistive Circuits and Power Distribution

Lesson 12: Block Wrap-Up and Project 1 Kickoff

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Where We Have Been

Obj	You can…	Lesson
1.1	Analyze a DC circuit (KVL, KCL, dividers, power)	2–4
1.2	Size a fuse or circuit breaker	5
1.3	Analyze an AC circuit using RMS values	6
1.4	Compute reactive and apparent power	7
1.5	Compute efficiency of a system	8
1.6	Analyze a transmission system with transformers	9
1.7	Analyze a system with power converters	10
1.8	Compare designs with a decision matrix	11

Eight objectives, one capability: analyze a power system and recommend a design.

The Thread: One Resistor to a Power System



- Each lesson added one box to a diagram you can now analyze end to end
- Project 1 asks you to **build** that diagram rather than be handed it
- Block 2 does the same thing for *signals* instead of power

Recap: Circuit Analysis and Protection (1.1–1.2)

- $V = IR$ and $P = IV$; in series $R_{\text{EQ}} = \sum R$, in parallel R_{EQ} is smaller than any branch
- **Voltage divider** uses the element's own R; **current divider** uses the *other* one
- KVL around any loop $= 0$; KCL at any node $= 0$; check with conservation of power
- Fuse or breaker rating window: $[\,1.1\,I_s,\ 1.5\,I_s\,]$, then pick from the available table

Seen on Quiz 1: current-divider numerator swapped, and fuse ratings chosen below I_s (which would trip during normal operation).

Recap: AC, Power, and Efficiency (1.3–1.5)

- $v(t) = V_{\text{bias}} + A\cos(2\pi f t + \phi)$; $V_{\text{rms}} = \sqrt{V_{\text{bias}}^2 + V_{pk}^2/2}$, which reduces to $V_{pk}/\sqrt{2}$ **only when** $V_{\text{bias}} = 0$
- With $\phi = \phi_V - \phi_I$: $P = V_{\text{rms}} I_{\text{rms}} \cos\phi$ (W), $Q = V_{\text{rms}} I_{\text{rms}} \sin\phi$ (VAR), $S = V_{\text{rms}} I_{\text{rms}}$ (VA)
- $S^2 = P^2 + Q^2$ and pf $= \cos\phi = P/S$
- $\eta = P_{\text{out}}/P_{\text{in}}$; efficiencies of cascaded stages **multiply**
- 1 hp $= 745.7$ W

Seen on Quiz 2: P and Q added arithmetically instead of as a right triangle, and peak values used where RMS was required.

Recap: Transmission, Conversion, Selection (1.6–1.8)

- $a = N_1/N_2 = V_1/V_2 = I_2/I_1$; $a < 1$ steps up, $a > 1$ steps down
- Line loss $= I^2 R_{\text{line}}$, computed with the current *in that segment*
- Converters are efficiency stages: $P_{\text{in}} = P_{\text{out}}/\eta$. Power factor applies on AC segments only
- Decision matrix: normalize ($x/x_{\max}$ or $x_{\min}/x$), weight to sum 1.0, score, then test whether the winner survives a weight change

Watch for on Quiz 3: the turns ratio inverted for current, and line loss computed with the load current instead of the line current.

Equation Sheet Tour

You get the ECE 215 equation sheet on every quiz and exam. Know what is on it **before** the quiz.

- It gives you the **equations**, not the **method**. Knowing that $S^2 = P^2 + Q^2$ exists does not tell you when to reach for it
- Nothing on it tells you which current to use in I^2R — that is judgment you build by working problems
- Practice problems on the course website use the same sheet. Work them with it in front of you

The sheet removes memorization, not thinking.

Project 1: Power Distribution

You are designing the power system for a **classified prototype aerial platform**, in teams of **2–4**.

- **Part 1 — you are the contractor.** Design a system that energizes eight loads to spec. You want a better design than the other teams
- **Part 2 — you are the government evaluator.** You receive the other teams' designs and rate them objectively with a decision matrix
- You do not see anyone else's design until your Part 1 is submitted

Both halves of the contracting process, in one project.

The Eight Loads

Load	Description	Voltage	Specification
A	Recirculation fans	240 V_{rms}	8 kW, pf $= 0.8$ lagging
B	Fuel pumps	240 V_{rms}	12 kVA, pf $= 0.6$ lagging
C	Cabin lighting	120 V_{rms}	6 kW, pf $= 0.8$ lagging
D	Cabin fans	120 V_{rms}	5 hp, $\eta = 88.89\%$, pf $= 0.8$ lagging
E	Auto-pilot & controls	48 V DC	$R = 2\,\Omega$
F	Brake power	48 V DC	0.75 hp, $\eta = 85\%$
G	Communications	24 V DC	500 W
H	Flight displays	24 V DC	25 A

Notice that every single load type is something you learned to handle in Lessons 6–10. Nothing here is new.

The Constraints

- Generator must not exceed **30 kW real power**, attached to either a 240 V or 120 V bus
- A resistor of 0.016–$0.022\,\Omega$ between generator and first bus models **wiring losses** (no cost)
- Only the **COTS converters** in Table 2 may be used
- Every load, bus, and converter needs its **own circuit breaker**
- Cost of conversion and protection $\leq$ **$500,000**
- Volume of conversion equipment $\leq$ **25 m**^{3}

A design that violates any constraint is not a worse design — it is a non-compliant one.

The Evaluation Criteria

The government will score on **cost**, **efficiency**, and **volume**, with a stated priority:

Cost is weighted $2\times$ *efficiency, and efficiency is weighted* $2\times$ *volume.*

That is a ratio of $4 : 2 : 1$, so the weights are:

Measure	Ratio	Weight
Cost	4	$4/7 = 0.571$
Efficiency	2	$2/7 = 0.286$
Volume	1	$1/7 = 0.143$

This is Objective 1.8 applied directly — and it tells you where to spend your design effort.

Deliverables and Grading

Three Gradescope submissions, **1 point each**:

- **Submission 1 (group)** — system design, due **Mon 14 Sep, 2359**
  - Diagram easy to read, clearly labeled, meets every requirement
  - Mathematical analysis provided, legible, clearly labeled
- **Submission 2 (group)** — decision matrix on the other designs, due **Wed 16 Sep, 2359**
  - Auto-graded: **trivial math errors will not earn credit**. Rounding is fine
  - Supporting analysis must be included
- **Submission 3 (individual)** — short questions on your analysis, due **Wed 16 Sep, 2359**
  - **Concise** technical writing. Lengthy responses will not earn credit

Authorized: calculator/Excel/MATLAB, equation sheet, slides, readings, practice problems, **GenAI Level 2 only**.

Wrap-Up

Where we are:

- Block 1 is complete — Objectives 1.1 through 1.8
- Project 1 is the block's capstone: design a system, then evaluate someone else's
- Every tool it needs is a tool you already have

Next lessons:

- **Lessons 13–14 — Project 1 workdays.** Bring a laptop and your team
- **Submission 1** due **Mon 14 Sep, 2359**; **Submissions 2–3** due **Wed 16 Sep, 2359**
- **Quiz 3** (Objectives 1.6–1.7) is due later, on **Mon 21 Sep, 2359**