



ECE 495 – Electromagnetic Warfare and Survivability

Block 2: RF Electronic Warfare Lesson 15: Electromagnetic Protect

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Fall 2026

L11–L14 were **ES** — listening: hear the emitter, sort it, find its bearing, cross it into a fix.

Now turn the problem around. The threat is doing all of that to *us*. Our radars and links must keep working while the enemy tries to intercept and jam them.

Today: Electromagnetic Protect — how we radiate and survive.

By the end of this lesson, you will be able to:

- Define **EP** and place it against ES and EA
- Explain how **LPI** hides a radar that must still radiate
- Describe **frequency** and **polarization agility** as anti-jam tools
- Explain why most jamming enters through the **side-lobes**

EP protects our own use of the spectrum — against enemy EA *and* friendly interference.

- Make radars and links **resistant** to jamming and EMI
- **Harden** against large electromagnetic disturbances
- **LPI** systems — be hard to intercept in the first place
- Signature reduction — the low-observable half, deferred to B3

ES listens, EA denies — EP keeps us in the fight while both happen.

A radar has to transmit to work. But from L11–L12 we know the cost: a one-way listener hears the radar long before the radar's two-way echo closes the loop.

- Every watt radiated is a watt the threat RWR can intercept
- Every transmission is a chance to be located and jammed
- Turning the radar off is safe — and useless

EP is the art of staying useful while giving the threat as little to work with as possible.

The cheapest signal to intercept is the one never sent.

- **EMCON** — lean on passive sensors (RWR, IR/EO, off-board data link); radiate only when you must
- **Delay radiation** — go active at the last moment, not a second before
- **Power management** — emit only enough to close *this* shot, not the maximum

Cut transmit power and the threat's intercept range falls with it — the RWR has to come to you.

When you must radiate, **spread** the energy so no single slice looks like much.

- A long, coded pulse (chirp or phase code) spreads energy over a **wide band**
- To an intercept receiver it looks weak and **noise-like** — poor wideband SNR
- The radar's **matched filter** re-concentrates that energy into a sharp peak — high SNR for us

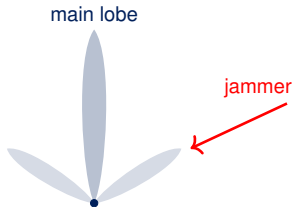
Spread to hide; compress to see. The eavesdropper has neither key.

Do not sit still in the spectrum — a predictable emitter is an easy target.

- **Frequency agility** — hop the carrier pulse-to-pulse; a **spot jammer** cannot follow, and the RWR struggles to sort a moving signal
- Hopping also **decorrelates** clutter and target glint — a sensing bonus
- **Polarization agility** — flip polarization to beat a *cross-pol* jammer

Agility forces the jammer to spread thin — the heart of today's interactive demo.

A jammer rarely sits in your main beam. It pours energy in through the **side-lobes**.



- **Ultra-low side-lobes** — starve every off-axis path at once
- **Side-lobe blanker** — a guard channel rejects *wideband* side-lobe pulses
- **Side-lobe canceler** — an auxiliary antenna adaptively **nulls** a *narrowband* jammer

Protect the main beam by policing everything around it.

Each EP technique answers a specific attack (a preview of L17–L18):

EP technique	EA it counters
Ultra-low side-lobes	All side-lobe jamming and intercept
Side-lobe canceler	Narrowband side-lobe jamming
Side-lobe blanker	Wideband side-lobe jamming
Anti-cross-pol	Cross-polarization jamming
Pulse compression	Deceptive jamming without the code
Frequency agility	Spot jamming
PRF jitter	Cover pulses

No single trick wins — EP is **layered**, and every layer costs complexity.

Today's Interactive Demo: Hop the Jammer



Today's interactive demo.

- Park a spot jammer on a fixed radar — it denies every pulse
- Let the radar hop across N channels; the spot now catches only a fraction
- Force the jammer to barrage all N — its per-channel J/S drops $10 \log_{10} N$

Companion script: L15_FrequencyAgility.m

The jammer's power is fixed. Agility makes it choose where to lose.

Quick Exercise / Type-along: Beat the Jammer



A B-21 support jammer faces an agile threat radar. Reason about each:

1. The radar hops over 20 channels; you spot-jam 4. What fraction gets through?
2. You switch to barrage over all 20. What happens to your J/S per channel?
3. Now the radar runs ultra-low side-lobes. Which jamming path just got harder?
4. Which EP trick defeats a jammer that copies and replays the pulse, but cannot reproduce its code?

Key ideas:

- EP keeps our spectrum working against jamming and interference
- LPI hides a radar that must radiate — emit less, spread, then compress
- Agility makes a predictable emitter unpredictable — spot jamming fails
- Most jamming enters the side-lobes; EP is layered and never free

Next lesson:

- **L16: EP for communications** — spread spectrum (DSSS/FHSS), processing gain
- Pre-flight quiz for L16 due before class