AD FALCON API Manual

PML Example — Uncoupled Dynamic Impulse (Implicit)

Javad Ghorbani

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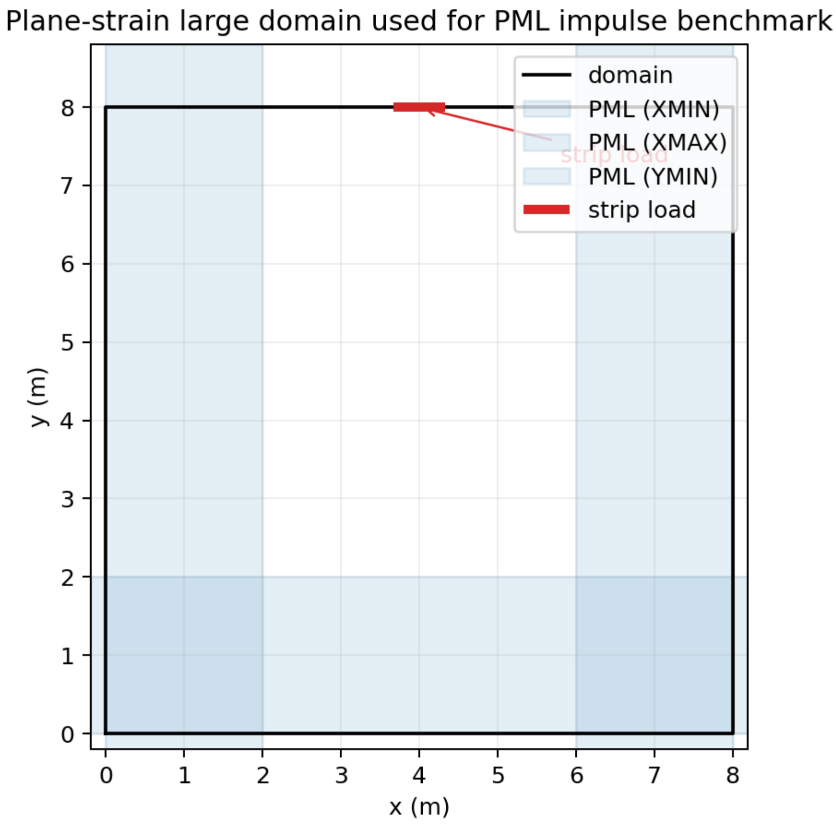

Figure 1: Geometry + PML placement

1 PML Example — Uncoupled Dynamic Impulse (Implicit)

This page is a **worked example** showing that PML reduces reflections for an **uncoupled plane-strain dynamic** problem (mechanics only).

1.1 Model summary

- Geometry: **8 m × 8 m plane-strain** domain (`x ∈ [0,8]`, `y ∈ [0,8]`)
- Load: short **tabular impulse** applied as a strip load at the top surface
- Time integration: **implicit** (`@@SimMode: Dynamic`, `@@TimeIntegration: Implicit`)
- Comparison: **truncated** vs **PML on `XMIN`, `XMAX`, `YMIN`**

1.2 Loading used

The base files define the strip load magnitude via `NormalPressures ...` on the top edge. To better expose boundary reflections, a short **bipolar impulse** is applied via a **tabular load factor**:

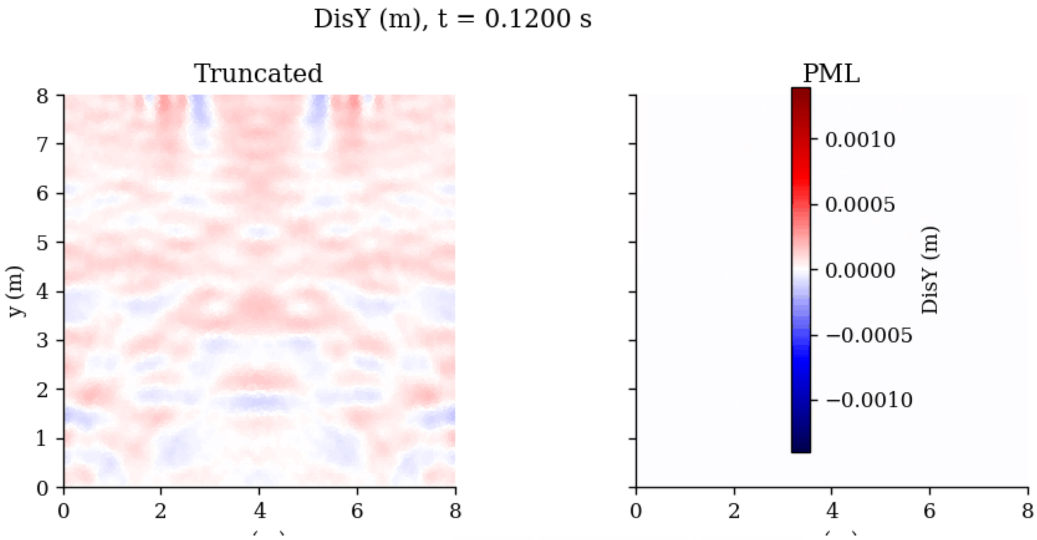

Figure 2: DisY evolution: truncated vs PML (side-by-side)

- `LoadType Tabular Step 1`
- `TabularData 0 0; 0.001 1; 0.002 -1; 0.003 0; 0.12 0`

  Here `dt = StepTime / NumberSteps = 0.12 / 240 = 5e-4` s.

1.3 Results

The animation below shows the **DisY** field evolution side by side for the same impulse load:

Figure: DisY field evolution for the same impulse load (left: truncated, right: PML).

Note: animated GIFs loop in the **web** version of the manual. In the **PDF** export, animations are typically rendered as a single (static) frame.

The plot below shows the **applied pressure time history** alongside **several DisY probes** (truncated vs PML), including a probe close to the PML boundary and probes in the interior.

Figure: Applied pressure history (top) and DisY probe responses (bottom) for truncated vs PML (probes include near-boundary and interior locations).

1.4 Input files

- Truncated: `pml_impulse_large_pl_noncoupled_truncated.txt`
- With PML: `pml_impulse_large_pl_noncoupled_pml.txt`

1.5 PML parameter sensitivity (what to change and why)

The `% PML Layer` block in the PML input file controls how strongly the layer damps outgoing waves:

- `@@Thickness` — thickness of the absorbing layer (m). Increasing thickness usually **reduces reflections** because the wave is attenuated more gradually over a longer distance. If it is

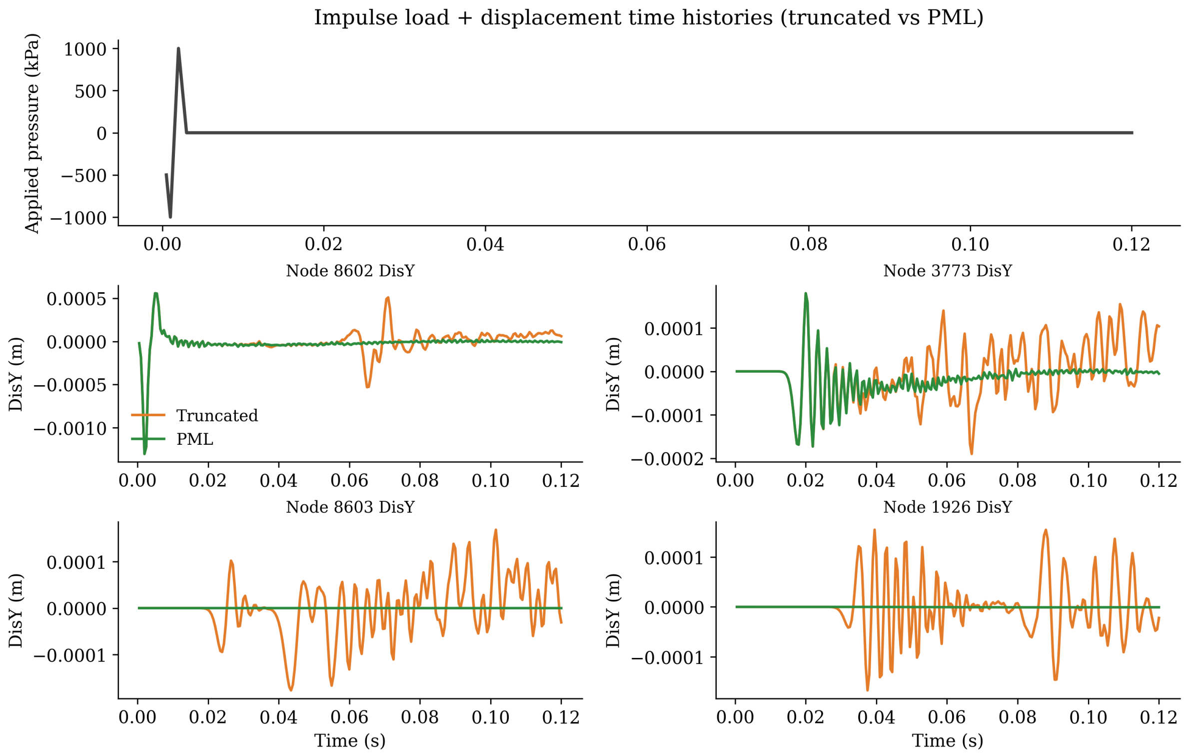

Figure 3: Impulse load and DisY probe: truncated vs PML

too thin, the damping ramp is steep and the PML behaves closer to a hard truncation.

- `@@SigmaMax` — peak damping strength at the outer edge. Too small → **under-damping** and visible reflections. Too large → an overly abrupt impedance change, which can also **increase reflections** and distort the solution near the layer.
- `@@AlphaMax` — low-frequency (long-wavelength) damping bias. Increasing it tends to improve absorption of low-frequency content, but very large values can overdamp the layer and affect nearby response.
- `@@Exponent` — grading of the damping profile through the thickness. Larger values concentrate damping closer to the outer edge; smaller values spread damping more evenly. In practice, a moderate exponent avoids “sharp” transitions that can reflect.
- `@@KappaMax` — coordinate-stretching factor. In FALCON’s uncoupled impulse examples it is commonly kept near `1.0`; changing it affects the wave speed inside the PML and can alter absorption behavior.

Sensitivity should be evaluated using at least one probe close to a PML boundary (to see the reflected arrivals) and one in the interior (to confirm the PML does not contaminate the near field).

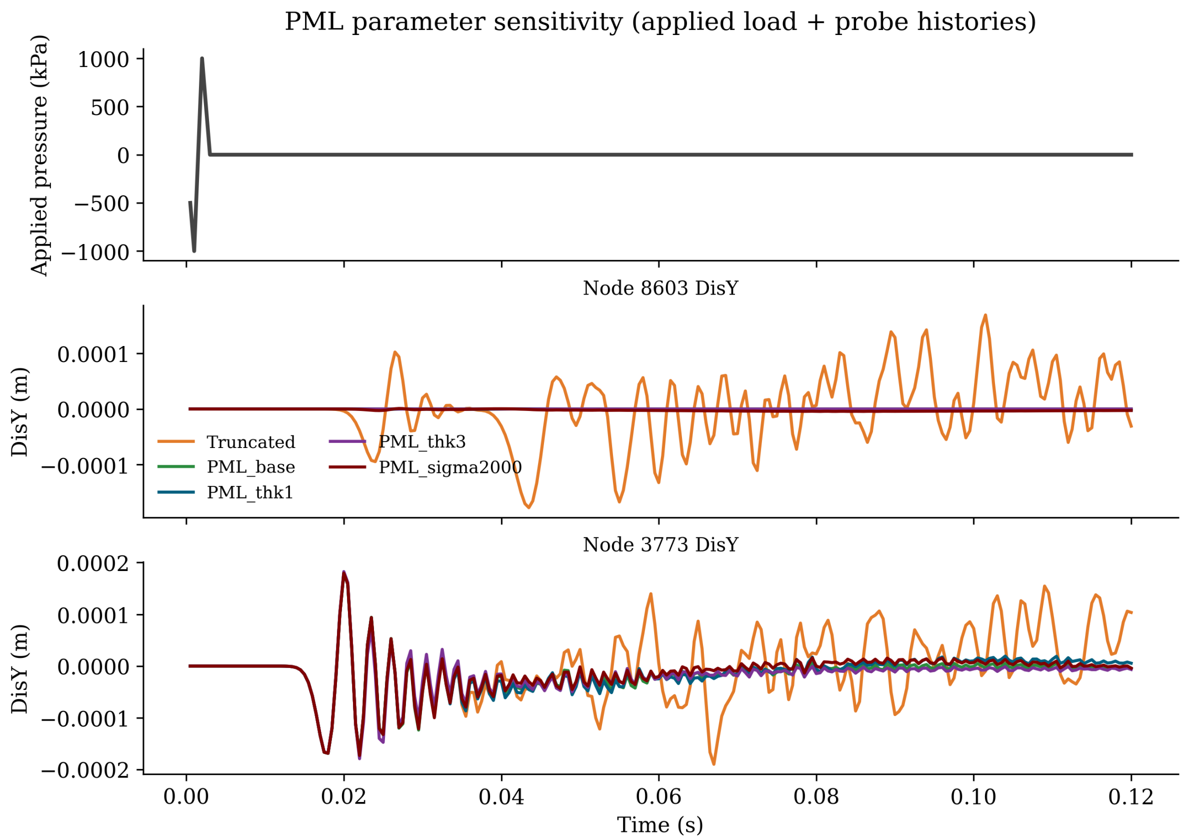

Figure 4: PML sensitivity: DisY probe near XMIN

1.5.1 Example sensitivity sweep (this impulse case)

The figure below compares a near-boundary probe (`Node 8603 DisY`, near `XMIN`) **and** an interior probe (`Node 3773 DisY`) for:

- **Truncated** (no PML)
- **PML base** (the provided PML input)
- **PML with thinner layer** (`@@Thickness` smaller)
- **PML with thicker layer** (`@@Thickness` larger)
- **PML with weaker damping** (`@@SigmaMax` smaller)

Figure: Sensitivity sweep comparing truncated vs PML variants at a near-boundary probe (to see reflected arrivals) and an interior probe (to confirm minimal near-field contamination).

1.5.2 PML input blocks used in the sweep

The *only* change between these PML variants is the `% PML Layer` block.

PML base (provided file):

```
% PML Layer
@@Thickness: 2.0
@@SigmaMax: 7000.0
@@KappaMax: 1.0
@@AlphaMax: 2000.0
@@Exponent: 2.0
@@Sides: XMIN XMAX YMIN
@@Debug: No
%%%
```

PML thinner (`@@Thickness = 1.0`):

```
% PML Layer
@@Thickness: 1.0
@@SigmaMax: 7000.0
@@KappaMax: 1.0
@@AlphaMax: 2000.0
@@Exponent: 2.0
@@Sides: XMIN XMAX YMIN
@@Debug: No
%%%
```

PML thicker (`@@Thickness = 3.0`):

```
% PML Layer
@@Thickness: 3.0
@@SigmaMax: 7000.0
@@KappaMax: 1.0
@@AlphaMax: 2000.0
@@Exponent: 2.0
@@Sides: XMIN XMAX YMIN
@@Debug: No
%%%
```

PML weaker damping (`@@SigmaMax = 2000.0`):

```
% PML Layer
@@Thickness: 2.0
@@SigmaMax: 2000.0
@@KappaMax: 1.0
@@AlphaMax: 2000.0
```

```
@@Exponent: 2.0
@@Sides: XMIN XMAX YMIN
@@Debug: No
%%%
```

How to read the trends

- Increasing `@@Thickness` typically reduces late-time oscillations because the outgoing wave is attenuated more gradually (smaller effective reflection from the “start” of the layer).
- Decreasing `@@SigmaMax` tends to leave more residual reflections because the wave is not damped enough before reaching the outer boundary of the PML region.
- Making the PML *too aggressive* (very large `@@SigmaMax` and/or very sharp grading via `@@Exponent`) can also increase reflections due to an abrupt impedance change, even though the layer is “stronger”.

See also: Perfectly Matched Layer (PML)