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Supplementary: Feature-Based Circuit Fault Diagnosis with Classical Machine Learning Baseline

This supplementary material was not counted toward the 3–6-page limit. Additional details were included so that reproducibility would not be reduced by space limits.

1. Hyperparameter search spaces

The search spaces were not hidden, and the exact grids used
by the training script were as follows.

1.1. SVM grid

```
svm_param_grid = {
"svc__C": [0.1, 1.0, 10.0],
"svc__gamma": ["scale", 0.01, 0.1, 1.0],
}
```

1.2. k-NN grid

```
knn_param_grid = {
"knn__n_neighbors": [3, 5, 7],
"knn__weights": ["uniform", "distance"],
}
```

1.3. Shallow NN randomized search

Five randomized candidates were sampled from:

```
hidden_units in {32, 64, 128}
dropout in {0.0, 0.2, 0.4}
learning_rate in {1e-4, 1e-3, 1e-2}
batch_size in {32, 64}
epochs = 25
```

2. Artifact layout

A consistent artifact layout was used so that results were not
lost.

```
artifacts/
label_map.json
X_train.npy, X_val.npy, X_test.npy
y_train.npy, y_val.npy, y_test.npy
scaler_params.json
svm_YYYYMMDD_HHMMSS.joblib
knn_YYYYMMDD_HHMMSS.joblib
shallow_nn_YYYYMMDD_HHMMSS.keras
* evaluation_YYYYMMDD_HHMMSS.json
```

3. Observed failure mode

A majority-class collapse was printed for the SVM and shallow
NN baselines. Because it was not desired to hide this behavior, it was documented directly:

- Minority classes were not predicted by the SVM and shallow
NN.
- The achieved accuracy matched the empirical prior of the
majority class (50.63% on the test split).
- Macro-F1 was not improved beyond the baseline implied
by this collapse.

4. Recommended next fixes (not yet implemented)

- Class-weighted objectives were not used; it is recommended
that class weight="balanced" be added
for SVM and a weighted loss be used for the NN.
- Oversampling/under-sampling was not tested; it is recommended
that stratified batch sampling be added.
- Richer representations were not trained; it is recommended
that the full response curve be treated as a 1D signal and encoded with a CNN or Transformer.