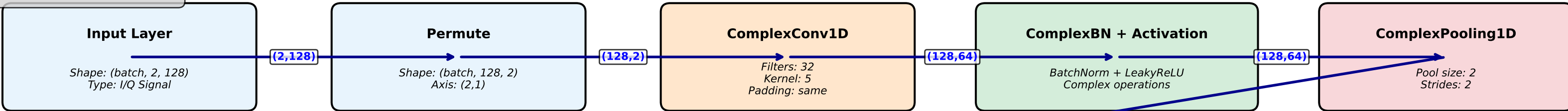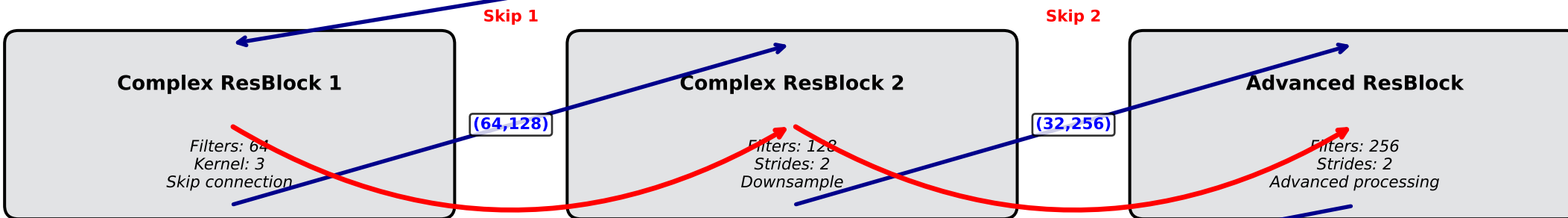# Lightweight Hybrid Model - Detailed Layer Specifications

Model Statistics:
- Total Parameters: ~1.3M
- Complex Parameters: ~0.9M
- Real Parameters: ~0.4M
- FLOPs: ~50M
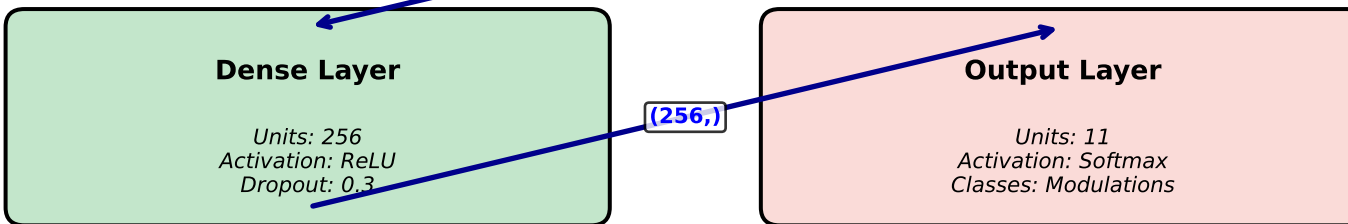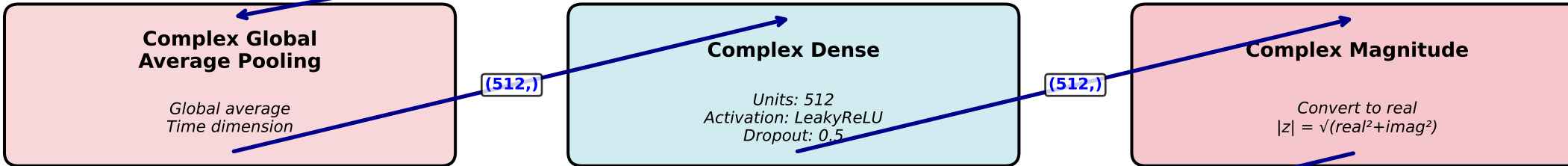- Memory Usage: ~15MB
- Inference Time: 2.3ms

Phase 1: Complex Feature Extraction

Input Layer
Shape: (batch, 2, 128)
Type: I/Q Signal

(2,128) →

Permute
Shape: (batch, 128, 2)
Axis: (2,1)

(128,2) →

ComplexConv1D
Filters: 32
Kernel: 5
Padding: same

(128,64) →

ComplexBN + Activation
BatchNorm + LeakyReLU
Complex operations

(128,64) →

ComplexPooling1D
Pool size: 2
Strides: 2

(64,64)

Phase 2: Complex Residual Learning

Skip 1

Complex ResBlock 1
Filters: 64
Kernel: 3
Skip connection

(64,128)

Complex ResBlock 2
Filters: 128
Strides: 2
Downsample

(32,256)

Skip 2

Advanced ResBlock
Filters: 256
Strides: 2
Advanced processing

Phase 3: Global Feature Processing

Complex Global Average Pooling
Global average
Time dimension

(512,)

Complex Dense
Units: 512
Activation: LeakyReLU
Dropout: 0.5

(512,)

Complex Magnitude
Convert to real
$|z| = \sqrt{(real^2 + imag^2)}$

(512,)

Dense Layer
Units: 256
Activation: ReLU
Dropout: 0.3

(256,)

Output Layer
Units: 11
Activation: Softmax
Classes: Modulations

Phase 4: Classification