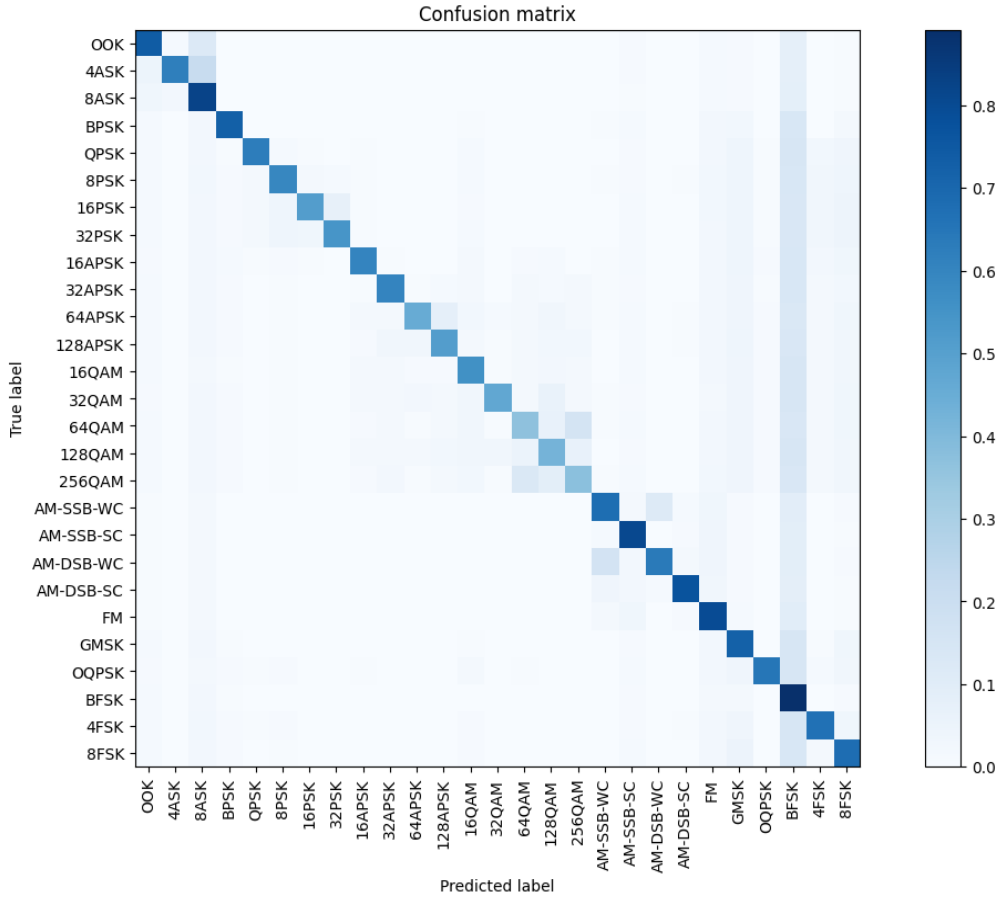
FINN Radio ML on FPGA

Report from building and training model (VGG10 - 27modulations)

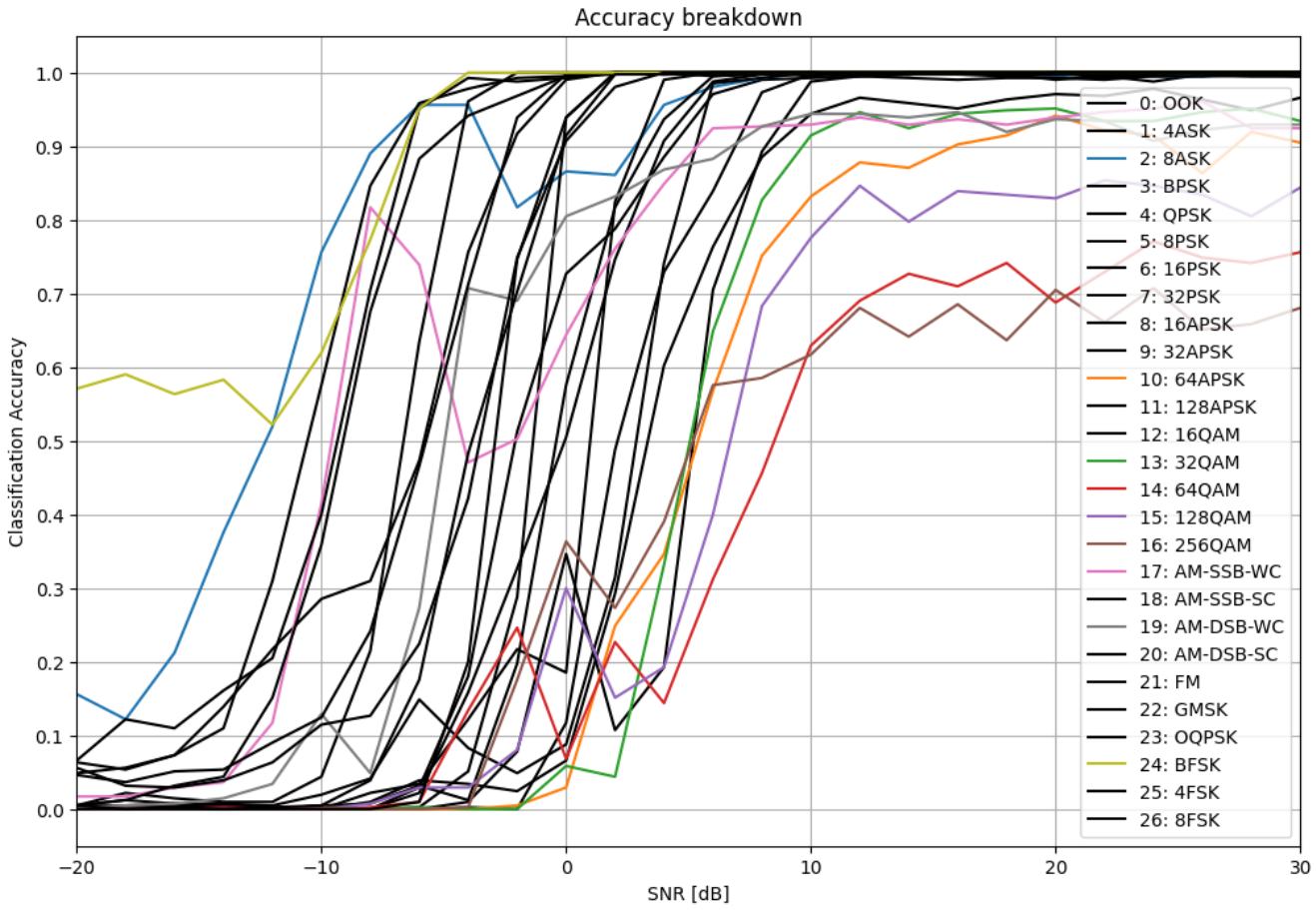
- The model followed the architecture (VGG10) mentioned in *RadioML Meets FINN: Enabling Future RF Applications With FPGA Streaming Architectures*

Building Model
• Seven 1D-Convolutional layers, kernel size of 3, each followed by Batch Normalization, ReLU activation, and 1D Maxpool that reduces the layer by half • One Flatten Layer • Two Linear Layers, each follwed by Batch Normalization and ReLU activation • One Final Linear Layers performing modulation classification
Total parameters (all trainable): 160932

- The model ran for 15 epochs (stopped early due to no improvements), and has accuracy of 61.5746% for all SNRs. At the highest SNR (30dB), the model has an accuracy of 95.4291%



Confusion Matrix (across all SNRs)



Accuracy Breakdown of Each Classification (across all SNRs)

Report from running throughput and verification on FPGA

- Throughput or FPS is measured in [images/s] or frames per second.
- For runtime, the model is tested on 1 batch with size 1024 frames with 27 modulations.

VGG10 (27 modulations) – 8 bits for weights and activations (w8a8)
runtime[ms]: 420.3033447265625,
throughput[images/s]: 2436.3355962969686,
DRAM_in_bandwidth[MB/s]: 4.989615301216191,
DRAM_out_bandwidth[MB/s]: 0.0024363355962969684,
fclk[mhz]: 249.9975,
batch_size: 1024,
fold_input[ms]: 0.0896453857421875,
pack_input[ms]: 0.0667572021484375,
copy_input_data_to_device[ms]: 2.5424957275390625,
copy_output_data_from_device[ms]: 0.1270771026611328,
unpack_output[ms]: 0.5090236663818359,
unfold_output[ms]: 0.064849853515625

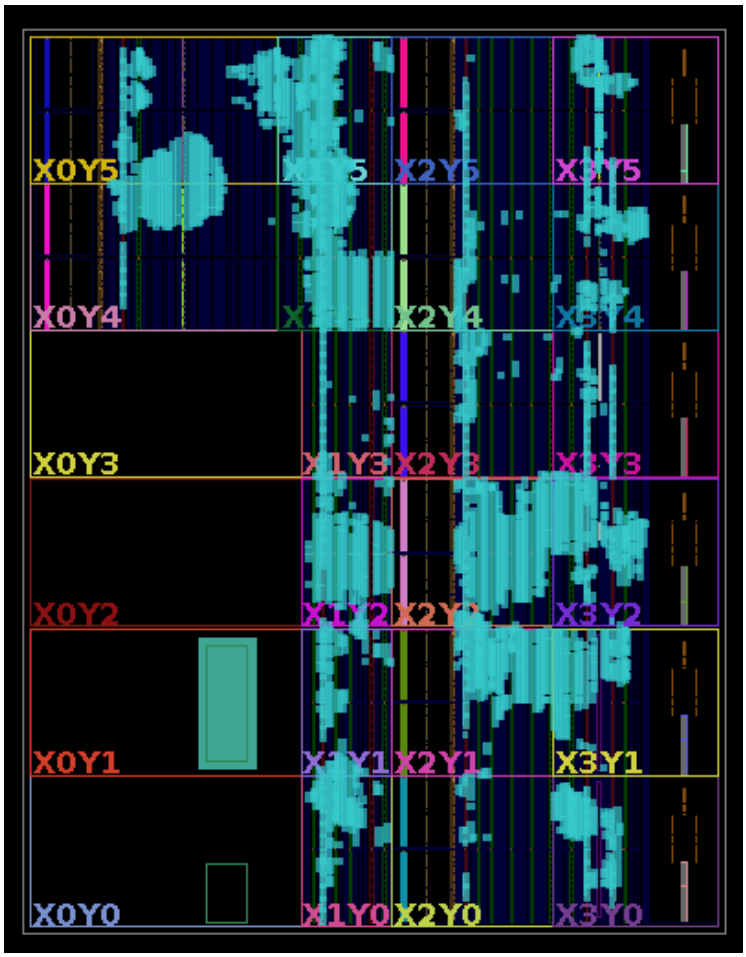
Accuracy at 30db on FPGA: 10564 / 11070 = 95.42908762420957%	Accuracy at 30db before FINN compiling: 95.4291%
Accuracy at all SNRS on FPGA: 177222 / 287820= 61.57390035438816%	Accuracy at all SNRS before FINN compiling: 61.5746%

Report from FINN estimated report

Post synthesis report
Total Flip flops: 56656 Total Look-up Tables: 33630 Total BRAM_36K: 177 Total BRAM_18K: 61

Report from analyzing the final stitch project on Vivado

Running implementation on Vivado
Total Flip flops: 453 Total Look-up Tables: 2680 Total BRAM: 205



Hardware Design Layout