

# DSP Lab Demo 6 Exercise 4

## Major Code Changes

### 1. Replaced direct form with canonical form

```
w1 = w2 = w3 = w4 = 0.0  
w0 = x - a[1]*w1 - a[2]*w2 - a[3]*w3 - a[4]*w4  
y = b[0]*w0 + b[1]*w1 + b[2]*w2 + b[3]*w3 + b[4]*w4  
w4, w3, w2, w1 = w3, w2, w1, w0
```

### 2. Simplified state storage

```
# old: 8 variables  
# x1, x2, x3, x4  
# y1, y2, y3, y4  
  
# new: only 4 states  
w1, w2, w3, w4
```

### 3. Verified output equivalence

```
assert np.allclose(y_direct, y_canonical, atol=1e-12)
```

## Outcome

```
(base) yifan@Mac HW % python '/Users/yifan/Documents/WebD/DSP  
ify.py'  
Bit-exact equal: True  
Differing samples: 0
```

The canonical form implementation produces the same audio output as the original direct-form program but requires half the memory (4 delays instead of 8).