# Data analysis of Engine run on Friday May 3rd 2019

- Duration of run was
- Captured vibration data (3D) and OBD data

## read obd and accelerometer data files

```
obd = readmatrix('obd_friday_main.csv');
acc = readmatrix('test_friday_real.csv');
```

```
obd_t = obd(:,1);
obd_2 = obd(:,2);
obd_tpos = obd(:,3);
obd_load = obd(:,4);
obd_5 = obd(:,5);
obd_ctemp = obd(:,6);
obd_rpm = obd(:,7);
obd_ignt = obd(:,8);
obd_vin = obd(:,9);
obd_airt = obd(:,10);
obd_map = obd(:,11);
obd_12 = obd(:,12);
obd_13 = obd(:,13);
obd_14 = obd(:,14);
obd_15 = obd(:,15);
obd_16 = obd(:,16);
```

```
acc_t = acc(:,1);
acc_x = acc(:,2);
acc_y = acc(:,4);
acc_z = acc(:,6);
```

```
acc_x(isnan(acc_x))=0;
acc_y(isnan(acc_y))=0;
acc_z(isnan(acc_z))=0;
```

```
f1 = figure(1); clf;
hold on;
yyaxis left;
plot(obd_t(71:end), obd_rpm(71:end)); % time alignment
ylabel("rpm");
yyaxis right;
plot(acc_t, acc_x);
plot(acc_t, acc_y);
plot(acc_t, acc_z);
ylabel("v @ 100mV/g");
hold off;
legend({"Engine RPM", "vibration"});
```

```
xlabel("time (s)");
```
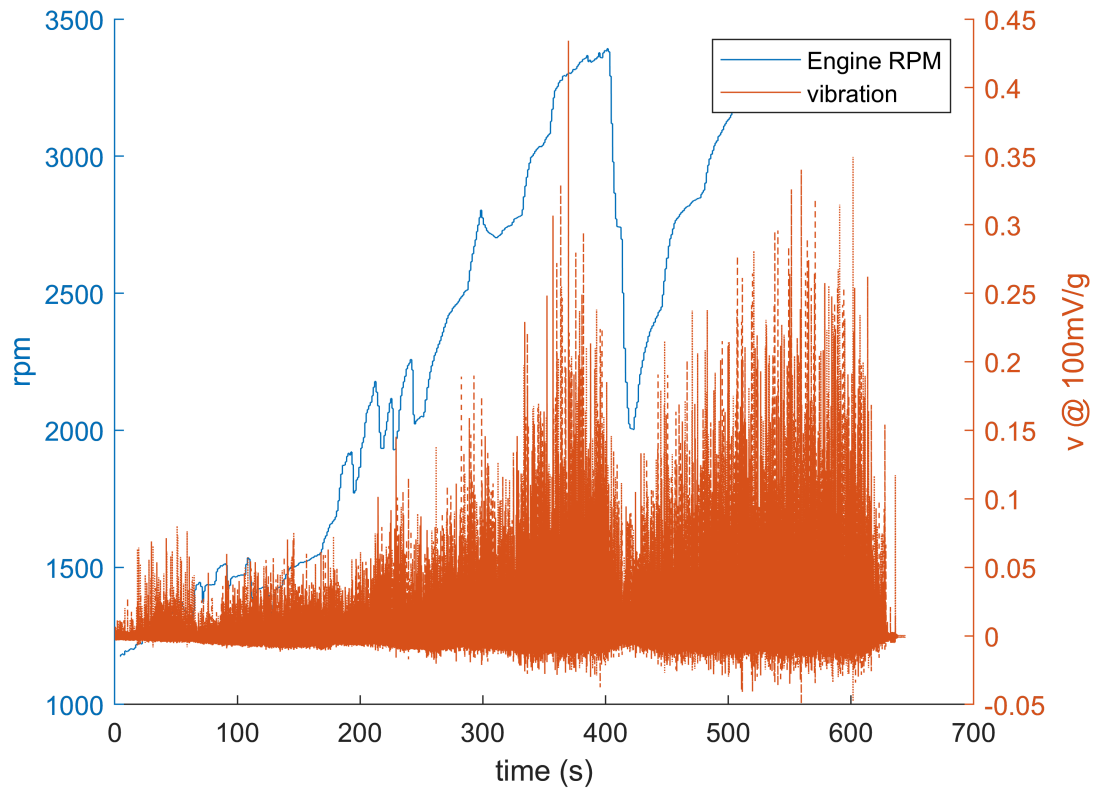


```
f22 = figure(22); clf;
hold on;
yyaxis left;
plot(obd_t, obd_rpm, 'b');
ylabel("rpm");
yyaxis right;
plot(obd_t, obd_tpos, 'g-');
plot(obd_t, obd_load, 'r-');
ylabel("%");
hold off;
legend({"Engine RPM", "Throttle Pos", "Engine Load"}, 'location', 'southeast');
xlabel("time (s)");
```
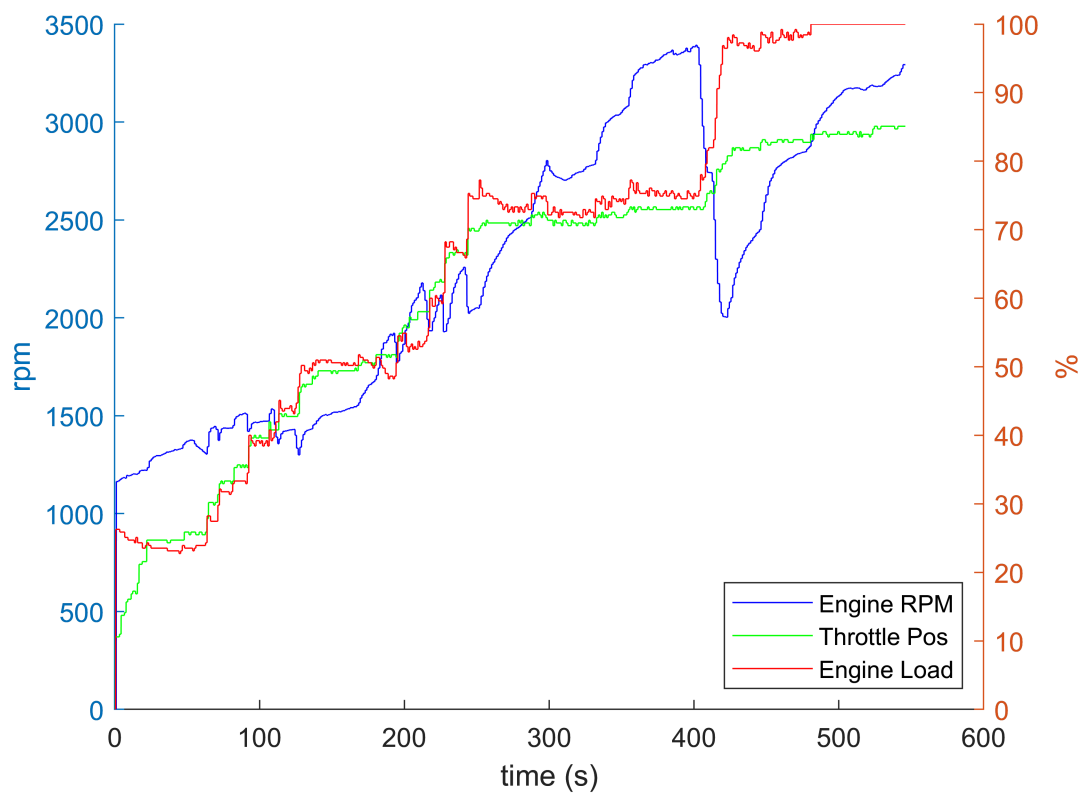
```
f23 = figure(23); clf;
hold on;
yyaxis left;
plot(obd_t, obd_rpm, 'b');
ylabel("rpm");
yyaxis right;
plot(obd_t, obd_ignt, 'r');
ylabel("?");
hold off;
legend({"Engine RPM", "Ignition Timing"}, 'location', 'southeast');
xlabel("time (s)");
```
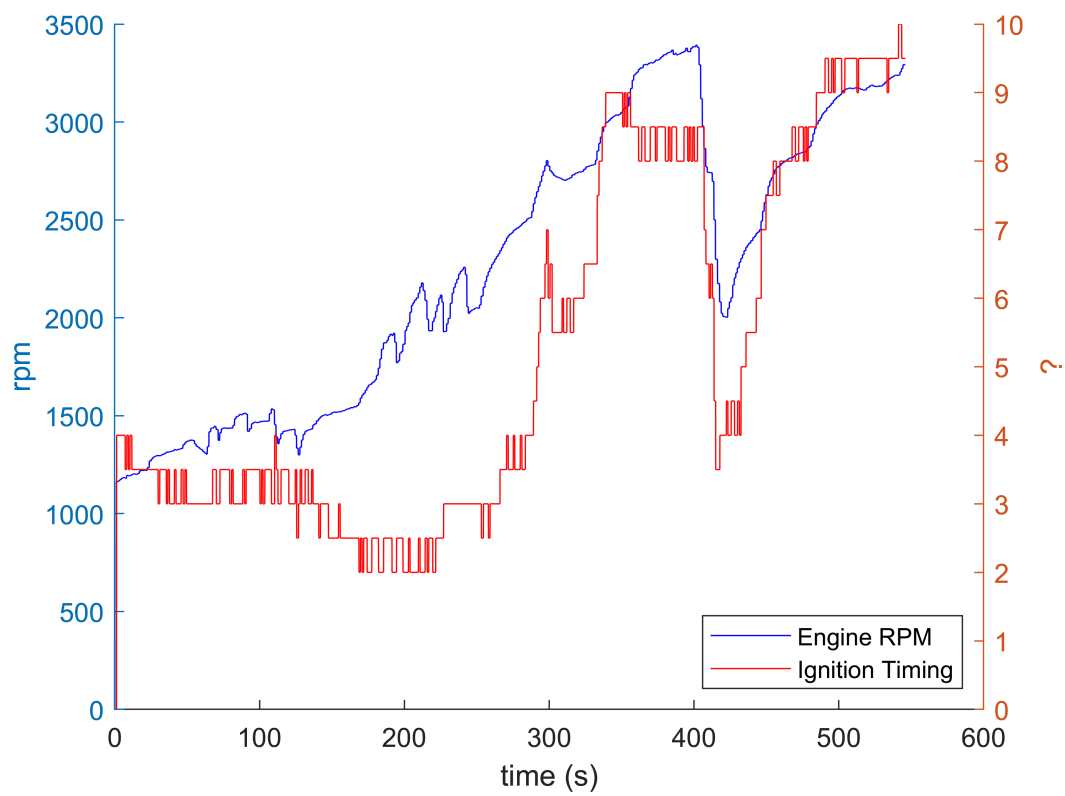
```
rpm_temp = obd_rpm(71:end);
obd_t_temp = obd_t(71:end);
acc_t_temp = acc_t(1:3494500);
acc_x_temp = acc_x(1:3494500);
```
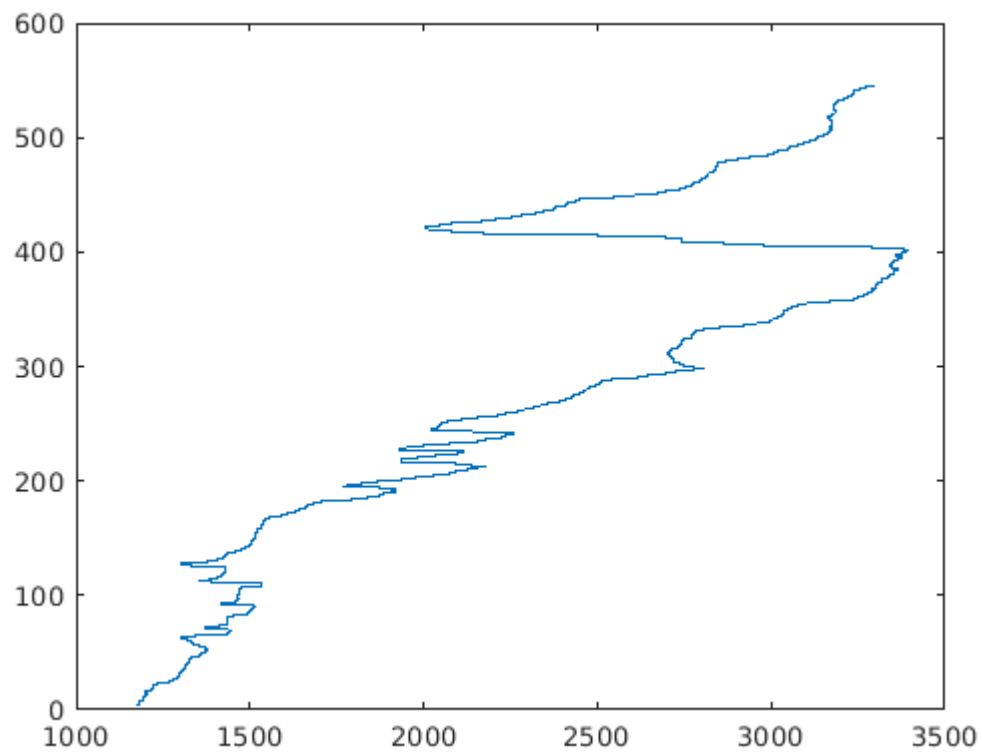
```
f3 = figure(3); clf;
%f3.Position = [0 0 1200 800];
title('raw accelerometer data');

subplot(311);
plot(acc_t, acc_x);
title('acc_x');
ylim([-.1 .4]);

subplot(312);
plot(acc_t, acc_y);
title('acc_y');
ylim([-.1 .4]);

subplot(313);
plot(acc_t, acc_z);
title('acc_z');
ylim([-.1 .4]);
```
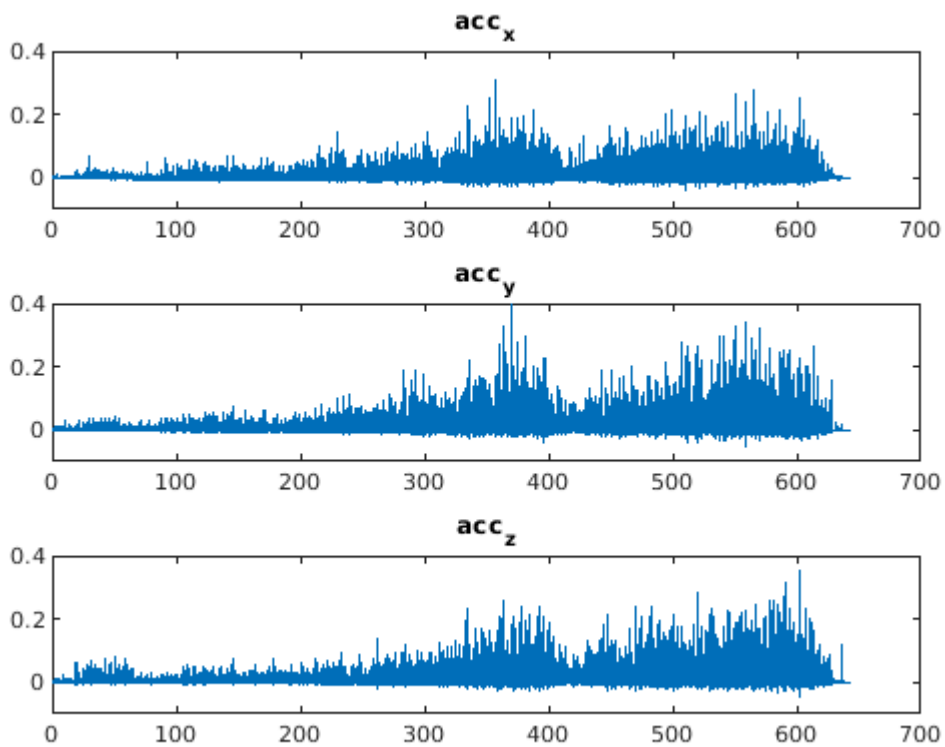
## Spectral Analysis

```
sample_rate = 6400;
N = length(acc_t);
t = (0:N-1)/sample_rate;
hz_vals = linspace(0, sample_rate/2, floor(N/2)+1);
powers_x = abs(fft(detrend(acc_x(:,1)))/N).^2;
f24 = figure(24); clf;
plot(hz_vals, powers_x(1:length(hz_vals)));
xlabel("frequency (hz)");
ylabel("power");
title("power spectrum of acc_x");
```

FFT of acc$_x$
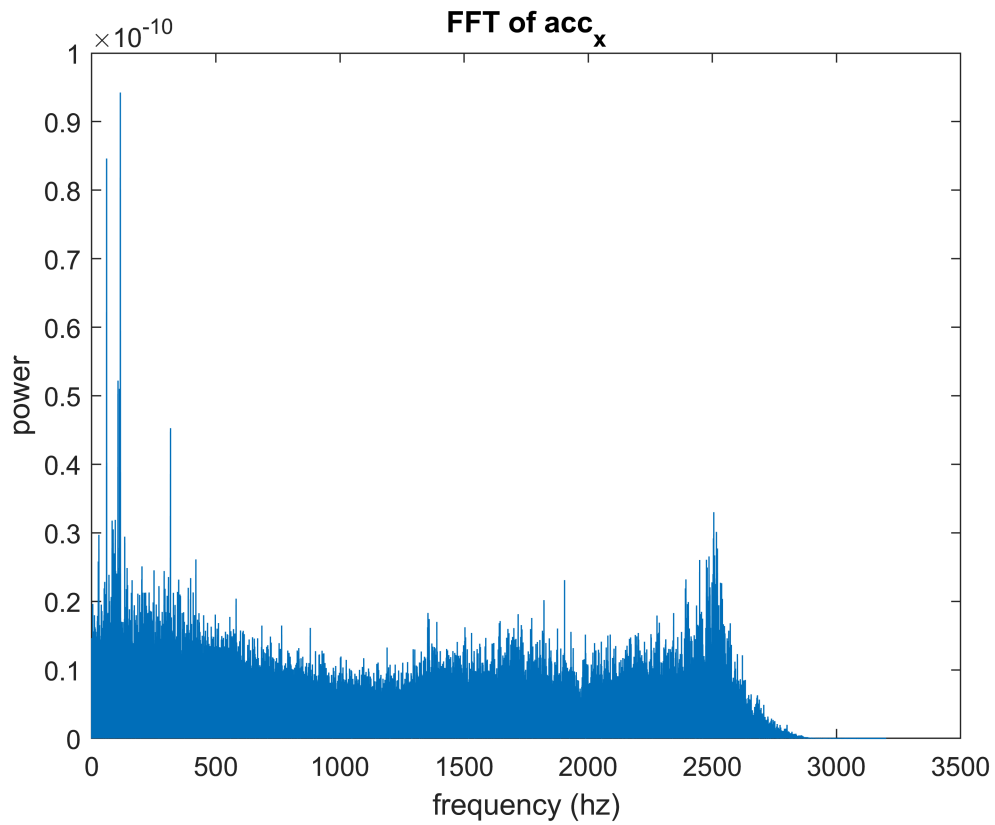
```
powers_y = abs(fft(detrend(acc_y(:,1)))/N).^2;
f25 = figure(25); clf;
plot(hz_vals, powers_y(1:length(hz_vals)));
xlabel("frequency (hz)");
ylabel("power");
title("power spectrum of acc_y");
```

**power spectrum of acc_y**
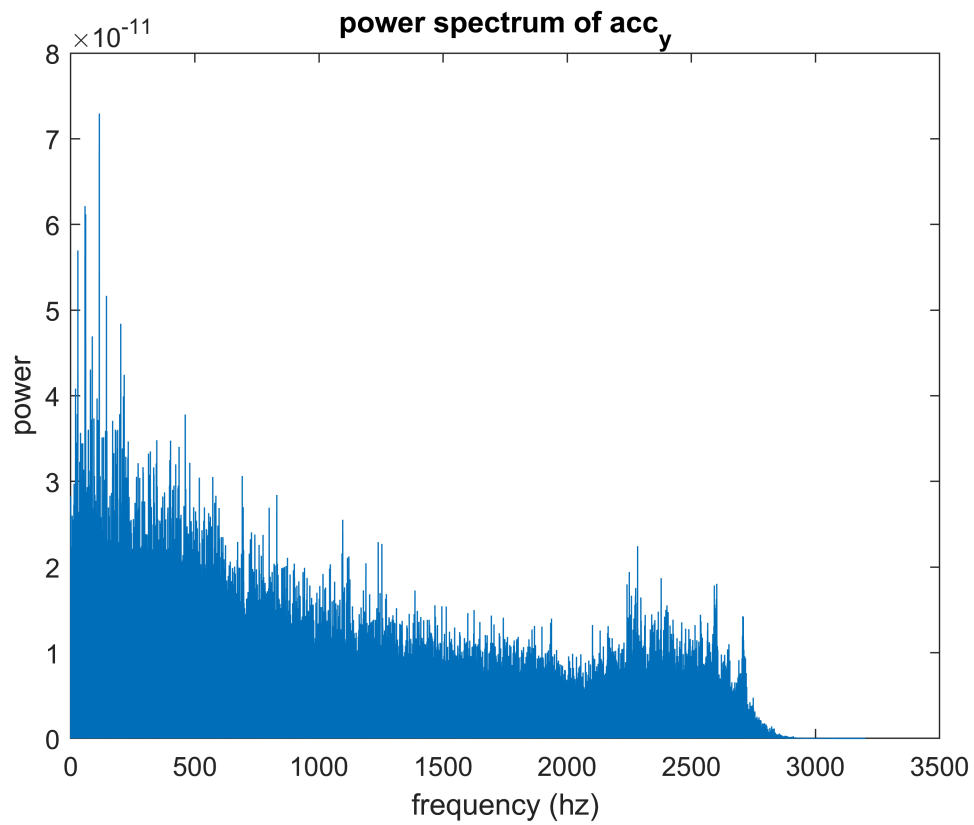
```
powers_z = abs(fft(detrend(acc_z(:,1)))/N).^2;
f25 = figure(25); clf;
plot(hz_vals, powers_z(1:length(hz_vals)));
xlabel("frequency (hz)");
ylabel("power");
title("power spectrum of acc_z");
```

## power spectrum of acc$_z$
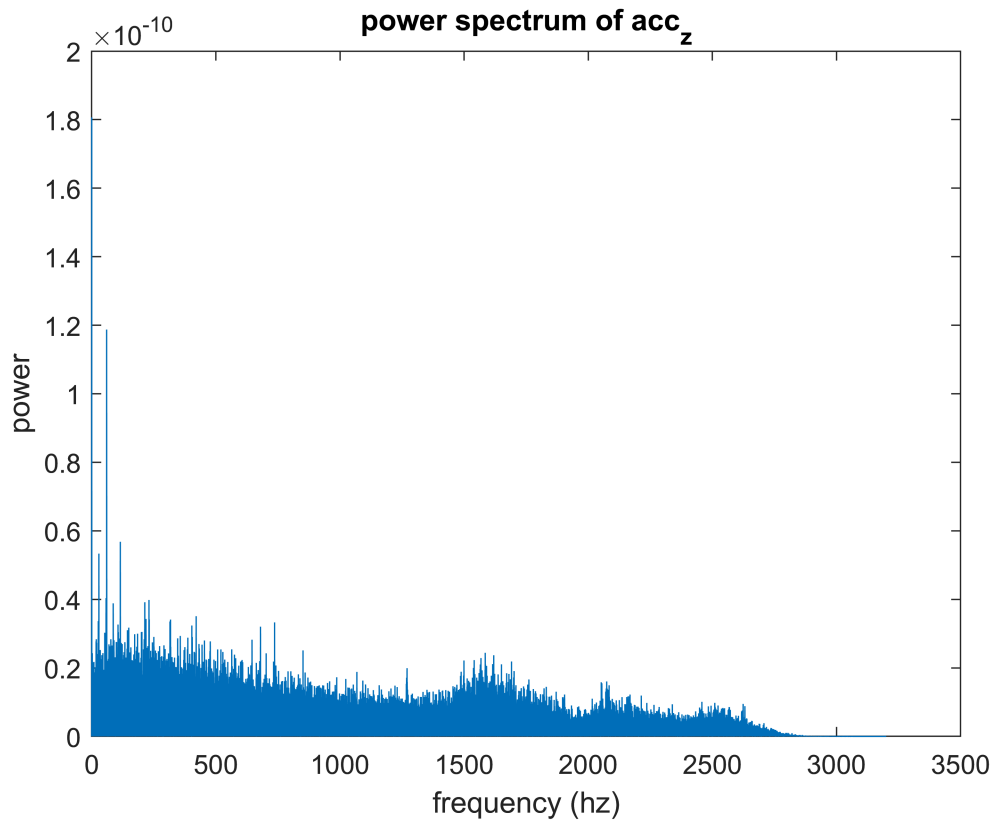


```
%powers = abs(fft(acc_x(:,1))/N).^2;
```

```
[spectrumx, frequencyx, timex] = spectrogram(detrend(acc_x(:,1)), hann(1000), 100, [], sample_r

f26 = figure(26); clf;
f26.Position = [0 0 600 300];
imagesc(timex, frequencyx, abs(spectrumx).^2);
ax = gca;
%ax.CLim = [8 12];
%ax.YLim = frequency([1 dsearchn(frequency, 12000)]);
%ax.XLim = time([1 end]);
colormap(parula(24));
c = colorbar();
c.Label.String = "frequency presence";
set(c, 'YTick', []);
xlabel("time (s)");
ylabel("frequency (hz)");
title("spectrogram of acc_x");
```

spectrogram of acc$_x$
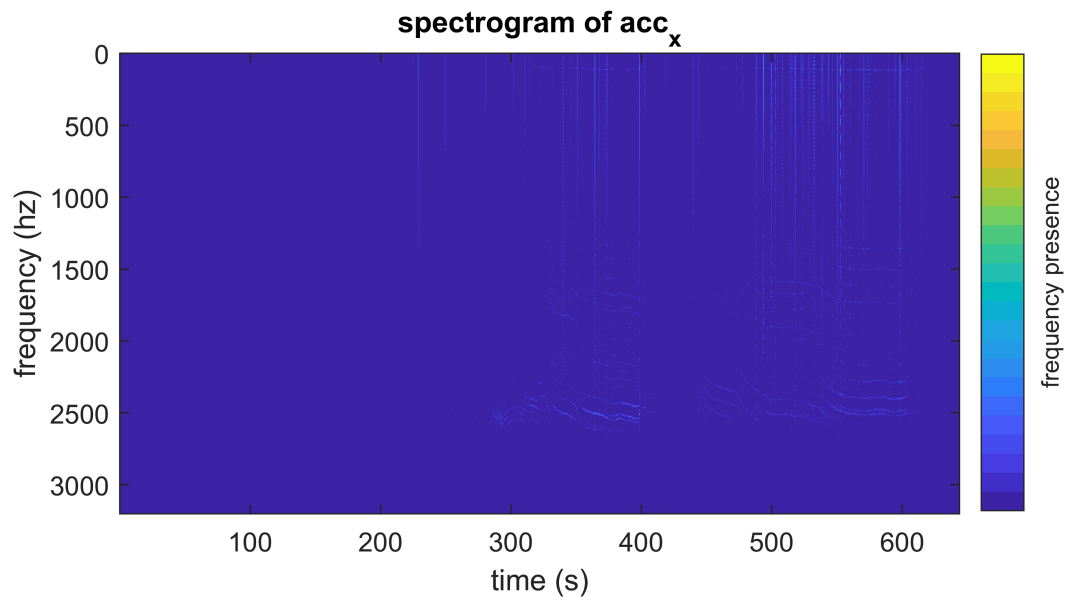
```
[spectrumy, frequencyy, timey] = spectrogram(detrend(acc_y(:,1)), hann(1000), 100, [], sample_r

f26 = figure(26); clf;
f26.Position = [0 0 600 300];
imagesc(timey, frequencyy, abs(spectrumy).^2);
ax = gca;
%ax.CLim = [8 12];
%ax.YLim = frequency([1 dsearchn(frequency, 12000)]);
%ax.XLim = time([1 end]);
colormap(parula(24));
c = colorbar();
c.Label.String = "frequency presence";
set(c, 'YTick', []);
xlabel("time (s)");
ylabel("frequency (hz)");
title("spectrogram of acc_y");
```

**spectrogram of acc$_y$**
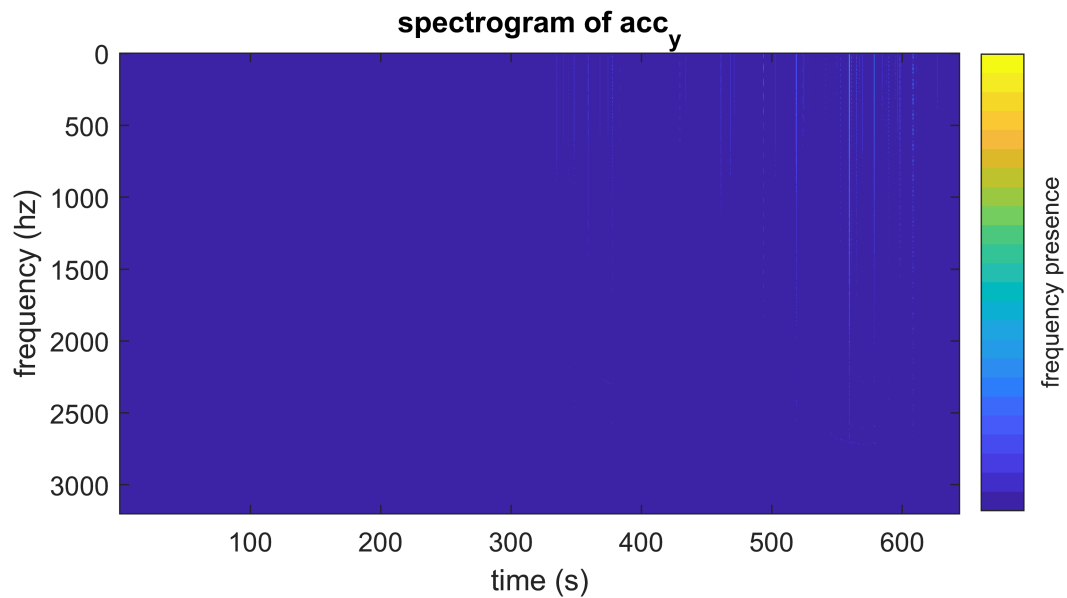
```
[spectrumz, frequencyz, timez] = spectrogram(detrend(acc_z(:,1)), hann(1000), 100, [], sample_r

f26 = figure(26); clf;
f26.Position = [0 0 600 300];
imagesc(timez, frequencyz, abs(spectrumz).^2);
ax = gca;
%ax.CLim = [8 12];
%ax.YLim = frequency([1 dsearchn(frequency, 12000)]);
%ax.XLim = time([1 end]);
colormap(parula(24));
c = colorbar();
c.Label.String = "frequency presence";
set(c, 'YTick', []);
xlabel("time (s)");
ylabel("frequency (hz)");
title("spectrogram of acc_z");
```

spectrogram of acc$_z$
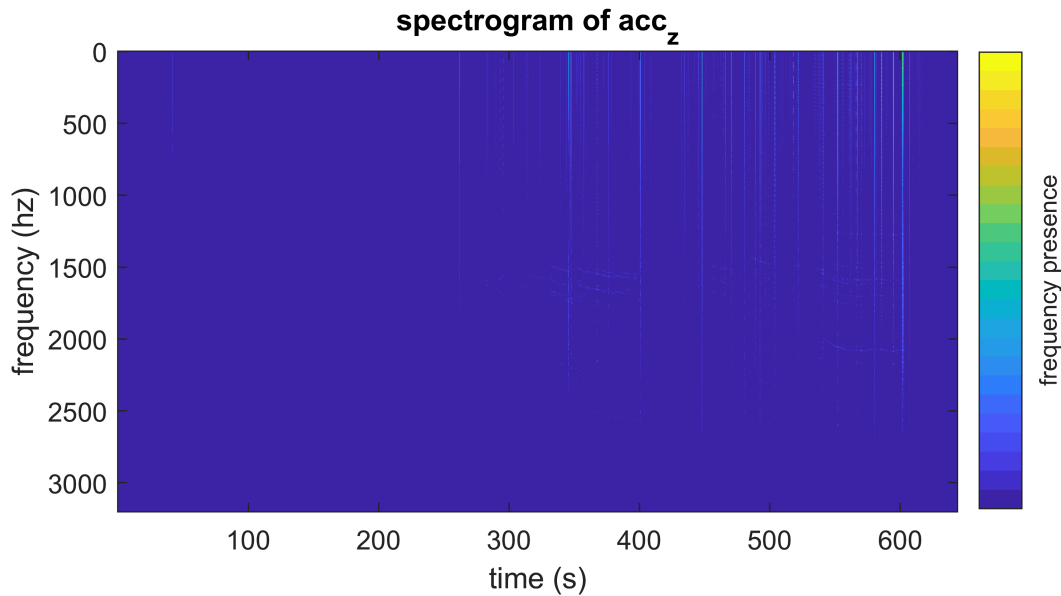
```
f4 = figure(4); clf;
f4.Position = [0 0 1200 800];
subplot(311);
%plot(hz_vals, powers(1:length(hz_vals)));
plot(hz_vals, fft(acc_x(1:length(hz_vals))));
```

Warning: Imaginary parts of complex X and/or Y arguments ignored

```
title("FFT of acc_x");
ylim([-10 10]);

subplot(312);
%plot(hz_vals, powers(1:length(hz_vals)));
plot(hz_vals, fft(acc_y(1:length(hz_vals))));
```
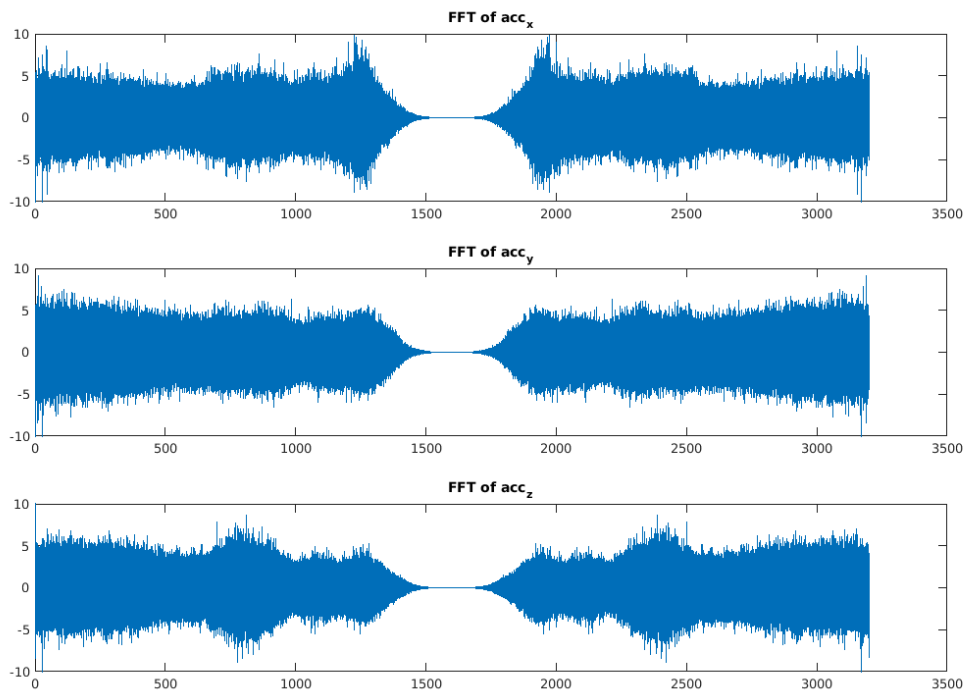
Warning: Imaginary parts of complex X and/or Y arguments ignored

```
title("FFT of acc_y");
ylim([-10 10]);

subplot(313);
%plot(hz_vals, powers(1:length(hz_vals)));
plot(hz_vals, fft(acc_z(1:length(hz_vals))));
```

Warning: Imaginary parts of complex X and/or Y arguments ignored

```
title("FFT of acc_z");
ylim([-10 10]);
```

**FFT of acc_x**



**FFT of acc_y**



**FFT of acc_z**

## DWT of acc_x

```matlab
[cA, cD] = dwt(acc_x, 'sym4');
f5 = figure(5); clf;
f5.Position = [0 0 1200 200];
plot(cD);
title("dwt of acc_x");
```
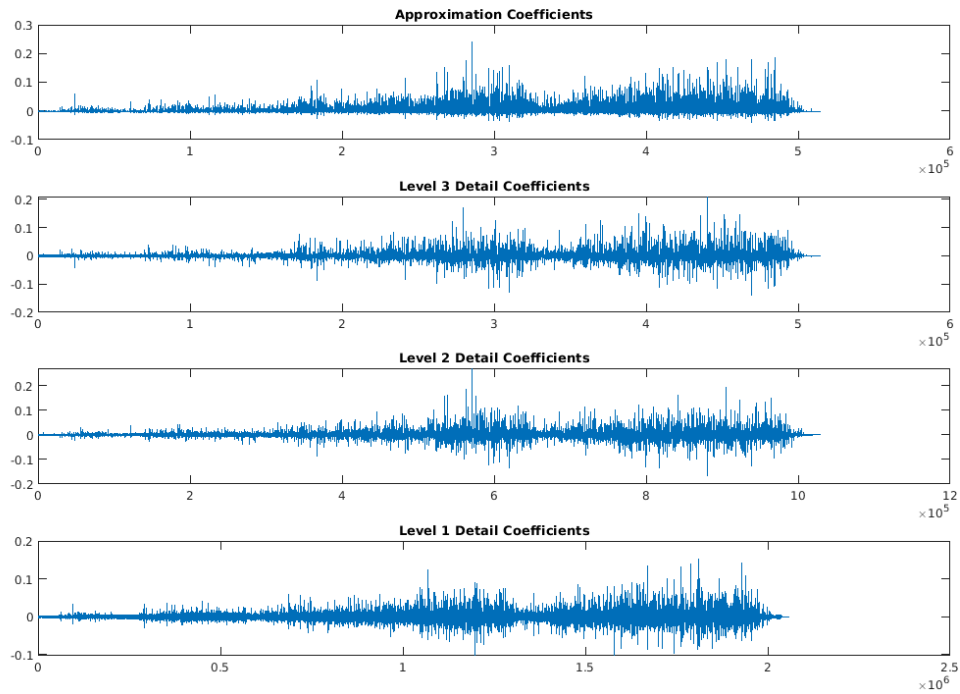


dwt of acc_x
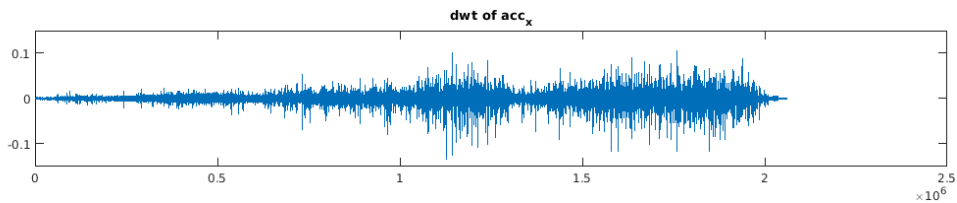
```matlab
[c,l] = wavedec(acc_x, 3, 'db2');
approx = appcoef(c,l,'db2');
[cd1,cd2,cd3] = detcoef(c,l,[1 2 3]);
f6 = figure(6); clf;
f6.Position = [0 0 1200 800];
subplot(4,1,1);
plot(approx);
title('Approximation Coefficients');
subplot(4,1,2);
```

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```
plot(cd3);
title('Level 3 Detail Coefficients');
subplot(4,1,3);
plot(cd2);
title('Level 2 Detail Coefficients');
subplot(4,1,4);
plot(cd1);
title('Level 1 Detail Coefficients');
```



## OBD Plots

```
f7 = figure(7); clf;
plot(obd_t,obd_2);
title("obd_2");
```
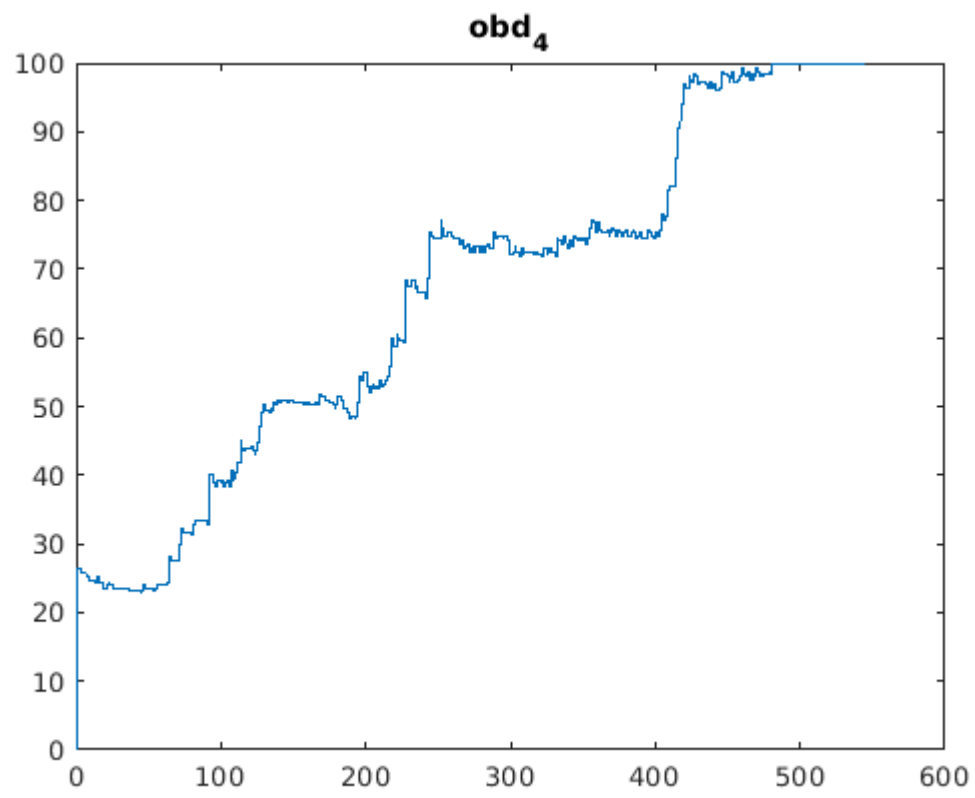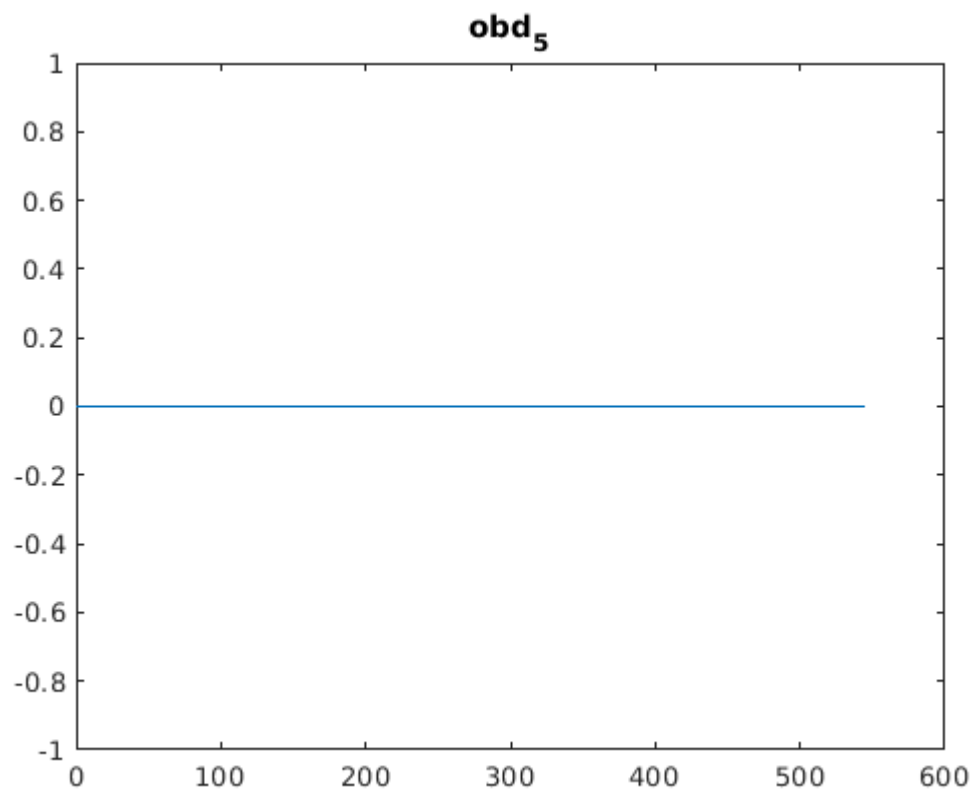
## $\mathbf{obd_2}$
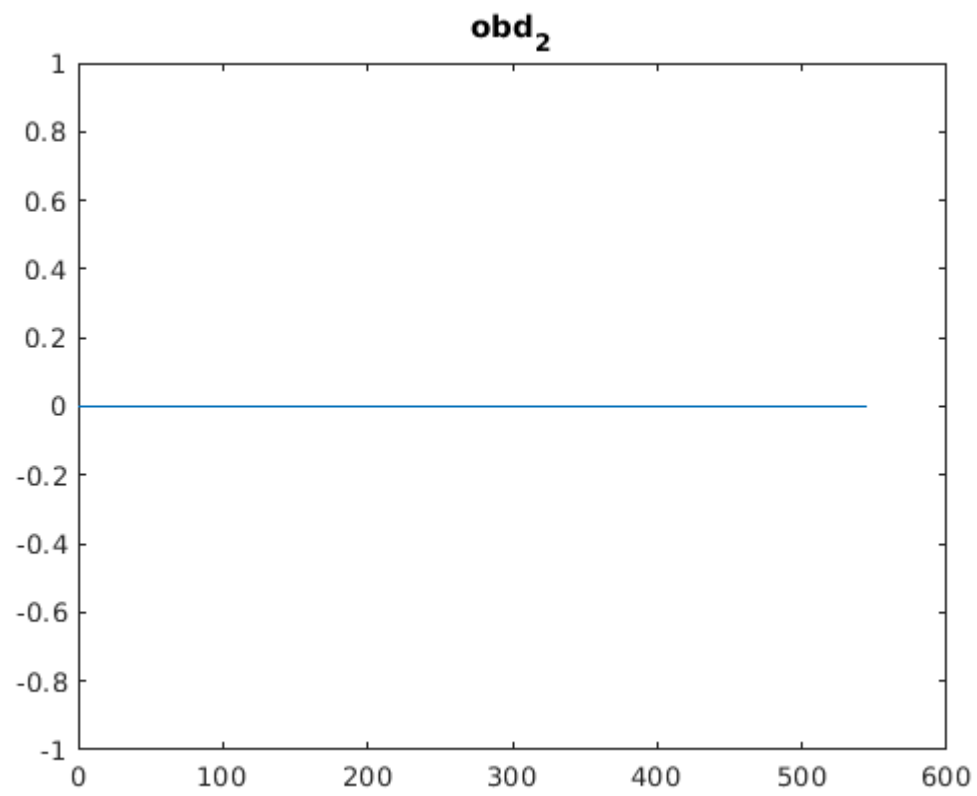


```
f8 = figure(8); clf;
plot(obd_t,obd_3);
title("obd_3");
```
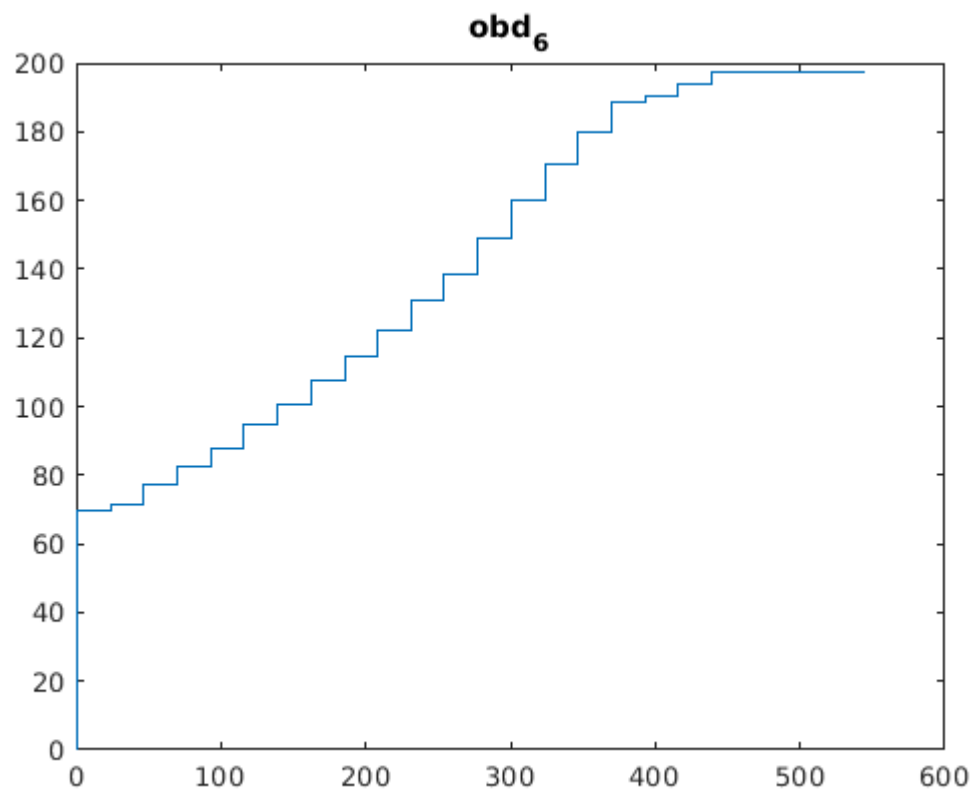
**obd$_3$**
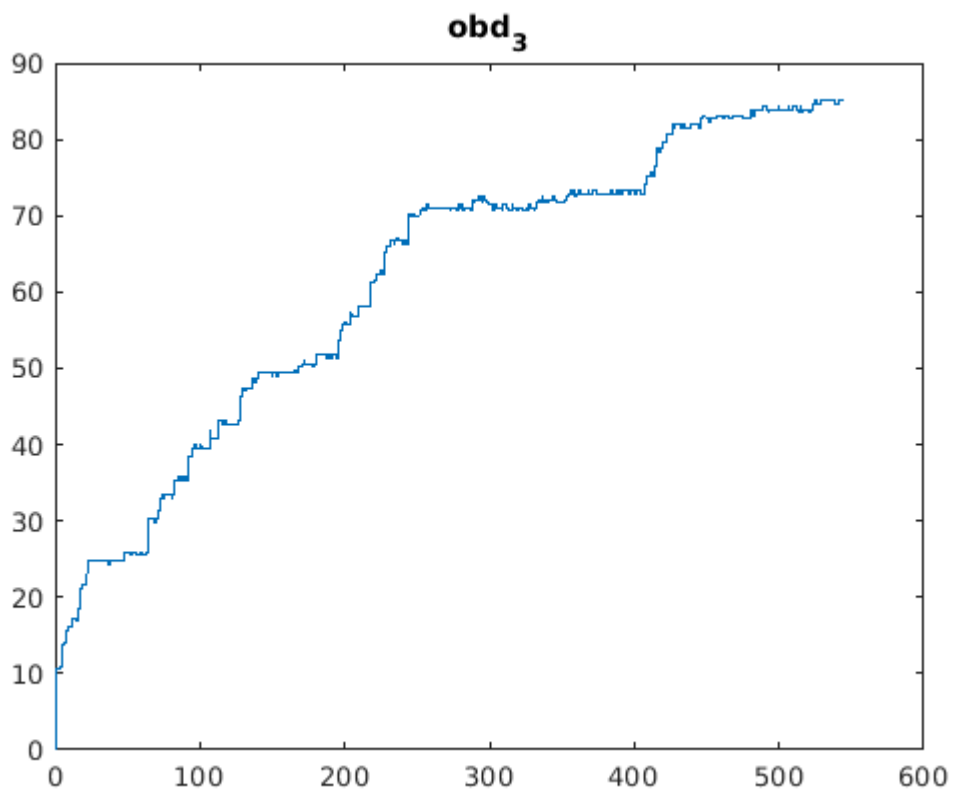
```
f9 = figure(9); clf;
plot(obd_t,obd_4);
title("obd_4");
```
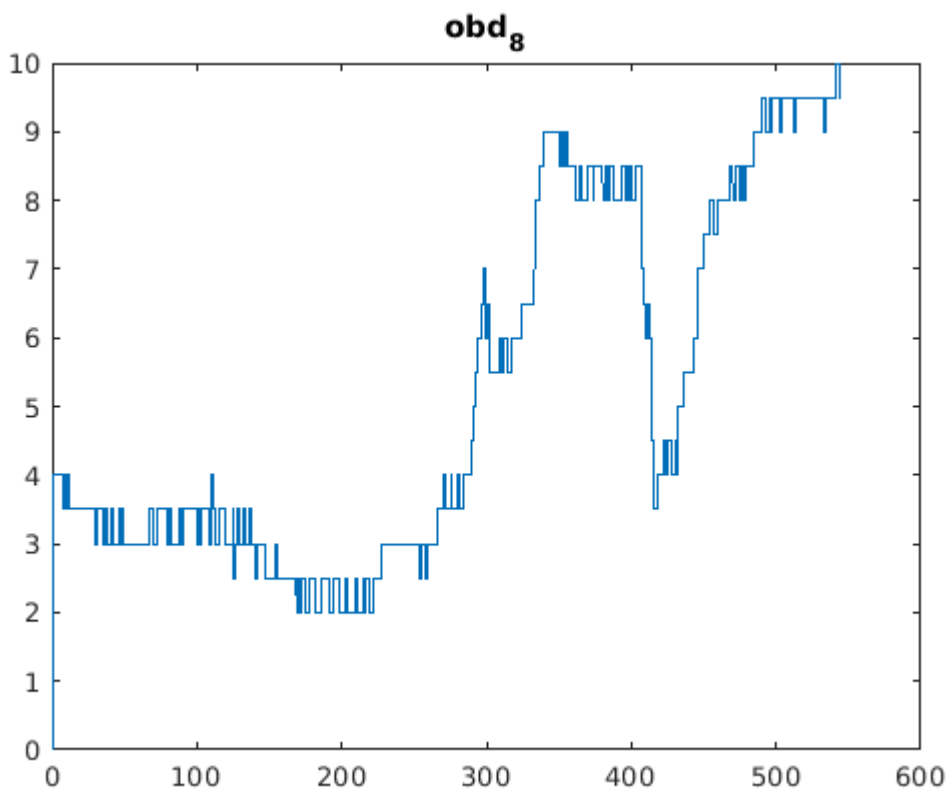
**obd$_4$**



```
f10 = figure(10); clf;
plot(obd_t,obd_5);
title("obd_5");
```
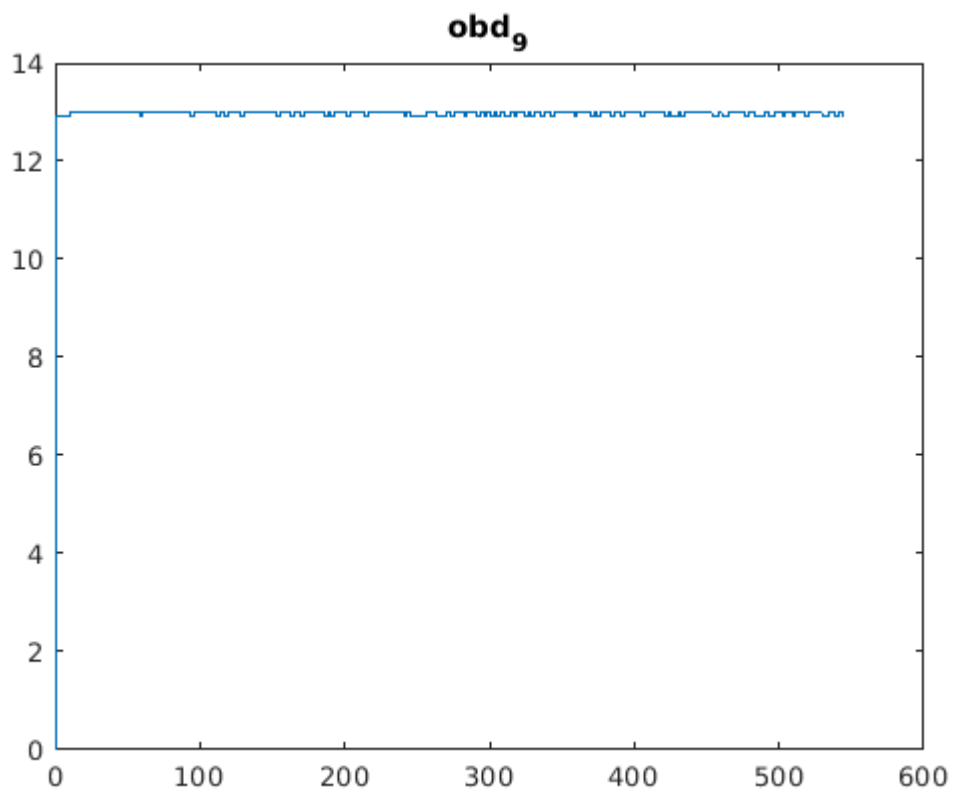
**obd$_5$**

```
f11 = figure(11); clf;
plot(obd_t,obd_6);
title("obd_6");
```
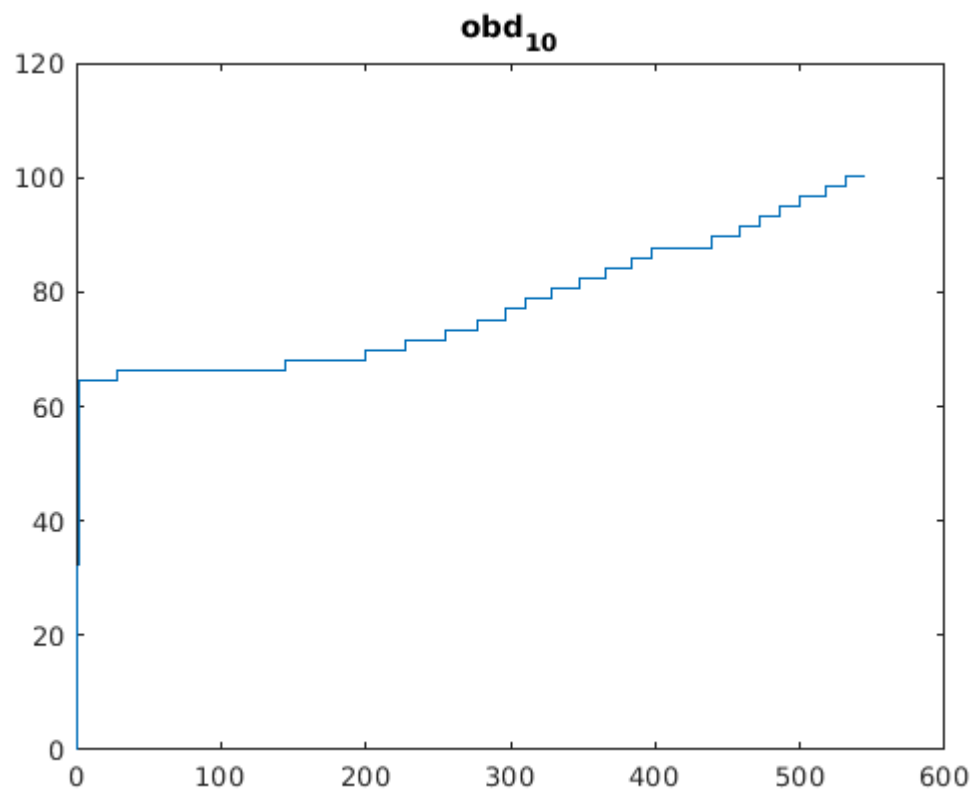
**obd$_6$**

```
f12 = figure(12); clf;
plot(obd_t,obd_8);
title("obd_8");
```
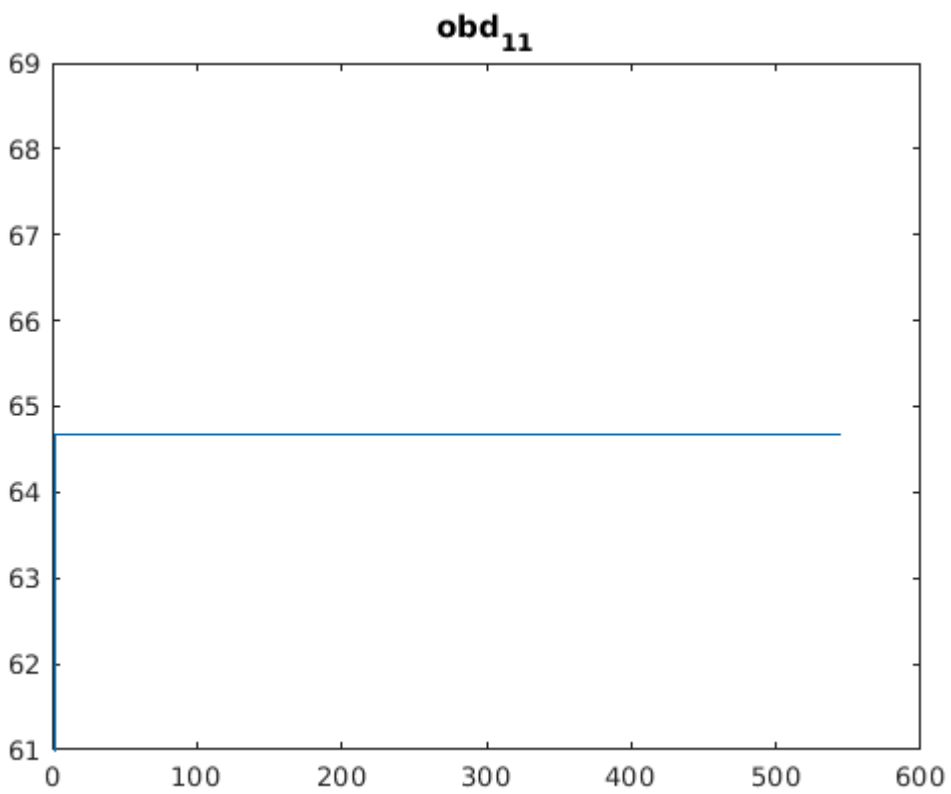
**obd$_8$**

```
f13 = figure(13); clf;
plot(obd_t,obd_9);
title("obd_9");
```
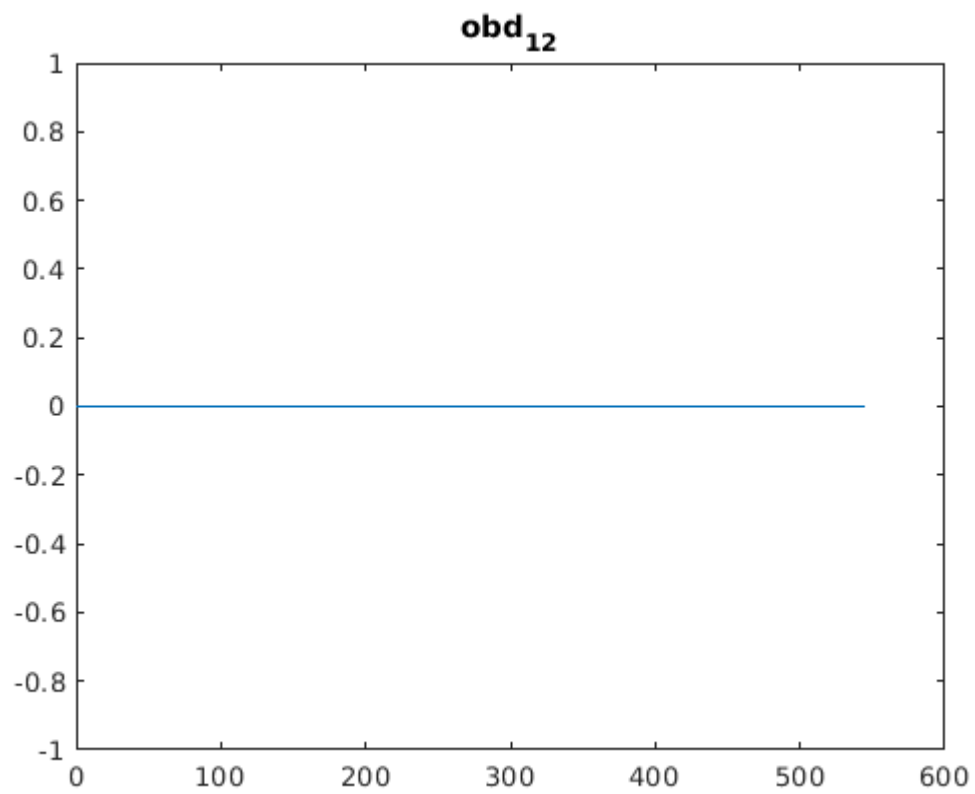
$obd_9$

```
f14 = figure(14); clf;
plot(obd_t,obd_10);
title("obd_{10}");
```
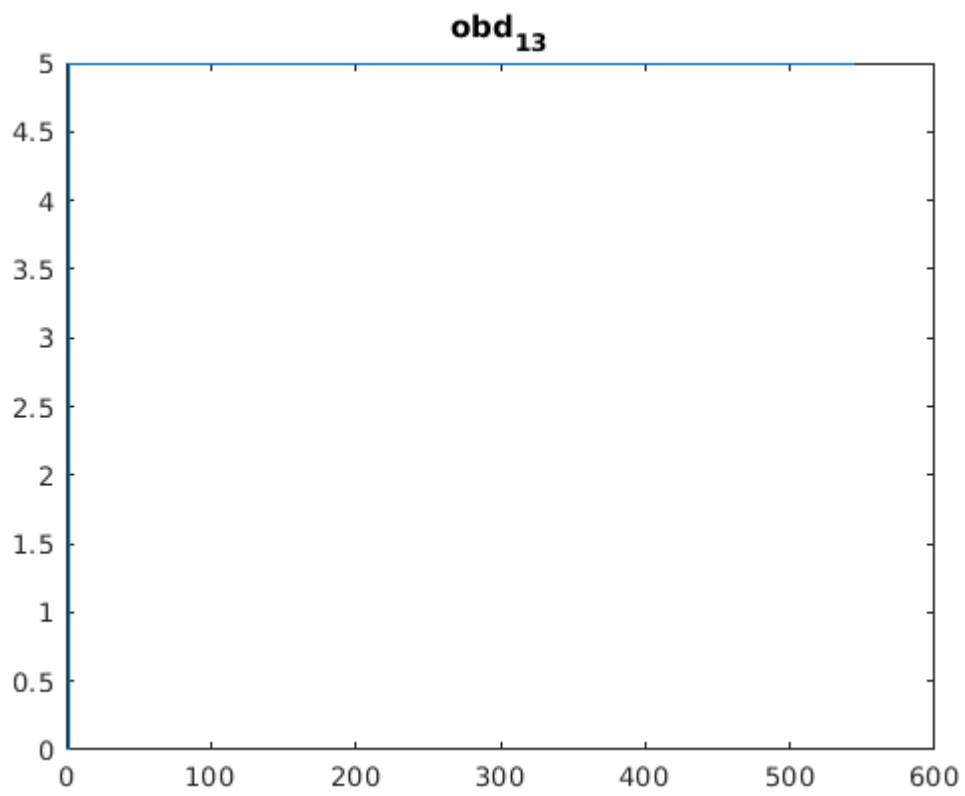
**obd$_{10}$**

```
f15 = figure(15); clf;
plot(obd_t,obd_11);
ylim([61 69]);
title("obd_{11}");
```
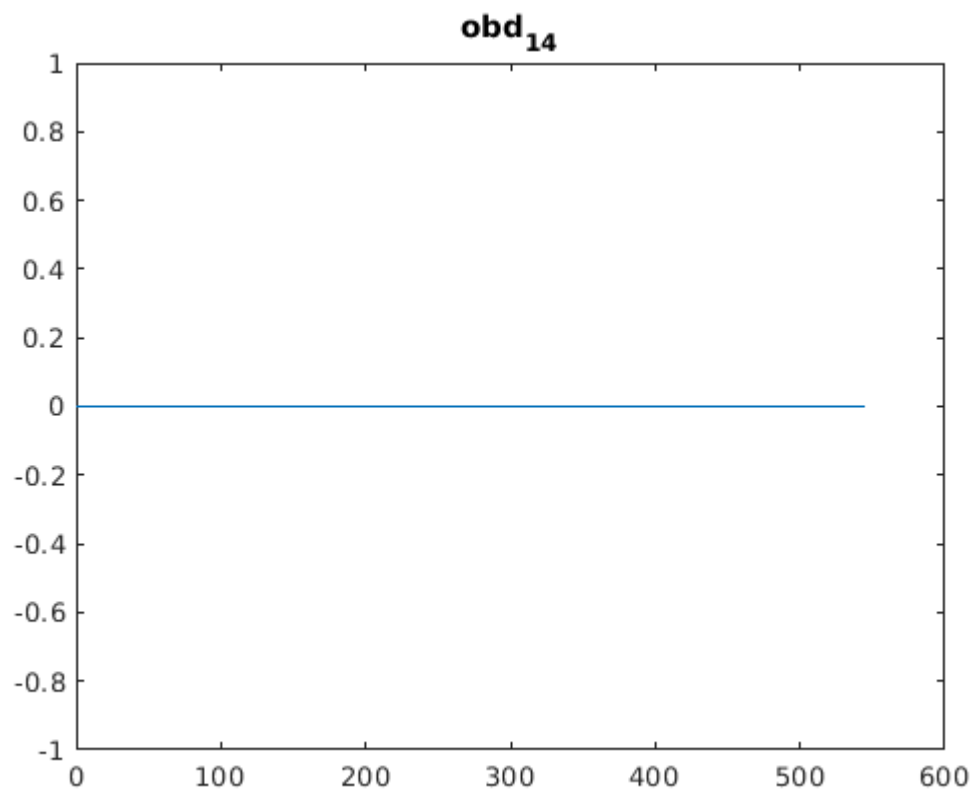
**obd$_{11}$**

```
f16 = figure(16); clf;
plot(obd_t,obd_12);
title("obd_{12}");
```
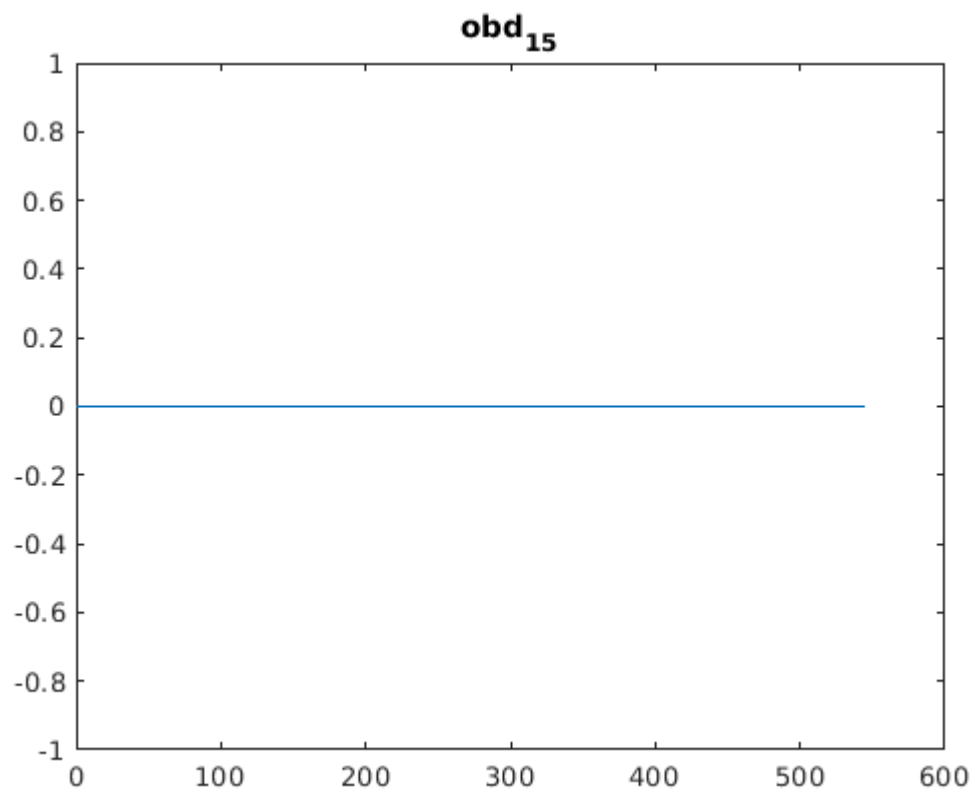
**obd$_{12}$**

```
f17 = figure(17); clf;
plot(obd_t,obd_13);
title("obd_{13}");
```

**obd$_{13}$**

```
f18 = figure(18); clf;
plot(obd_t,obd_14);
title("obd_{14}");
```

$obd_{14}$

```
f19 = figure(19); clf;
plot(obd_t,obd_15);
title("obd_{15}");
```

**obd$_{15}$**



```
f20 = figure(20); clf;
plot(obd_t,obd_16);
title("obd_{16}");
```

**obd$_{16}$**