DSP Core Functions and Logic Flow

```
import numpy as np
from numpy import fft as fft
import matplotlib.pyplot as plt
import scipy.signal as signal
```

Remove Baseline and Check for Anomalies:

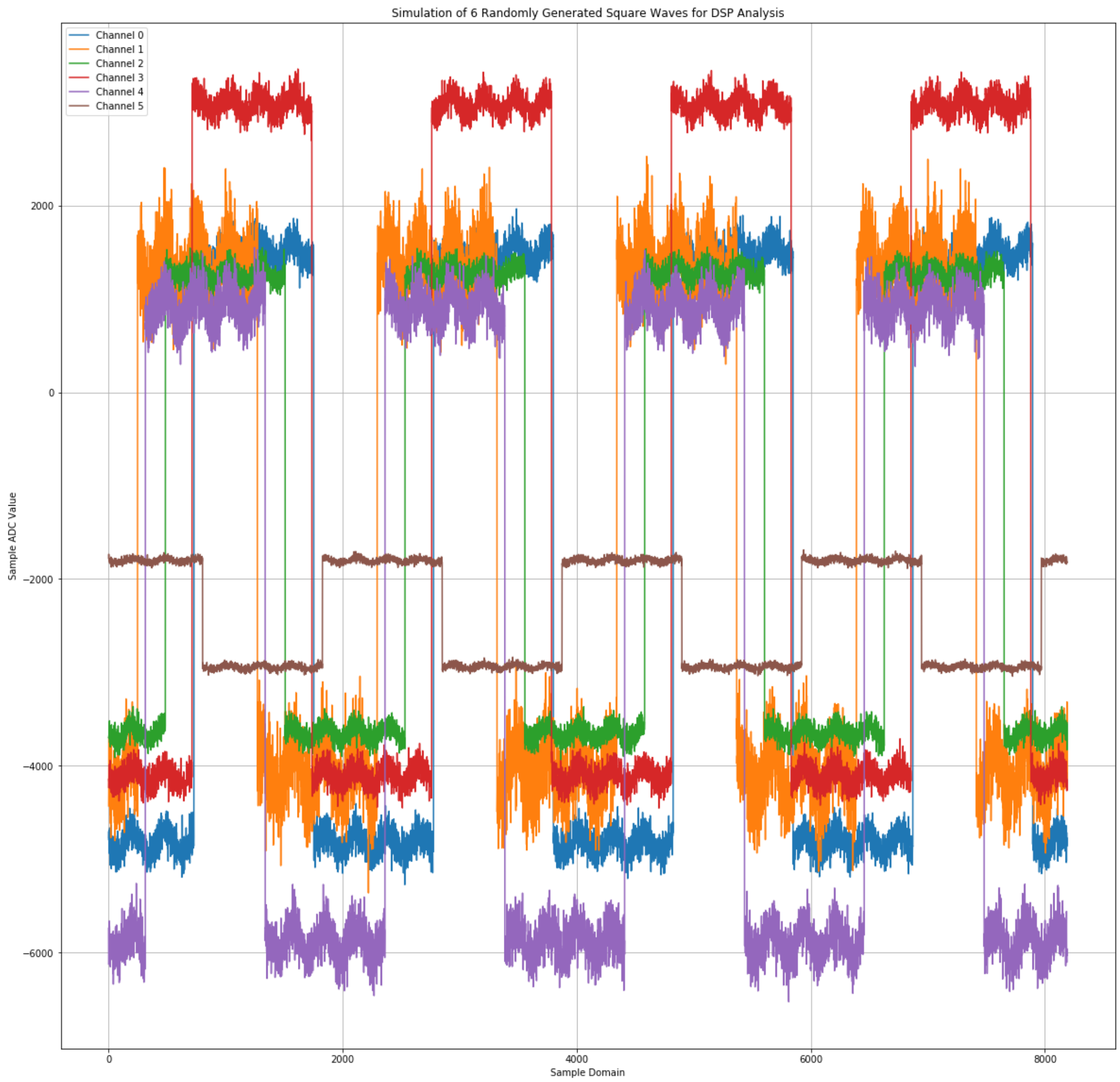
Goal is to quickly find anomalies and filter out any baseline signals in the phase angle and Marine Resistivity data components from the signals. The most reduced, compressed output format possible is best.

```
# Make simulated "baseline" signals and process them with dsp()
def simulate_squares(number_of_channels, dc_offset_max, dc_offs
et_min,
                              amplitude_max, amplitude_min):
    N = 8192  # number of samples
    T = 1 # Sampling period (seconds)
    f_s = 8192  # [Samples/second]
    t = np.linspace(0, N-1, N, endpoint=False)
    offsets = np.random.randint(low=1, high=60, size=number_of_
channels)
    # define the matrix of signals.

    all_channel_wavepacket = np.empty((N, number_of_channels))

    for j in range(number_of_channels):
        TIME_OFFSET = N / offsets[j]  # time offset provided fo
r simulation
        AMP = np.random.randint(amplitude_min, amplitude_max)
# amplitude (in ADC values)
        NOISE_LVL = AMP / np.random.randint(low=10, high=40)  #
Naive way to set noise on the signal (not true SNR)
        DC_OFFSET = np.random.randint(dc_offset_min, dc_offset_
max)  # DC offset in ADC values
        F_tx = 4.00  # Fundamental frequency of the waveform (H
z)
        noise = NOISE_LVL * np.random.normal(0, 1, t.shape)
        pure_sig = AMP * signal.square(2 * np.pi * F_tx * t - T
IME_OFFSET) + NOISE_LVL * np.sin(np.pi* 60 *t) + DC_OFFSET
        sig = pure_sig + noise
        all_channel_wavepacket[:, j] = sig
    return t, all_channel_wavepacket
```

```python
# Plotting the waveforms as a sanity check:
def plot_all_waveforms(t, signals):
    domain_size = t.shape[0]
    plt.figure(figsize=(20,20))
    number_of_channels = signals.shape[-1]
    for p in range(number_of_channels):
        plt.plot(t, signals[:, p], label='Channel %s' % p)
    plt.title(f"Simulation of {number_of_channels} Randomly Gen
erated Square Waves for DSP Analysis")
    plt.xlabel('Sample Domain')
    plt.ylabel('Sample ADC Value')
    plt.grid(True)
    plt.legend()
    plt.show()
```

```python
# Simulate 6 channels of baseline noisy data with variable offs
ets within certain ranges.
q_channels = 6  # number of channels
T = 1 # Sampling period (seconds)
f_s = 8192  # [Samples/second]
# Random parameter ranges
base_offset_max = 4000
base_offset_min = -4000
base_amp_max = 4000
base_amp_min = 500

t_domain, baseline_packets = simulate_squares(q_channels, base_
offset_max, base_offset_min,
                                base_amp_max, base_amp_min)
```

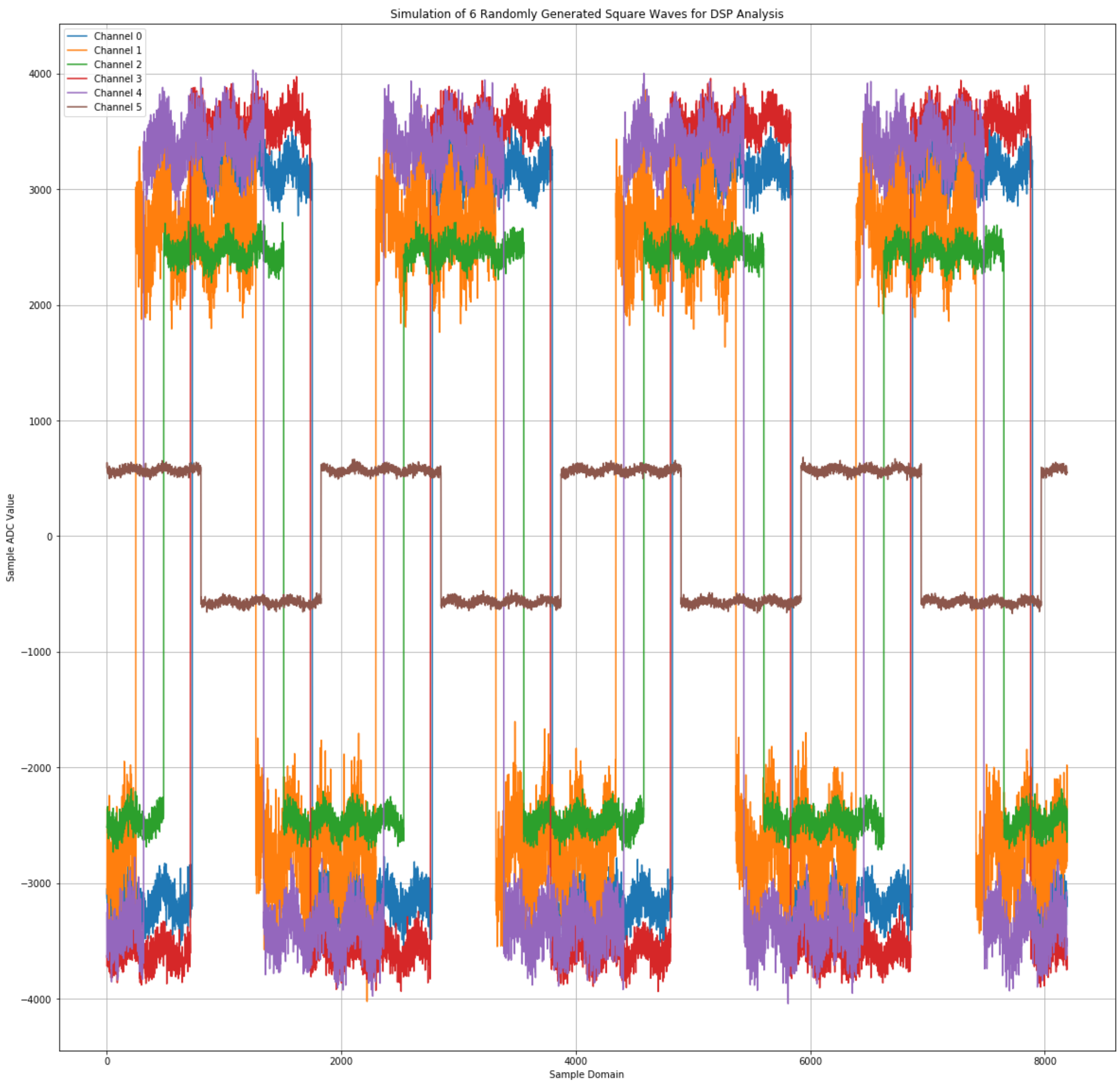
```python
# Sanity Check plot
plot_all_waveforms(t_domain, baseline_packets)
```




```python
def remove_dc_offset(sig):
    print(f"sig.shape = {sig.shape}")
    q_channels = sig.shape[-1]
    for q in range(0, q_channels):
        offset_average = np.average(sig[:, q])
        print(f"Waveform Average Value for Channel [q] = {offse
t_average}")
        sig[:, q] = sig[:, q] - offset_average
    return sig
```

```python
# Sanity  check that offset removal still works...
ac_baseline_packets = remove_dc_offset(baseline_packets)
plot_all_waveforms(t_domain, ac_baseline_packets)
```

```
sig.shape = (8192, 6)
Waveform Average Value for Channel [q] = -1654.9084281614605
Waveform Average Value for Channel [q] = -1335.2025225951375
Waveform Average Value for Channel [q] = -1179.7178559638328
Waveform Average Value for Channel [q] = -514.0711285297014
Waveform Average Value for Channel [q] = -2481.255211053809
Waveform Average Value for Channel [q] = -2369.853682407852
```



Filtering

```
def butterworth_digital_lpf(sig, n_samples, f_sample, f_order,
f_cut, analysis_plot=False):
    """
    .. function:: butterworth_analog_lpf
    .. description::
    :param sig:
    :param order:
    :param f_cut:
    :return w:
    :return h:
    :return filt_sig:
    """
    # Define second-order sections representation of the IIR fi
lter.
    sos = signal.butter(f_order, f_cut, 'lp', fs=f_sample, anal
og=False, output='sos')
    # Apply the filter to our signal.
    filt_sig = signal.sosfilt(sos, sig)

    if analysis_plot:
        # Compute the numerator and denominator polynomials of
the IIR filter.
        b, a = signal.butter(f_order, f_cut, 'lp', fs=f_sample,
analog=False)
        # Compute the frequency response of an analog filter.
        w, h = signal.freqs(b, a)
        # and plot results:
        t = np.linspace(0, n_samples - 1, n_samples)
        plot_wave_freqresp_filter(t, sig, filt_sig, w, h, f_ord
er, f_cut)

    return filt_sig
```

```
def plot_wave_freqresp_filter(t, s, filt_s, w, h, f_order, f_c)
:
    """
    .. function:: plot_wave_freqresp_filter
    .. description::
    :param t:
    :param s:
    :param filt_s:
    :param w:
```

```
    :param h:
    :param order:
    :param f_c:
    :return NONE:
    """
    plt.figure(figsize=(17, 5))

    # Raw Waveform
    plt.subplot(131)
    plt.plot(t, s)
    plt.title('Raw Waveform')
    plt.xlabel('Sample Domain')
    plt.ylabel('Sample ADC Value')
    plt.grid(True)

    # Filtered Waveform
    plt.subplot(132)
    plt.plot(t, filt_s)
    plt.title('Filtered Waveform Copy')
    plt.xlabel('Sample Domain')
    plt.ylabel('Sample ADC Value')
    plt.grid(True)

    # Butterworth Filter BODE plot (Right Subplot)
    plt.subplot(133)
    plt.semilogx(w, 20*np.log10(abs(h)))
    plt.title(f'{f_order}-Order \n Butterworth Filter \n
Frequency Response')
    plt.xlabel('Frequency [rad/s]')
    plt.ylabel('Amplitude [dB]')
    plt.margins(0, 0.1)
    plt.grid(which='both', axis='both')
    plt.axvline(f_c, color='green') # cutoff frequency

    plt.tight_layout()
    plt.show()
```

Triggering

```
def rising_edge_trigger(filt_zeroed_sig, filt_sig_gradient, gradient_max, N):
    """
    """
    positive_trigger_indices = (j for j in range(N - 1) if
                                ((filt_sig_gradient[j] >= (2/3) * gradient_max) and
                                 filt_zeroed_sig[j - 1] < filt_zeroed_sig[j]))
    t0 = next(positive_trigger_indices)
    print(f"First rising trigger found at index {t0}!")
    return t0
```

```
def falling_edge_trigger(filt_zeroed_sig, filt_sig_gradient, gradient_max, N):
    """
    """
    negative_trigger_indices = (j for j in range(N-1, 0, -1)  if
                                ((filt_sig_gradient[j] <= (2/3) * -gradient_max) and
                                 filt_zeroed_sig[j + 1] < filt_zeroed_sig[j]))
    tf = next(negative_trigger_indices)
    print(f"Last falling trigger found at index {tf}!")
    return tf
```

```
def set_triggers(s_t_matrix, f_s, filter_order, filter_cut, analysis_plot):
    """
    .. function: set_triggers:
    .. description::
    :param s_t_matrix:
    :param filter_order:
    :param filter_cut:
    :return t0s:
    :return nlengs:
    """
    # definitions:
    q_channels = s_t_matrix.shape[-1]
    n_raw = s_t_matrix.shape[0]
    t0s = []
    nlengs = []

    # for each channel-q:
    for q in range(0, q_channels):
        # filter
        filt_signal = butterworth_digital_lpf(s_t_matrix[:, q], n_raw, f_s, filter_order, filter_cut, analysis_plot)
        # compute gradient and max gradient value of filtered signal
        filt_g_signal = np.gradient(filt_signal)
        g_max = np.nanmax(filt_g_signal)
        n_filt = filt_signal.shape[0]
        # get first positive trigger t0q
        t0q = rising_edge_trigger(filt_signal, filt_g_signal, g_max, n_filt)
        # get last negative trigger tfq
        tfq = falling_edge_trigger(filt_signal, filt_g_signal, g_max, n_filt)
        t0s.append(t0q)
        nlengs.append(np.abs(tfq - t0q))
    return t0s, nlengs
```

```
def shift_signal_to_triggers(time_series_q, t0q, n_min):
    """
    .. function:: shift_signals_to_triggers
    .. description::
    :param time_series_q:
    :param t0q:
    :param n_min:
    :return channel_out:  Output array of length `n_min` for ch
annel-q shifted to the global t0 and trimmed to match `n_min`.
    """
    return np.roll(time_series_q, -t0q)[0: n_min]
```

```
def time_series_conditioning(raw_time_series_matrix, f_s, f_ord
er, f_cut, analysis_plot):
    """
    .. fucntion:: signal_conditioning
    .. description::
    :param time_series_matrix:
    :return win_sig_0: Trigger-windowed ORIGINAL noisy signals
(no filters) array with offset removed and start times (t0q) fo
r channel-q shifted to match using triggers.
    """
    # definitions
    # number of channels q
    q_channels = raw_time_series_matrix.shape[-1]

    # Remove DC offsets
    zeroed_time_series_matrix = remove_dc_offset(raw_time_serie
s_matrix)

    # Locate trigger times and return arrays of t_starts and n_
lengths. Include filter parameters.
    t_starts, n_lengths = set_triggers(zeroed_time_series_matri
x, f_s, f_order, f_cut, analysis_plot)

    # set the minimum trimmed length to match all channels-q
    n_min = np.nanmin(n_lengths)
    # adjust the minimum length to n_min - 1 if the value for n
_min is odd (for simplifying FFTs later)
    if n_min % 2 != 0:
        n_min = n_min - 1
```

```
    # define complex output signal array based on `n_min` and `
q_channels`
    output_signal_matrix = np.empty((n_min, q_channels), dtype=
np.complex64)

    # Iteratively Shift signals in each channel over and trunca
te to match the others
    # based on the start triggers and array lengths determined
by `set_triggers()`
    for q in range(0, q_channels):
        print(f"Shifting signal start and trimming length for s
ignal channel {q + 1}")
        output_signal_matrix[:, q] = shift_signal_to_triggers(r
aw_time_series_matrix[:, q], t_starts[q], n_min)

    # testprint
    print(f"output_signal_matrix dimensions are now {output_sig
nal_matrix.shape}...")
    return output_signal_matrix
```

```
def phase_difference_spectrum(s0k, sqk):
    """
    .. function:: phase_difference_spectrum()
    .. description:: Estimate the phase angle of each waveform
and the associated shift between them, holding
    S_a(k) as a reference wavform and taking the difference of
the derived phase arrays.

    The phase shift corresponds to modulation of the complex pa
rt of the transmitted/
    received waveform, which is an indication of either inducti
ve or capacitive frequency-
    dependent responses of the signal due to the electrical net
work betweewn the electrodes
    formed by the water and target.

    Calculate the phase shift from a reference spectrum (sa_k)
and a shifted spectrum (sb_k)

    :param s0k:
    :param sqk:
    :return phase_shift_spectrum:
```

```
    """
    phase0k = np.angle(s0k)
    phaseqk = np.angle(sqk)
    phase_shift = np.subtract(phaseqk, phase0k)

    for m in range(phase_shift.shape[0]):
        if phase_shift[m] > np.pi:
            phase_shift[m] = 2.00 * np.pi - phase_shift[m]
        elif phase_shift[m] < -np.pi:
            phase_shift[m] = phase_shift[m] + 2.00 * np.pi
        else:
            continue
    # Correct greater than 2pi radian shifts to 0 rad shift + a
ctual shift.
#     corrected_phase_shift = np.where(phase_shift > np.pi, 2*n
p.pi - phase_shift, phase_shift)
#     corrected_phase_shift = np.where(phase_shift < -np.pi, np
.mod(2*np.pi, phase_shift), phase_shift)
#     corrected_phase_shift = np.where(np.abs(phase_shift) > np
.pi, np.mod(2*np.pi, phase_shift), phase_shift)
    # something is screwy here... is it resetting the values?
#     phase_shift = np.mod(phase_shift, 2*np.pi)
#     phase_shift = corrected_phase_shift

    return phase_shift
```

```
def apparent_impedance_spectrum(s0k, sqk):
    """
    Estimate the apparent impedance spectrum ||Z(k)||^2 for a s
hunt(s0_k) <--> RX Channel (sq_k) pair by taking the magnitude
squared
    of the difference between the two complex spectra. This yie
lds the REAL part of the complex impedance of the target and wa
ter network
    between RX electrodes and removes the internal real impedan
ce from the transmitter shunt.

    :param s0k:
    :param sqk:
    :return zqk:
    """
    zqk = np.absolute(s0k - sqk)
    return zqk
```

```
# define a DSP signal processing function that calls the other
relevant functions.
def packet_dsp(t, s_t, period, f_s, filter_order=4, filter_cut=
200, filter_analysis_plot=False):
    """
    .. function::
    .. description::
    :param t:
    :param s_t:
    :param tau:
    :param filter_order:
    :param filter_cut:
    :return k_domain:
    :return conditioned_time_series:
    :return marine_ip_k:
    :return marine_r_k:
    """
    # def time_series_conditioning(raw_time_series_matrix, f_s,
f_order, f_cut, analysis_plot
    conditioned_time_series = time_series_conditioning(s_t, f_s
, filter_order, filter_cut, filter_analysis_plot)
    number_of_channels = conditioned_time_series.shape[-1]
    print("Now computing FFT, Marine Resistivity, and Marine IP
Responses for the packet...")
```

```
    N_samples = conditioned_time_series.shape[0]
    # definitions for numpy arrays and constants
    tau = np.float(period / f_s)
    k_domain = fft.fftfreq(N_samples, tau)
    s_k = np.zeros((k_domain.shape[0], number_of_channels), dty
pe=np.complex64)
    marine_ip_k = np.zeros((k_domain.shape[0], number_of_channe
ls), dtype=np.complex64)
    marine_r_k = np.zeros((k_domain.shape[0], number_of_channel
s), dtype=np.complex64)
    # iterate over all channels to compute the FFT, phase diffe
rence between shunt and channels, and apparent impedance spectr
a between channels
    for q in range(0, number_of_channels):
        # calculate frequency spectra
        s_k[:, q] = fft.fft(conditioned_time_series[:, q])
        marine_ip_k[:, q]= phase_difference_spectrum(s_k[:,0],
s_k[:,q])
        marine_r_k[:, q] = apparent_impedance_spectrum(s_k[:, 0
], s_k[:, q])
    # verbose print
    print(f"Yielded two matrices: marine_ip_k ({marine_ip_k.sha
pe}) and marine_r_k ({marine_r_k.shape}))")
    return k_domain, conditioned_time_series, marine_ip_k, mari
ne_r_k
```

```
def plot_phase_shift_and_magnitude(raw_signal, triggered_signal
, k, marine_ip_k, marine_r_k):

    number_of_channels = raw_signal.shape[-1]
    t_raw = np.linspace(0, raw_signal.shape[0] - 1, raw_signal.
shape[0], endpoint=False)
    t_triggered = np.linspace(0, triggered_signal.shape[0] - 1,
triggered_signal.shape[0], endpoint=False)

    plt.figure(figsize=(20, 20))

    # Raw waveforms replotted for comparison.
    plt.subplot(221)
    for p in range(number_of_channels):
        plt.plot(t_raw, raw_signal[:, p], label='Channel %s' %
p if p != 0 else 'Transmit Shunt')
```

```
    plt.title(f"Simulation of {number_of_channels} Single Packe
t of \n Randomly Generated Square Waves for DSP Analysis")
    plt.xlabel('Sample Number')
    plt.ylabel('Shifted Sample ADC Value (Arb. Units)')
    plt.grid(True)
    plt.legend()

    # Triggered, AC-only waveforms plotted for comparison.
    plt.subplot(222)
    for p in range(number_of_channels):
        plt.plot(t_triggered, triggered_signal[:, p], label='Ch
annel %s' % p if p != 0 else 'Transmit Shunt')
    plt.title(f"Simulation of {number_of_channels} Single Packe
t of \n Randomly Generated Square Waves Shifted and Trimmed to
Match\n in Signal Conditionining Stage")
    plt.xlabel('Sample Number')
    plt.ylabel('Shifted Sample ADC Value (Arb. Units)')
    plt.grid(True)
    plt.legend()

    # Triggered Phase Shift across all channels
    plt.subplot(223)
    for p in range(1, number_of_channels):
        plt.plot(fft.fftshift(k), fft.fftshift(marine_ip_k[:, p
]), label='Channel %s' % p if p != 0 else 'Transmit Shunt')
    plt.title('Single Simulated Baseline Packet $p$ \n Marine I
P Response $\Delta\phi_{p}(k)$ by Frequency')
    plt.xlabel('Frequency $\omega$ Domain [Hz]')
    plt.ylabel('Corrected Phase Angle Deflection ${S_a}\angle{S
_b}$ [Radians]')
    plt.xlim(0,200)
    plt.ylim(-np.pi, np.pi)
    plt.grid(True)
    plt.legend()

    # Triggered ||Z||^2 across all channels
    plt.subplot(224)
    for p in range(1, number_of_channels):
        plt.semilogy(fft.fftshift(k), fft.fftshift(marine_r_k[:
,p]), label='Channel %s' % p if p != 0 else 'Transmit Shunt')
    plt.title('Single Simulated Baseline Packet $p$ \n Marine R
esistivity Response $||Z_{p}(k)||^{2}$ by Frequency')
```

```
    plt.xlabel('Frequency $\omega$ Domain [Hz]')
    plt.ylabel('Spectral Intensity')
    plt.grid(which='both', axis='both')
    plt.xlim(0,200)
    plt.ylim(1000, np.max(fft.fftshift(marine_r_k[:200])))
    plt.legend()

    plt.tight_layout()
    plt.show()
```

```
k, conditioned_signals, marine_ip_k, marine_r_k = packet_dsp(t_
domain, baseline_packets, T, f_s, filter_order=4, filter_cut=20
0)
```

```
sig.shape = (8192, 6)
Waveform Average Value for Channel [q] = 1.9895196601282805e-13
Waveform Average Value for Channel [q] = -8.526512829121202e-14
Waveform Average Value for Channel [q] = -1.4210854715202004e-13
Waveform Average Value for Channel [q] = -1.7053025658242404e-13
Waveform Average Value for Channel [q] = -2.842170943040401e-14
Waveform Average Value for Channel [q] = 3.552713678800501e-14
First rising trigger found at index 741!
Last falling trigger found at index 7923!
First rising trigger found at index 259!
Last falling trigger found at index 7441!
First rising trigger found at index 497!
Last falling trigger found at index 7679!
First rising trigger found at index 725!
Last falling trigger found at index 7907!
First rising trigger found at index 326!
Last falling trigger found at index 7508!
First rising trigger found at index 1839!
Last falling trigger found at index 6973!
Shifting signal start and trimming length for signal channel 1
Shifting signal start and trimming length for signal channel 2
Shifting signal start and trimming length for signal channel 3
Shifting signal start and trimming length for signal channel 4
Shifting signal start and trimming length for signal channel 5
Shifting signal start and trimming length for signal channel 6
output_signal_matrix dimensions are now (5134, 6)...
Now computing FFT, Marine Resistivity, and Marine IP Responses for the pa
cket...
Yielded two matrices: marine_ip_k ((5134, 6)) and marine_r_k ((5134, 6)))
```

```
plot_phase_shift_and_magnitude(baseline_packets, conditioned_si
gnals, k, marine_ip_k, marine_r_k)
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
Warning: Casting complex values to real discards the imaginary part
  return array(a, dtype, copy=False, order=order)
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```

```
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/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
Warning: Casting complex values to real discards the imaginary part
  return array(a, dtype, copy=False, order=order)
/anaconda3/lib/python3.6/site-packages/matplotlib/transforms.py:923: Comp
lexWarning: Casting complex values to real discards the imaginary part
  self._points[:, 1] = interval
```

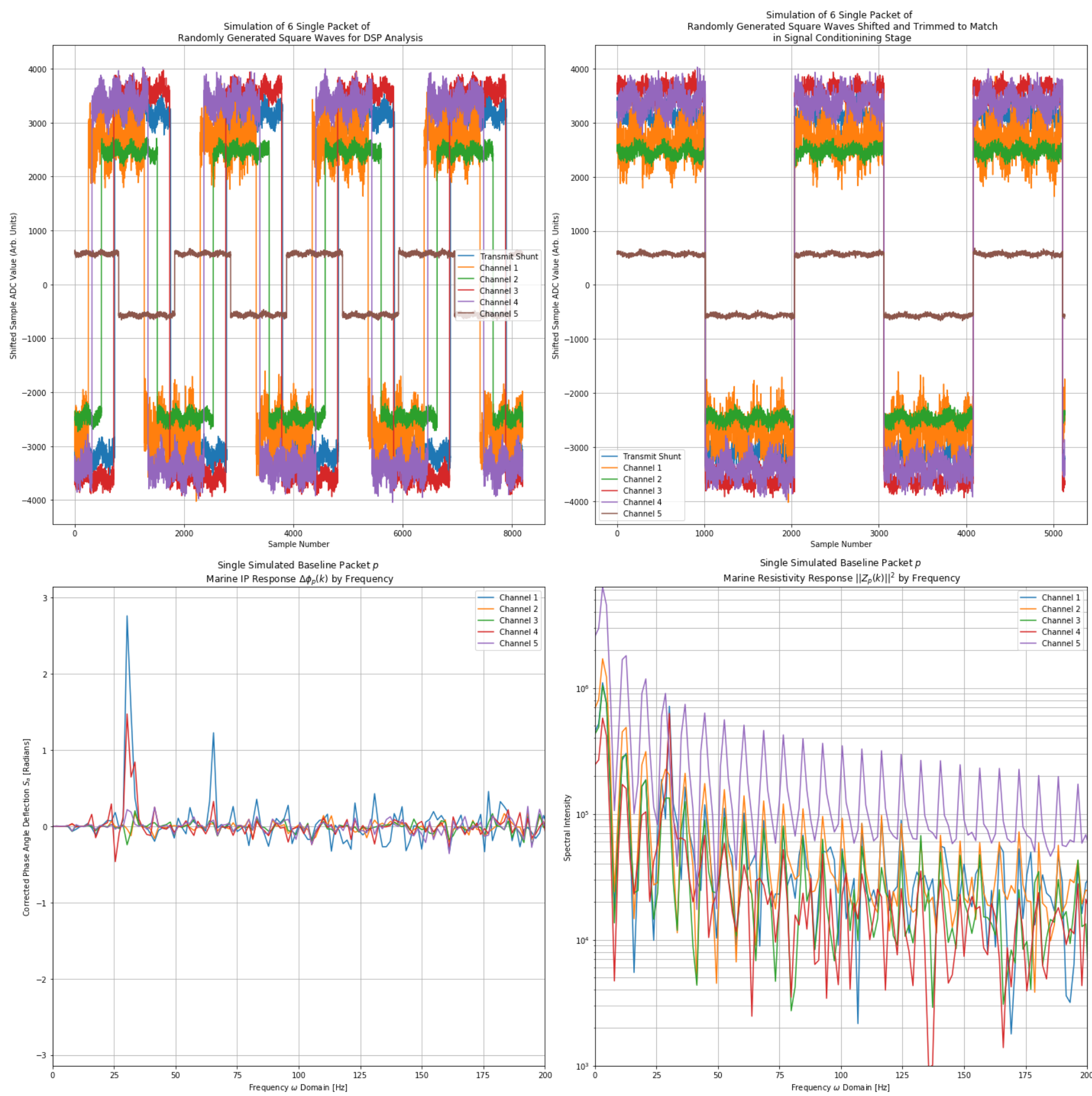

Baseline Generation Continued: Simulating a Multi-Packet Baseline

with square waves of slightly variable amplitude, random time-offset and more-or-less fixed noise level.

```
n_samples = 8192 # per packet
p_packets = 150  # number of packets to generate and average
# Simulate 6 channels of baseline noisy data with variable offs
ets within certain ranges.
q_channels = 6  # number of channels in each packet with simula
ted waveforms.
T = 1 # Sampling period (seconds)
f_s = 8192  # [Samples/second]
# Random parameter ranges
base_offset_max = 4000
base_offset_min = -4000
base_amp_max = 4000
base_amp_min = 500

baseline_packet_set = np.empty((n_samples, q_channels, p_packet
s))

for p in range(0, p_packets):
    t_domain, baseline_packet_set[:, :, p] = simulate_squares(q
_channels, base_offset_max, base_offset_min, base_amp_max, base
_amp_min)

average_baseline_packet = np.average(baseline_packet_set, axis=
2)
average_baseline_packet.shape
```

```
(8192, 6)
```

To Highlight the Order of Operations:

```
k, conditioned_baseline, baseline_ip_response, baseline_r_respo
nse = packet_dsp(t_domain, average_baseline_packet, T, f_s, fil
ter_order=4, filter_cut=200)
```

```
sig.shape = (8192, 6)
Waveform Average Value for Channel [q] = 253.7282549596245
Waveform Average Value for Channel [q] = -233.04961350121113
Waveform Average Value for Channel [q] = -21.702907161318386
Waveform Average Value for Channel [q] = 88.66226111270144
Waveform Average Value for Channel [q] = 135.4811991492826
Waveform Average Value for Channel [q] = -29.91438462676719
First rising trigger found at index 155!
Last falling trigger found at index 7924!
First rising trigger found at index 743!
Last falling trigger found at index 7920!
First rising trigger found at index 149!
Last falling trigger found at index 7884!
First rising trigger found at index 152!
Last falling trigger found at index 7329!
First rising trigger found at index 455!
Last falling trigger found at index 7632!
First rising trigger found at index 1248!
Last falling trigger found at index 6996!
Shifting signal start and trimming length for signal channel 1
Shifting signal start and trimming length for signal channel 2
Shifting signal start and trimming length for signal channel 3
Shifting signal start and trimming length for signal channel 4
Shifting signal start and trimming length for signal channel 5
Shifting signal start and trimming length for signal channel 6
output_signal_matrix dimensions are now (5748, 6)...
Now computing FFT, Marine Resistivity, and Marine IP Responses for the pa
cket...
Yielded two matrices: marine_ip_k ((5748, 6)) and marine_r_k ((5748, 6)))
```

```
plot_phase_shift_and_magnitude(average_baseline_packet, conditi
oned_baseline, k, baseline_ip_response, baseline_r_response)
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
Warning: Casting complex values to real discards the imaginary part
  return array(a, dtype, copy=False, order=order)
/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
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/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
Warning: Casting complex values to real discards the imaginary part
```

```
  return array(a, dtype, copy=False, order=order)
/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
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/anaconda3/lib/python3.6/site-packages/numpy/core/_asarray.py:85: Complex
Warning: Casting complex values to real discards the imaginary part
  return array(a, dtype, copy=False, order=order)
/anaconda3/lib/python3.6/site-packages/matplotlib/transforms.py:923: Comp
lexWarning: Casting complex values to real discards the imaginary part
  self._points[:, 1] = interval
```

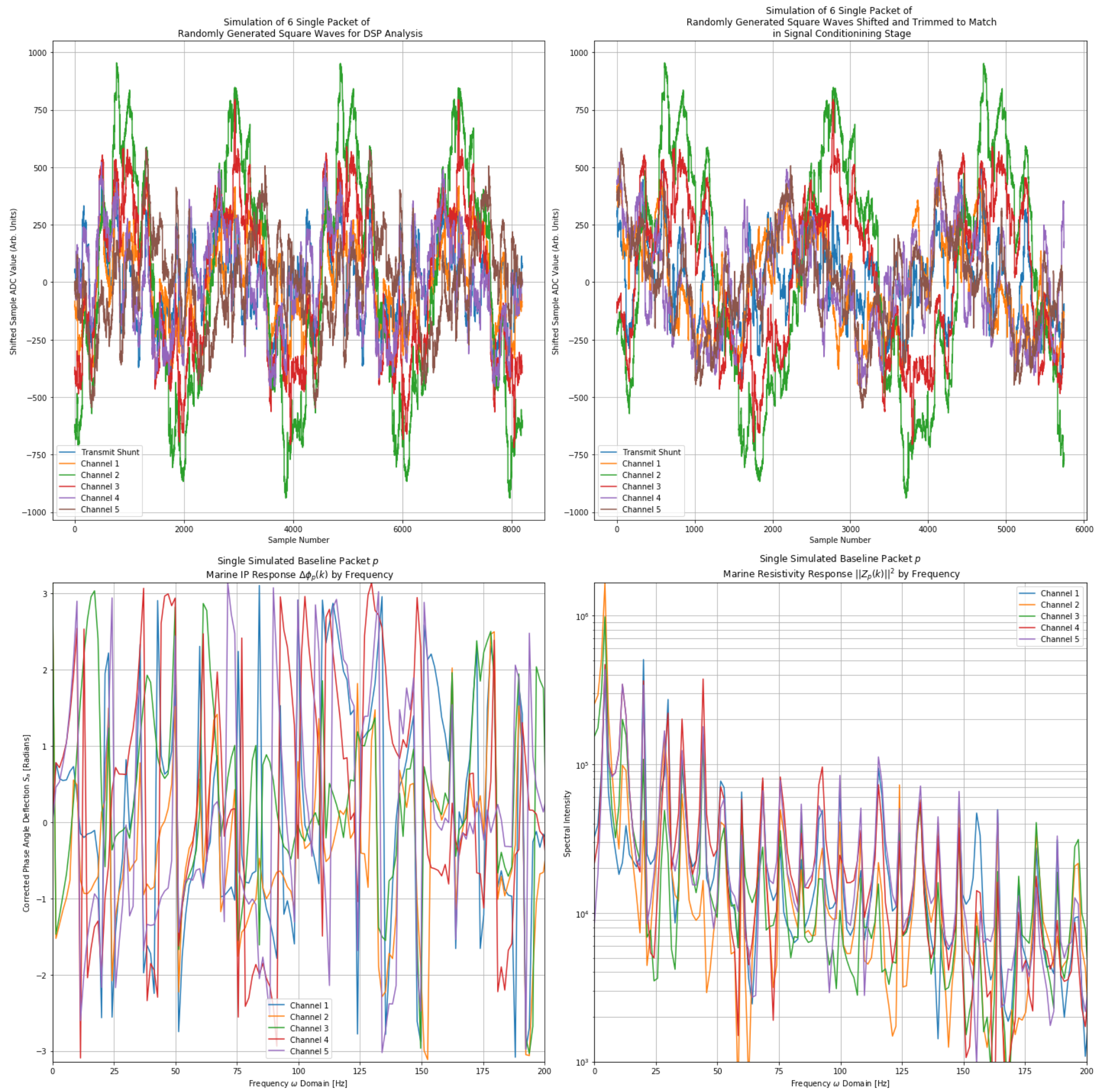

Notice how this data set is substantially messier, even **with triggering logic** because the spectrum is applied after the time series are averaged. Strangely, the Marine resistivity data looks a bit tighter in this simulation. Keep in mind, the conditions are more or less random between the packets -- however this highlights the need for properly ordered DSP core functions, as the following will show.

```
tau = np.float(T / f_s)
k_domain = fft.rfftfreq(n_samples, tau)

baseline_packet_set = np.empty((n_samples, q_channels, p_packet
s))
mip_set = np.empty((number_of_frequencies, q_channels, p_packet
s))
mr_set = np.empty((number_of_frequencies, q_channels, p_packets
))

# TODO: Fix this so the average spectra can be calculated...
for p in range(0, p_packets):
    t_domain, baseline_packet_set[:, :, p] = simulate_squares(q
_channels, base_offset_max, base_offset_min, base_amp_max, base
_amp_min)
    _, _, mip, mr = packet_dsp(t_domain, baseline_packet_set[:,
:, p], T, f_s, filter_order=4, filter_cut=200)


# avg_conditioned_signals = np.average(conditioned_baselines, a
xis=2)
avg_ip_response = np.average(mip_set[:200, :, :], axis=2)
avg_r_response = np.average(mr_set[:200, :, :], axis=2)

# avg_conditioned_signals.shape
avg_ip_response.shape
avg_r_response.shape
```

```
sig.shape = (8192, 6)
Waveform Average Value for Channel [q] = -1323.276446954973
Waveform Average Value for Channel [q] = 1802.4309113574773
Waveform Average Value for Channel [q] = -1389.0491967180023
Waveform Average Value for Channel [q] = 838.7444559524079
Waveform Average Value for Channel [q] = -2959.585725560444
Waveform Average Value for Channel [q] = 1617.7461539082874
First rising trigger found at index 459!
Last falling trigger found at index 7641!
First rising trigger found at index 1754!
Last falling trigger found at index 6888!
First rising trigger found at index 1561!
Last falling trigger found at index 6694!
First rising trigger found at index 704!
Last falling trigger found at index 7886!
First rising trigger found at index 1528!
Last falling trigger found at index 6663!
First rising trigger found at index 725!
Last falling trigger found at index 7907!
Shifting signal start and trimming length for signal channel 1
Shifting signal start and trimming length for signal channel 2
Shifting signal start and trimming length for signal channel 3
Shifting signal start and trimming length for signal channel 4
Shifting signal start and trimming length for signal channel 5
Shifting signal start and trimming length for signal channel 6
output_signal_matrix dimensions are now (5132, 6)...
Now computing FFT, Marine Resistivity, and Marine IP Responses for the pa
cket...
Yielded two matrices: marine_ip_k ((5132, 6)) and marine_r_k ((5132, 6)))
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-435-9d8343acd457> in <module>
      8 for p in range(0, p_packets):
      9     t_domain, baseline_packet_set[:, :, p] = simulate_squares(q_channels, base_offset_max, base_offset_min, base_amp_max, base_amp_min)
---> 10     _, _, mip_set[:, :, p], mr_set[:, :, p] = packet_dsp(t_domain, baseline_packet_set[:, :, p], T, f_s, filter_order=4, filter_cut=200)
     11 
     12 # avg_conditioned_signals = np.average(conditioned_baselines, axis=2)

ValueError: could not broadcast input array from shape (5132,6) into shape (4097,6)
```

Generate a Variable Simulation "Measurement Set"