# Key points

I think regardless of cross-talk, there is always an image even if phase mismatch is 0.

I think EVM and image suppression should basically be the same values.

EVM should only be impacted if the image and signal overlap in frequency; otherwise the gain and phase “error” is corrected by channel equalization.

# IQ DC transceiver

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**Upconversion:**

Equivalent formulation:

**Downconversion:**

Equivalent formulation:

This derivation ignores the term and the ½ scaling from multiplying trigonometric functions.

Upconversion multiplies by , downconversion multiplies by .

## Tx IQ mismatch

**RF model:**

Upconversion:

Ideal downconversion ( represents the downconverted impaired signal):

There is cross-talk because of phase mismatch. We can write this in matrix form.

**Lowpass equivalent model:**

No mismatch:

With mismatch:

Multiplying out, we get the exact same baseband signal as in the RF model.

**Image suppression:**

is a linear superposition of and , where .

is the desired signal; is the image.

Image suppression is given by

For a tone input, ,

When the signal is only on one side of the LO (as is often the case in OFDM signals), the image and the signal do not overlap, and EVM is not impacted (with equalization).

**EVM:**

### Compensation

Let and be the quadrature baseband signals after compensation. Then the downconverted baseband signal is

To perfectly recover the original quadrature baseband signals, we want

Solve for .

Solve for .

can be written as a linear superposition of and .

### Measurement

Clean this section up.

1. Use SPDFT to isolate amplitude and phase of signal and image.
2. Estimate and .
3. Get the correct sign of and .

Run SPDFT to estimate amplitude and phase at signal and image frequencies.

represents the common frequency response.

After SPDFT, we get

This is just image suppression.

Alternate phase calc:

Two equations, two unknowns.

The above equations do not distinguish between both quantities being positive or negative.

### Frequency dependence

I and Q have a phase difference of 90 degrees. If the phase response is identical on I and Q, then the phase difference is no longer 90 degrees and they are not orthogonal.

With perfect symmetry,

Otherwise,

Nice, full circle.

Do these equations match? Remember, in the model below, is the mismatch, not the phase response. In the model above, is the phase response.

Basically, is – the lowpass equivalent model for mismatch in LO – equal to this model?

Let’s simplify. These are the two lowpass models:

So we need

4 equations, 4 unknowns. Solve for to satisfy the equations. Then the models are the same. I don’t need to know though. I just need to estimate and . Prove this in simulation.

PEQ compensates for common response, so what’s left over should be mismatch?

## Rx IQ mismatch

## Modeling mismatch on one branch vs. both branches

# PAPR

**Lowpass signal:**

**For a single-carrier QPSK signal,**

Then

PAPR of is equal to PAPR of the individual I and Q.

**For a modulated tone,**

Then

PAPR of is -3dB relative to the PAPR of the individual I and Q.

**For an OFDM signal, the PAPR of and the individual I and Q differs by less than 3dB in simulation, but in practice, we typically assume 3dB difference when determining setpoints in the digital front end.**

**PAPR usually refers to the lowpass equivalent signal (the envelope of the RF signal), but if you also calculate PAPR for the RF signal, it will be +3dB relative to .**