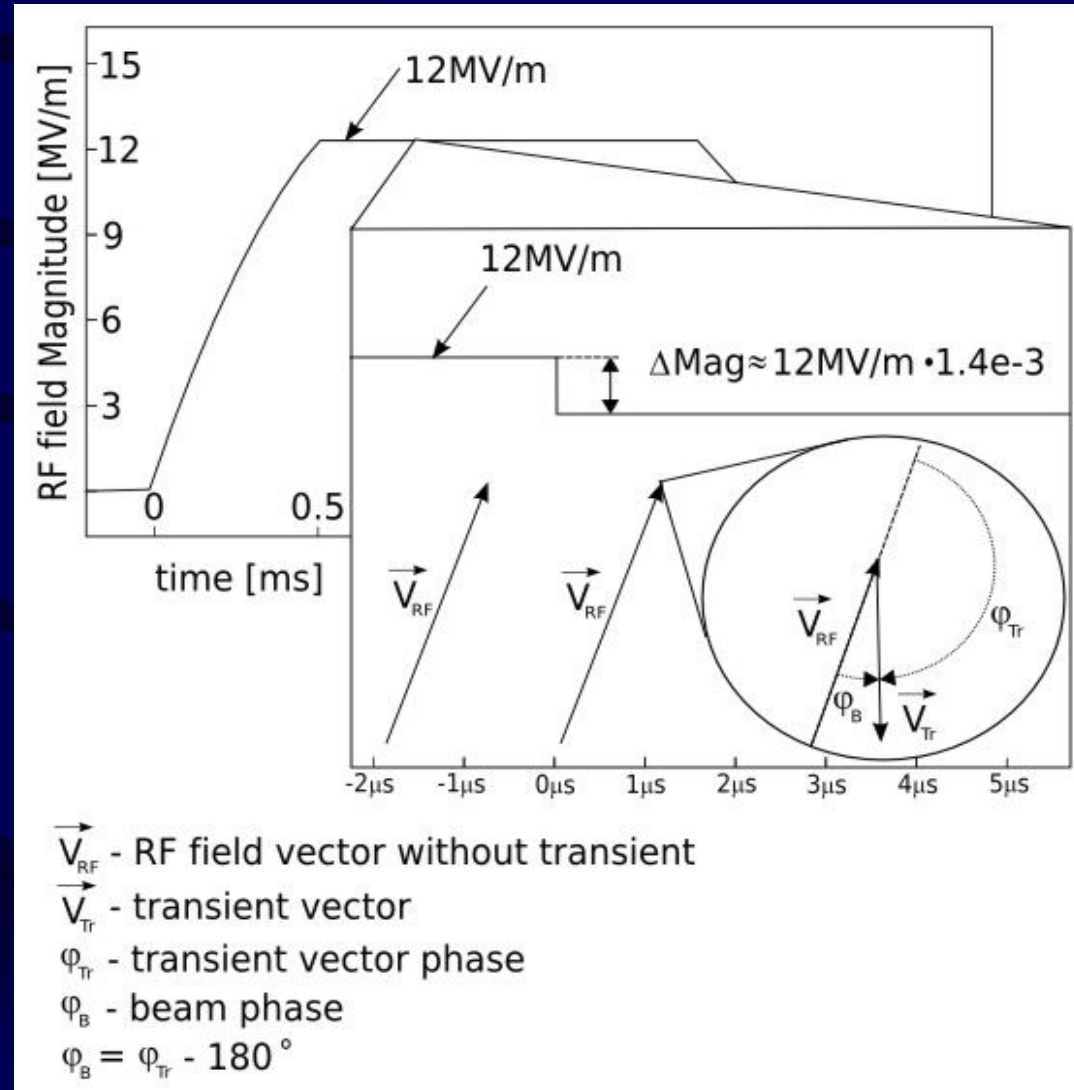


Amplitude And Phase Calibration Based On Beam Induced Transient Detection

Author: Paweł Pawlik

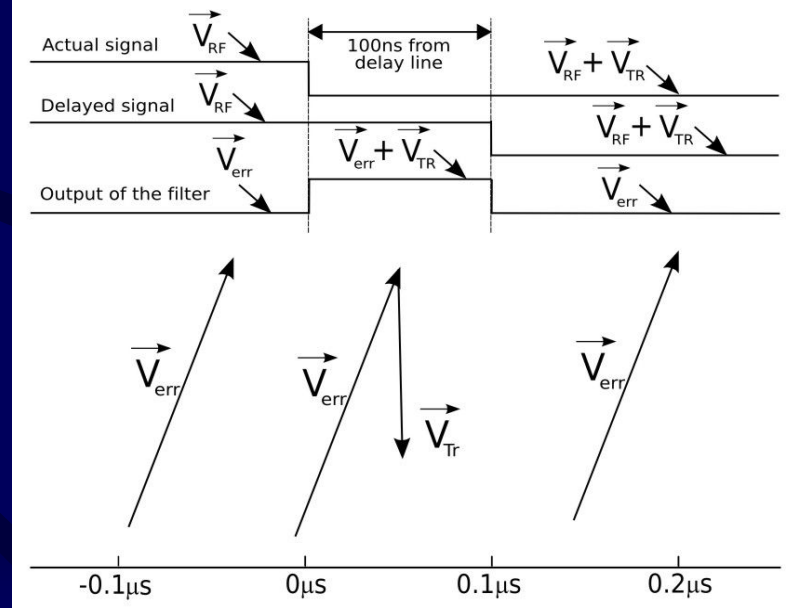
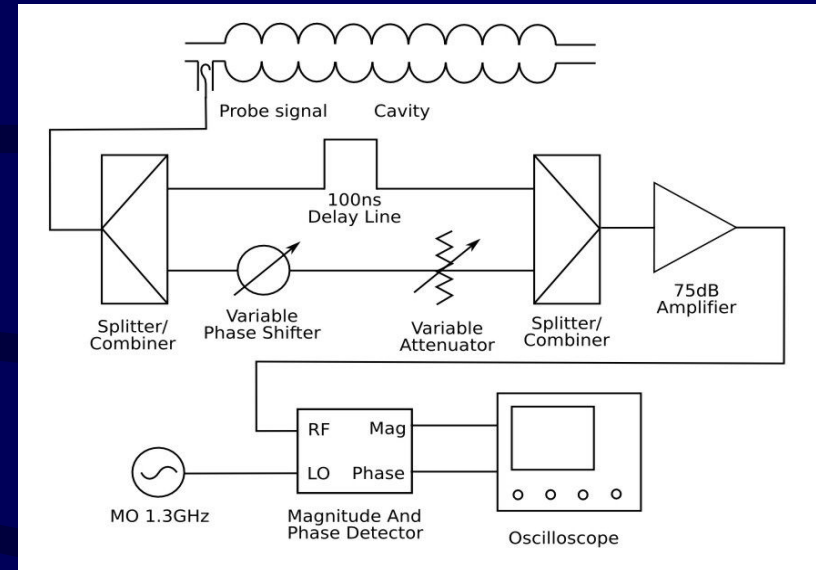
Single Bunch Induced Transient

- Single bunch going through the cavity induces a vector change in the RF field.
- Phase of this vector field change called transient depends on the phase between beam and the RF Field.
- For 0° of phase between beam and RF Field (on crest acceleration) we get 180° phase difference between transient vector and RF field vector in the cavity.



Beam Induced Transient Detection

- Filtration: Subtracting actual signal from delayed one, by precisely adjusting phase difference at the input of second combiner to 180° and magnitudes to the same value.
- To achieve 100dB attenuation precision better than 0.01° and $1e-5$ in magnitude is required.
- Amplified output of filter by 75dB has information about transient vector as a pulse with width equal 100ns (delay of the delay line)

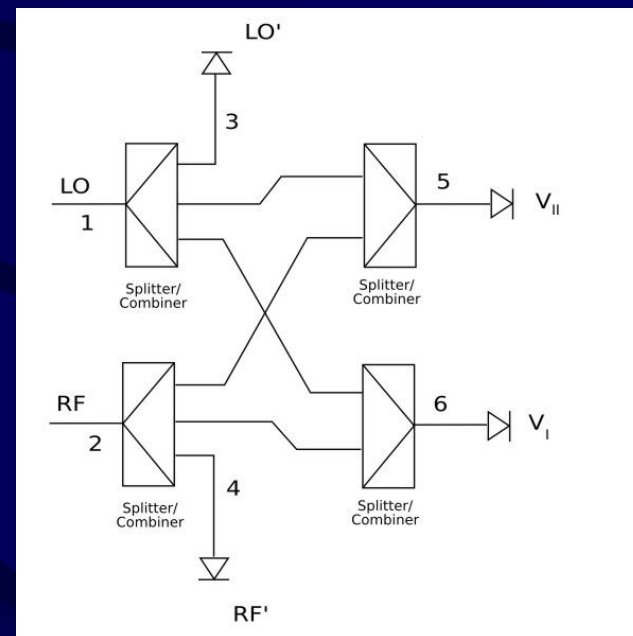
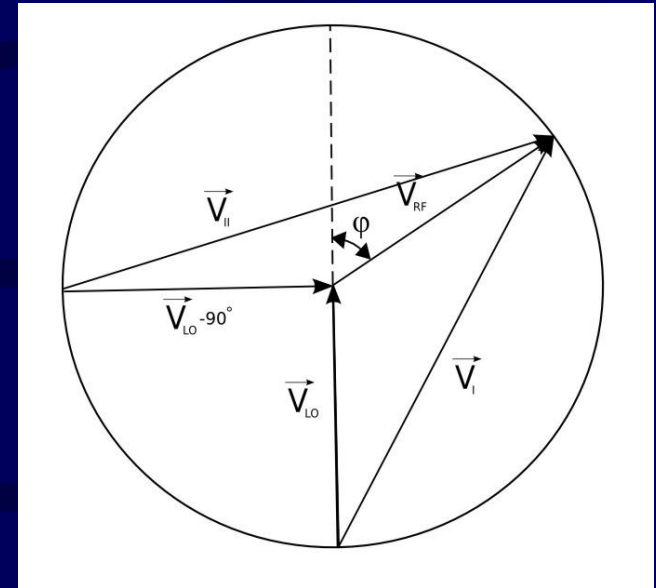


Beam Induced Transient Detection Hardware

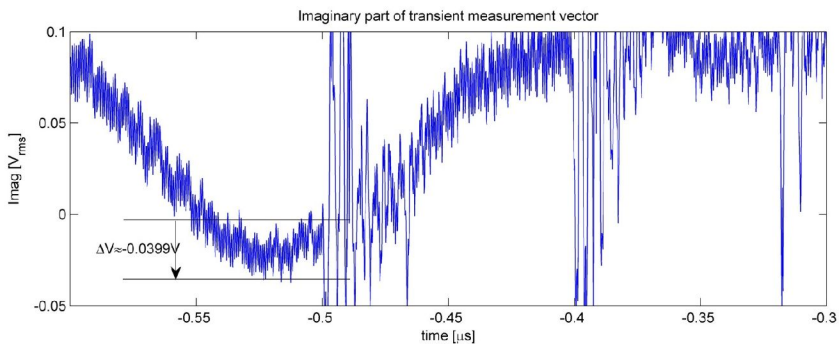
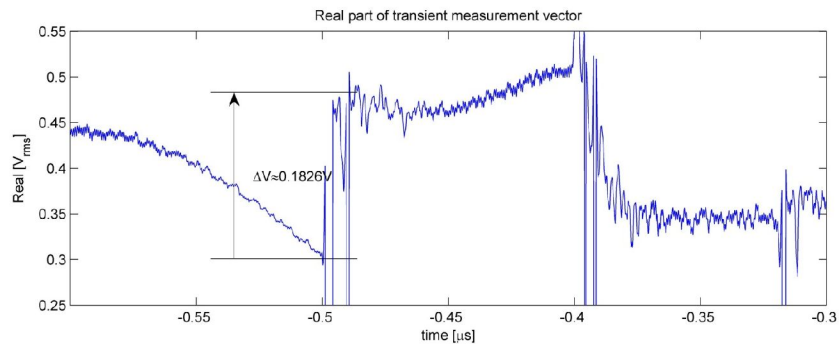


Low Noise Magnitude And Phase Detection Based on The Law of Cosines

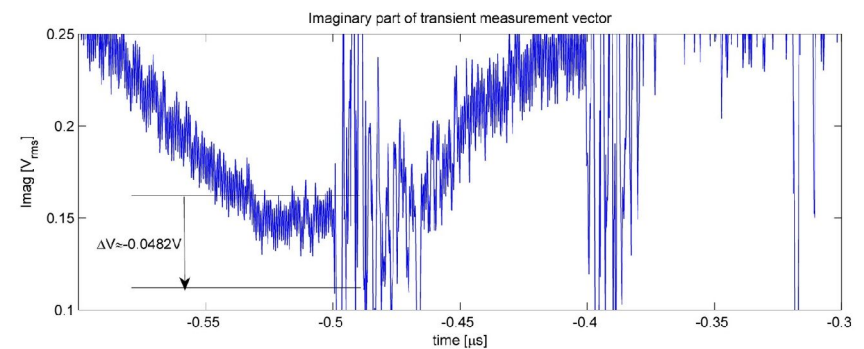
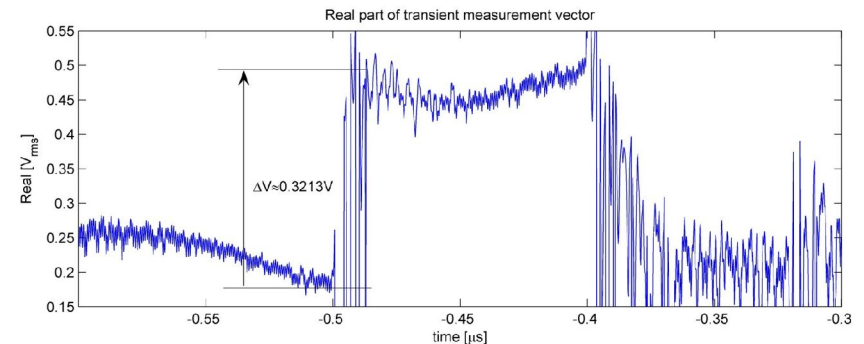
- To detect transients that are more than 60dB smaller than the carrier low noise method is required
- Phase detection with Analog Devices IQ demodulator failed (noise was too large)
- Phase detection with device that detects magnitudes of RF, LO and the sum of them with Schottky detector is better (noise coming from diodes is very small)



1nC And 2nC Single Bunch Induced Transients

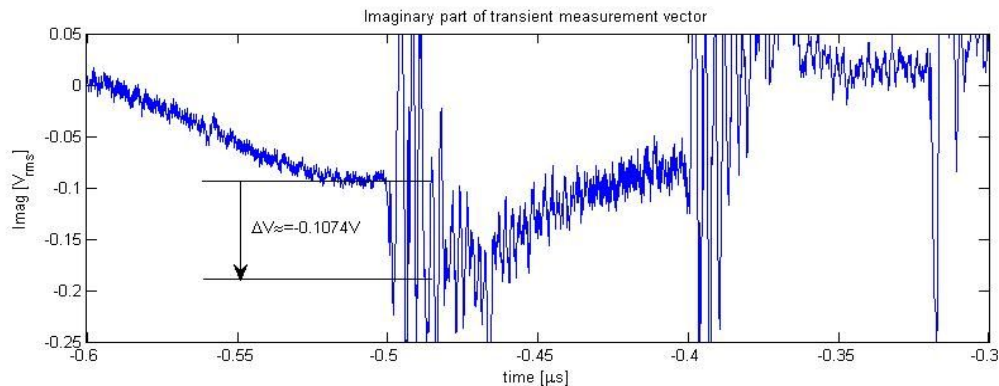
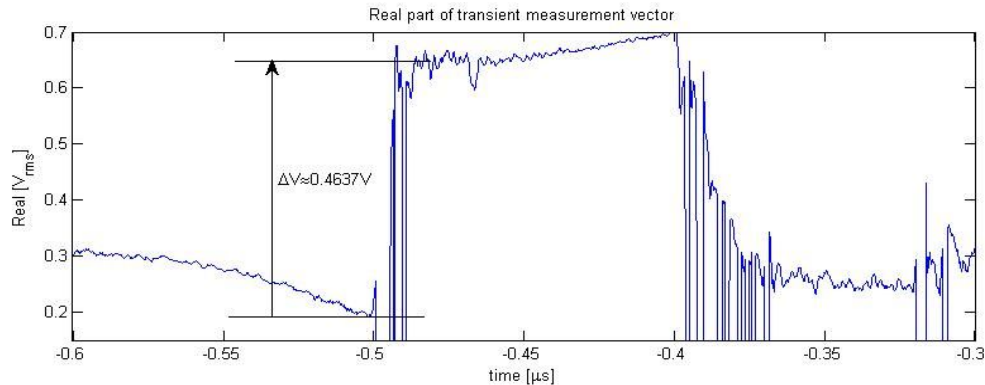


1nC Single Bunch Induced Transient



2nC Single Bunch Induced Transient

Measurement Results



Measurement results of calculated beam phases from captured single bunch induced transients for 3 different bunch charges. Measurements at cavity 3 module ACC1. Expected value $\approx -10^\circ$.

Measurement of 3nC single bunch induced transient (phase calibrated for direct beam phase calculation).

Charge [nC]	Phase [deg]	Phase error [deg]
1	-12,326	-2,326
2	-11,3168	-1,3168
3	-13,0406	-3,0406

Current and Future work

- Finished:
 - RF filter for beam induced transient detection
 - Hardware for low noise RF signal vector measurement based on the Law of Cosines
 - Successful beam phase measurement (with new hardware for RF signal vector measurement)
- Current work:
 - Automation of the RF filter adjustment
 - Preparation of connection to DOOCS system
- Future work:
 - Replacement of LeCroy Oscilloscope with a different ADC
 - Improvement of signal to noise ratio for more accurate and automated measurements