SPWR027

IF-MIXTURE PERFORMANCE DURING CAVITY CONDITIONING AT STF KEK

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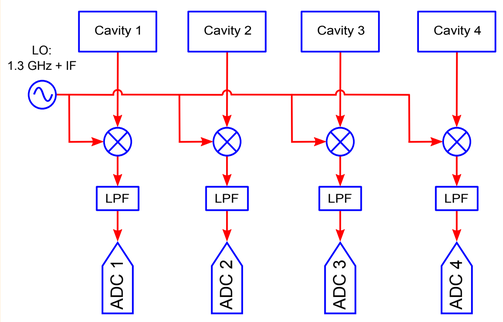
Abstract

Superconducting RF Test Facility (STF) at High Energy Accelerator Research Organization, Japan (KEK) was built for research and development of International Linear Collider (ILC). To satisfy the stability requirement of the accelerating field, the digital low-level RF (LLRF) control system is employed. In this control system, signal from cavity is down-converted into intermediate frequency (IF) signal before being digitized by analog-to-digital converter (ADC). A digital LLRF control system with IF-mixture algorithm has been developed and evaluated. IF-mixture is a technique that combines several IFs and read by only one ADC.

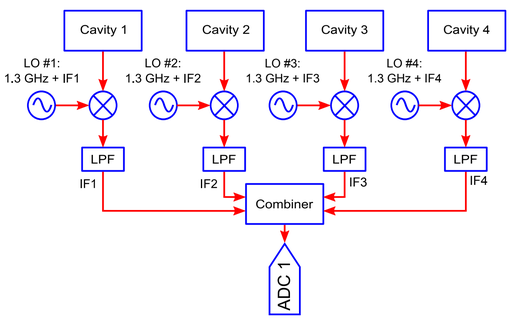
IF-mixture Technique

ILC requires amplitude and phase stability of 0.07 % (RMS) and 0.24° (RMS), respectively [1]. In ILC, one LLRF station is composed of one klystron driving 39 cavities. In order to operate vector-sum feedback control, one RF station requires approximately 120 ADC. IF-mixture is proposed to reduce the required number of ADC [2].

Typical Technique:



IF Mixture Technique:



IF Selection:

I and Q components from the ADC sampled signal ($X(n)$) [3]:

$$I_i = \frac{2}{L}\sum_{n=0}^{L-1} X(n)\cos\left(\frac{2\pi\cdot N_i}{L}\cdot n\right)$$

$$Q_i = \frac{2}{L}\sum_{n=0}^{L-1} X(n)\sin\left(\frac{2\pi\cdot N_i}{L}\cdot n\right)$$

IF must be selected carefully to avoid interference from intermodulation product because of combiner non-linearity.

Chosen Parameters:

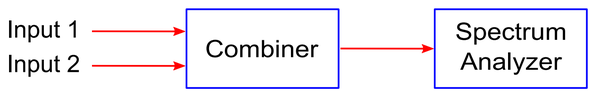
Sampling Rate = 81.25 MHz

L = 18 ; N = 1, 3, 5, 7

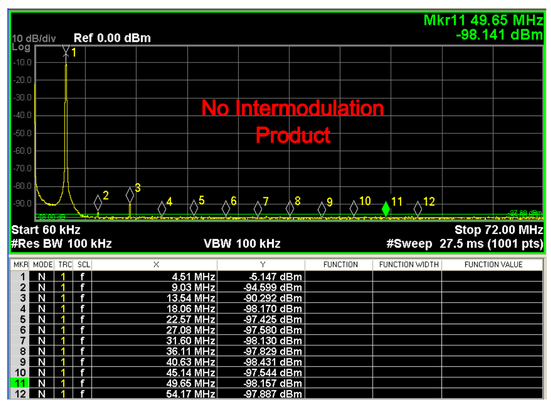
IF_1 = 4.5 MHz ; IF_3 = 13.5 MHz

IF_5 = 22.5 MHz ; IF_7 = 31.5 MHz

Combiner intermodulation measurement:

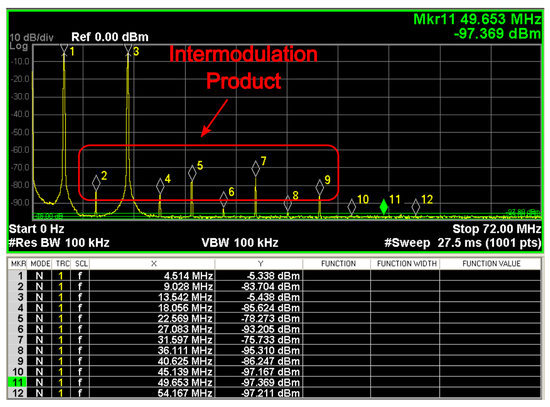


Ex. Input 1 = IF1 ; Input 2 = NOT CONNECTED



MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	4.51 MHz	-5.147 dBm			
2	N	1	f	9.03 MHz	-94.599 dBm			
3	N	1	f	13.54 MHz	-90.292 dBm			
4	N	1	f	18.06 MHz	-98.170 dBm			
5	N	1	f	22.57 MHz	-97.425 dBm			
6	N	1	f	27.08 MHz	-97.590 dBm			
7	N	1	f	31.60 MHz	-98.130 dBm			
8	N	1	f	36.11 MHz	-97.829 dBm			
9	N	1	f	40.63 MHz	-98.431 dBm			
10	N	1	f	45.14 MHz	-97.544 dBm			
11	N	1	f	49.65 MHz	-98.157 dBm			
12	N	1	f	54.17 MHz	-97.887 dBm			

Ex. Input 1 = IF_1 ; Input 2 = IF_3



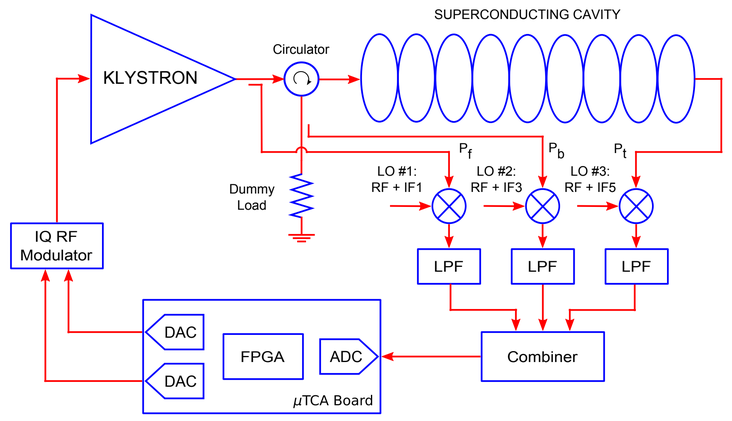
MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	4.514 MHz	-5.338 dBm			
2	N	1	f	9.028 MHz	-83.704 dBm			
3	N	1	f	13.542 MHz	-5.438 dBm			
4	N	1	f	18.056 MHz	-85.624 dBm			
5	N	1	f	22.569 MHz	-78.273 dBm			
6	N	1	f	27.083 MHz	-93.205 dBm			
7	N	1	f	31.597 MHz	-75.733 dBm			
8	N	1	f	36.111 MHz	-95.310 dBm			
9	N	1	f	40.625 MHz	-98.247 dBm			
10	N	1	f	45.139 MHz	-97.167 dBm			
11	N	1	f	49.653 MHz	-97.369 dBm			
12	N	1	f	54.167 MHz	-97.211 dBm			

IF-mixture is implemented on μTCA.0 board:

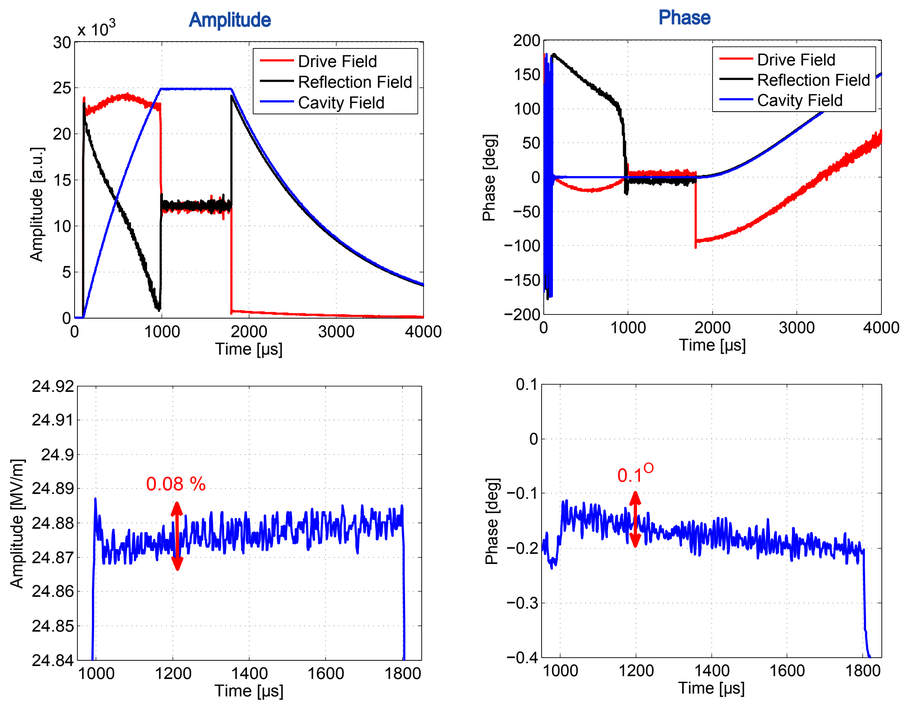
- Xilinx Virtex XCF5FX70T
- Power PC with Linux Installed
- 4 x 16-bit ADC (LTC2208)
- 2 x 16-bit DAC (AD9783)

Performance of IF-mixture

Simplified schematic for evaluation:

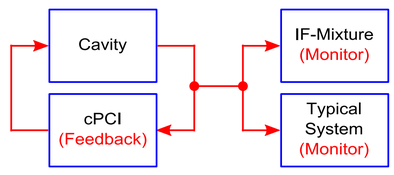


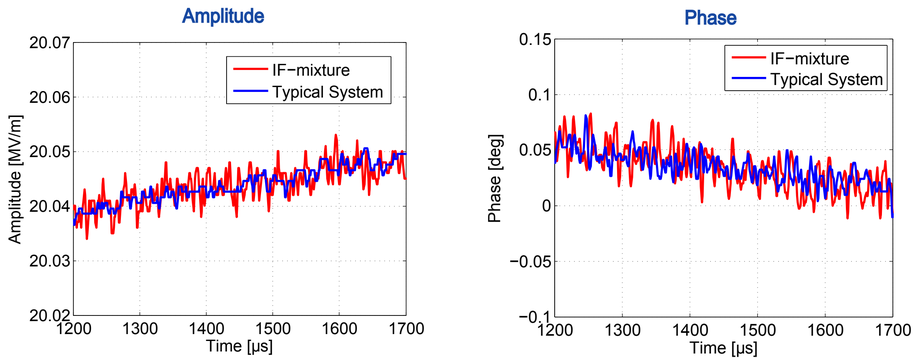
IF-mixture



Amplitude Stability: **0.015 %(RMS)** ; Phase Stability: **0.018° (RMS)**

Comparison with typical system:





System	Amp. Stability %.rms	Phase Stability deg.rms
IF-mixture	**0.019**	**0.018**
Typical System	**0.015**	**0.014**

Summary

- Combined signal can be separated into corresponding IFs as expected.
- Under feedback control operation, amplitude and phase stability of IF-mixture are 0.015 % (RMS) and 0.018 (RMS), respectively.
- This result of stability can fulfill the ILC requirement, therefore the IF-mixture technique is possible to be applied in the ILC.

References

[1] "ILC Tecnical Design Report", http://www.linearcollider.org/ILC/?pid=1000895.

[2] T. Matsumoto et al., "Digital Low-Level RF Control System with Four Intermediate Frequencies at STF", PAC09, Vancouver, Canada, 2009.

[3] M. Grecki et al., "Estimation of IQ Vector Components of RF Field", Proc. 12th Int. Conf Mixed Design of Integrated Circuits and Systems, 2005.