SENSORS

SENIS
magnetic & current measurement

Application Note AN001:

SENCS1Dx - FREQUENCY RESPONSE MEASUREMENT

2. Contents

3. INTRODUCTION

In this application note the measurement of the frequency response is described, which uses the specialized equipment for high frequency test of the SENIS novel integrated current sensor SENCS1Dx in various application configurations.

The current sensor SENCS1Dx measures the magnetic field generated around a current carrying conductor and converts the measured magnetic field to the voltage proportional to the current that needs to be measured.

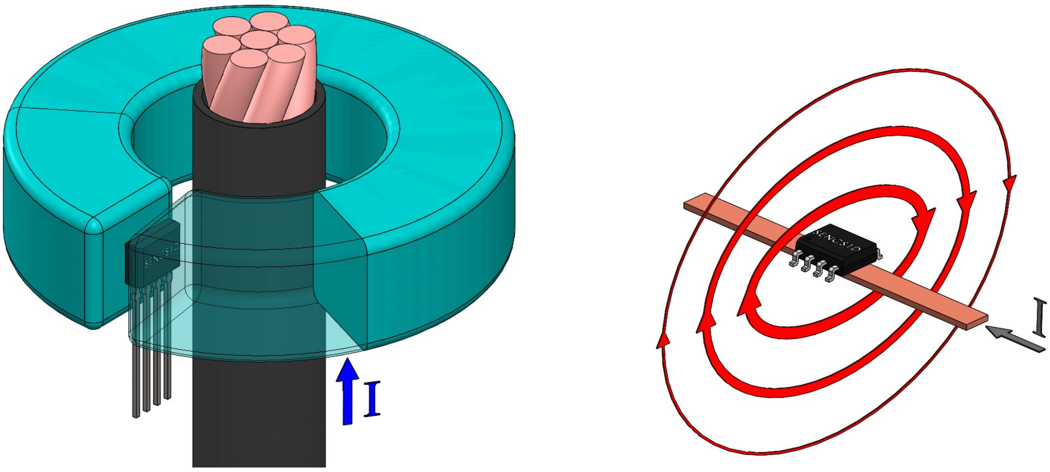


Figure 1: *Full scale linear output 2.5V +/-2V is proportional to the current flowing trough the conductor*

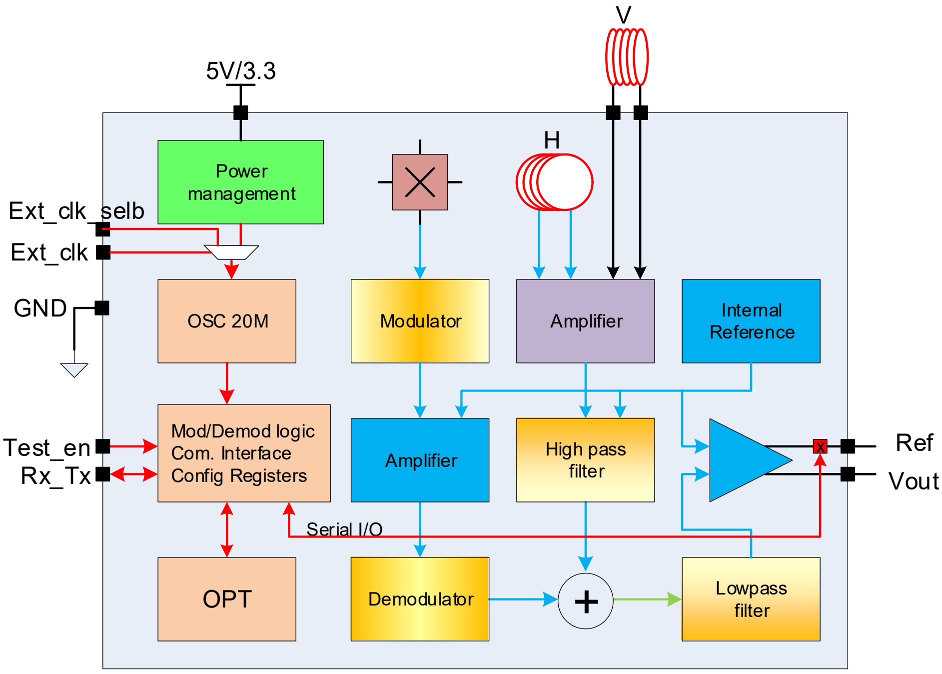


Figure 2: *Block Diagram of SENCS1Dx*

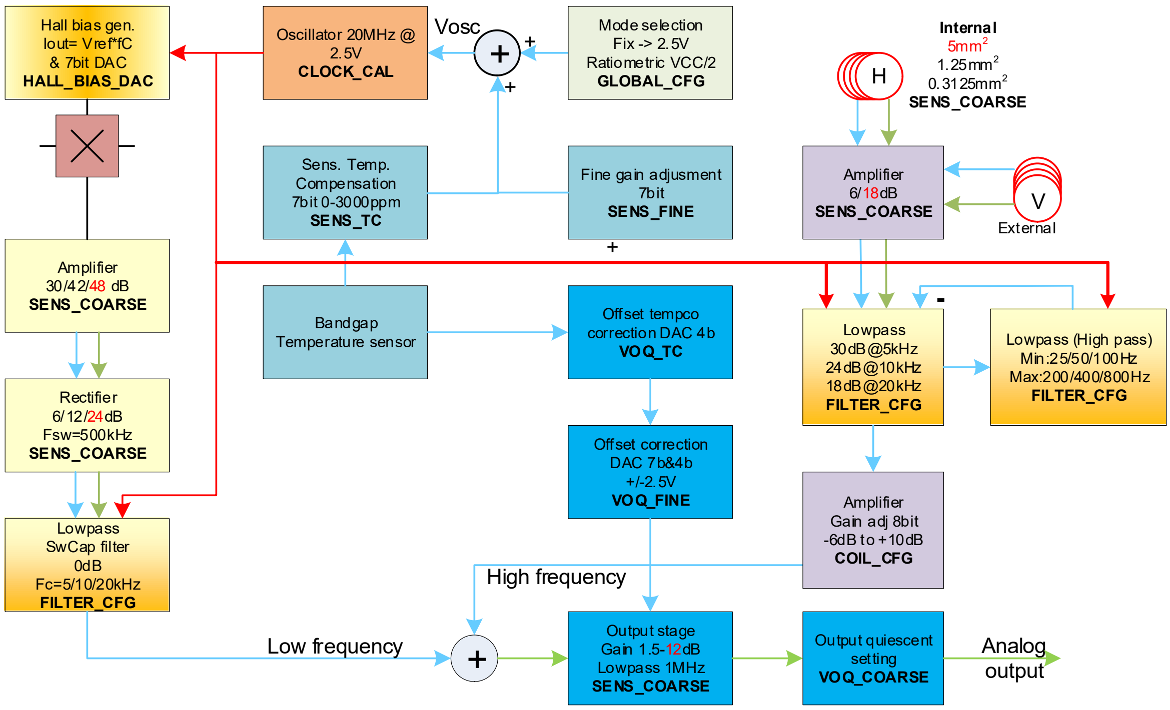


Figure 3: *SENCS1Dx analog signal processing*

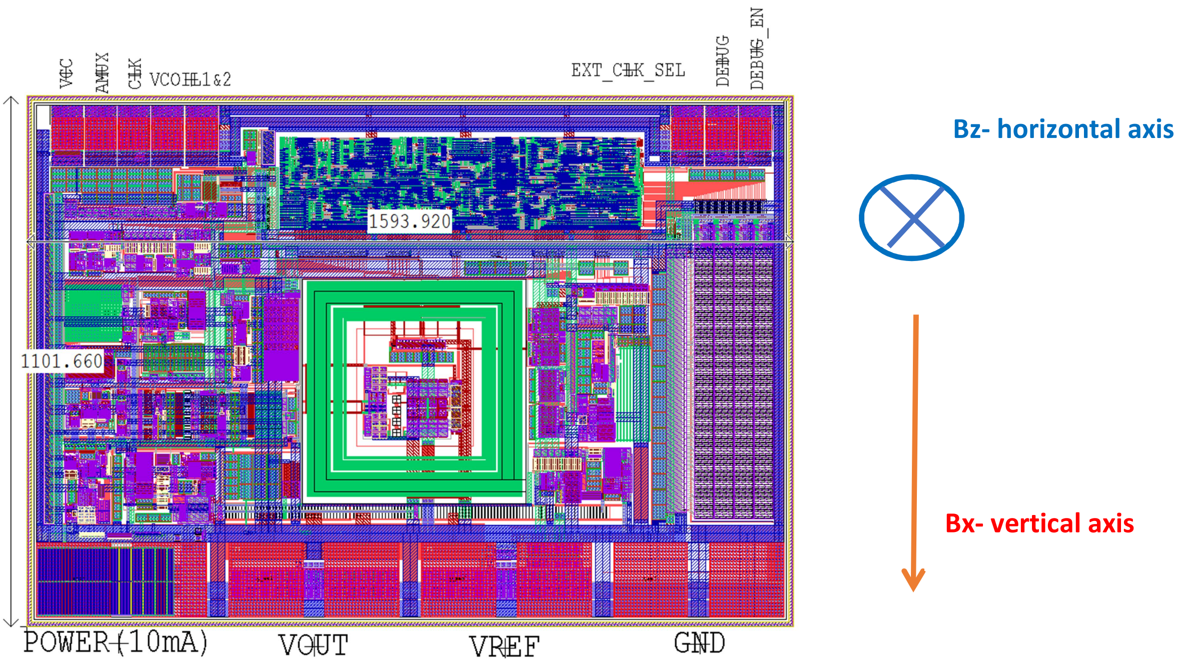
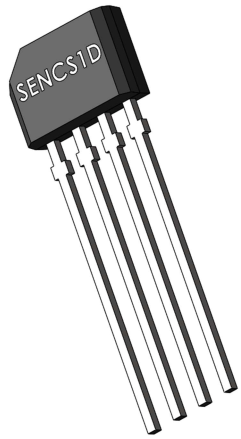


Figure 4: *SENCS1Dx ASIC layout, revD01, Dimension: 1.6 x 1.1mm x 0.41(thickness)*



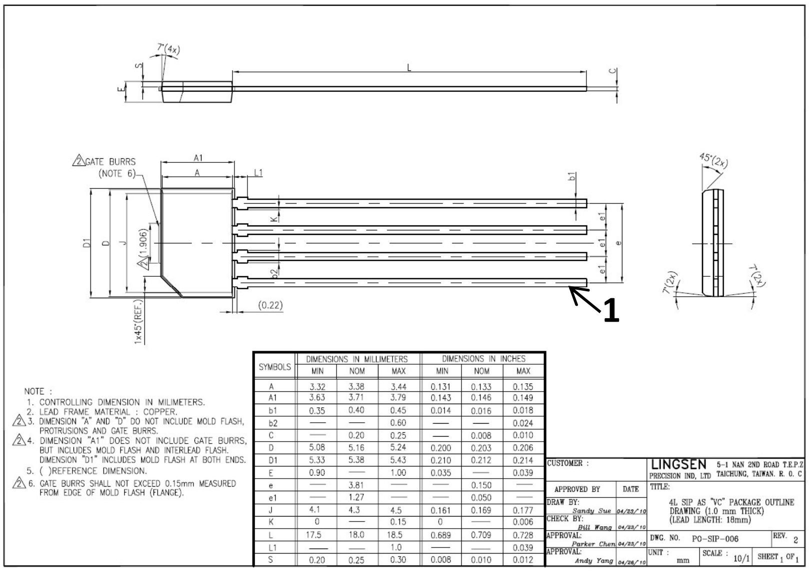


Figure 5: *SIP4 Housing*

Pin #	Symbol	Type	Description.
1	**VCC**	POWER	Main power supply (from 3.3V to 5V)
2	**VOUT**	OUTPUT	Signal output
3	**VREF**	Output/Input	Quiescent reference output; also used as programming interface; single wire
4	**GND**	GROUND	Ground

Table 1. *Table 1: Pin list and function.*

4. SETUP FOR MEASUREMENT

Test conditions:		Note
VCC[V]	5V	
CLK [MHz]	0x00	8 MHz
HALL_BIAS_DAC register	0x50	2.4 mA
Hall senzor	HH / VH	
FILTER_CFG		
COIL_CFG		
B stimulus [mT]	0.225mT	
Temperature [°C]	Room Temperature	

Table 2. Test conditions

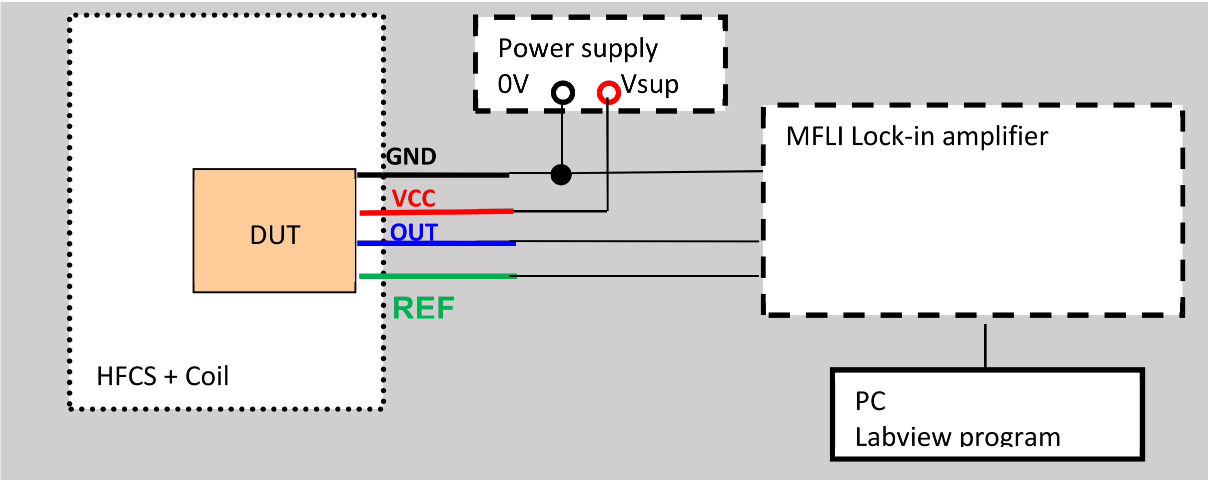


Figure 6: Block diagram of the frequency response measurement set-up

Figure 7: HFCS - High Frequency Current Source is a bipolar current source capable to deliver up to 10App in a frequency range from 20Hz to more than 1MHz.

The input signal (Vin) to the system is an AC voltage, with the amplitude of up to 5Vpp generated by a lock-in amplifier. This signal is amplified and fed to a Bipolar current source, capable of driving AC current up to 10App @ $R_{LOAD}=0\Omega$, in the frequency range 20Hz to more than 1MHz. The Bipolar current source delivers a current into miniaturized Helmholtz coils or any other load. For precise measurement of the output (Helmholtz coil) current, a shunt-type current monitor is available.
The Mini Helmholtz Coil is made as combination of two one-turn coils integrated on two printed circuit boards each. They can be connected to a current source by an IEEE 1284 (36 pins male) connector.

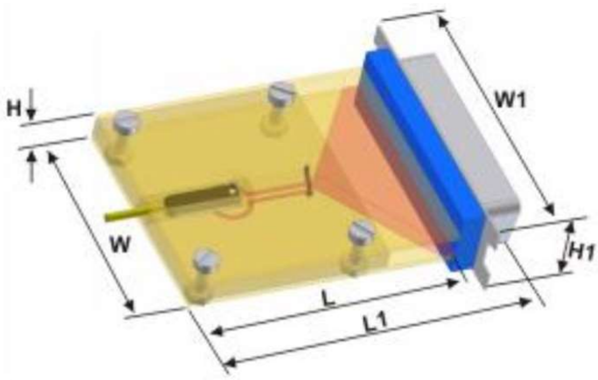


Figure 8: *Mini Helmholtz coil*

The SENCS1Dx sensor is inserted into coil and response is measured.

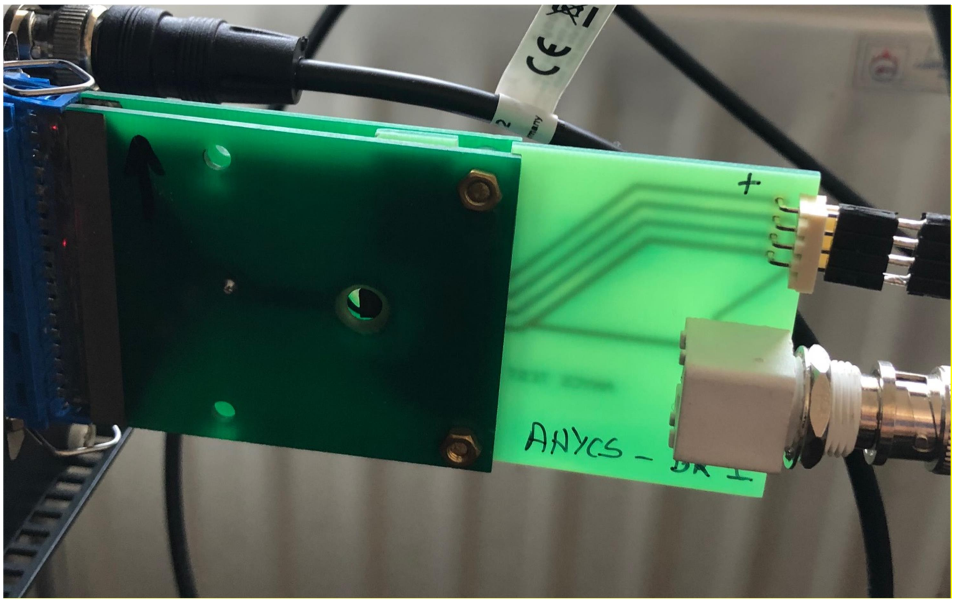


Figure 9: *Photo of the SENCS1Dx Test board inserted into the Mini Helmholtz Coil pcb*

The signal from the SENCS1Dx sensor is measured with MFLI locking amplifier

Figure 10: *MFLI Lock-in Amplifier, DC - 5 MHz, 60 MSp/s, 16 bits*

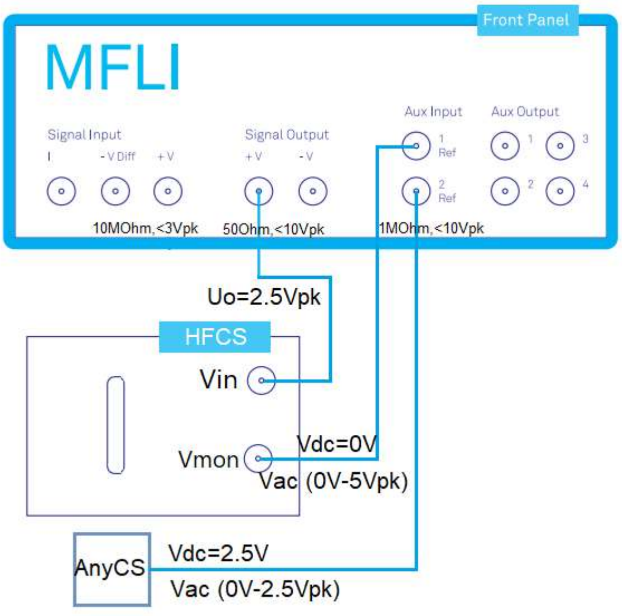


Figure 11: *Wiring diagram, illustrative purpose*

Due to theMini Helmholtz Coil and the parasitic inductance, the stimulus has a self-resonance and it is necessary to measure Vmon and sensor Vout in the same time. The MFLI is upgraded with the dual demodulators.

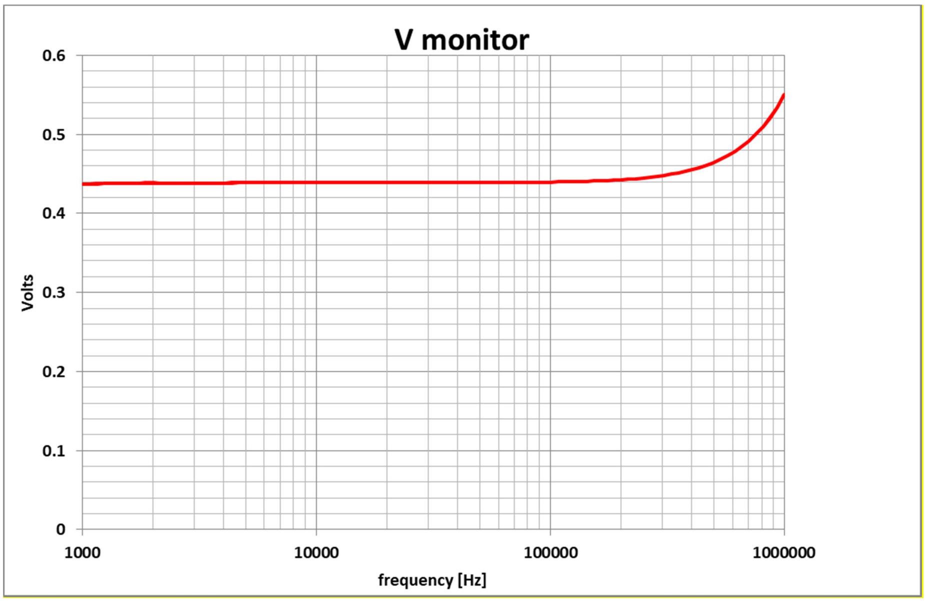


Figure 12: Vmonitor (Vmon) frequency response

The value of the magnetic field in the Helmholtz coil during measurement was 0.44mT

The main register which configure response are FILTER_CFG and COIL_CFG

Register ID	Address	Mode	Bits	Meaning	Default
FILTER_CFG	0x14	R/W	1:0	Low -pass filter corner frequency selection: ‘00’: 5k, ‘01’:10k, ‘10’:20k	‘01’
			2	‘1’: Enable 160k low pass for Hall sensor	‘0’
			3	‘1’: Disable Coil path	‘0’
			4	‘1’: Disable Coil high pass	‘0’
			7:5	Temperature threshold selection	0x3

Table 3. Register FILTER_CFG settings.

Register ID	Address	Mode	Bits	Meaning	Default
COIL_CFG	0x13	R/W	3:0	Gain adjustment Fine (4b) 0.06dB/step, 0dB -> 1dB *Note: The coil amplifier overall gain is controlled by the SENS_COARSE register. This register is used to match the gain of the Hall cell.*	0x7
			7:4	Gain adjustment Coarse (4b) 0.75dB/step, 0dB -> 12dB Note: The coil amplifier overall gain is controlled by GAIN register. This register is used to match the gain of the Hall cell	0x7

Table 4. Registers for gain setting – fine sensitivity of internal Coil

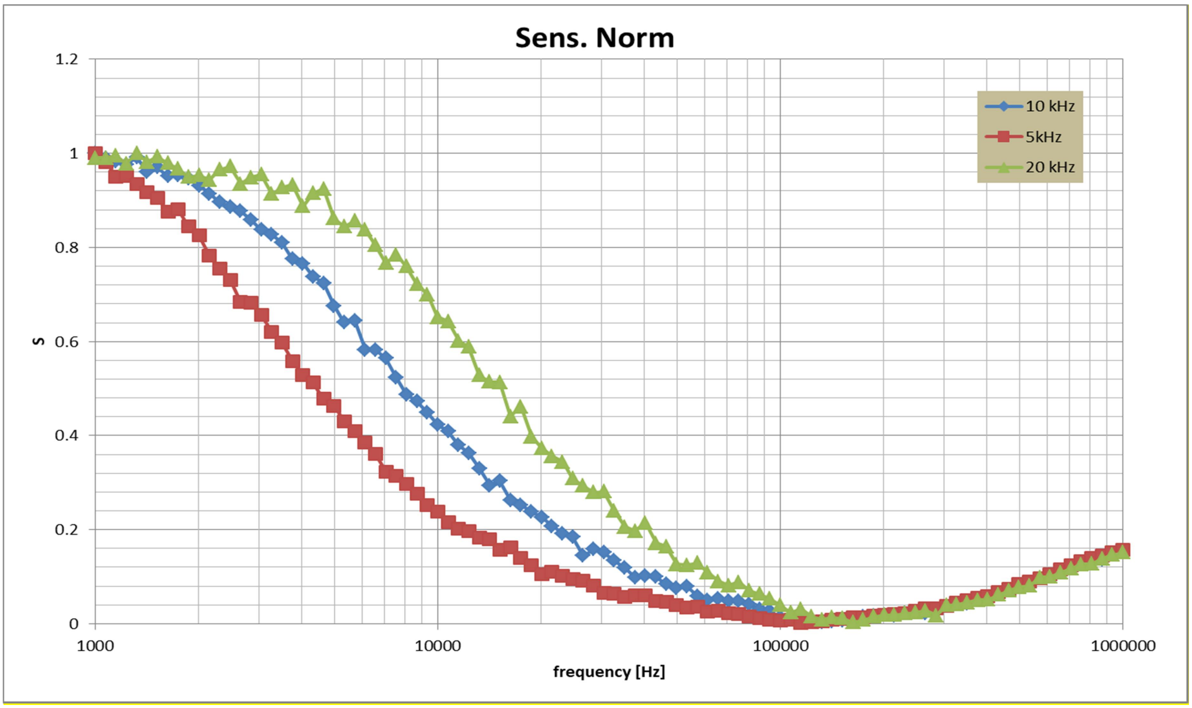


Figure 13: *Influence of the low pass filter corner frequency when "enable 160 kHz LP" for the Hall signal is disabled and Coil path disabled*

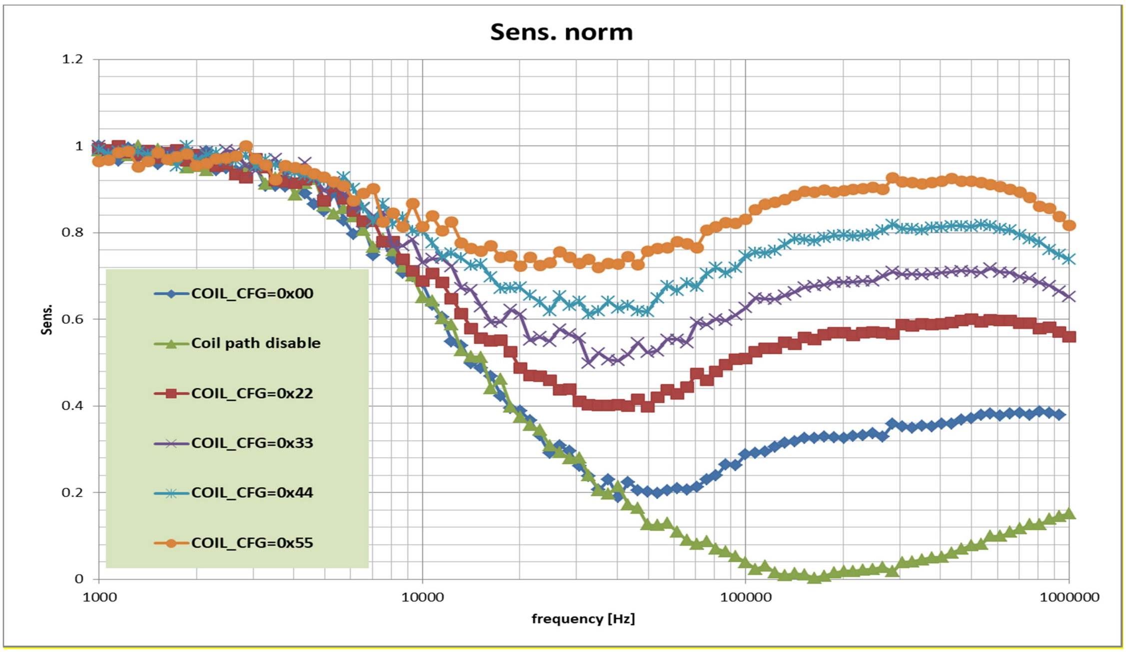


Figure 14: *Influence of COIL_CFG settings with the Coil path enabled, with 20kHz LP filter and disabled High pass filter*

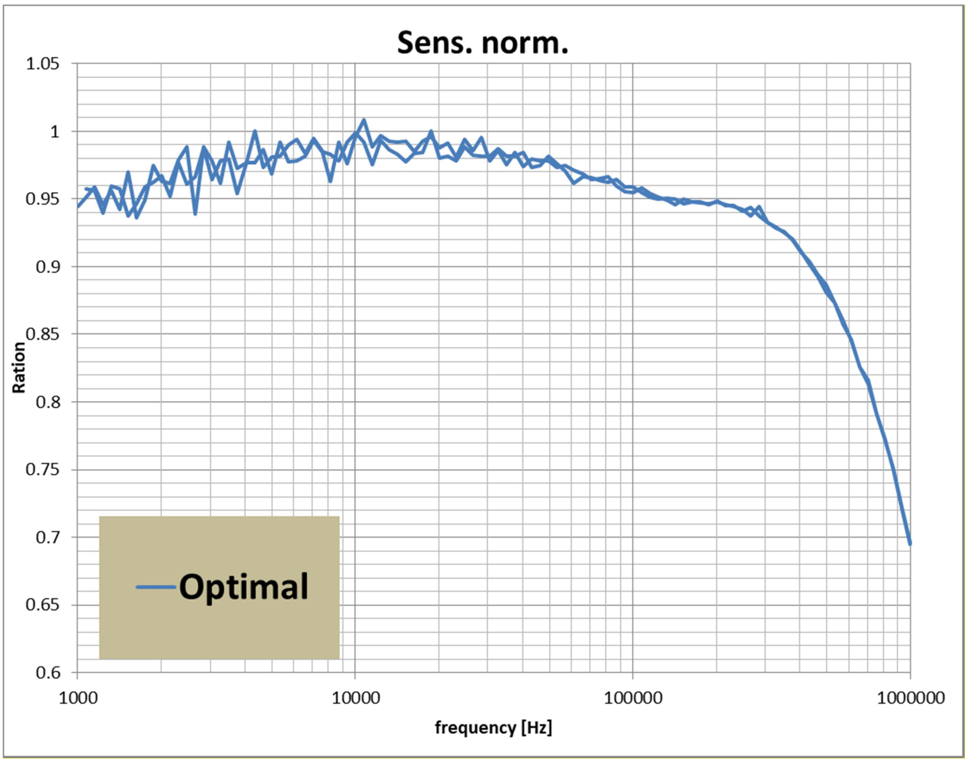


Figure 15: Optimal AC response

For the Optimal AC response the configuration shall be as follows:

Parameter	Value	Note
Sensor	HH	GLOBAL_CFG=00
Range	5mT	2.4mA
Ibias	0.96mA (@8MHz)	HALL_BIAS_DAC=0x50
Oscilator	8MHz	OSC=0x00
Hall magnetic polarisation	Field enter IC	
Coil magnetic polarisation	Reverse	
Filter	2 kHz (@8MHz)	FILTER_CFG=0x20
160 kHz LP	Disable	
Coil path	Enable	
Coil high pass	Disable	
Coil Gain	0x68	COIL_CFG=0x68
Spinning	4 Phase	HALL_CFG=11
STATUS	0x0F	OTP programmed

Table 5. Optimal configuration for Offset and AC response

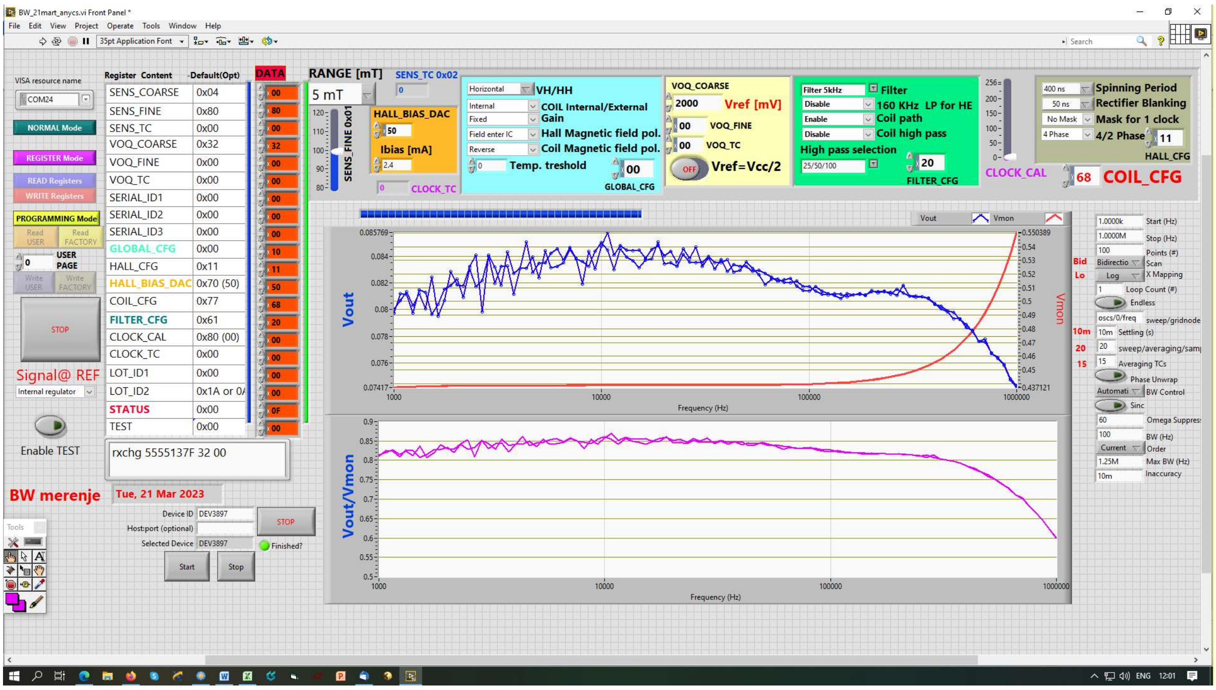


Figure 16: *Lab-view software can be included in the delivery of the complete set-up*

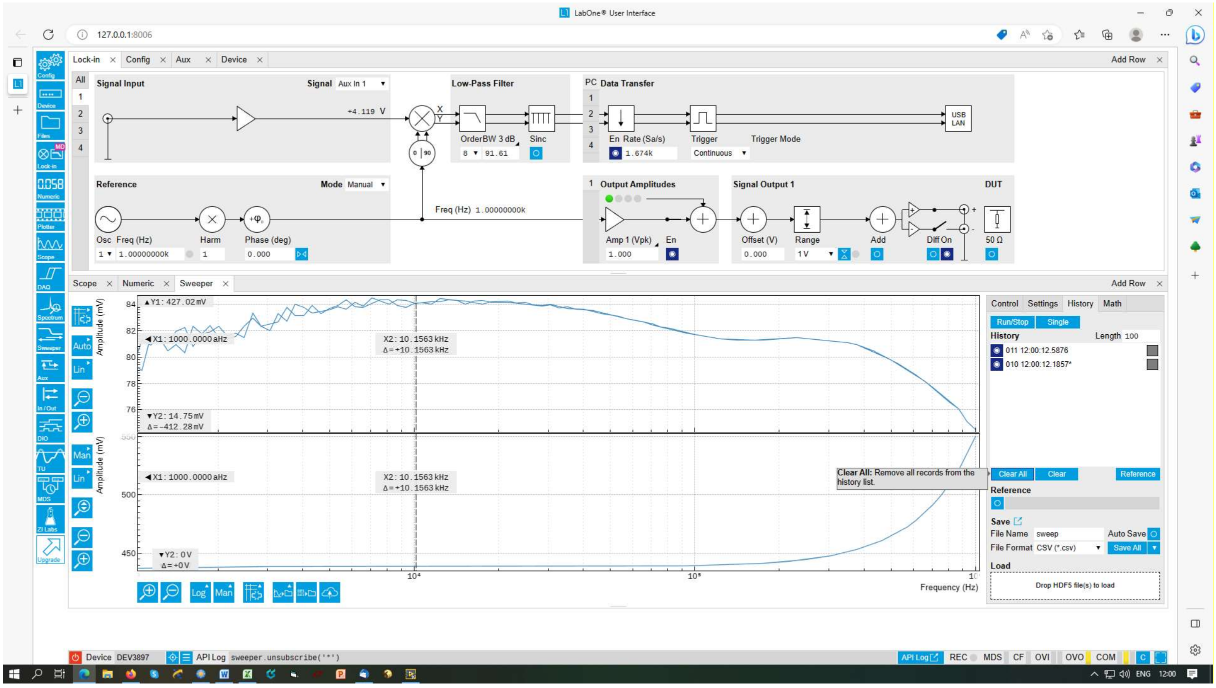


Figure 17: *MFLI screen*

5. METODOLOGY FOR OPTIMAL FREQUENCY RESPONSE

Starting with HALL channel enabled, with coil disabled, with coil amp=0x00 and with Lpf=10kHz

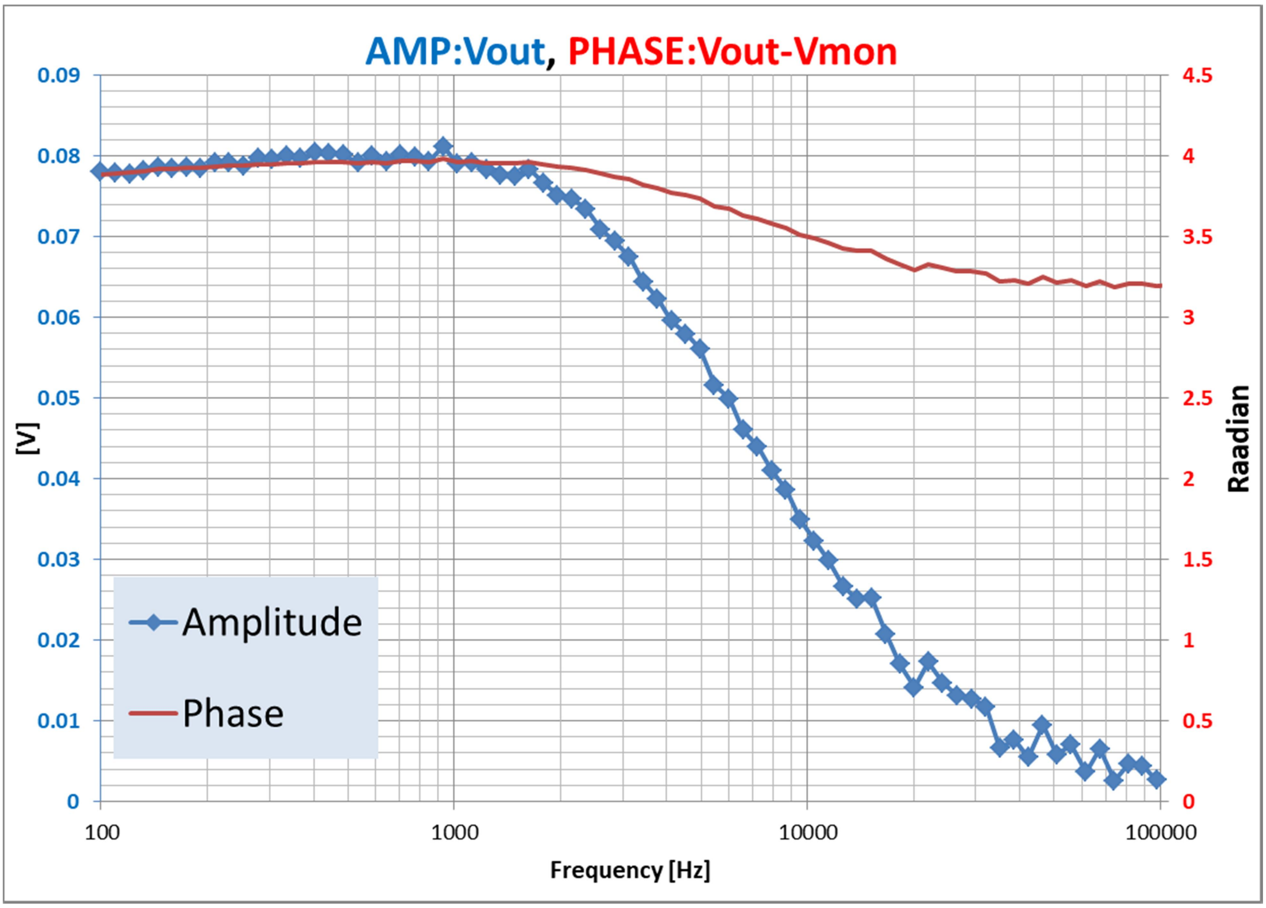


Figure 18: Amplitude and Phase response

Left side (HALL) has 80mV amplitude and for the COIL, the same value is set.

Then continue with the Coil channel setting: Hall bias=0, Coil enable, HPF enable, LP:10 kHz

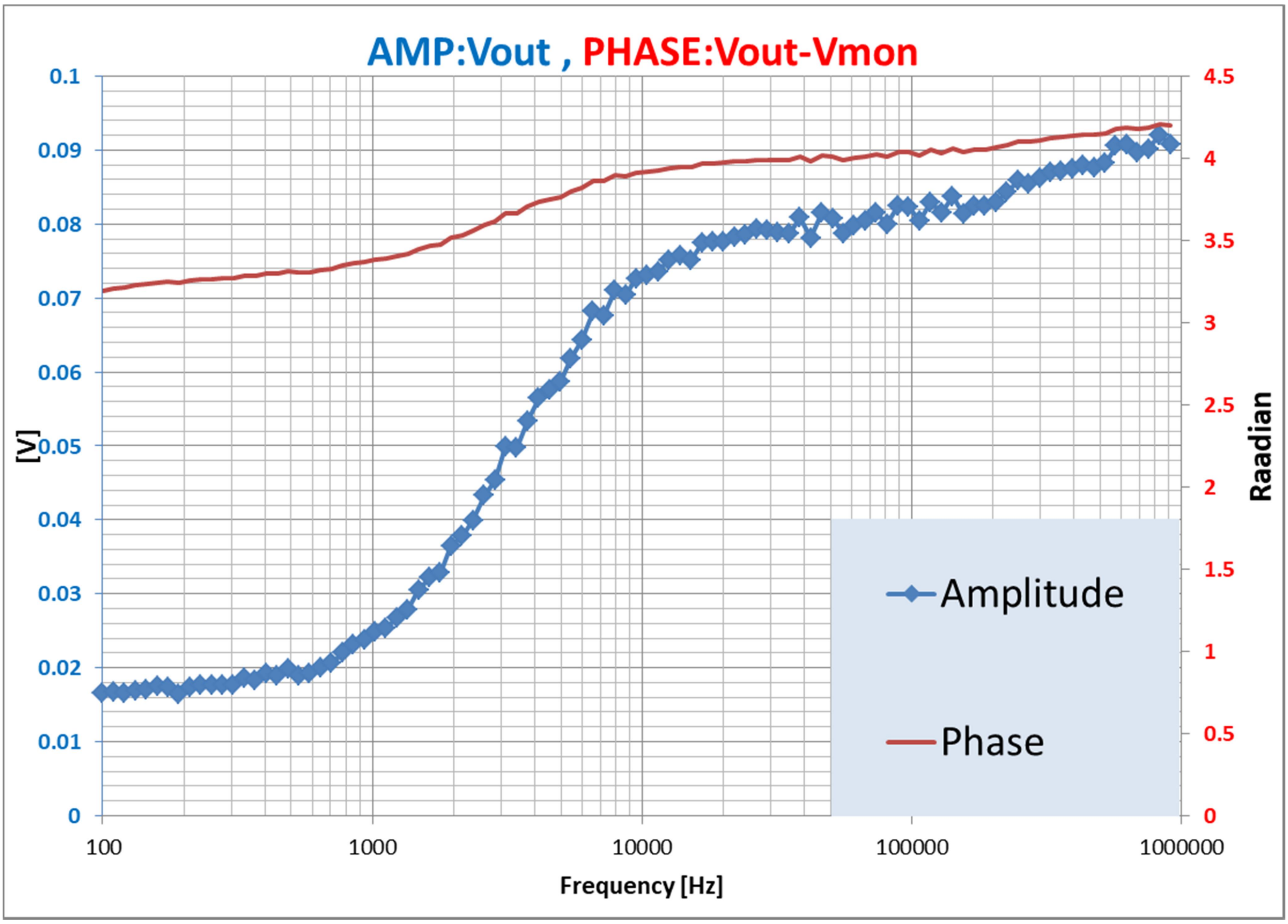


Figure 19: Amplitude and Phase response

For the frequencies higher than 100kHz the amplitude response increases, since Vmon (that indicates the current trough the Helmholtz coil) also increases.

Then both channels are on and the frequency response is measured, so the normalized graphs are as follows:

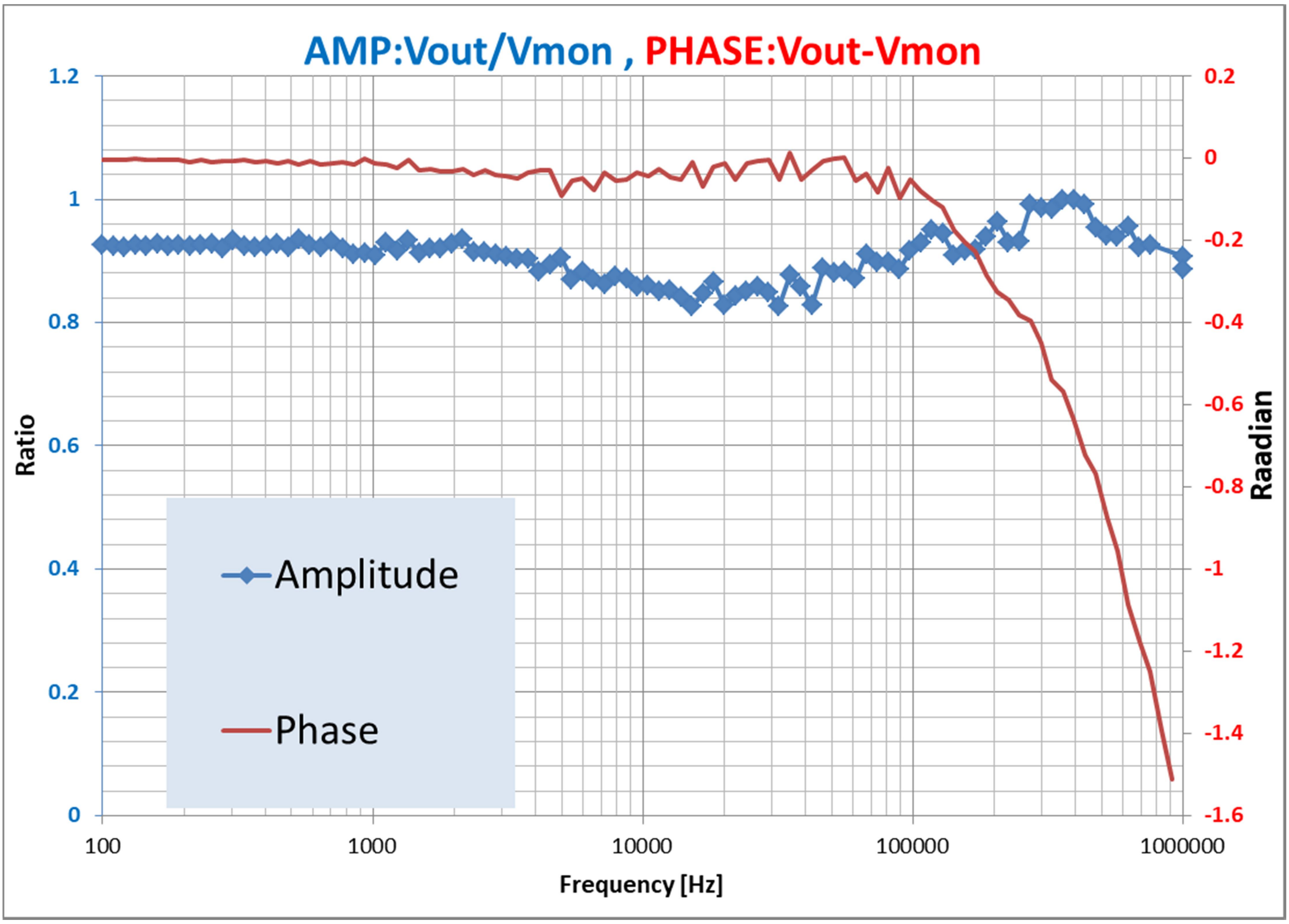


Figure 20: *Amplitude and Phase response*

If the polarity of the Coil is reversed, the better Amplitude response can be obtained.

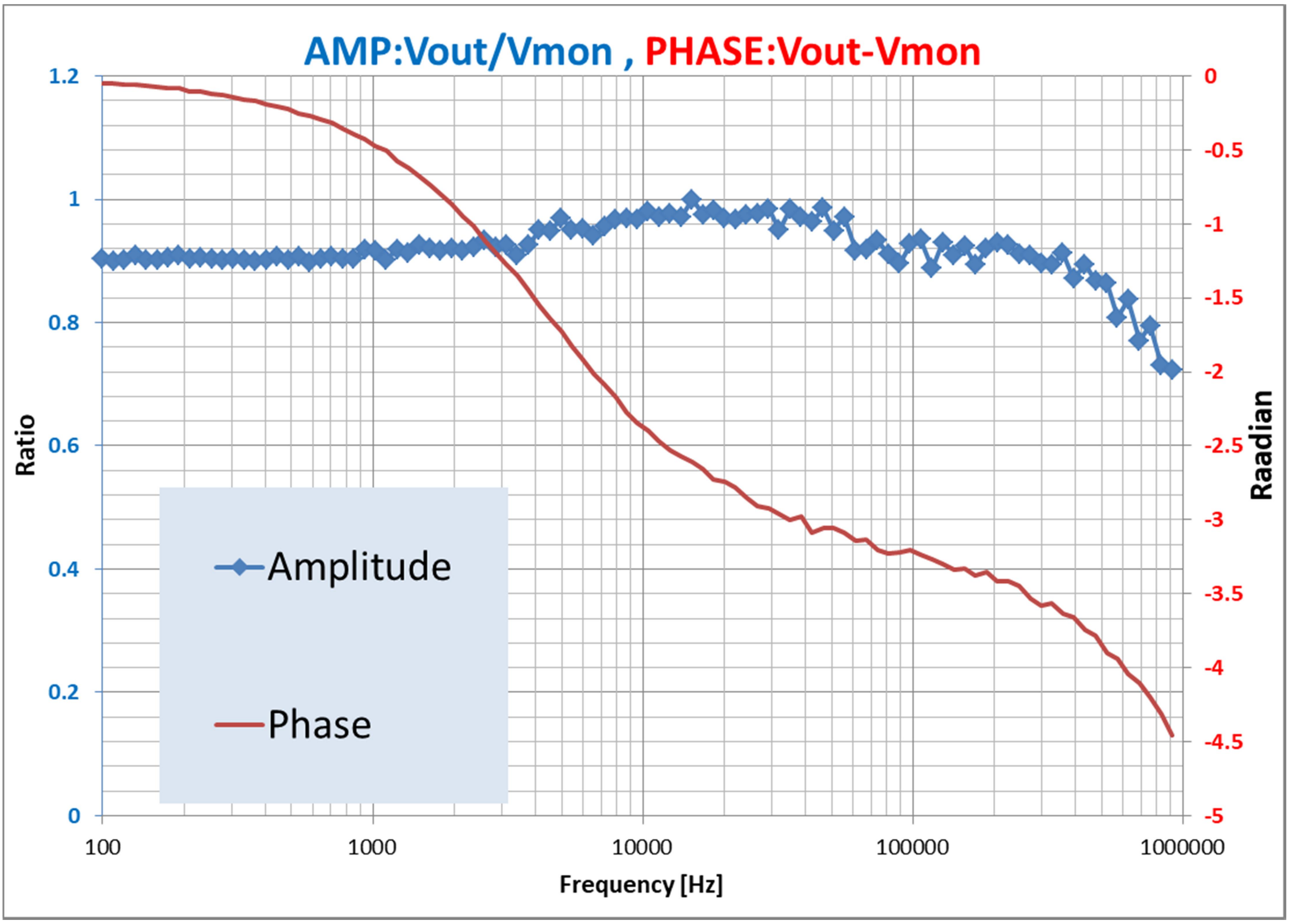


Figure 21: *Amplitude and Phase response*