

Application Note AN001:

SENCS1Dx - FREQUENCY RESPONSE MEASUREMENT

2. Contents

3.	INTRODUCTION	2
4.	SETUP FOR MEASUREMENT	5
5.	METODOLOGY FOR OPTIMAL FREQUENCY RESPONSE	12



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

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Figure 3: SENCS1Dx analog signal processing



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

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Figure 5: SIP4 Housing

SENCSI

Pin # Symbol		Туре	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
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Table 1.Table 1: Pin list and function.



4. SETUP FOR MEASUREMENT



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

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



Figure 11: Wiring diagram, illustrative purpose

Due to the Mini 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:	'01'
				'00': 5k, '01':10k, '10':20k	
			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	0x7
				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.	
			7:4	Gain adjustment Coarse (4b) 0.75dB/step, 0dB ->	0x7
				12dB	
				Note: The coil amplifier overall gain is controlled by	
				GAIN register. This register is used to match the	
				gain of the Hall cell	

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

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

Table 5.Optimal configuration for Offset and AC response

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resource name	Register Content	-Default(Opt) DAT	A RANGE [mT] SENS_TC 0x02		waa cauper	· · · · · · · · · · · · · · · · · · ·	256:
OM24	SENS_COARSE	0x04	5 mT	√ 0	Herizontal VH/HH	A 2000	Filter SkHz Filter	200- Spinning Period
	SENS_FINE	0x80	120-	HALL_BIAS_DAC	Internal COIL Internal/External	vret [mv]	Finable Coil path	150- No Mask y Mask for 1 clock
NORMAL Mode	SENS_TC	0x00	110	50	Field enter IC V Hall Magnetic field pol.	00 VOQ_FINE	Disable Coil high pass	100- 4 Phase V 4/2 Phase 11
	VOQ_COARSE	0x32	100	Ibias [mA]	Reverse Coil Magnetic field pol.	00 VOQ_TC	High pass selection	50-
EGISTER Mode	VOQ_FINE	0x00	90- S	2.4	👌 Temp. treshold 🗍 00	Off Vref=Vcc/2	25/50/100	
EAD Registers	VOQ_TC	0x00	N 100		GLOBAL CFG		FILTER_CFG	68 COIL_CFG
RITE Registers	SERIAL_ID1	0x00						
RAMMING Mode	SERIAL_ID2	0x00					Vout	Vmon 1.0000k Start (Hz)
Read	SERIAL_ID3	0x00		0.085769	· ^ ·			0.550389 1.0000M Stop (Hz)
USER	GLOBAL_CFG	0x00		0.084-	AN ANANANA	MALAN		0.54 100 Points (#)
PAGE	HALL_CFG	0x11			ALAVANA AN V V	na na habar		0.52 Lo Log X Mappin
R FACTORY	HALL_BIAS_DA	C 0x70 (50)	- L	0.082-		V**	Damanada	0.51 1 Loop Count (#)
	COIL_CFG	0x77	E E	0.08-	•		the second second	0.5 Endless
STOP	FILTER_CFG	0x61	i s	1				0.49 9 0scs/0/freq sweep/g
	CLOCK_CAL	0x80 (00)		0.078-			/	0.47 20 20 Second (S)
	CLOCK_TC	0x00		0.076-				0.46 15 15 Averaging TCs
nal@ REF	LOT_ID1	0x00		1				0.45 Phase Unwrap
al regulator 🔍	LOT_ID2	0x1A or 0/		0.07417-	10000		100000	1000000 Automati V BW Contr
\sim	STATUS	0x00	_			Frequency (Hz)		Sinc Sinc
	TEST	0x00		0.9		-		100 Divides
able TEST	rxcha 555513	7E 32 00	_ י	185-	Andress			Current
			5	0.8				1.25M Max BW (
			<u>ب</u>	0.75				10m maccurac
merenje	Tue, 21 Mar 2	2023	<u> </u>	0.7				
	Device	e ID DEV3897		1.65				
	Host port (option	nal)		0.6				
Ā	Selected Dev	Fi	nishedr (1.55				
0	S	itart Stop		0.5				
2				1000	10000	Emplote (141)	100000	1000000
						mednency (ext)		

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

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