

A 60 GSa/s InP-DHBT-THA with 50 GHz Bandwidth for High Bit Rate Communication Systems

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Abstract — A 60 GSa/s THA is designed and realized in InP-DHBT process. The THA presents a small signal bandwidth of 50 GHz. For +4 dBm and -4 dBm input powers, 60 GSa/s spectral measurements give a THD of -37.3 dB and -51.3 dB for input frequency up to 2 GHz and a THD of -30.1 dB and -38.7 dB up to 15 GHz. Temporal measurement illustrates the THA operation for a 2 GHz sinusoid input signal sampled at 60 GHz.

Keywords— InP, DHBT, ADC, Amplifier, Switched Emitter Follower.

I. INTRODUCTION

For high bit rate communications, a wide bandwidth Analog to Digital Circuit (ADC) used as a decision circuit improves the receiver performances. Track&Hold Amplifier (THA) which is the main ADC block and whose function is to hold and to store an analog signal value during the hold mode operation, requires a wide bandwidth a good isolation and a sufficient resolution.

50 GSa/s THA [1,2] realized in SiGe and InP technologies using the Switched Emitter Follower (SEF) structure has been reported.

In this article we present a 60 GSa/s fully differential InP-DHBT THA. Experimental characterizations are performed in frequency and time domains. These results demonstrate a good obtained for a -4 dBm and + 4 dBm input signal respectively. S-parameter measurement gives a bandwidth of 50 GHz. Time domain measurements depict clean levels for 2 GHz-input signal sampled at 60 GHz.

II. CIRCUIT DESIGN

The THA presented in figure 1, consists of a Cherry-Hooper input buffer [2], a double differential pair clock buffer, a core using an enlarged SEF and a degenerated differential pair output buffer.

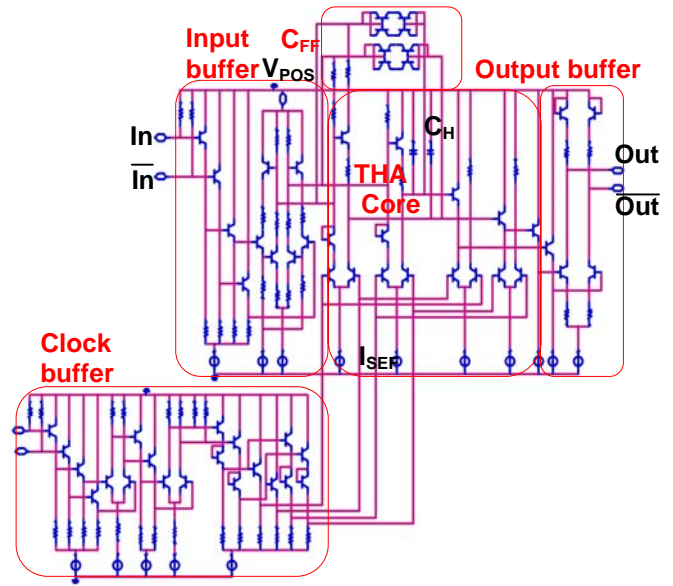


Fig. 1. Simplified schematic of the wide-bandwidth THA

A. A Large bandwidth SEF structure

A large bandwidth double stage SEF presented in [3] is used to design the THA core in order to improve the THA isolation. Indeed, the isolation is 20 dB better for the SEF with a second linearity up to 15 GHz, a THD of -38.7 dB and -30.1 dB are switch stage. To reduce the feedthrough, a pseudo-capacitance C_{FF} (Fig. 1) is used in order to cancel the off-state base-emitter transistor capacitance [4].

B. Clock buffer

A low jitter clock is obtained using a buffer realized with high current transistors. The high frequency clock driving the SEFs is realized by a double stage buffer. A biased voltage reference "Ref" permits to characterize the THA in track or in hold mode in addition to the sampled mode.

C. Technology & Realization

The in house InP-DHBT technology [5] was used to realize the THA. This 0.7 μm emitter width technology has a 2.5 $\text{mA}/\mu\text{m}^2$ current density. Frequency performances are 320 GHz and 380 GHz respectively for f_T and f_{max} . A 4.5 V

breakdown voltage is obtained thanks to the double heterojunction structure.

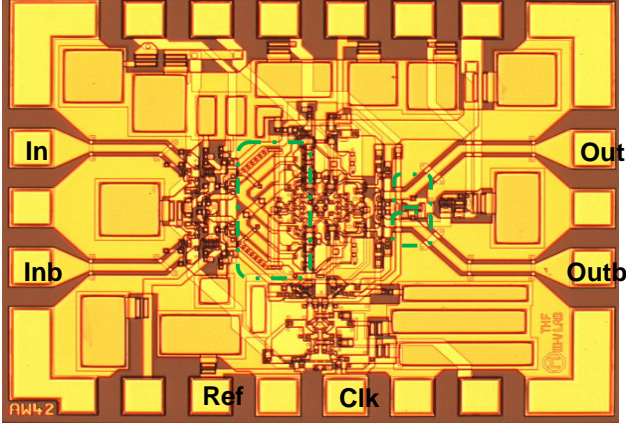


Fig. 2. Microphotograph of the circuit

The THA shown in figure 2 has $1.5 \times 1.2 \text{ mm}^2$ chip size. The influence of the lines and the circuits decoupling has been taken into account.

III. EXPERIMENTAL SETUP AND RESULTS

A 65 GHz-vector network analyzer, a 50 GHz spectrum analyzer, low noise frequency synthesizers and 80 GSa/s oscilloscope are used to experimentally characterize the THA performances. To obtain the intrinsic THA performances all the additional elements has been measured. Spectral measurements are performed in a track&hold mode operation at 60 GSa/s.

A. Small signal bandwidth

65-GHz small signal characterization was done in a track-mode (Fig. 3). We obtained a 50 GHz small signal bandwidth of 50 GHz. The circuit has a -7.6 dB gain.

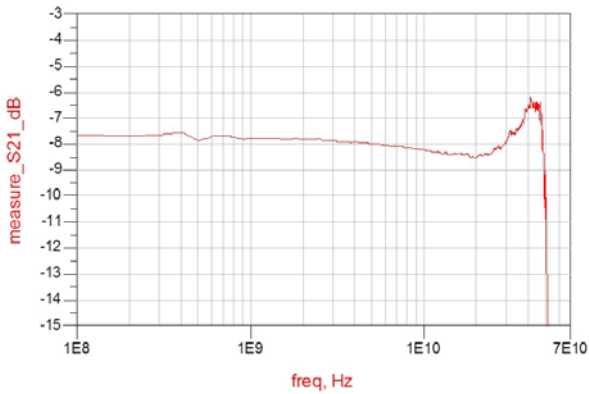


Fig. 3. Measured single-ended track-mode bandwidth

A inductive peaking due to particular lines (shown in Fig. 2) allows a bandwidth increase.

B. Spectral measurements

Spectral measurements were done at 60 GSa/s for + 4 and -4 dBm single-ended input powers. Figure 4 shows the measured spectrum for a 18,2 GHz input signal sampled at 60 GHz. The markers point in increasing order, the fundamental, the image frequency of harmonics H2 and H3 due to the 60 GHz sampling frequency and the harmonic H2. The unnumbered spectral line at 41.8 GHz is the image frequency of the fundamental. The SFDR is 28.3 dB and due to harmonic H2.

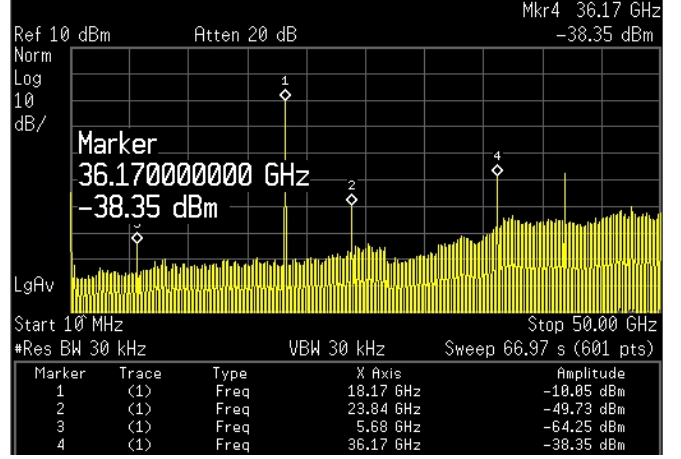


Fig. 4. Measured spectrum: Pin = +4 dBm at Fin= 18.2 GHz, Fclk=60GSa/s

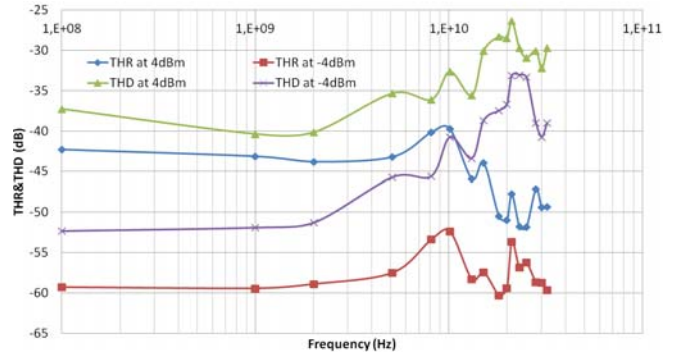


Fig. 5. Measured THD and THR at 60 GSa/s

Total Harmonics Distortion and Third Harmonics Rejection measured for +4 and -4 dBm single-ended input powers are shown in Fig. 5. For -4 dBm, the THR is -57.5 dB and -52.3 dB up 2 GHz and 30 GHz respectively. The THD is lower than -51.3 dB, -38.7 dB and -33 dB up to 2 GHz, 15 GHz and 25 GHz respectively. These THD are equals to 8.2, 6.1 and 5.2 effective bits respectively. For a +4 dBm input signal, the THD is lower than -37.3 dB and -30.1 dB up 2 GHz and 15 GHz respectively. This gives 5.8 and 4.7 ENOB respectively. Table I gives a performances comparison of high speed THA reported in literature.

TABLE I PERFORMANCES SUMMARY OF HIGH SPEED THA REPORTED IN LITERATURE

Ref	Fs (GHz)	Fin (GHz)	Input/Output Dynamic at Fin (mVpp)	Spectral Input (mVpp)	BW (GHz)	THD [Low Freq](dB)	THD [High Freq](dB)	Enob Low/High (bit)	Die-size (mm ²)	Supply (V)	Power (W)	Process / f _T (GHz)
1*	40	2	1000/700	500	27	50* [1 GHz]	37* [10 GHz]	8. /5.9	2.24	-6	1.9	InP / 210
1*	50	5	1000/625	400	>40* >50**	56.3* [3 GHz]	36.5* [25 GHz]	9. /5.8*	1.8	-6.2	1.85	InP / 300
1	40	6	1000/50	1000	16	50.5 [2 GHz at 12 GS]	32.4 [10 GHz at 40 GS]	8.1/5.1	1.8	5.5	0.56	SiGe / 200
2	50		630/290	630	42		35.1 [40 GHz at 40 GS]	5.5	1.47	4	0.64	SiGe 0.18μm
This work	60	5	1000/625	400	>50**	51.3 [2 GHz]	33 [25 GHz]	8.2 /5.2	1.8	-6.2	1.85	InP / 300

* track mode measurements ** S-parameter measurement

C. Transient characterization

The THA operation is demonstrated in figure 6 for a 400 mVpp-single-ended 2 GHz sinusoid input sampled at 60 GHz.

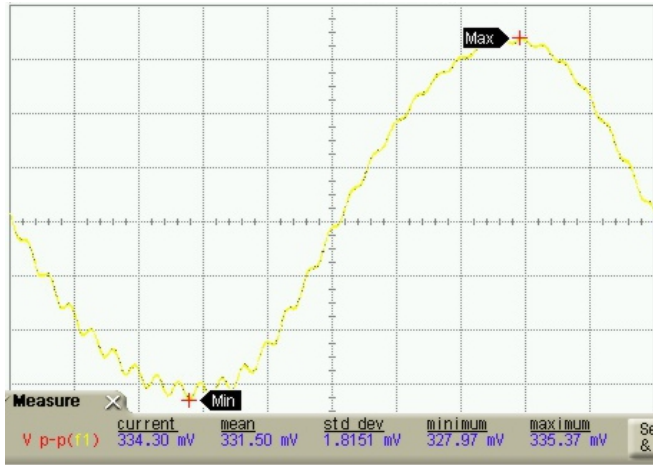


Fig.6. Differential output of a 2 GHz input sinusoid sampled at 60 GHz (50 mV/div, 50ps/div)

IV. CONCLUSION

The circuit has been characterized in small and large signal with S parameters, spectrum and transient

measurement. The THA realized in InP DHBT technology presents a 50 GHz small signal bandwidth and operates up to 60 GSa/s. Peaking effects are optimized and exploited to enlarge the bandwidth. Clean levels are obtained at 60 GSa/s. The THA presents a good linearity THR and THD lower than -38.7 and -52.3 dB were obtained up to 15 GHz for -4dbm single-ended input power.

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