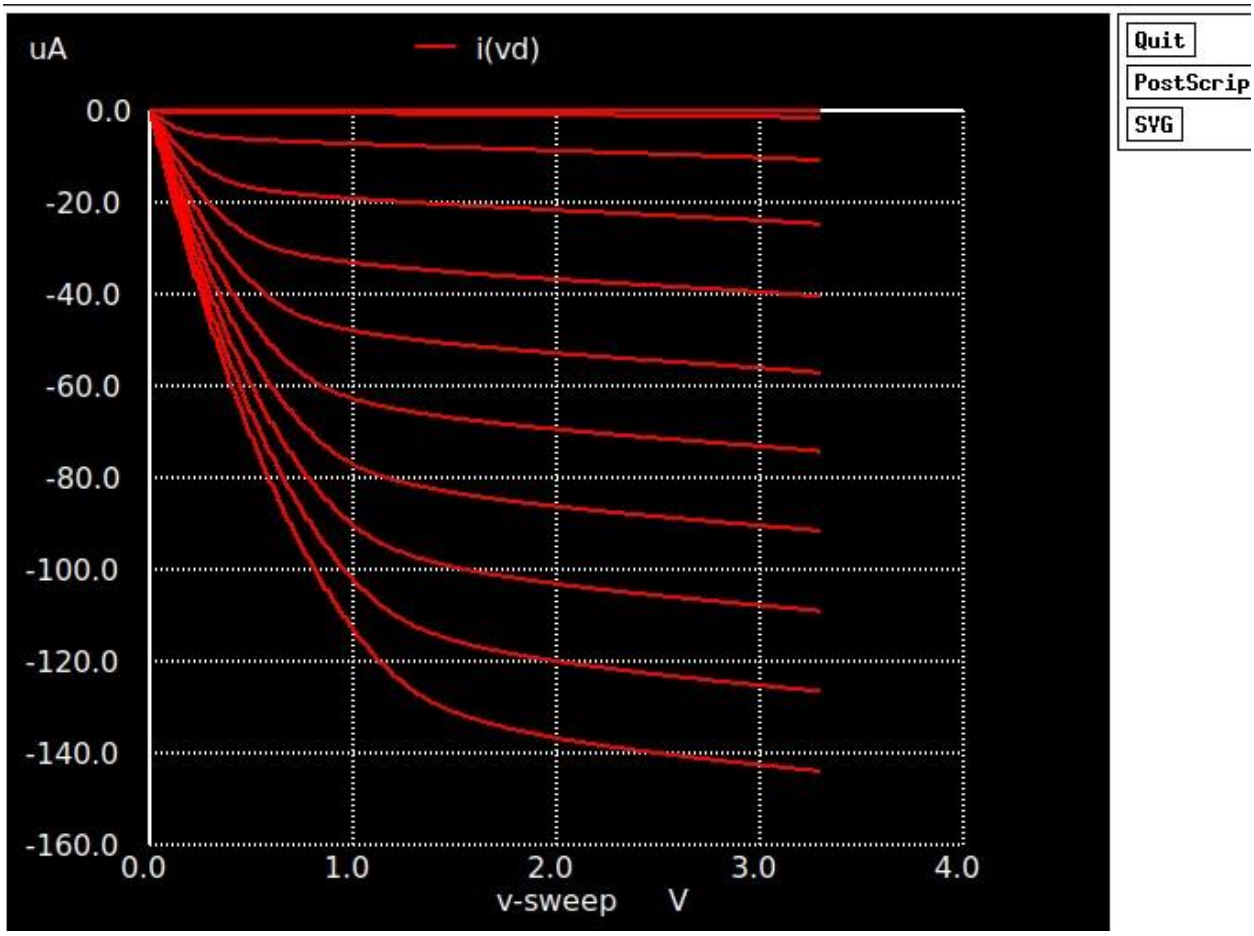
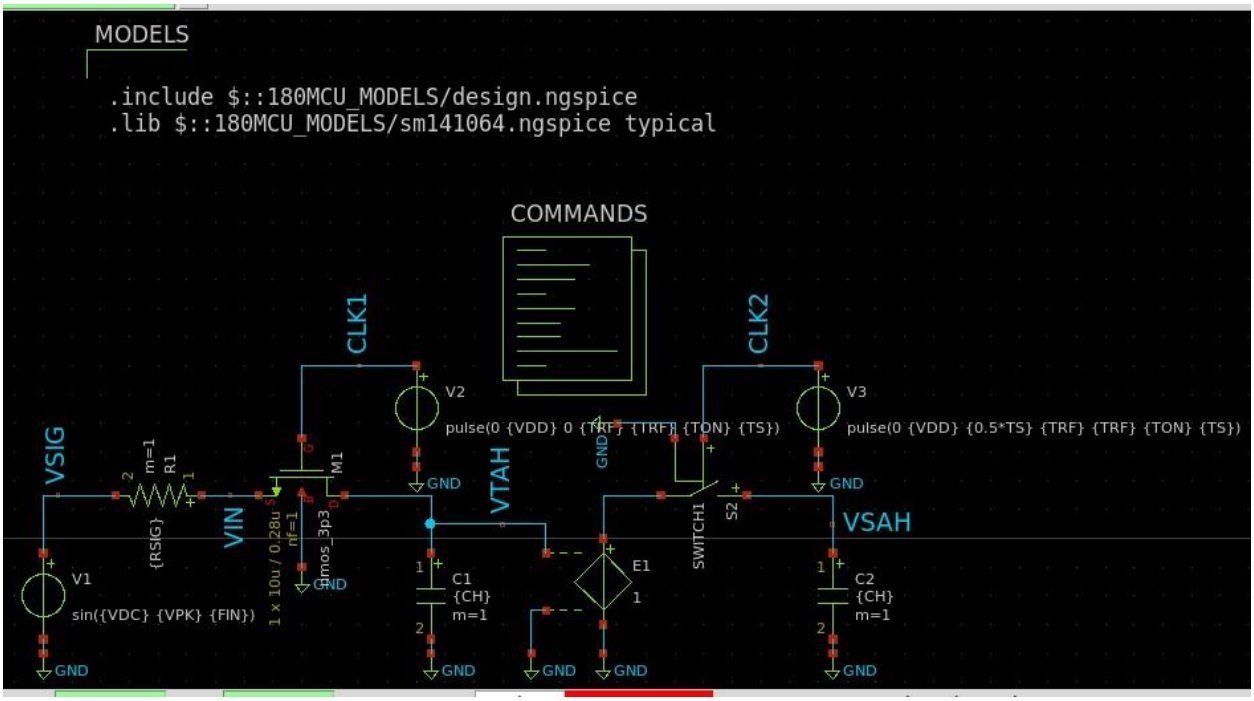
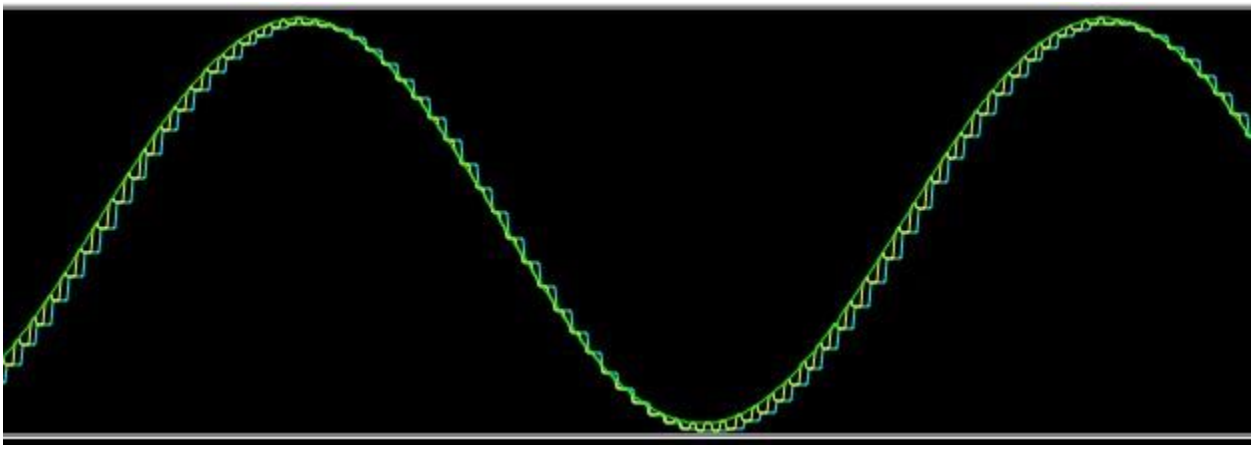
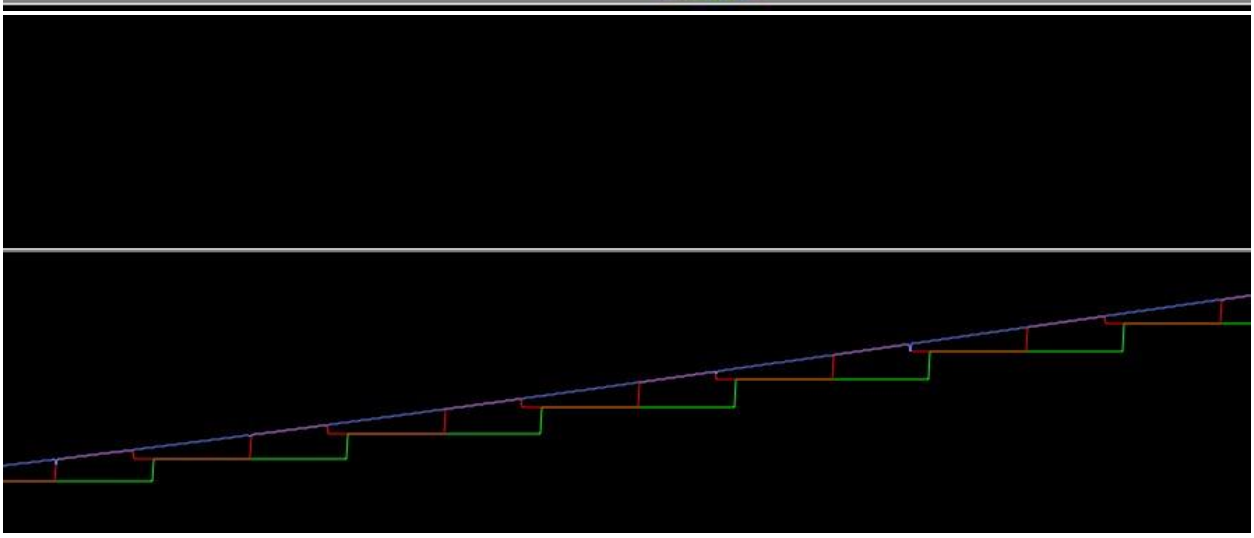
Lab 3

Part 1 (prelab)

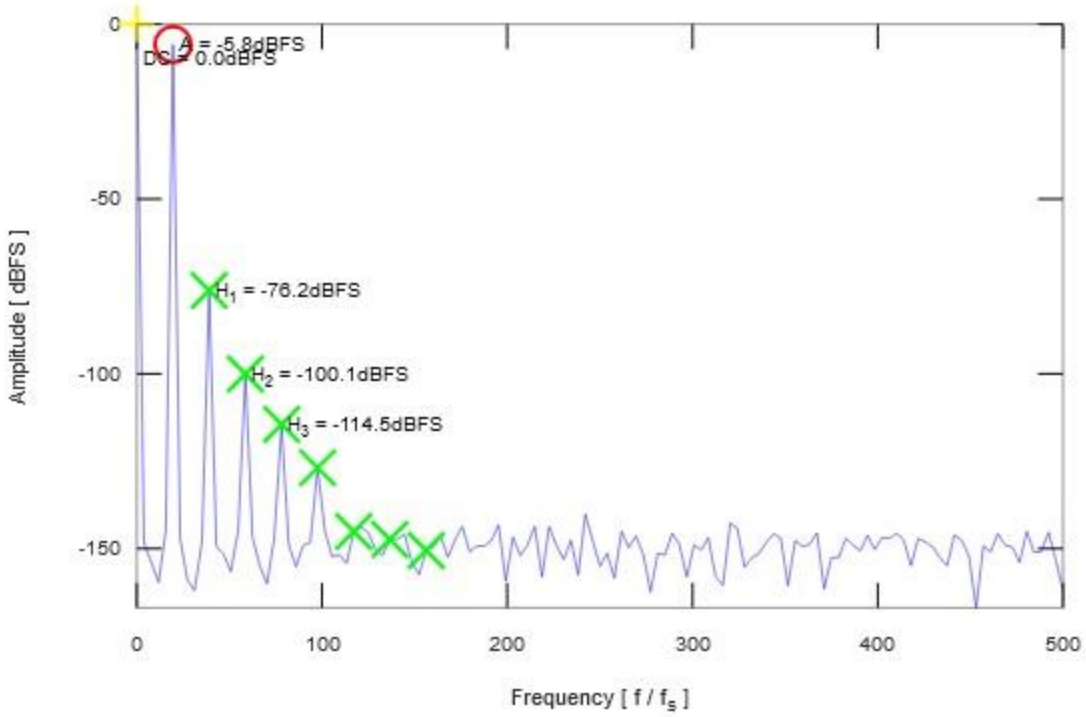



MODELS
.include $::180MCU_MODELS/design.ngspice
.lib $::180MCU_MODELS/sm141064.ngspice typical
COMMANDS
CLK1
CLK2
V2
V3
pulse(0 {VDD} 0 {TRF} {TRF} {TON} {TS})
pulse(0 {VDD} {0.5*TS} {TRF} {TRF} {TON} {TS})
VSIG
R1
m=1
{RSIG}
M1
VIN
nmos_3p3
nf=1
1 x 10u / 0.28u
VTAH
VSAH
SWITCH1
S2
V1
sin({VDC} {VPK} {FIN})
C1
{CH}
m=1
C2
{CH}
m=1
E1
GND

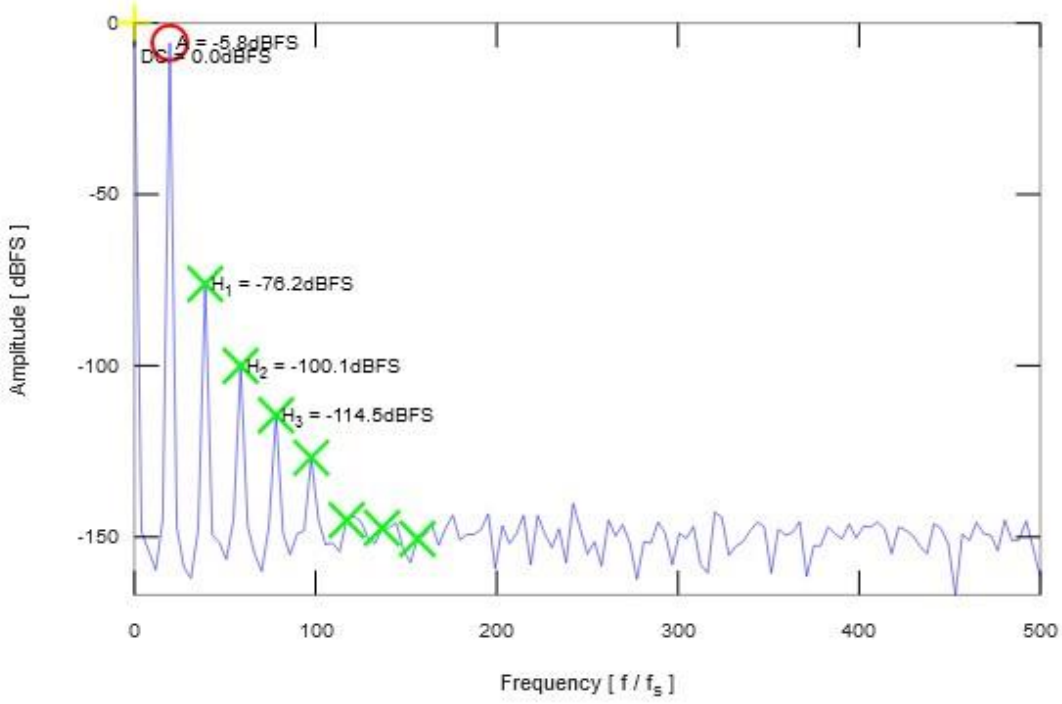




ENOB = 11.4-bit SNR = 121.8dB THD = -70.4dB SNDR =70.4dB SFDR = 70.4dB NoiseFl



N = 256 NoiseFloor = -148.5dB



	Lab3	Lab2
ENOB	11.4 bit	20.4 bit
SINAD	70.4 db	124.4 db
SNR	121.8 db	124.8 db
SFDR	70.4 db	139.5 db
THD	-70.4 db	-136.2 db
SIGNAL POWER	-8.85 db	-9 db
DC POWER	0 db	0db
Highest harmonic	Second harmonic (H1)	Fourth harmonic (H3) but with weak effect

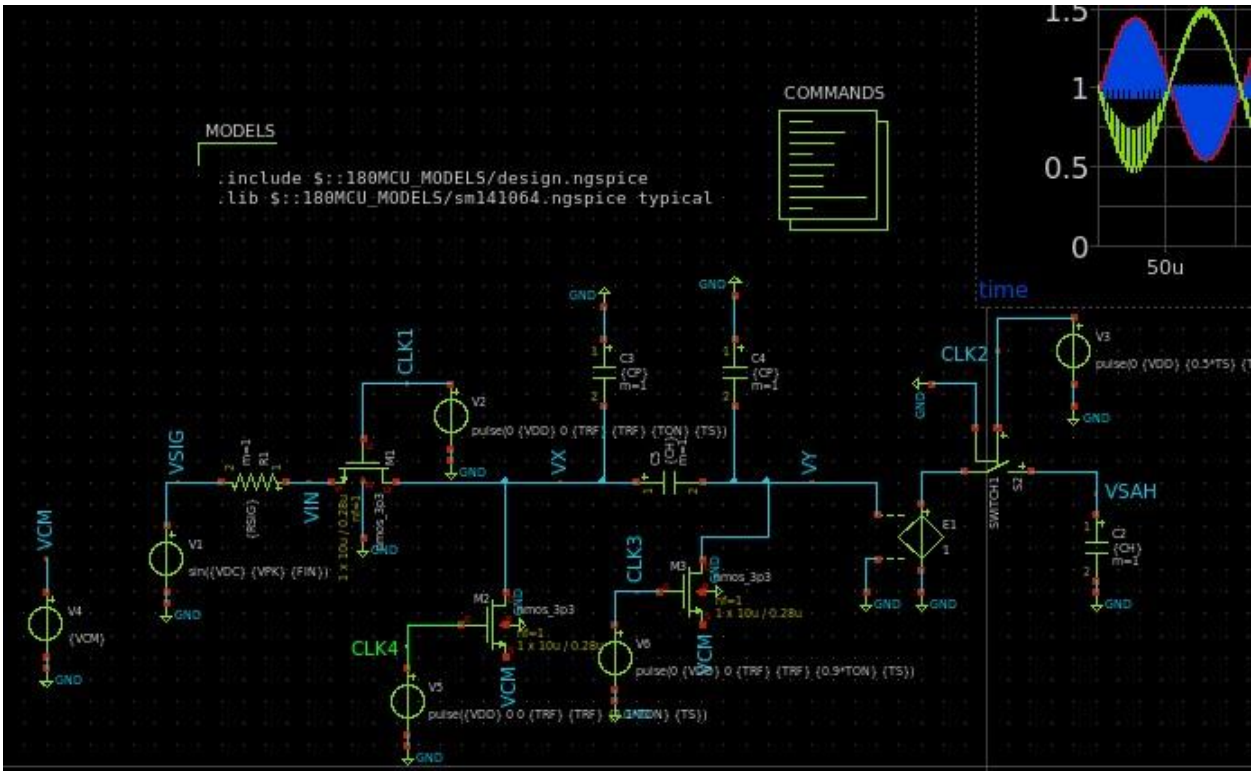
From the result we observe that replacing an ideal switch with Nmos increased the harmonic effect in frequency domain .

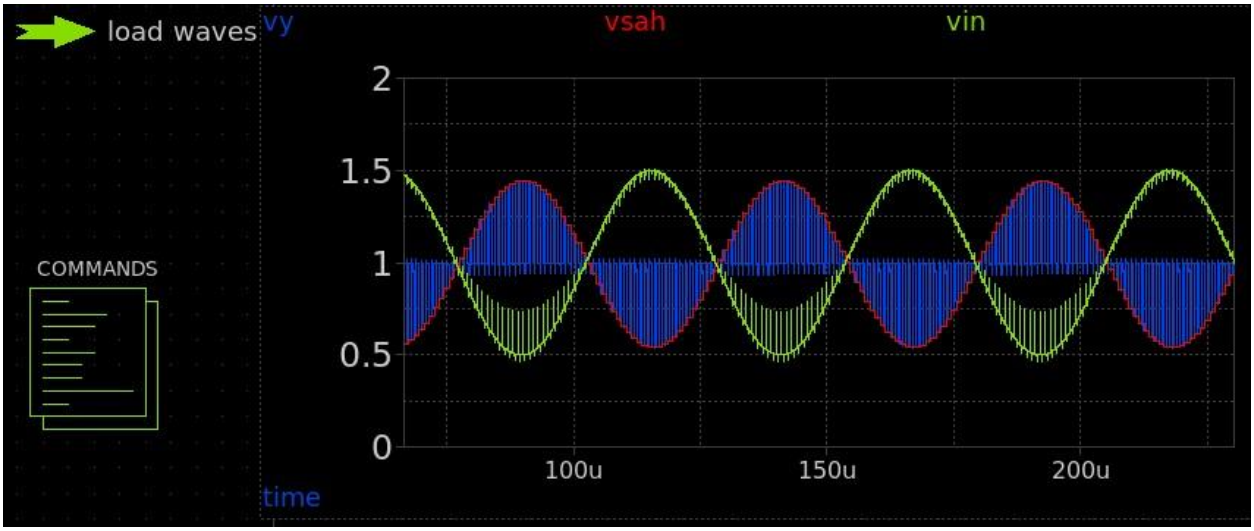
Second harmonic has large power decreasing noise floor .

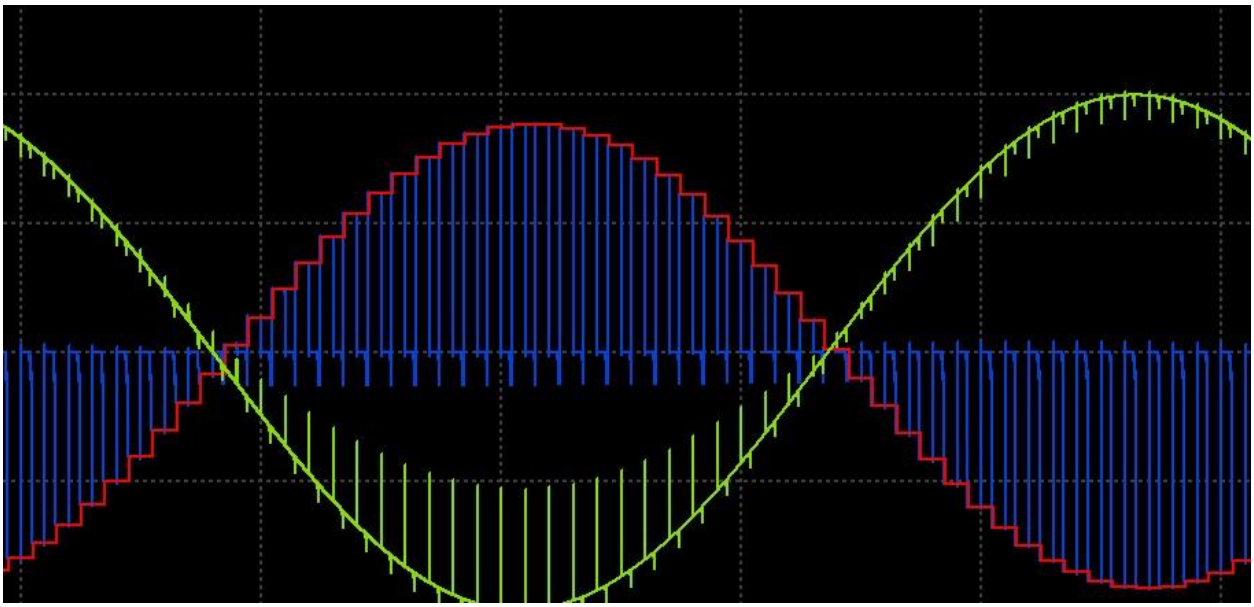
This observable harmonic effect leads to decreasing SNR , SNDR THD SFDR and the effective number of bits .

Replacing an ideal switch with a practical NMOS transistor introduces signal-dependent resistance, parasitic capacitances, charge injection, and body effect, all of which contribute to nonlinear distortion. These effects are asymmetric, which enhances even-order harmonics, particularly the second harmonic

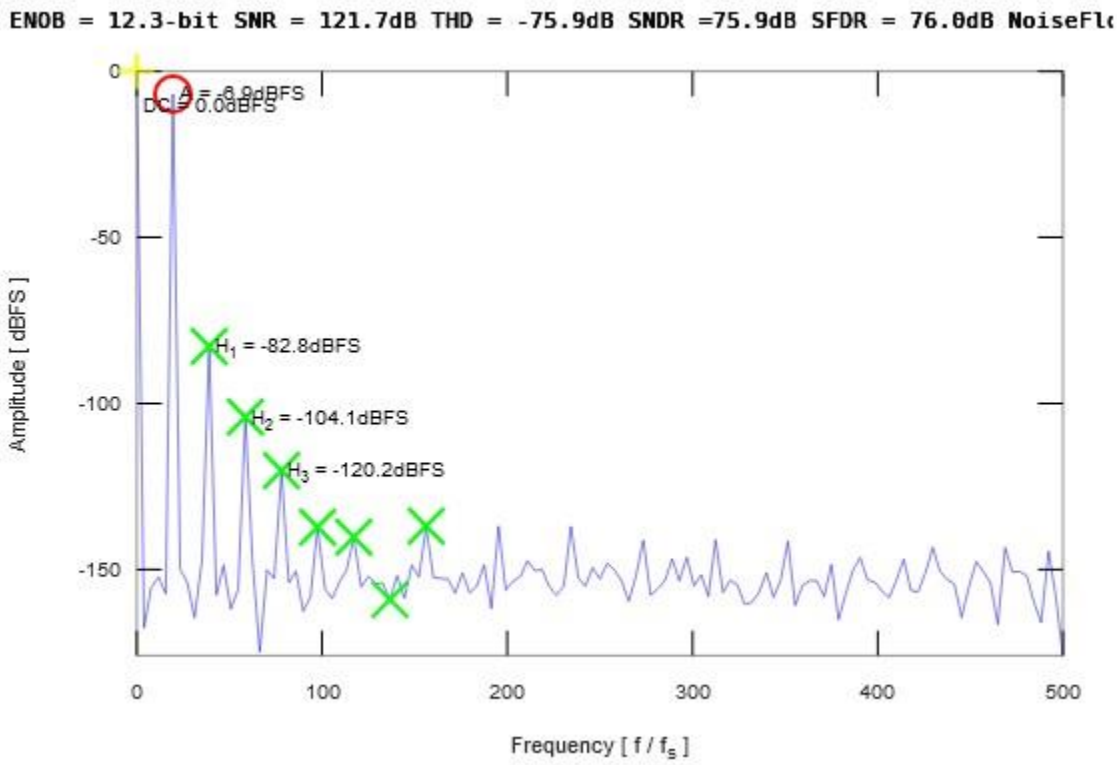
PART 2


MODELS
.include $::180MCU_MODELS/design.ngspice
.lib $::180MCU_MODELS/sm141064.ngspice typical
COMMANDS
time
CLK1
CLK2
CLK3
CLK4
VSIG
VIN
VX
VY
VCM
VSAH
GND


load waves
vy
vsah
vin
COMMANDS
time
2
1.5
1
0.5
0
100u
150u
200u



FFT:



N = 256 NoiseFloor = -149.4dB

	Part 1	Part 2
ENOB	11.4 bit	12.3 bit
SINAD	70.4 db	75.9 db
SNR	121.8 db	121.7 db
SFDR	70.4 db	76 db
THD	-70.4 db	-75.9 db
SIGNAL POWER	-8.85 db (-5.8db rms)	-13.8 db (-6.9db rms)
DC POWER	0 db	0db
Highest harmonic	Second harmonic (H1)	Second harmonic (H1)

from the plot we can see that bottom plate sampling enhance SFDR and SNDR due to decreasing the effect of harmonic distortion

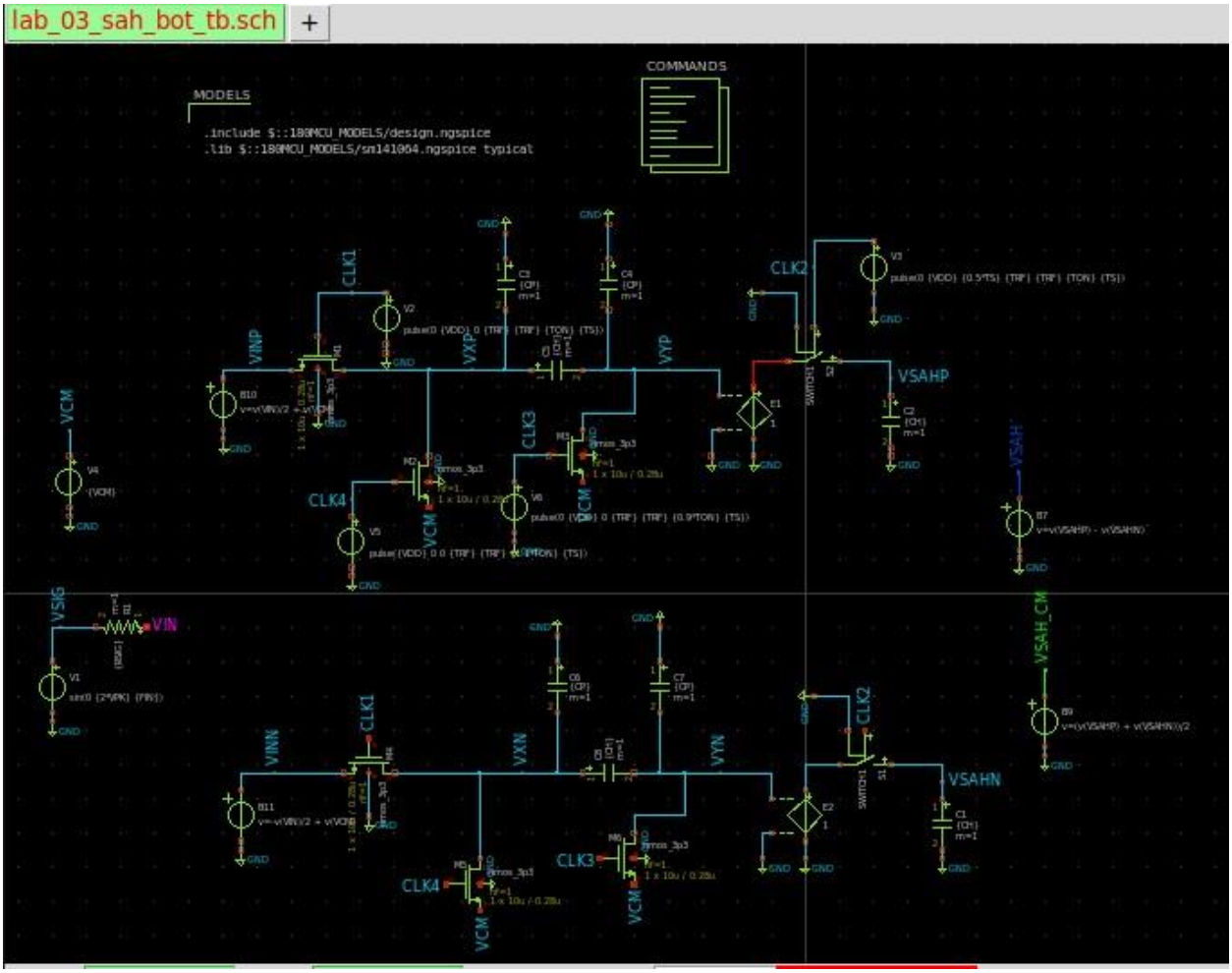
SNR is nearly the same as the harmonics doesn't affect it

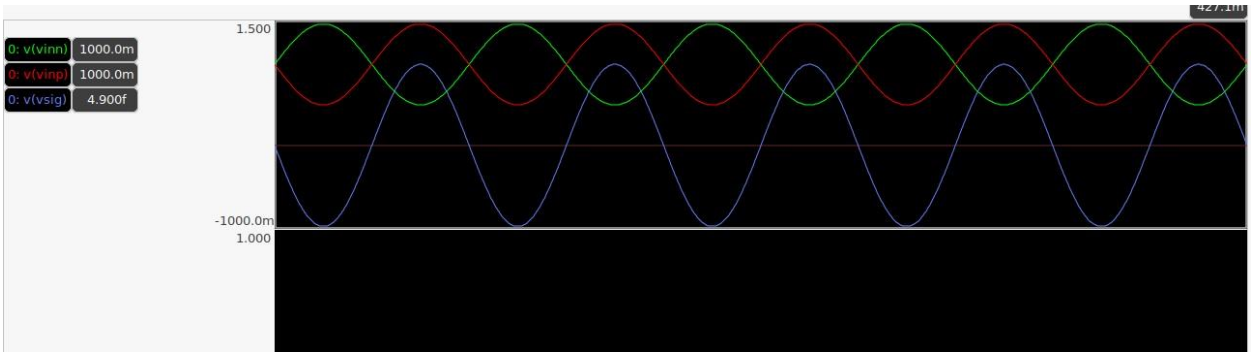
Signal power is affected with the bottom plate parasitic capacitance

The effective number of bits increased .

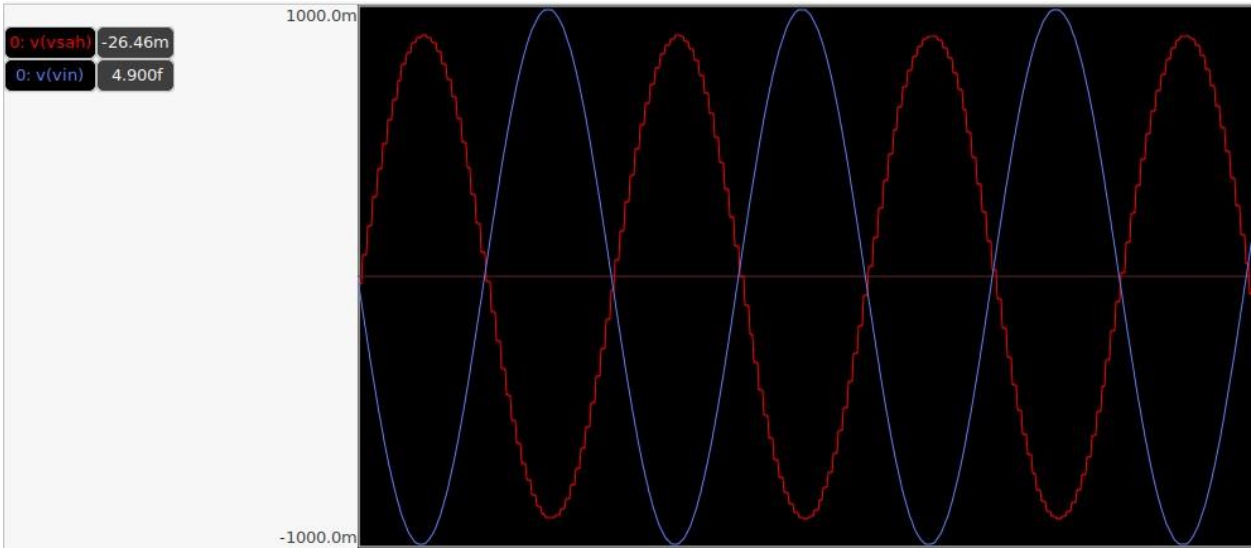
A practical NMOS transistor introduces signal-dependent resistance, parasitic capacitances, charge injection, and body effect, all of which contribute to nonlinear distortion. These effects are asymmetric, which enhances even-order harmonics, particularly the second harmonic

Part 3:


lab_03_sah_bot_tb.sch
+
COMMANDS
MODELS
.include $::180MCU_MODELS/design.ngspice
.lib $::180MCU_MODELS/sm141064.ngspice typical
CLK1
CLK2
CLK3
CLK4
VINP
VXP
VYP
VSAHP
VCM
VSIG
VIN
VINN
VXN
VYN
VSAHN
VSAH_CM


0: v(vinn) 1000.0m
0: v(vinp) 1000.0m
0: v(vsig) 4.900f
1.500
-1000.0m
1.000

Differential output

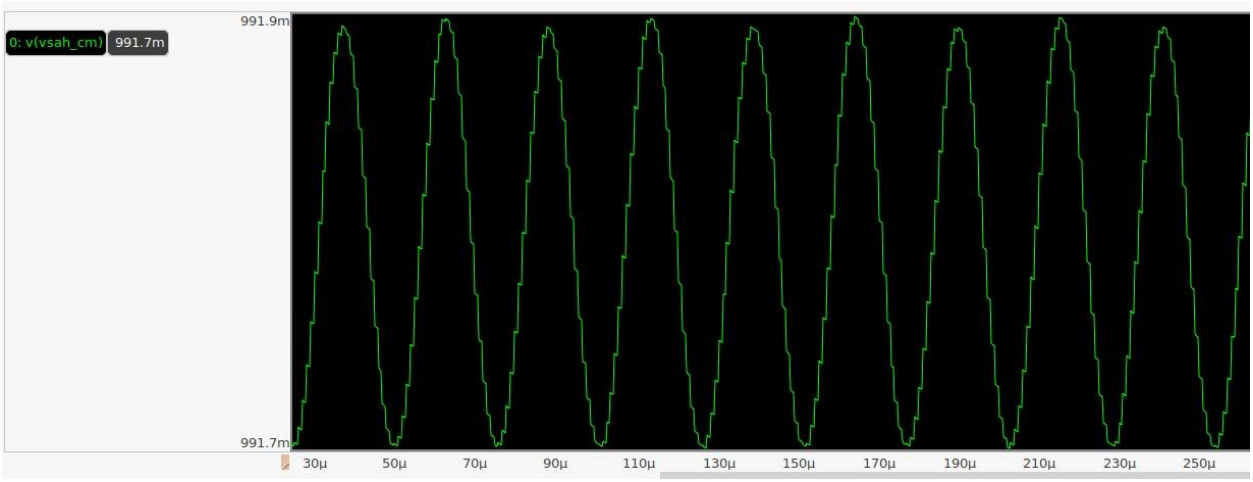


Comment:

Remains equal to the input peak-to-peak differential voltage but inverted.

Less distortion compared to a single-ended design and rejects even harmonics

Common mode waveform:

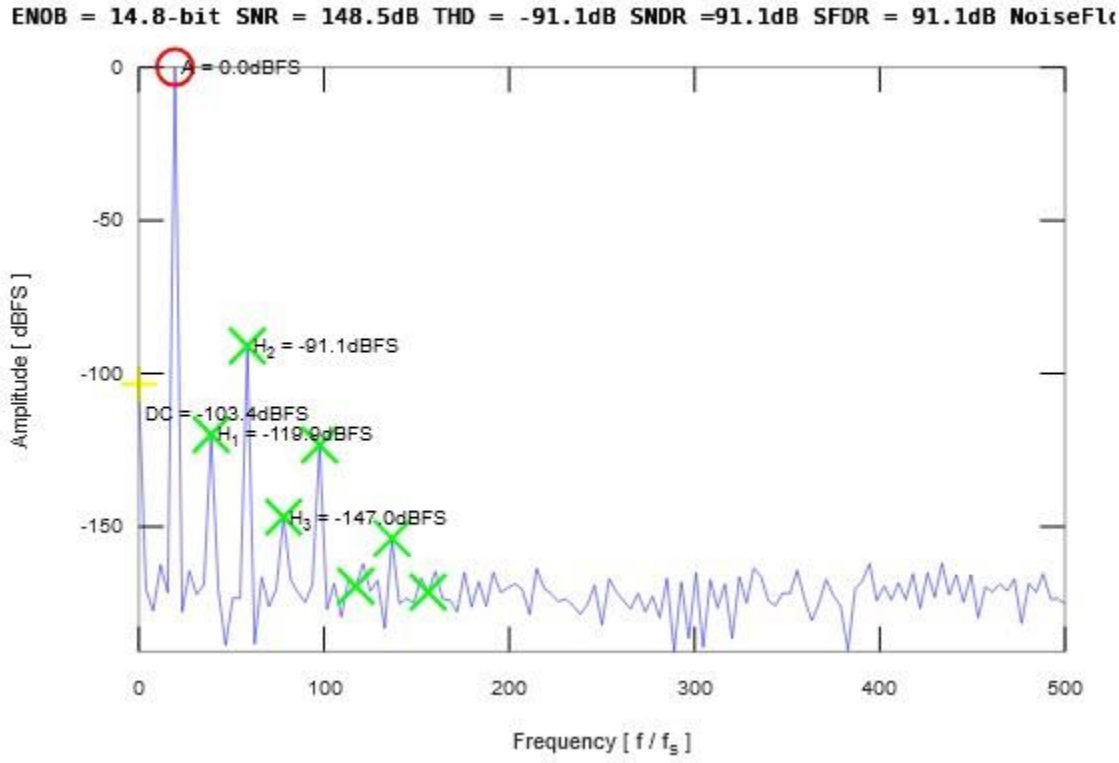


Comment :

Ideally constant but may exhibit small ripples due to mismatches.

Should be well-controlled to ensure minimal interference with the differential signal.

FFT:



N = 256 NoiseFloor = -170.1dB

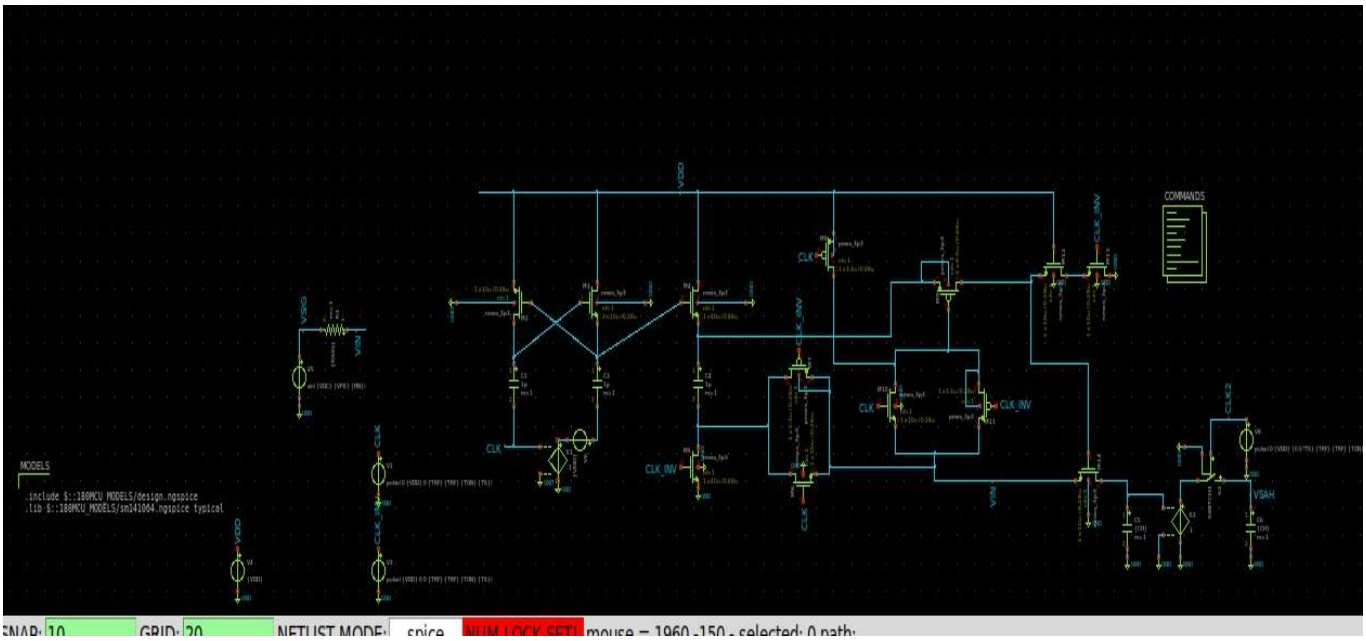
	Part 3	Part 2
ENOB	14.8 bit	12.3 bit
SINAD	91.1 db	75.9 db
SNR	148.5 db	121.7 db
SFDR	91.1 db	76 db
THD	-91.1 db	-75.9 db
SIGNAL POWER	0 db	-9.8 db (-6.9db rms)
DC POWER	0 db	0db
Highest harmonic	Third harmonic (H2)	Second harmonic (H1)

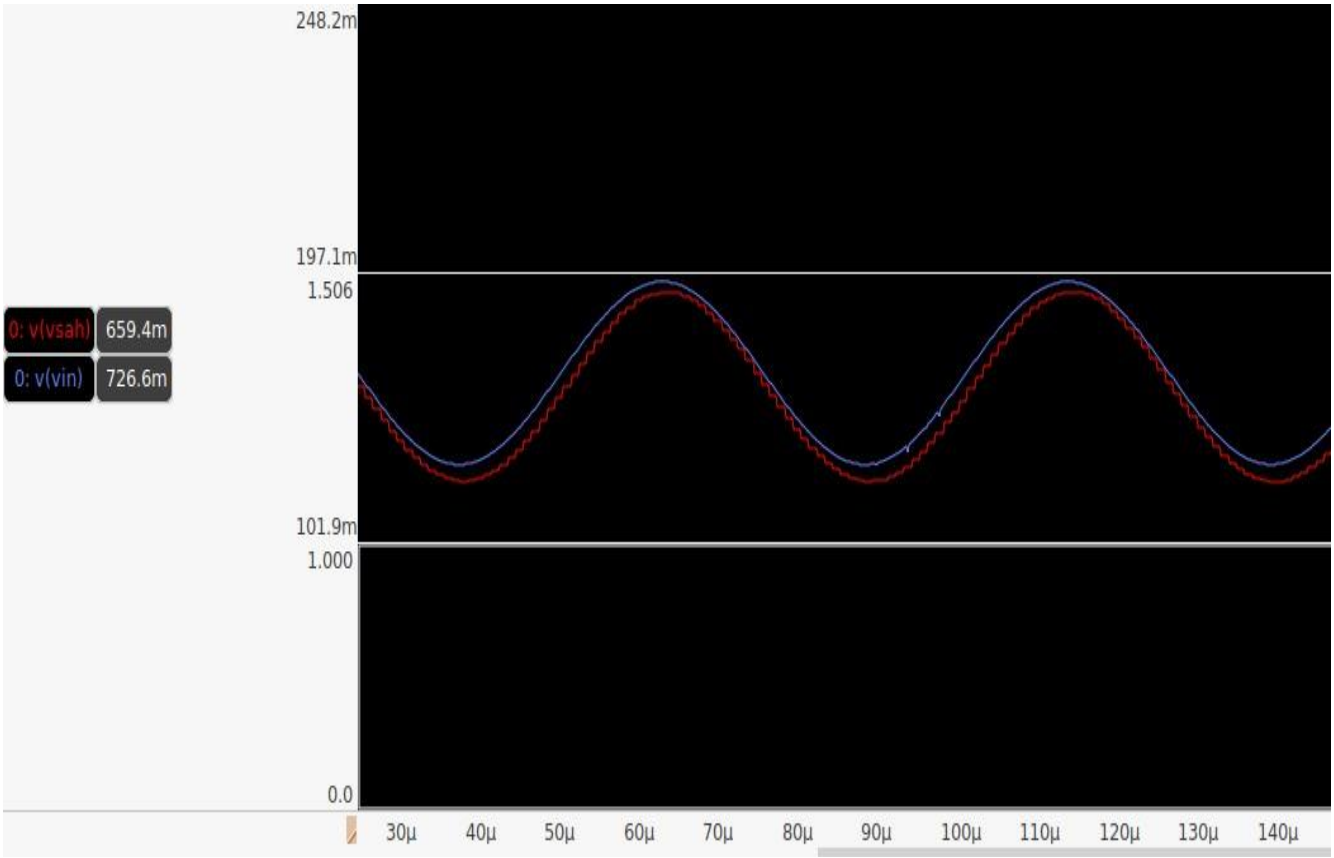
We can notice that using fully differential circuit enhanced both the SNR and SNDR as it helps in canceling even-order distortions, improving linearity, and reducing supply noise sensitivity.

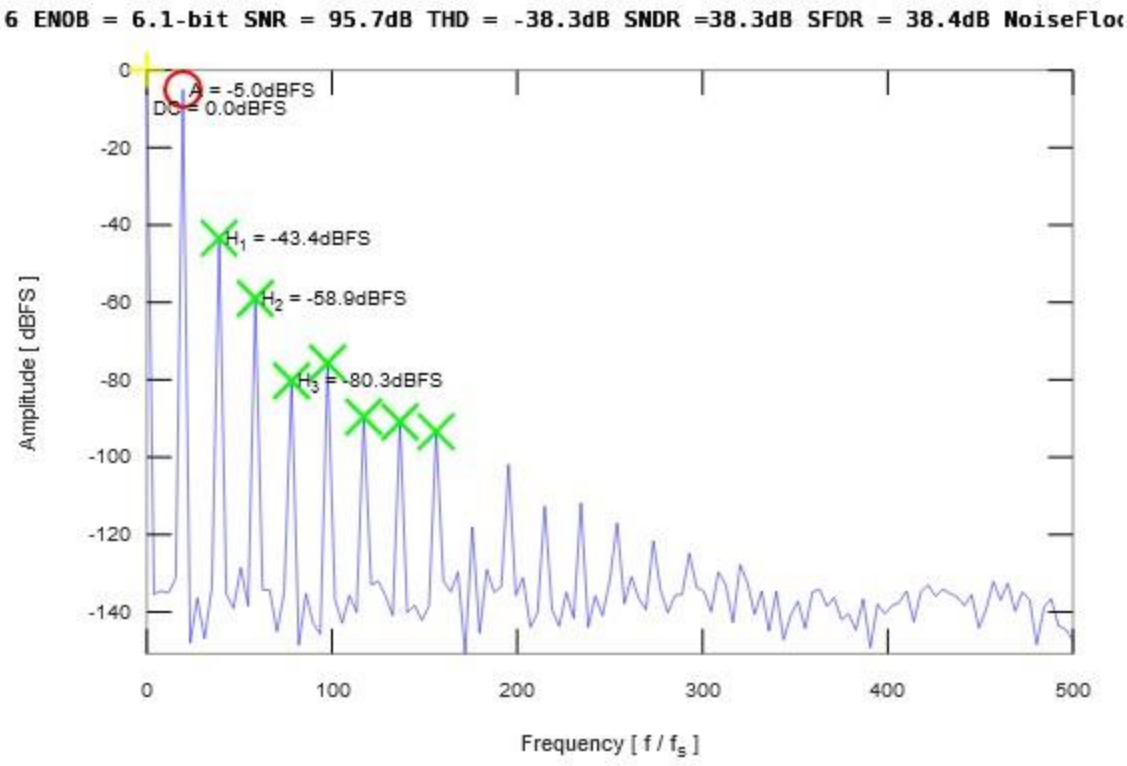
The rejection of even harmonics enhanced SFDR and now the third harmonic has the most peak .

The effective number of bits and signal power increased .

Bootstrabing circuit







We notice that the effective number of bits is low compared to the last parts and the harmonic distortion is highly observed .