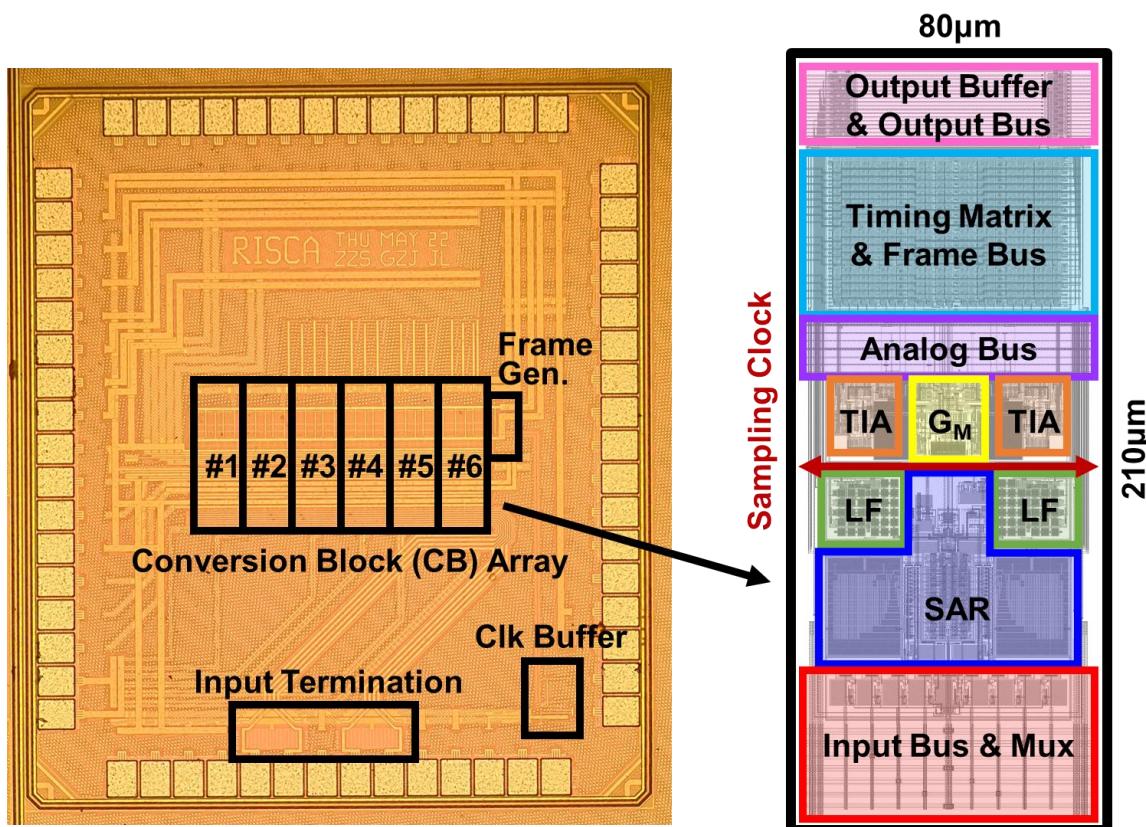


# Programmable A/D Converter Array

## Mode Cases and Configurations

Flexible ADC Architectures in One Chip



Zhishuai Zhang, Nan Sun, Lu Jie  
Tsinghua University

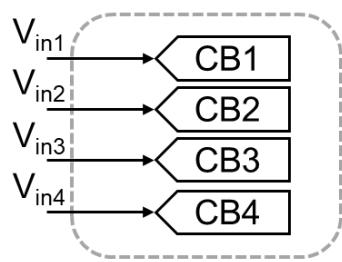
# Motivation



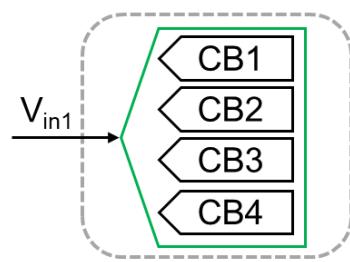
Mode	Baseband BW(MHz)
GSM	0.2
CDMA	<5
LTE	1.4~20
5G	5~100
Wi-Fi 5	20, 40
Wi-Fi 6	20, 40, 80, 160



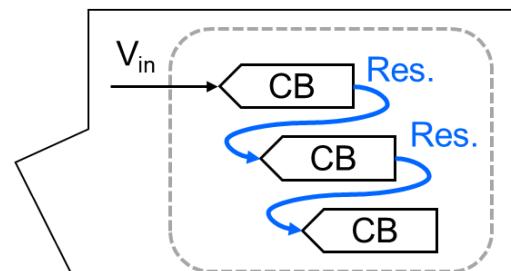
# Concept



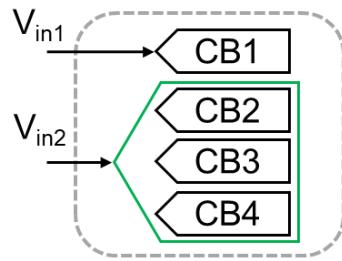
Multitasking



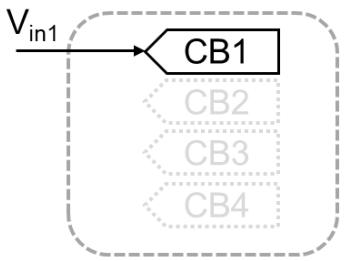
Aggregating for high performance



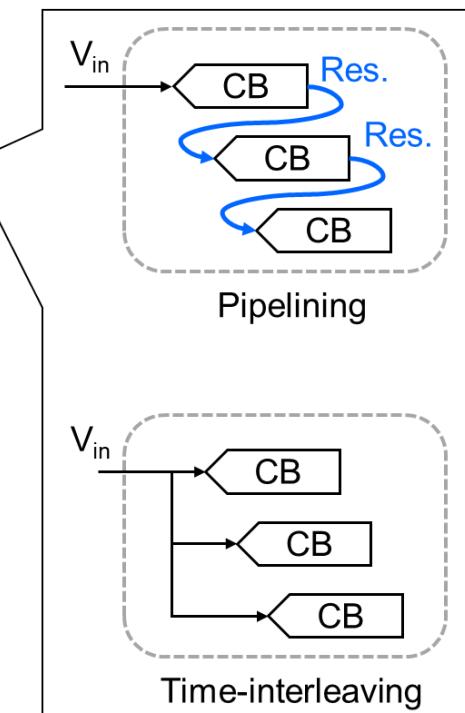
Pipelining



Mixed tasks

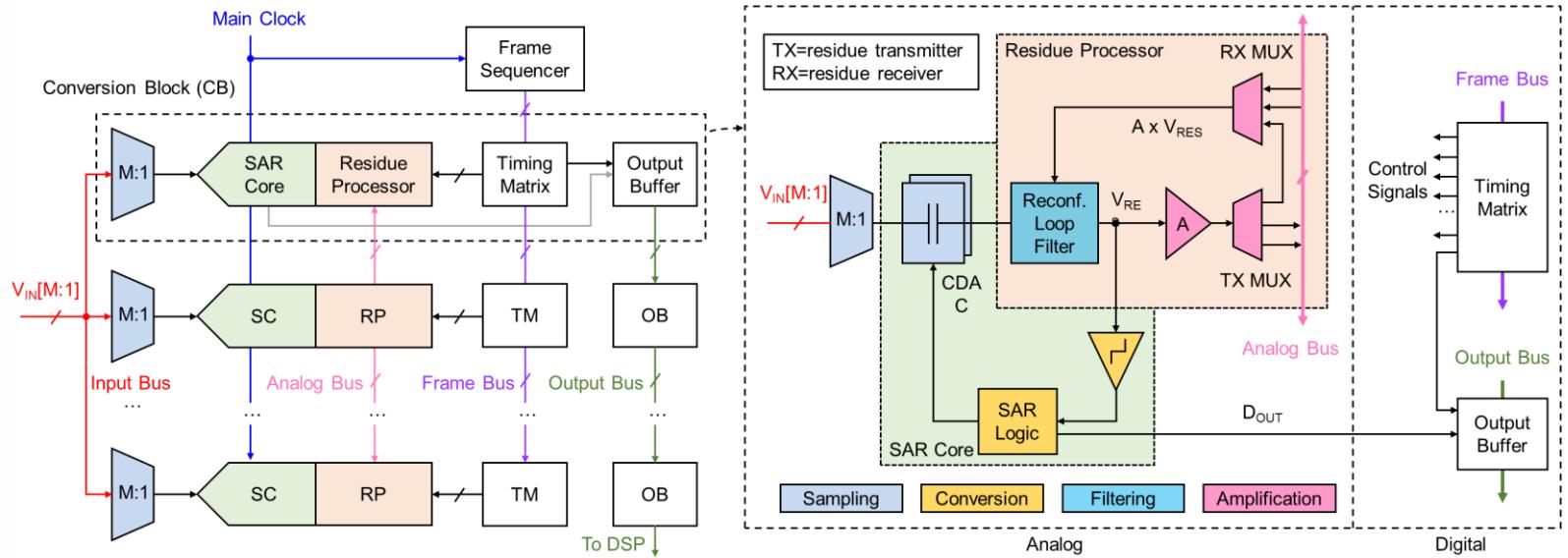


Partial hibernation for power saving

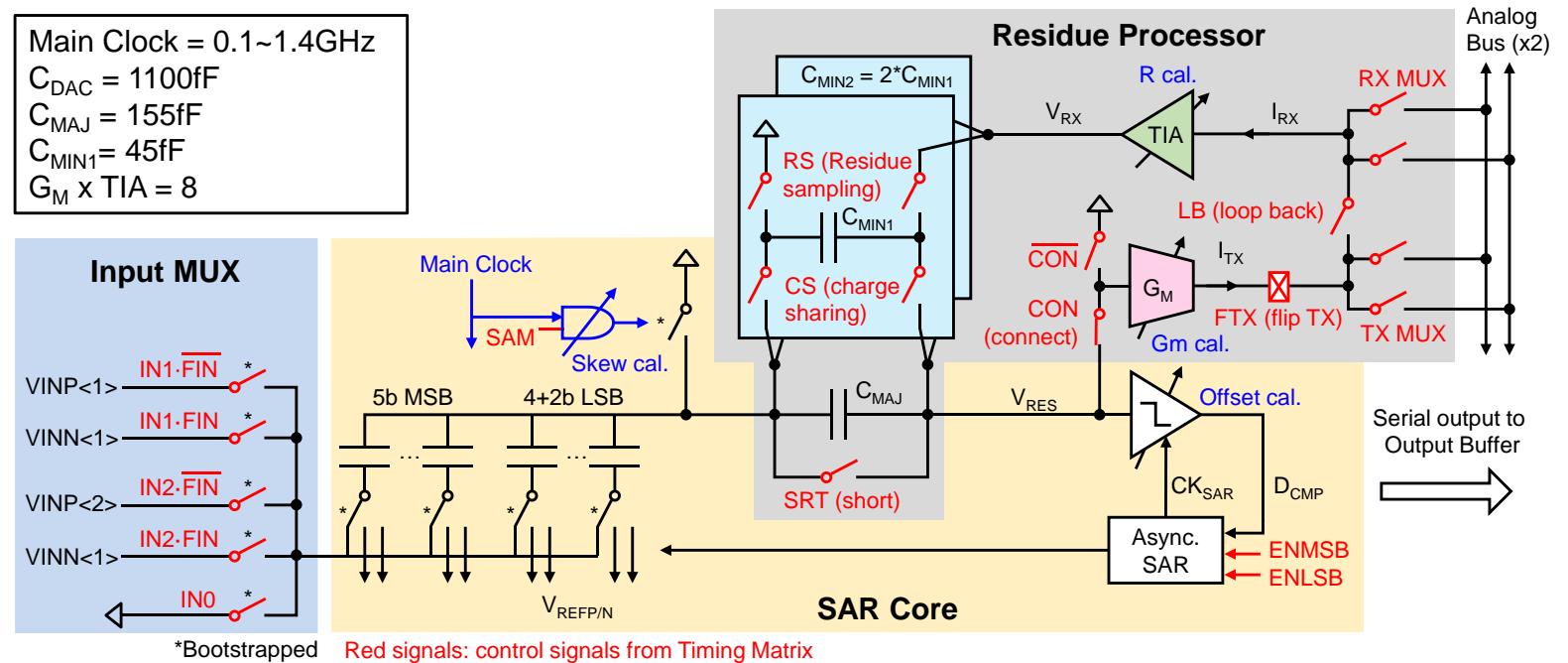


Time-interleaving

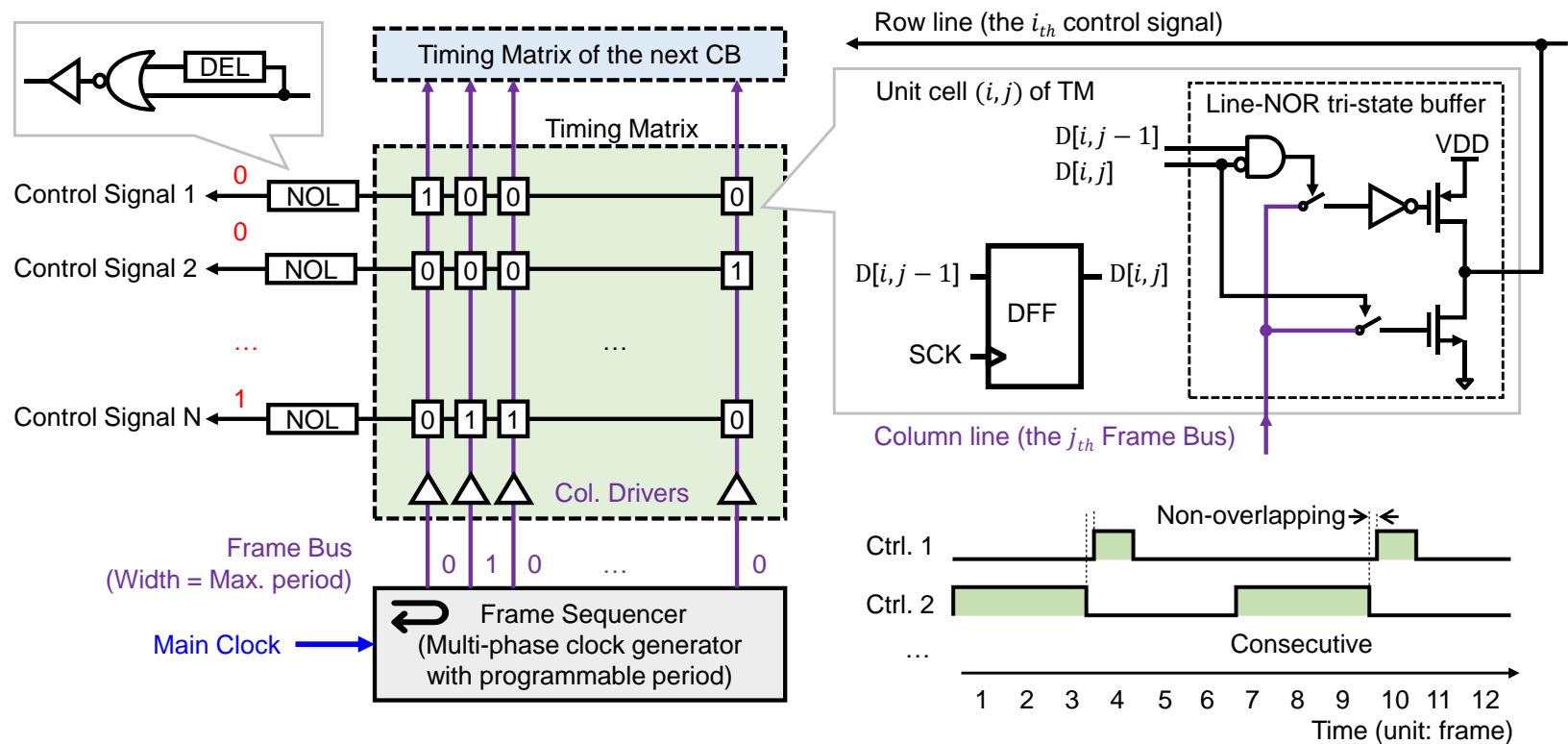
# Architecture



## Conversion Block (CB) Implementation

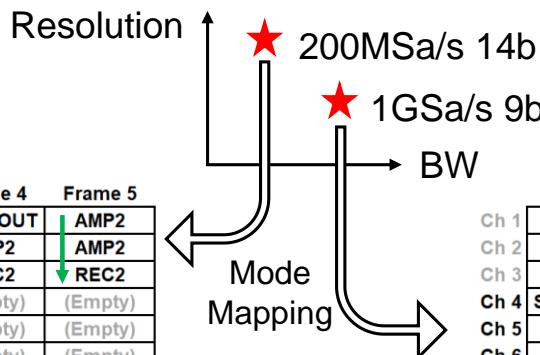


# Timing Matrix Implementation



# Workflow of PCA compilation

**Spec:**



**Timing Table:**

	Frame 1	Frame 2	Frame 3	Frame 4	Frame 5
Ch 1	SAM1	MSB	LSB	AMP2/OUT	AMP2
Ch 2	SAM1/OUT	MSB	LSB	AMP2	AMP2
Ch 3	MSB	LSB	OUT	REC2	REC2
Ch 4	(Empty)	(Empty)	(Empty)	(Empty)	(Empty)
Ch 5	(Empty)	(Empty)	(Empty)	(Empty)	(Empty)
Ch 6	(Empty)	(Empty)	(Empty)	(Empty)	(Empty)

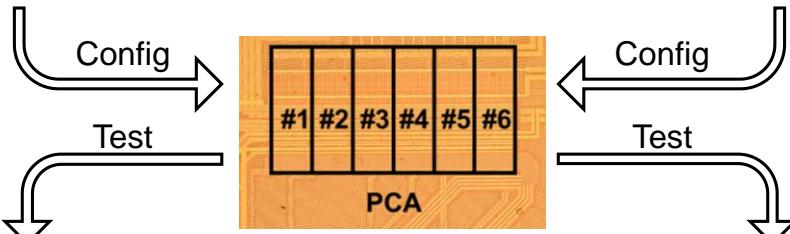
	Frame 1	Frame 2	Frame 3
Ch 1	(Empty)	(Empty)	(Empty)
Ch 2	(Empty)	(Empty)	(Empty)
Ch 3	(Empty)	(Empty)	(Empty)
Ch 4	SAM2/OUT	MSB	LSB
Ch 5	LSB	SAM2/OUT	MSB
Ch 6	MSB	LSB	SAM2/OUT

**Timing Matrices:**

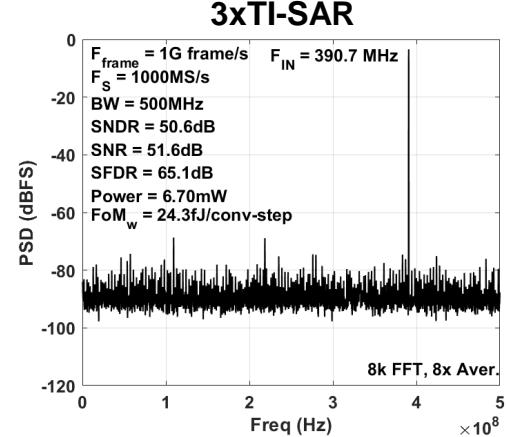
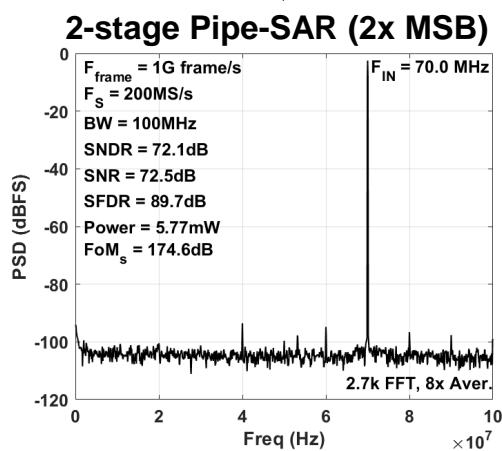
	Ch 1	Ch 2	Ch 3
OUT	0 0 0 1 0 0 0	OUT 1 0 0 0 0 0 0	OUT 0 0 1 0 0 0 0
SAM	1 0 0 0 0 0 0	SAM 1 0 0 0 0 0 0	SAM 0 0 0 1 1 0 0
MI0	0 0 0 0 0 0 0	MI0 0 0 0 0 0 0 0	MI0 0 0 0 1 1 0 0
MI1	1 0 0 0 0 0 0	MI1 1 0 0 0 0 0 0	MI1 0 0 0 0 0 0 0
MI2	0 0 0 0 0 0 0	MI2 0 0 0 0 0 0 0	MI2 0 0 0 0 0 0 0
MSB	0 1 0 0 0 0 ... 0	MSB 0 1 0 0 0 0 ... 0	MSB 0 0 1 0 0 0 ... 0
LSB	0 0 1 0 0 0 0	LSB 0 0 1 0 0 0 0	LSB 1 0 0 0 0 0 0
AMP	0 0 0 1 1 0 0	AMP 0 0 0 1 1 0 0	AMP 0 0 0 0 0 0 0
MT1	0 0 0 1 1 0 0	MT1 0 0 0 0 0 0 0	MT1 0 0 0 0 0 0 0
MT2	0 0 0 0 0 0 0	MT2 0 0 0 1 1 0 0	MT2 0 0 0 0 0 0 0
REC	0 0 0 0 0 0 0	REC 0 0 0 0 0 0 0	REC 0 0 0 1 1 0 0
MR1	0 0 0 0 0 0 0	MR1 0 0 0 0 0 0 0	MR1 0 0 0 0 0 1 1 0
MR2	0 0 0 0 0 0 0	MR2 0 0 0 0 0 0 0	MR2 0 0 0 0 0 0 0

	Ch 4	Ch 5	Ch 6
OUT	1 0 0 0 0 0 0	OUT 0 1 0 0 0 0 0	OUT 0 0 1 0 0 0 0
SAM	1 0 0 0 0 0 0	SAM 0 1 0 0 0 0 0	SAM 0 0 1 0 0 0 0
MI0	0 0 0 0 0 0 0	MI0 0 1 0 0 0 0 0	MI0 0 0 0 0 0 0 0
MI1	1 0 0 0 0 0 0	MI1 0 1 0 0 0 0 0	MI1 0 0 1 0 0 0 0
MI2	0 0 0 0 0 0 0	MI2 0 0 0 0 0 0 0	MI2 0 0 0 0 0 0 0
MSB	0 1 0 0 0 0 ... 0	MSB 0 1 0 0 0 0 ... 0	MSB 0 0 1 0 0 0 ... 0
LSB	0 0 1 0 0 0 0	LSB 0 0 1 0 0 0 0	LSB 1 0 0 0 0 0 0
AMP	0 0 0 1 1 0 0	AMP 0 0 0 0 0 0 0	AMP 0 0 0 0 0 0 0
MT1	0 0 0 0 0 0 0	MT1 0 0 0 0 0 0 0	MT1 0 0 0 0 0 0 0
MT2	0 0 0 0 1 1 0 0	MT2 0 0 0 0 0 0 0	MT2 0 0 0 0 0 0 0
REC	0 0 0 0 0 0 0	REC 0 0 0 0 0 0 0	REC 0 0 0 0 0 0 0
MR1	0 0 0 0 0 0 0	MR1 0 0 0 0 0 0 0	MR1 0 0 0 0 0 0 0
MR2	0 0 0 0 0 0 0	MR2 0 0 0 0 0 0 0	MR2 0 0 0 0 0 0 0

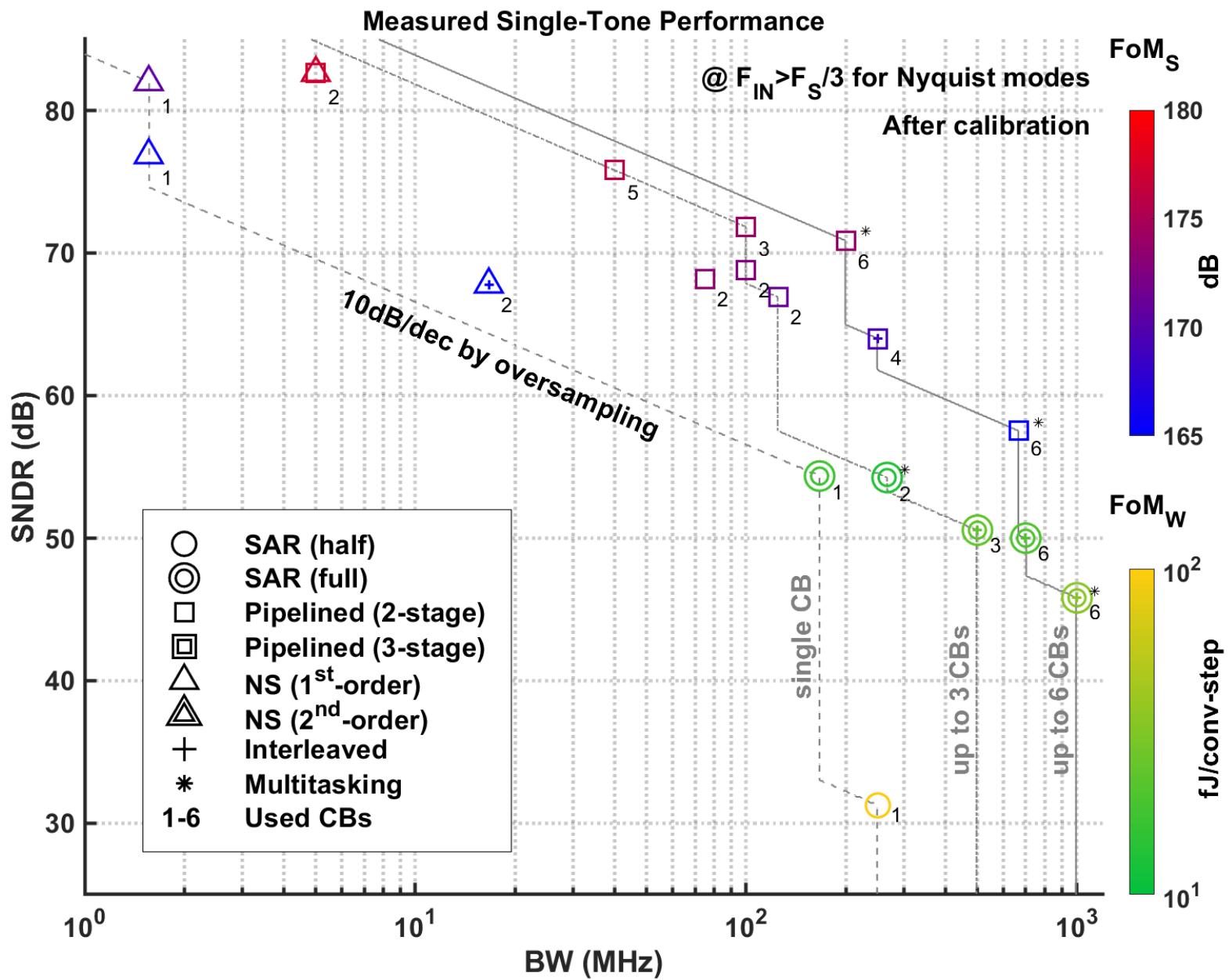
**PCA Platform:**



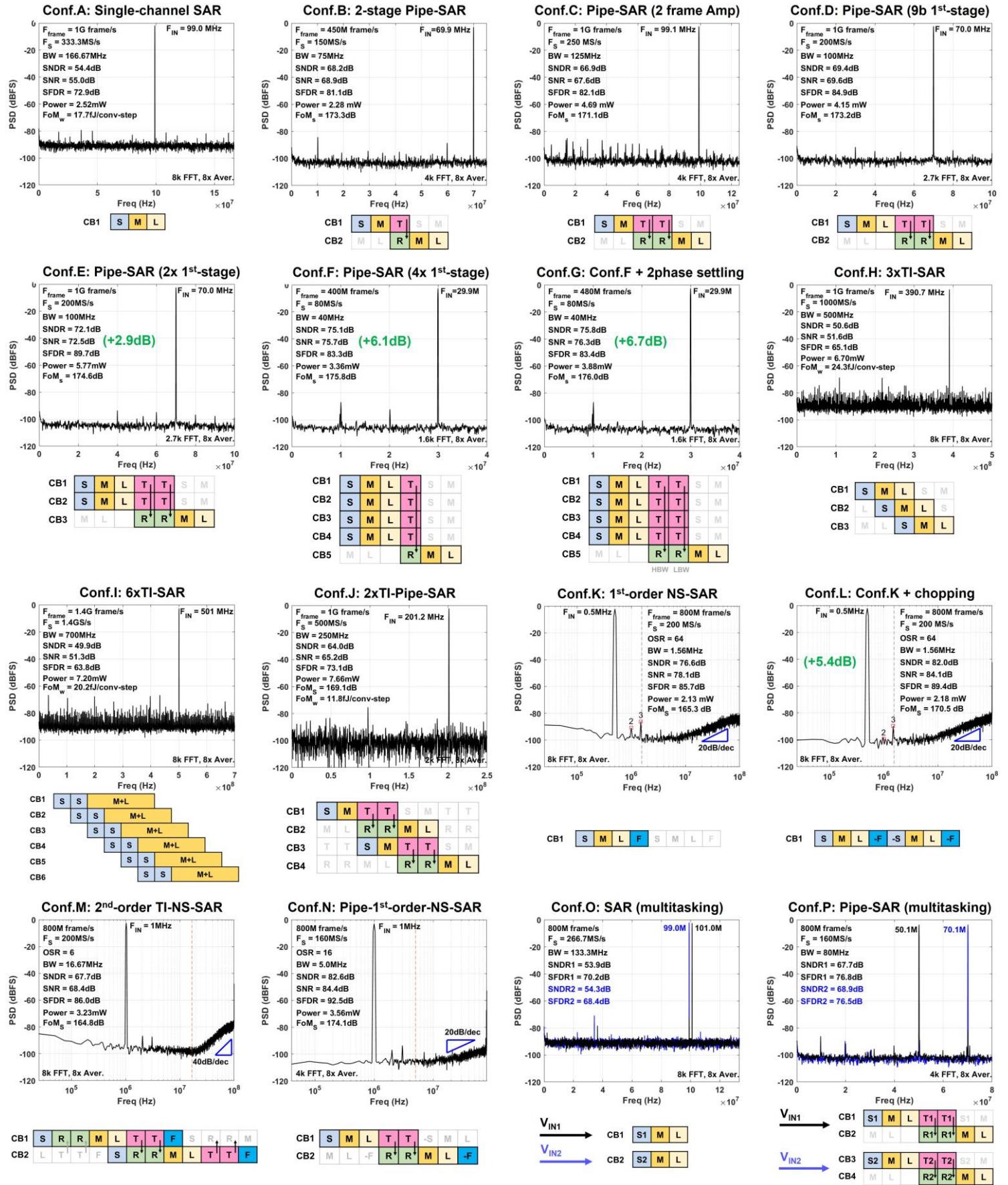
**Measured Spectra:**



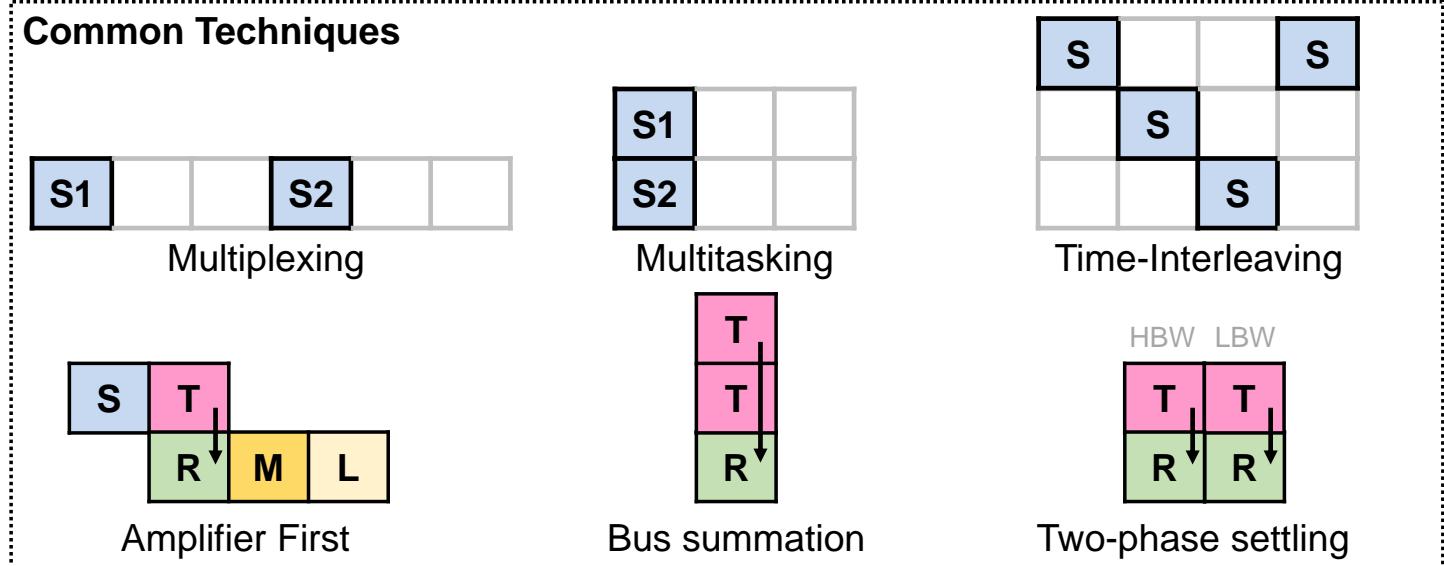
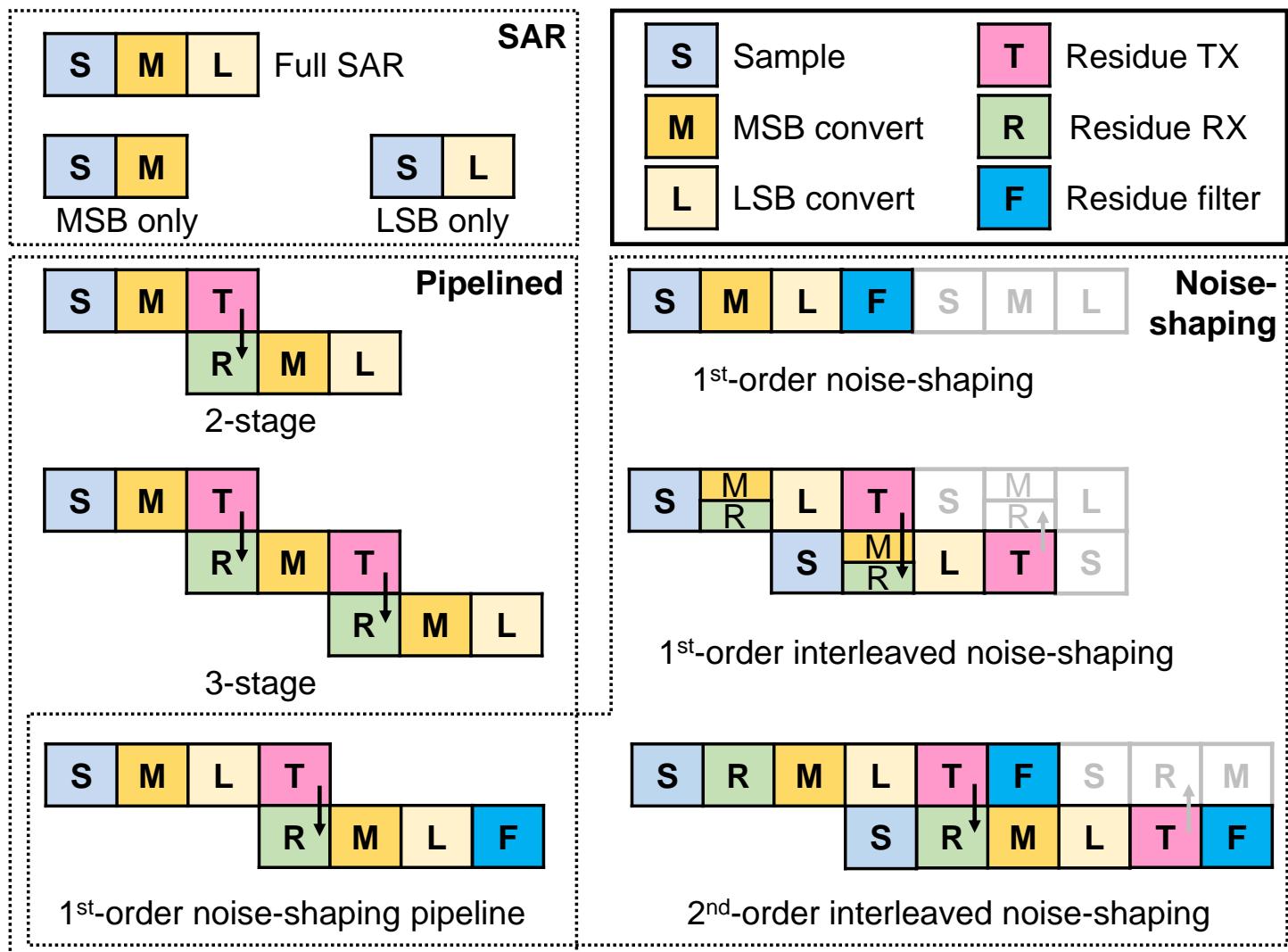
# Measured performances of 18 selected modes and corresponding CB usage



# Measured Spectra of 16 modes

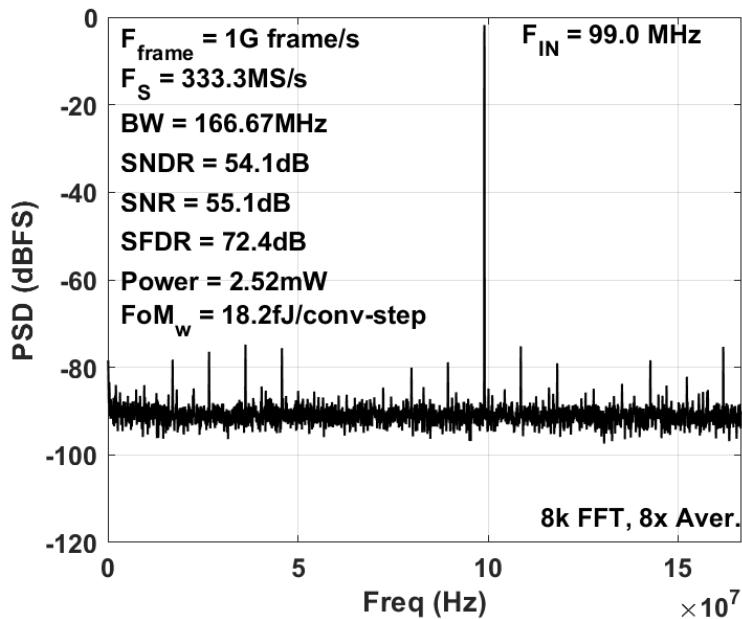


# Timing Table Templates



# [Example 1] : Single-channel SAR

## Measured spectrum at lab environment



## Timing Table

CB1    S    M    L

<b>S</b>	Sample	<b>T</b>	Residue TX
<b>M</b>	MSB convert	<b>R</b>	Residue RX
<b>L</b>	LSB convert	<b>F</b>	Residue filter

## Timing Matrix (CB 1)

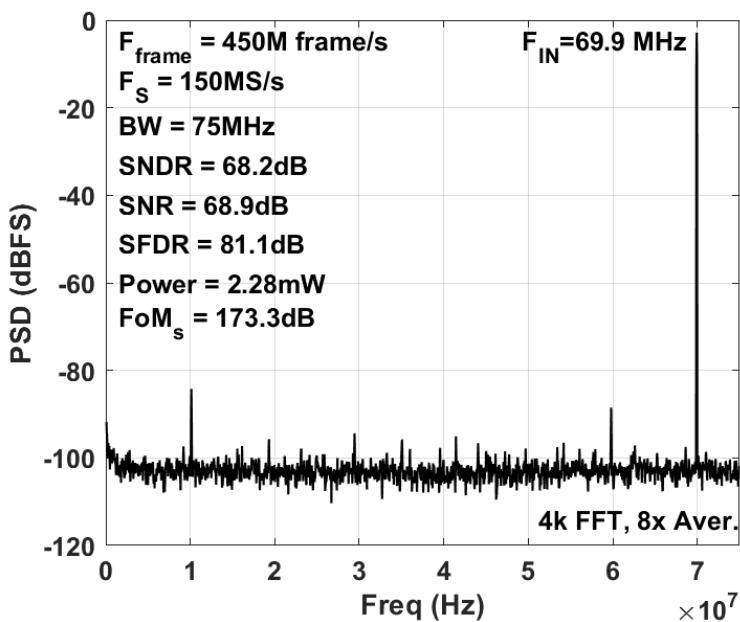
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	0	0	0	0	0	0
LSB	0	0	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## Timing Matrix (CB 2~6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 2] : 2-stage Pipe-SAR

Measured spectrum at lab environment



Timing Table

CB1	S	M	T	S	M
CB2	M	L	R	M	L
<b>S</b>	Sample	<b>T</b>	Residue TX		
<b>M</b>	MSB convert	<b>R</b>	Residue RX		
<b>L</b>	LSB convert	<b>F</b>	Residue filter		

Timing Matrix (CB 1)

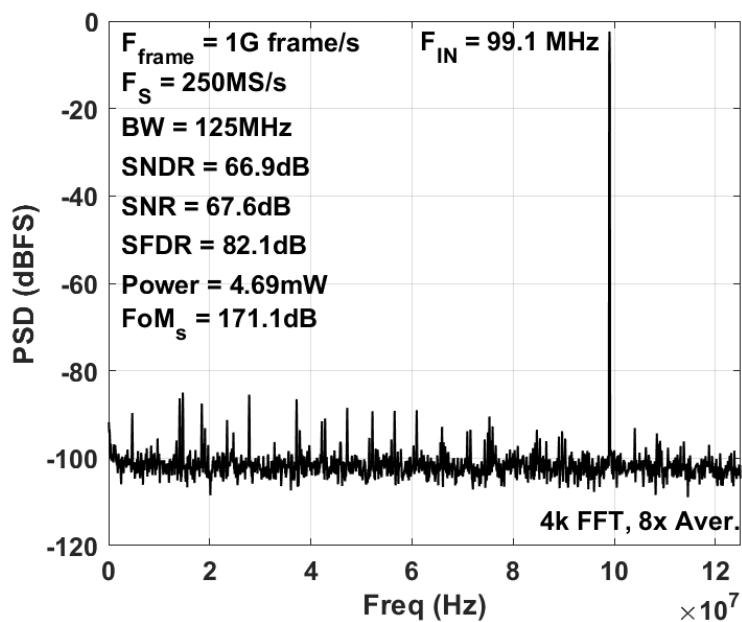
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	1	0	0	0	0	0
CON	0	1	1	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	1	1	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	1	0	0	0	0	0
RESET	0	0	1	0	0	0	0	0
MSB	1	0	0	0	0	0	0	0
LSB	0	1	0	0	0	0	0	0
SAM	0	0	1	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	1	1	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	1	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	1	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	1	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	1	1	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 3] : 2-stage Pipe-SAR (2 frame Amp)

Measured spectrum at lab environment



Timing Table

CB1	S	M	T	T	S	M
CB2	M	L	R	R	M	L

Legend:

- S** Sample
- T** Residue TX
- M** MSB convert
- R** Residue RX
- L** LSB convert
- F** Residue filter

Timing Matrix (CB 1)

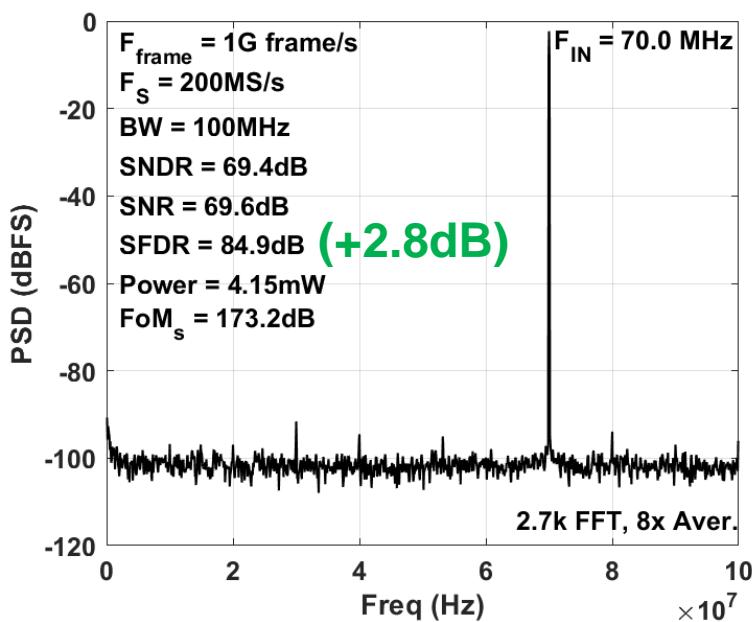
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	1	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	1	1	0	0	0	0
CON	0	1	1	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	1	1	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	1	0	0	0	0	0
RESET	0	0	1	1	0	0	0	0
MSB	1	0	0	0	0	0	0	0
LSB	0	1	0	0	0	0	0	0
SAM	0	0	1	1	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	1	1	1	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	1	1	0	0	0	0
CS 2	0	0	1	1	0	0	0	0
RS 1	0	0	1	1	0	0	0	0
RS 2	0	0	1	1	0	0	0	0
EN RX	0	0	1	1	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	1	1	0	0	0	0
MUX RX 2	0	0	1	1	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 4] : Pipe-SAR (9b 1<sup>st</sup> -stage)

Measured spectrum at lab environment



Timing Table

CB1	S	M	L	T	T	S	M
CB2	M	L		R	R	M	L
	<b>S</b>	<b>M</b>	<b>L</b>	<b>T</b>	<b>R</b>	<b>M</b>	<b>L</b>
	Sample	Residue TX					
	MSB convert	Residue RX					
	LSB convert	Residue filter					

Timing Matrix (CB 1)

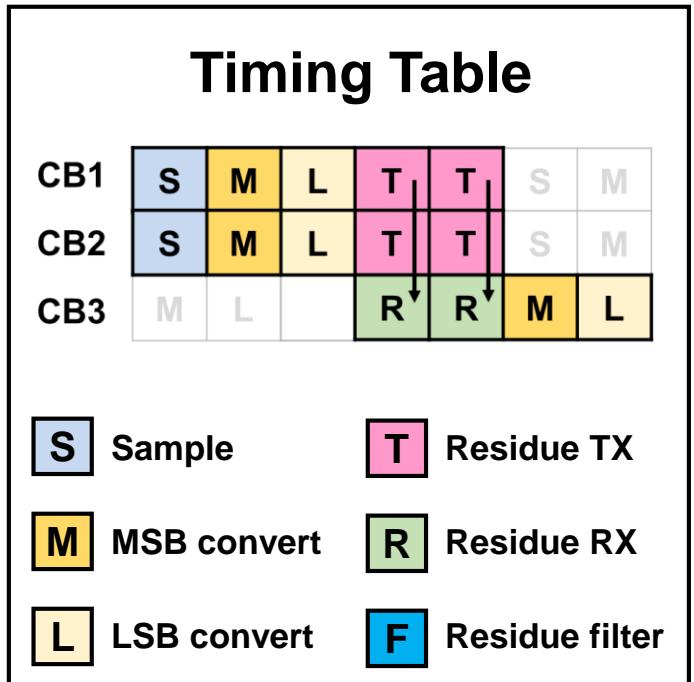
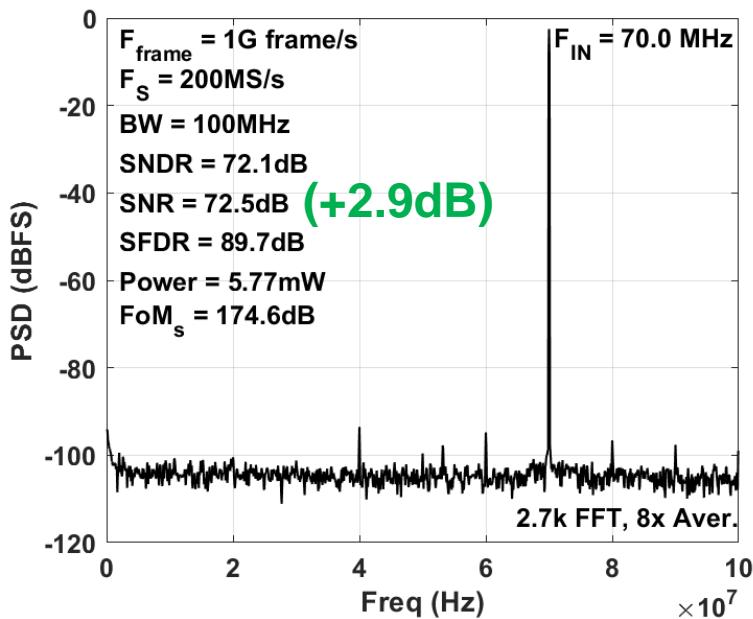
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	1	1	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	0	0	0	1	0	0	0	0
MSB	1	1	0	0	0	0	0	0
LSB	1	1	0	0	0	0	0	0
SAM	0	0	0	1	1	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	1	1	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	1	1	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	1	1	0	0	0
EN RX	0	0	0	1	1	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	1	1	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 5] : Pipe-SAR (2x 1<sup>st</sup>-stage Averaging)

## Measured spectrum at lab environment



## Timing Matrix (CB 1)

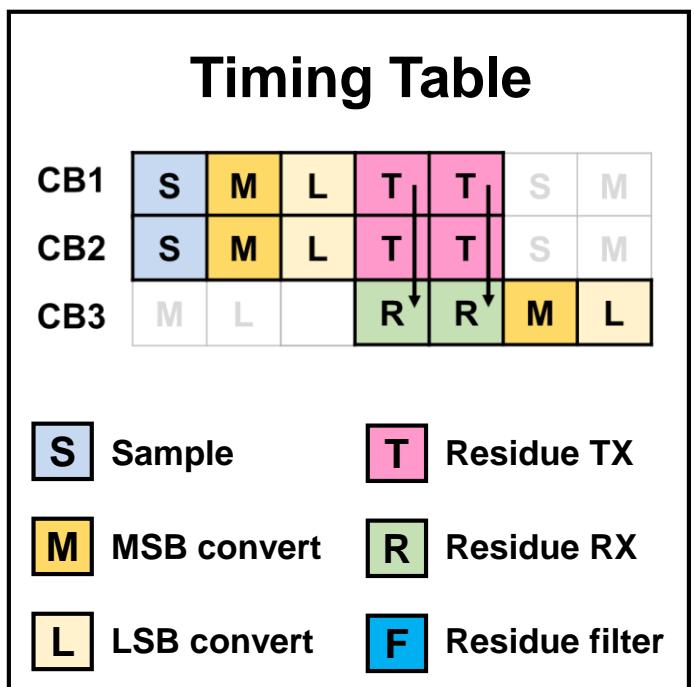
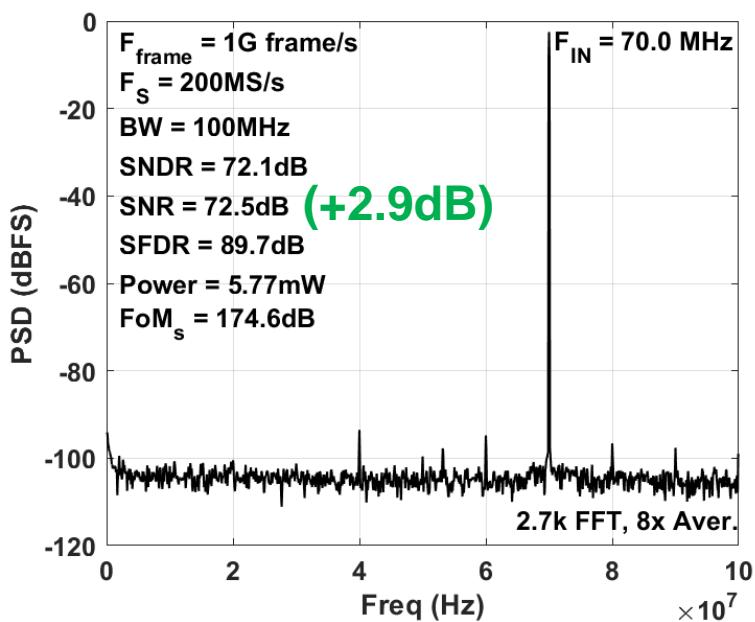
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	1	1	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	1	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	1	1	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 5] : Pipe-SAR (2x 1<sup>st</sup>-stage Averaging)

Measured spectrum at lab environment



Timing Matrix (CB 3)

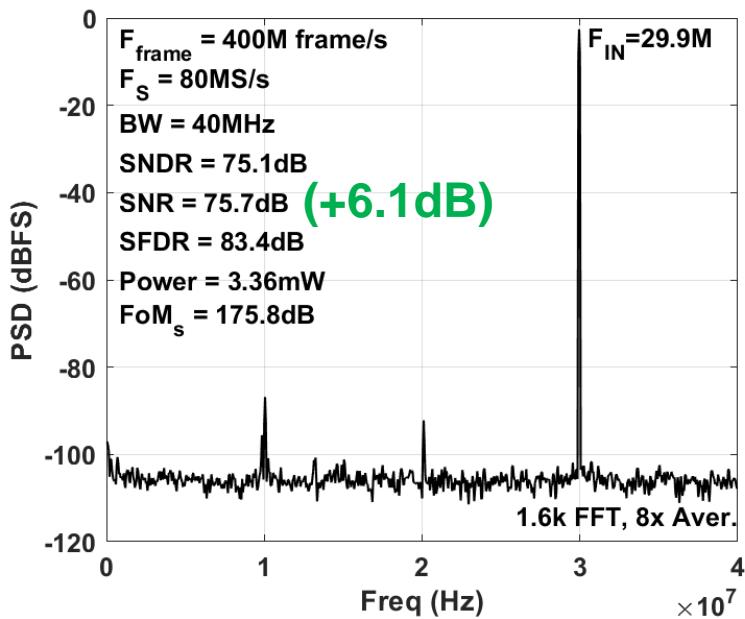
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	0	0	0	1	0	0	0	0
MSB	1	1	0	0	0	0	0	0
LSB	1	1	0	0	0	0	0	0
SAM	0	0	0	1	1	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	1	1	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	1	1	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	1	1	0	0	0
EN RX	0	0	0	1	1	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	1	1	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 4~6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 6] : Pipe-SAR (4x 1<sup>st</sup>-stage Averaging)

## Measured spectrum at lab environment



## Timing Table

CB1	S	M	L	T	S	M
CB2	S	M	L	T	S	M
CB3	S	M	L	T	S	M
CB4	S	M	L	T	S	M
CB5	M	L		R	M	L

## Timing Matrix (CB 1)

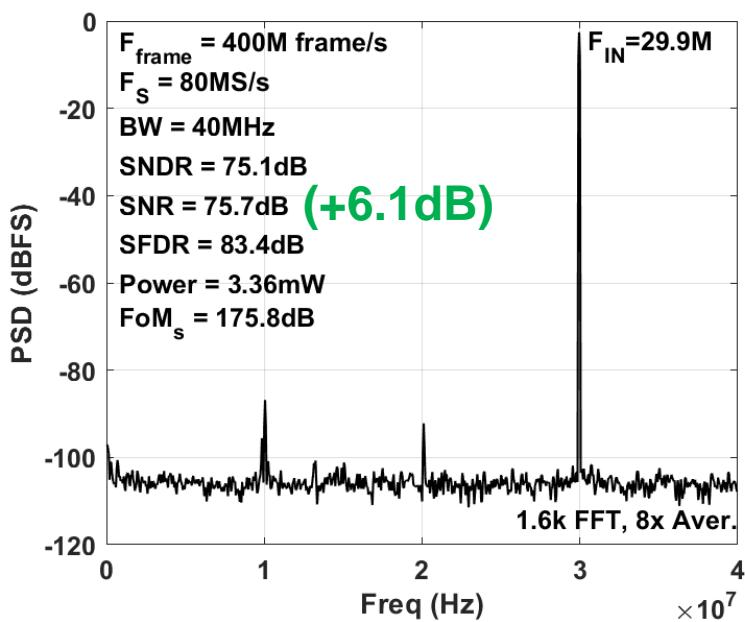
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	0	0	0	0
CON	0	0	0	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	1	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	0	0	0	0
CON	0	0	0	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 6] : Pipe-SAR (4x 1<sup>st</sup>-stage Averaging)

Measured spectrum at lab environment



Timing Table

CB1	S	M	L	T	S	M
CB2	S	M	L	T	S	M
CB3	S	M	L	T	S	M
CB4	S	M	L	T	S	M
CB5	M	L		R	M	L

Timing Matrix (CB 3)

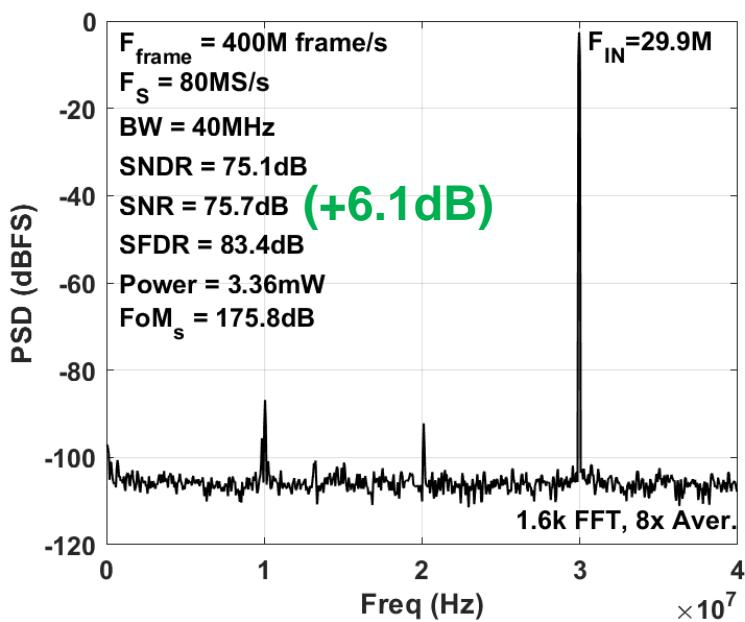
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	0	0	0	0
CON	0	0	0	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 4)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	1	0	0	0
RESET	0	0	0	0	1	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	0	0	0	0
CON	0	0	0	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 6] : Pipe-SAR (4x 1<sup>st</sup>-stage Averaging)

Measured spectrum at lab environment



Timing Table

CB1	S	M	L	T	S	M
CB2	S	M	L	T	S	M
CB3	S	M	L	T	S	M
CB4	S	M	L	T	S	M
CB5	M	L		R	M	L

Timing Matrix (CB 5)

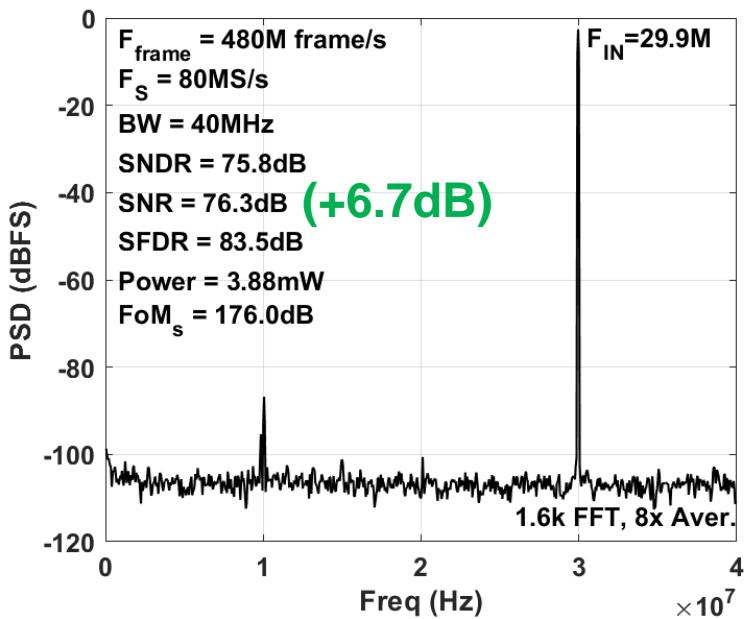
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	1	0	0	0	1	0	0	0
LSB	1	0	0	0	1	0	0	0
SAM	0	0	0	1	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	1	1	1	1	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	1	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	1	1	1	1	1	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	1	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	1	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 7] : Pipe-SAR (4x 1<sup>st</sup>-stage + 2-phase)

## Measured spectrum at lab environment



Timing Table							
CB1	S	M	L	T	T	S	M
CB2	S	M	L	T	T	S	M
CB3	S	M	L	T	T	S	M
CB4	S	M	L	T	T	S	M
CB5	M	L		R	R	M	L
				HBW	LBW		
2-phase settling							

## Timing Matrix (CB 1)

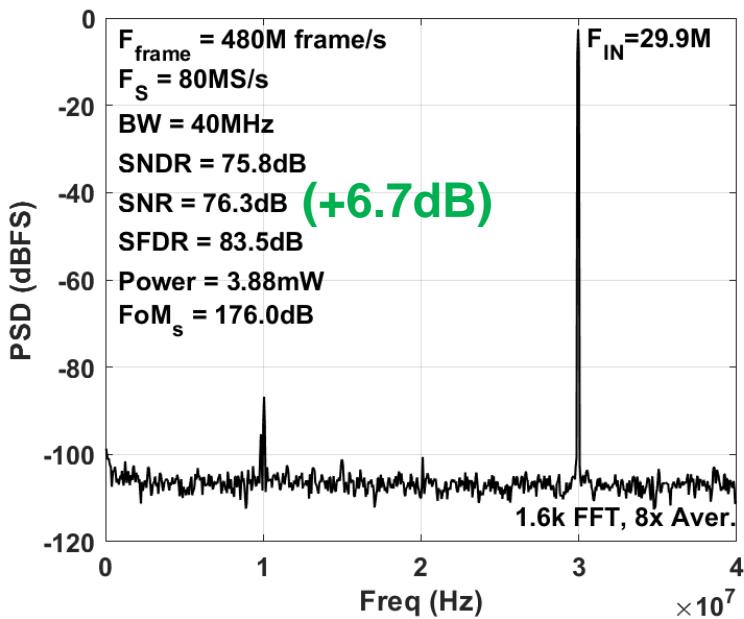
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	1	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	1	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 7] : Pipe-SAR (4x 1<sup>st</sup>-stage + 2-phase)

Measured spectrum at lab environment



Timing Table							
CB1	S	M	L	T	T	S	M
CB2	S	M	L	T	T	S	M
CB3	S	M	L	T	T	S	M
CB4	S	M	L	T	T	S	M
CB5	M	L		R	R	M	L
				HBW	LBW		
2-phase settling							

Timing Matrix (CB 3)

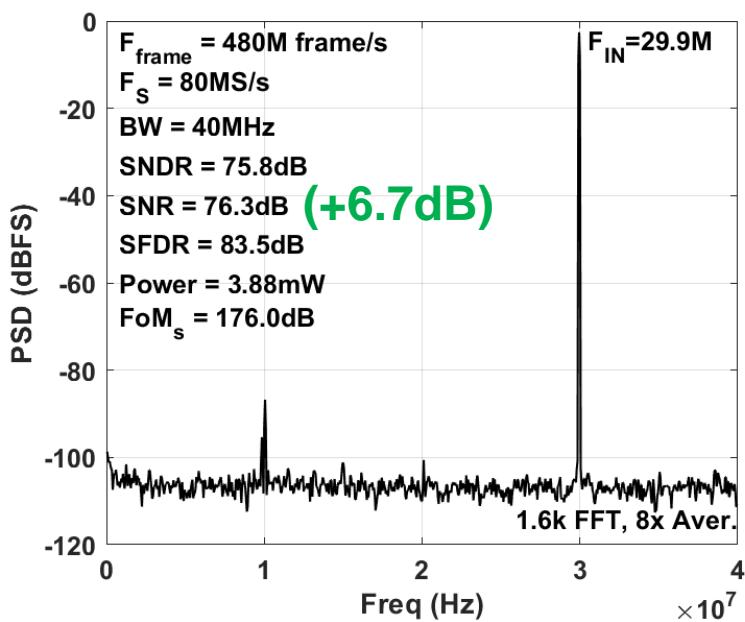
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	1	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	1	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 4)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	1	0	0
RESET	0	0	0	0	0	0	1	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	1	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 7] : Pipe-SAR (4x 1<sup>st</sup>-stage + 2-phase)

## Measured spectrum at lab environment



Timing Table							
CB1	S	M	L	T	T	S	M
CB2	S	M	L	T	T	S	M
CB3	S	M	L	T	T	S	M
CB4	S	M	L	T	T	S	M
CB5	M	L		R	R	M	L
				HBW	LBW		
2-phase settling							

Timing Matrix (CB 5)

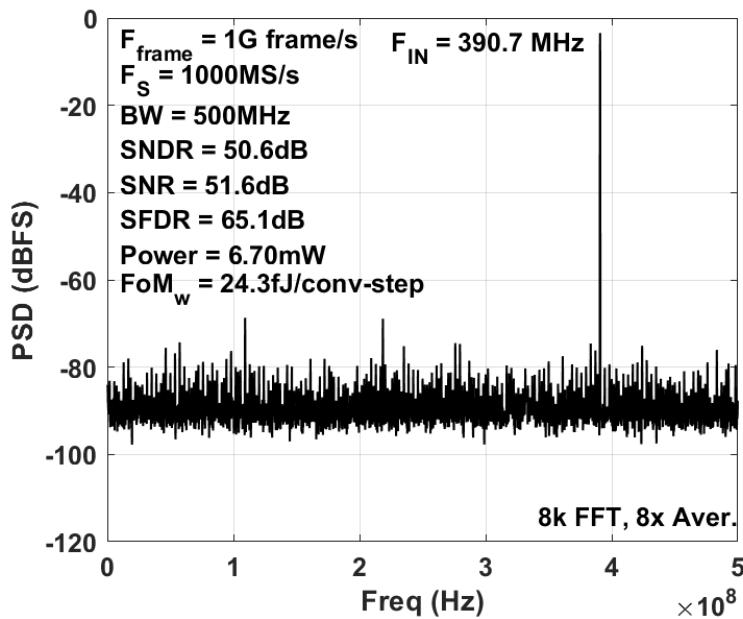
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	1	0	0	0	0	1	0	0
LSB	1	0	0	0	0	1	0	0
SAM	0	0	0	1	1	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	1	1	1	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	1	1	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	1	1	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	1	1	0	0	0
HBW	0	0	0	1	0	0	0	0
MUX RX 1	0	0	0	1	1	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 8] : 3xTI-SAR

### Measured spectrum at lab environment



### Timing Table

CB1	S	M	L	S	M
CB2	L	S	M	L	S
CB3	M	L	S	M	L

**S** Sample

**T** Residue TX

**M** MSB convert

**R** Residue RX

**L** LSB convert

**F** Residue filter

### Timing Matrix (CB 1)

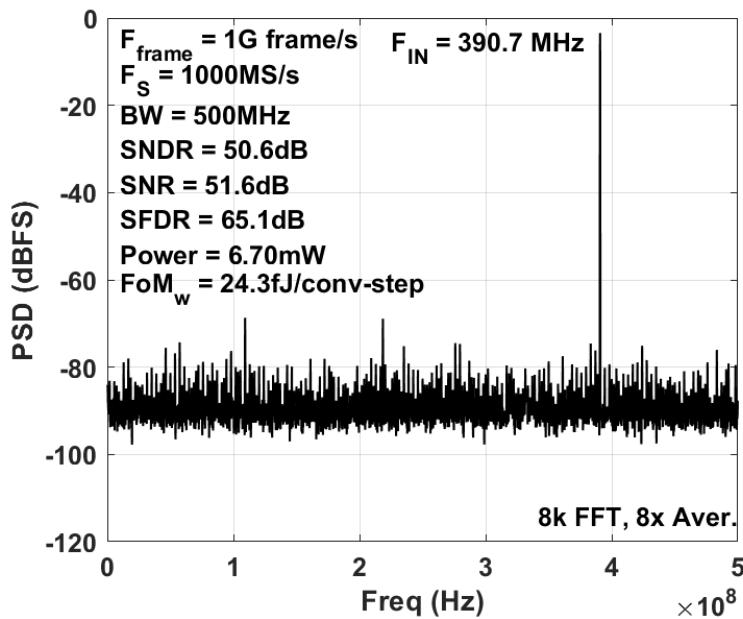
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

### Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	1	0	1	0	0	0	0	0
LSB	1	0	1	0	0	0	0	0
SAM	0	1	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	1	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 8] : 3xTI-SAR

### Measured spectrum at lab environment



### Timing Table

CB1	S	M	L	S	M
CB2	L	S	M	L	S
CB3	M	L	S	M	L

**S** Sample

**T** Residue TX

**M** MSB convert

**R** Residue RX

**L** LSB convert

**F** Residue filter

### Timing Matrix (CB 3)

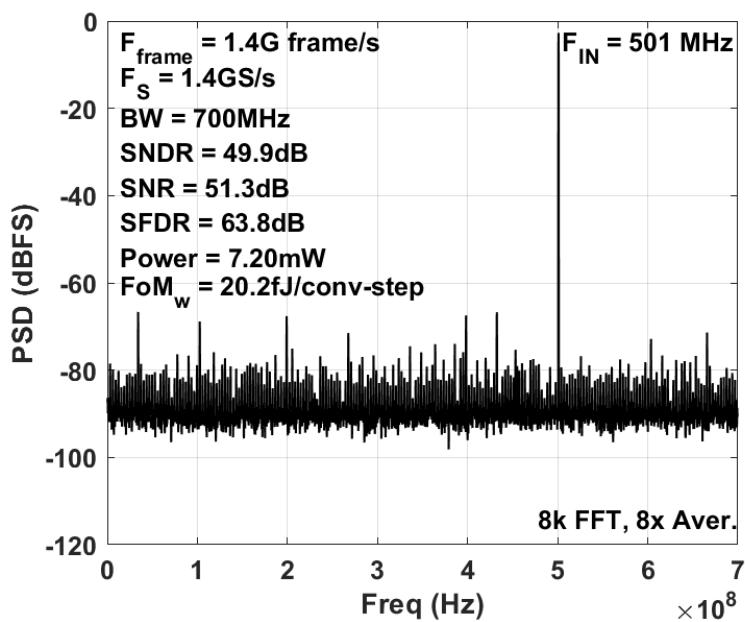
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	1	0	0	0	0	0
RESET	0	0	1	0	0	0	0	0
MSB	1	1	0	0	0	0	0	0
LSB	1	1	0	0	0	0	0	0
SAM	0	0	1	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	1	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

### Timing Matrix (CB 4~6)

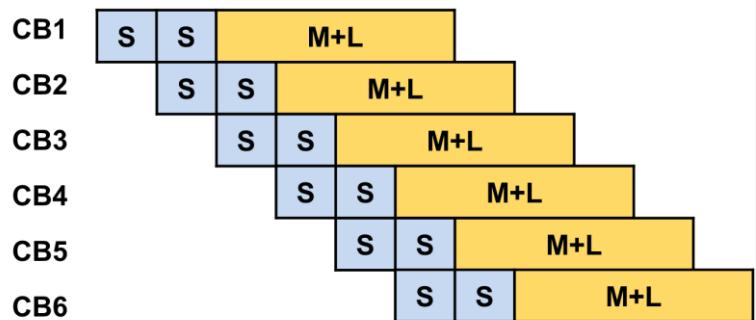
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 9] : 3xTI-SAR

### Measured spectrum at lab environment



### Timing Table



### Timing Matrix (CB 1)

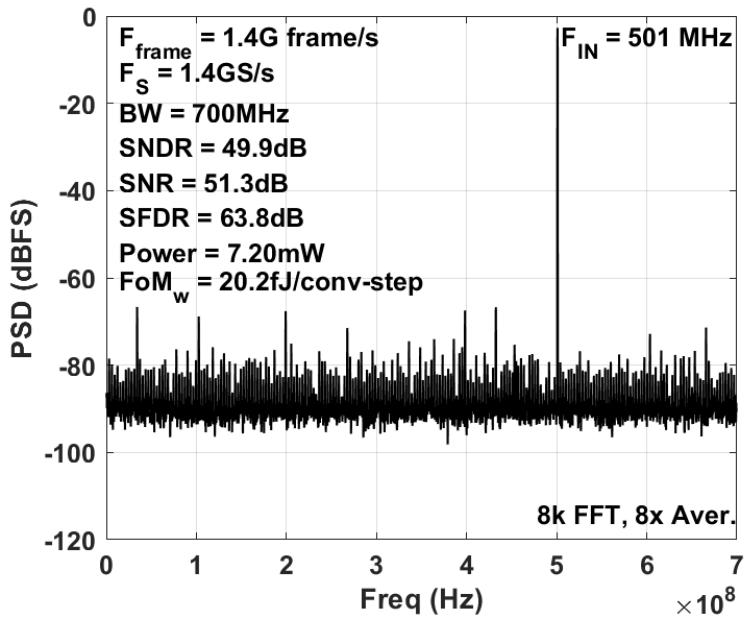
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	0	1	1	1	1	0	0
LSB	0	0	1	1	1	1	0	0
SAM	1	1	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	1	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

### Timing Matrix (CB 2)

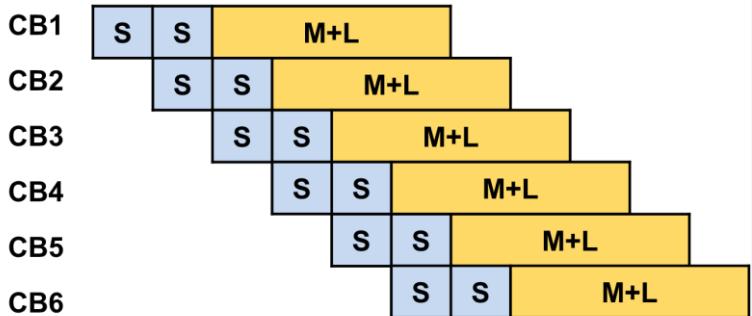
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	1	0	0	1	1	1	0	0
LSB	1	0	0	1	1	1	0	0
SAM	0	1	1	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	1	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 9] : 3xTI-SAR

### Measured spectrum at lab environment



### Timing Table



### Timing Matrix (CB 3)

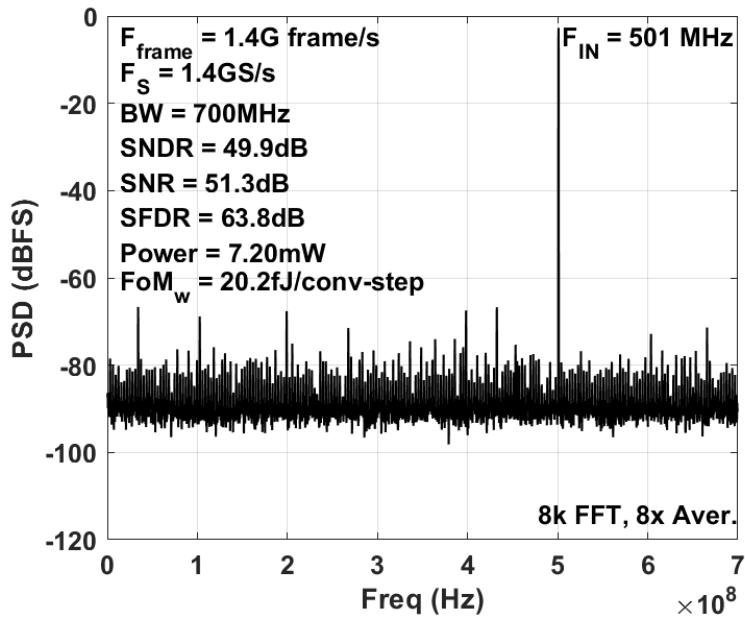
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	1	0	0	0	0	0
RESET	0	0	1	0	0	0	0	0
MSB	1	1	0	0	1	1	0	0
LSB	1	1	0	0	1	1	0	0
SAM	0	0	1	1	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	1	1	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

### Timing Matrix (CB 4)

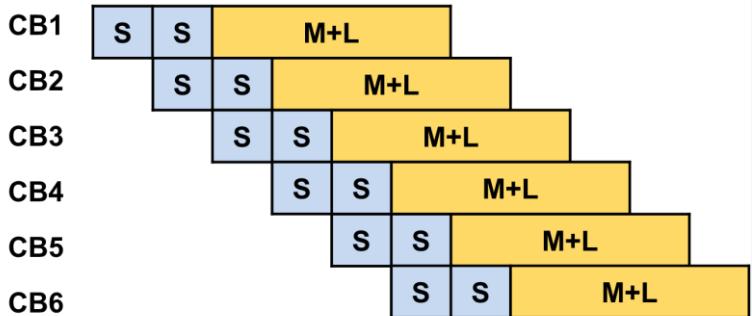
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	0	0	0	1	0	0	0	0
MSB	1	1	1	0	0	1	0	0
LSB	1	1	1	0	0	1	0	0
SAM	0	0	0	1	1	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	1	1	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	1	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 9] : 3xTI-SAR

### Measured spectrum at lab environment



### Timing Table



### Timing Matrix (CB 5)

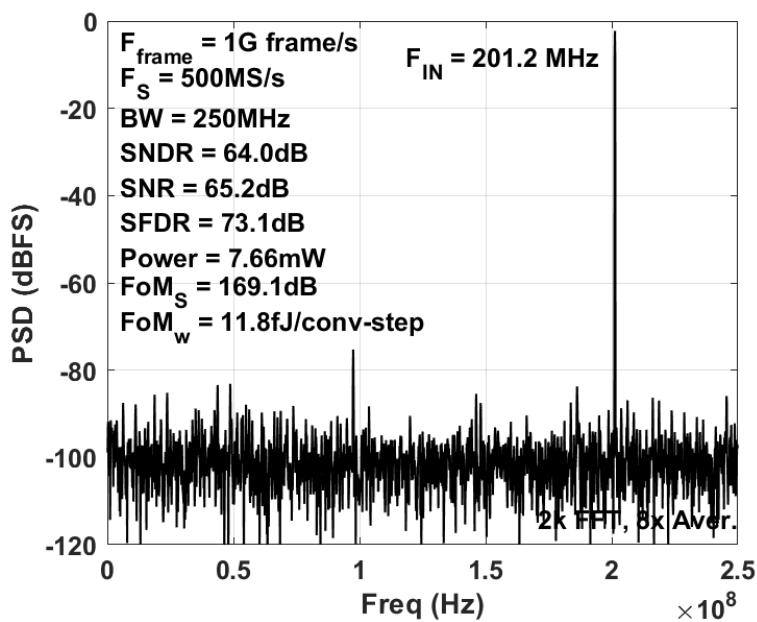
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	1	0	0	0
RESET	0	0	0	0	1	0	0	0
MSB	1	1	1	1	0	0	0	0
LSB	1	1	1	1	0	0	0	0
SAM	0	0	0	0	1	1	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	1	1	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

### Timing Matrix (CB 6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	1	0
RESET	0	0	0	0	0	0	1	0
MSB	0	1	1	1	1	1	0	0
LSB	0	1	1	1	1	1	0	0
SAM	1	0	0	0	0	0	1	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	0	0	0	1	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	1	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 10] : 2xTI-Pipe-SAR

## Measured spectrum at lab environment



## Timing Table

CB1	S	M	T	T	S	M	T	T
CB2	M	L	R	R	M	L	R	R
CB3	T	T	S	M	T	T	S	M
CB4	R	R	M	L	R	R	M	L

## Timing Matrix (CB 1)

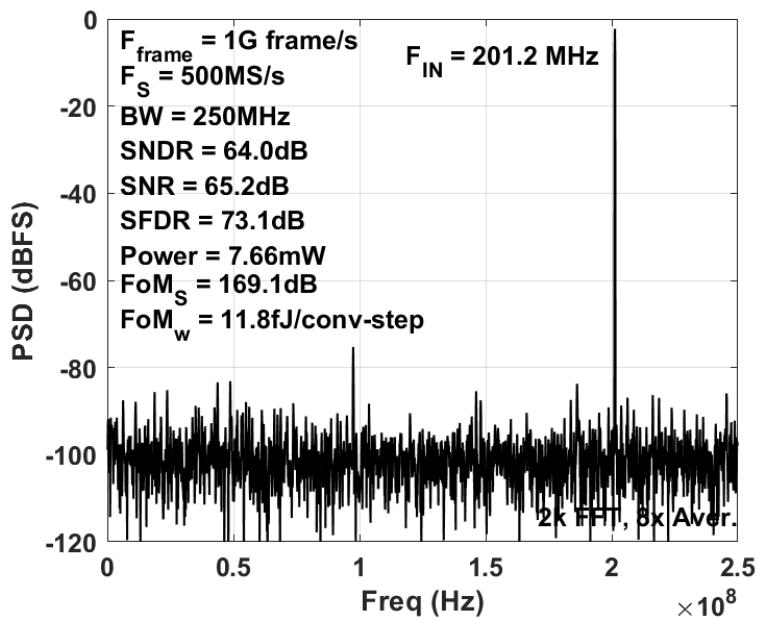
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	1	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	1	1	0	0	0	0
CON	0	0	1	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	1	1	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	0	0	0	1	0	0	0	0
MSB	1	1	0	0	0	0	0	0
LSB	1	1	0	0	0	0	0	0
SAM	0	0	1	1	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	1	1	1	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	1	1	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	1	1	1	1	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	1	1	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	1	1	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 10] : 2xTI-Pipe-SAR

## Measured spectrum at lab environment



## Timing Table

CB1	S	M	T	T	S	M	T	T
CB2	M	L	R	R	M	L	R	R
CB3	T	T	S	M	T	T	S	M
CB4	R	R	M	L	R	R	M	L

## Timing Matrix (CB 3)

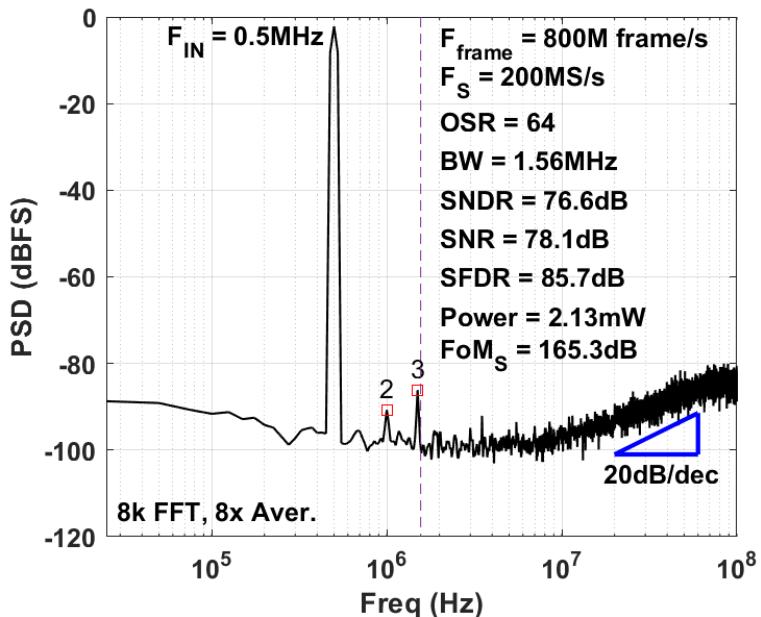
Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	1	0	0	0	0	0
RESET	0	0	1	0	0	0	0	0
MSB	0	0	0	1	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	1	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	1	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	1	1	0	0	0	0	0	0
CON	1	1	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	1	1	0	0	0	0	0	0

## Timing Matrix (CB 4)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	0	0	1	1	0	0	0	0
LSB	0	0	1	1	0	0	0	0
SAM	1	1	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	1	1	0	1	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	1	1	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	1	1	1	1	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	1	1	0	0	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	1	1	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 11] : 1<sup>st</sup> -order NS-SAR

Measured spectrum at lab environment



Timing Table

CB1	S	M	L	F	S	M	L	F
	<b>S</b>	Sample	<b>T</b>	Residue TX				
	<b>M</b>	MSB convert	<b>R</b>	Residue RX				
	<b>L</b>	LSB convert	<b>F</b>	Residue filter				

Timing Matrix (CB 1)

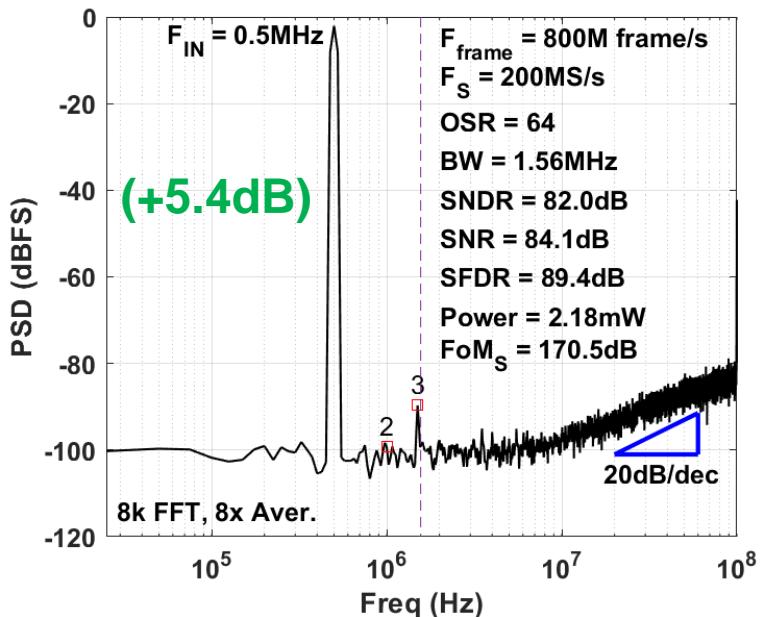
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	1	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	0	0	0	0	0	0	0
CS 1	0	1	0	0	0	0	0	0
CS 2	1	1	1	1	0	0	0	0
RS 1	0	0	0	1	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	1	0	0	0	0
HBW	1	1	1	1	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	0	0	0	0
CON	0	0	0	1	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	1	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2~6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 12] : 1<sup>st</sup> -order NS-SAR (+ chopping)

Measured spectrum at lab environment



Timing Table



**S** Sample

**T** Residue TX

**M** MSB convert

**R** Residue RX

**L** LSB convert

**F** Residue filter

Timing Matrix (CB 1)

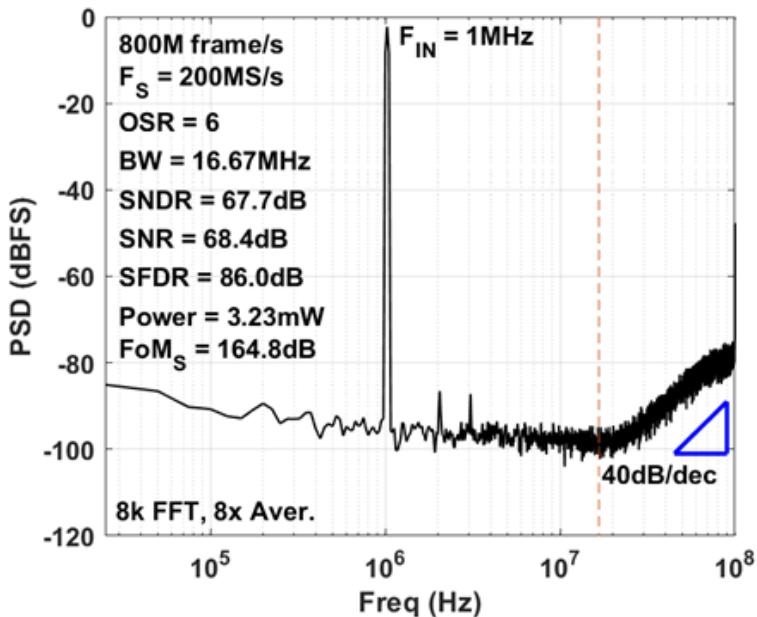
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	1	0	0	0
RESET	1	0	0	0	1	0	0	0
MSB	0	1	1	0	0	1	1	0
LSB	0	1	1	0	0	1	1	0
SAM	1	0	0	0	1	0	0	0
FLIP IN	0	0	0	0	1	1	1	1
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	1	1	1	1	0	1	1
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	0	0	0	1	0	0	0
CS 1	0	1	0	0	0	1	0	0
CS 2	1	1	1	1	1	1	1	1
RS 1	0	0	0	1	0	0	0	1
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	1	0	0	0	1
HBW	1	1	1	1	1	1	1	1
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	0	0	0	1
CON	0	0	0	1	0	0	0	1
FLIP TX	1	1	1	1	1	1	1	1
LOOPBACK	0	0	0	1	0	0	0	1
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2~6)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	0	0	0	0
RESET	0	0	0	0	0	0	0	0
MSB	0	0	0	0	0	0	0	0
LSB	0	0	0	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	0	0	0	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

## [Example 13] : 2<sup>nd</sup>-order TI-NS-SAR

Measured spectrum at lab environment



Timing Table

CB1	S	R	R	M	L	T	T	F	S	R	R	M
CB2	L	T	T	F	S	R	R	M	L	T	T	F

S Sample

M MSB convert

L LSB convert

T Residue TX

R Residue RX

F Residue filter

Timing Matrix (CB 1)

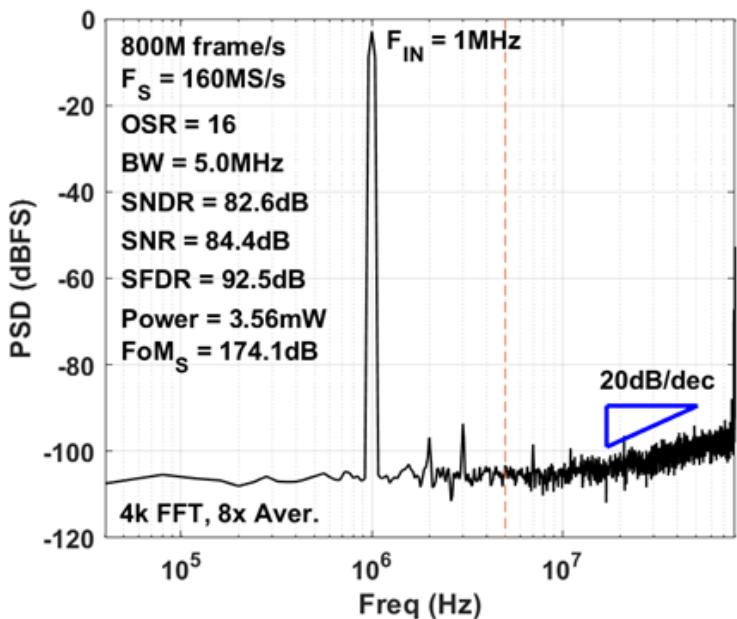
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	0	1	1	0	0	0	0
LSB	0	0	1	1	0	0	0	0
SAM	1	1	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	1	0	1	1	1	1	1
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	0	0	0	0	0	0
CS 1	0	0	1	1	0	0	0	0
CS 2	0	0	1	1	0	0	0	0
RS 1	0	0	0	0	0	0	1	1
RS 2	1	1	0	0	0	0	0	0
EN RX	1	1	0	0	0	0	1	1
HBW	1	1	1	1	1	1	1	1
MUX RX 1	1	1	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	1	1	1	1
CON	0	0	0	0	1	1	1	1
FLIP TX	0	0	0	0	0	0	1	1
LOOPBACK	0	0	0	0	0	0	1	1
MUX TX 1	0	0	0	0	1	1	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	1	0	0	0
RESET	0	0	0	0	0	1	0	0
MSB	0	0	0	0	0	0	0	1
LSB	0	0	0	0	0	0	0	1
SAM	0	0	0	0	0	1	1	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	1	1	1	1	1	0	1
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	1	1	0
CS 1	0	0	0	0	0	0	0	1
CS 2	0	0	0	0	0	0	0	1
RS 1	0	0	1	1	0	0	0	0
RS 2	1	1	0	0	0	0	0	0
EN RX	1	1	0	0	0	1	1	0
HBW	1	1	1	1	1	1	1	1
MUX RX 1	0	0	0	0	0	1	1	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	1	1	1	1	0	0	0	0
CON	1	1	1	1	0	0	0	0
FLIP TX	0	0	1	1	0	0	0	0
LOOPBACK	0	0	1	1	0	0	0	0
MUX TX 1	1	1	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 14] : Pipe-1<sup>st</sup> -order-NS-SAR

## Measured spectrum at lab environment



## Timing Table

CB1	S	M	L	T	T	-S	M	L
CB2	M	L	-F	R	R	M	L	-F

**S** Sample

**T** Residue TX

**M** MSB convert

**R** Residue RX

**L** LSB convert

**F** Residue filter

## Timing Matrix (CB 1)

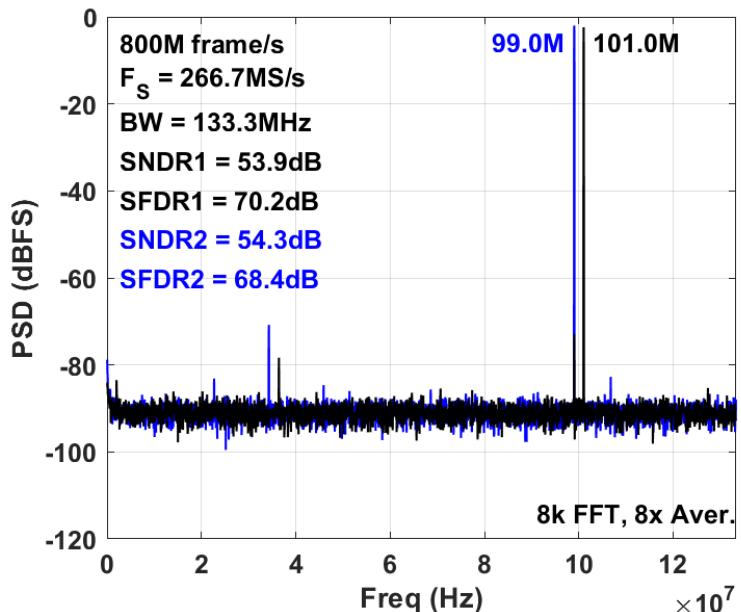
Frame	1	2	3	4	5	6	7	8	9	10
DISPATCH	1	0	0	0	0	0	1	0	0	0
RESET	1	0	0	0	0	0	1	0	0	0
MSB	0	1	1	0	0	0	1	1	0	0
LSB	0	1	1	0	0	0	1	1	0	0
SAM	1	0	0	0	0	0	1	0	0	0
FLIP IN	0	0	0	0	0	0	1	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	1	1	1	0	0	1	1
MUX IN 2	0	0	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	1	1	1	1	1
CS 1	0	0	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	1	1	1	1	1
MUX RX 1	0	0	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0	1	1
CON	0	0	0	1	1	0	0	0	1	1
FLIP TX	0	0	0	0	0	0	0	0	0	0
LB	0	0	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0	1	1
MUX TX 2	0	0	0	0	0	0	0	0	0	0

## Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8	9	10
DISPATCH	0	0	0	1	0	0	0	0	1	0
RESET	0	0	0	1	0	0	0	0	1	0
MSB	1	1	0	0	0	1	1	0	0	0
LSB	1	1	0	0	0	1	1	0	0	0
SAM	0	0	0	1	1	0	0	0	1	1
FLIP IN	0	0	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	1	1	0	0	0	1	1
MUX IN 1	0	0	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0	0	0
CS 1	1	1	0	0	0	1	1	0	0	0
CS 2	0	0	0	1	1	0	0	0	1	1
RS 1	0	0	1	0	0	0	0	1	0	0
RS 2	0	0	1	1	0	0	0	0	1	1
EN RX	0	0	1	1	1	0	0	0	1	1
HBW	1	1	1	1	1	1	1	1	1	1
MUX RX 1	0	0	0	1	1	0	0	0	1	1
MUX RX 2	0	0	1	0	0	0	0	1	0	0
EN TX	0	0	1	0	0	0	0	0	1	0
CON	0	0	1	0	0	0	0	0	1	0
FLIP TX	0	0	1	0	0	0	0	0	1	0
LB	0	0	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0	0	0
MUX TX 2	0	0	1	0	0	0	0	1	0	0

# [Example 15] : SAR (multitasking)

Measured spectrum at lab environment



Timing Table

$V_{IN1}$ →	CB1	S1	M	L
$V_{IN2}$ →	CB2	S2	M	L
<b>S</b> Sample		<b>T</b> Residue TX		
<b>M</b> MSB convert		<b>R</b> Residue RX		
<b>L</b> LSB convert		<b>F</b> Residue filter		

Timing Matrix (CB 1)

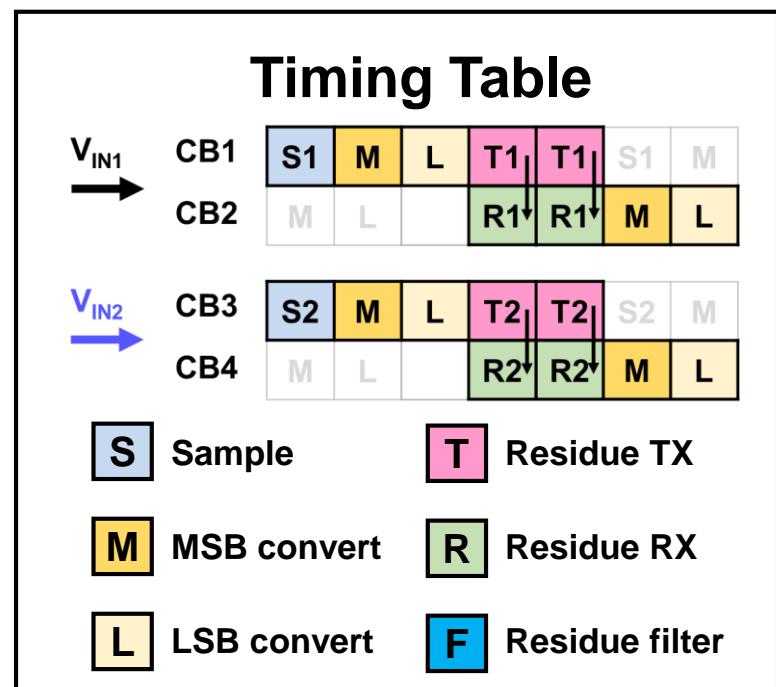
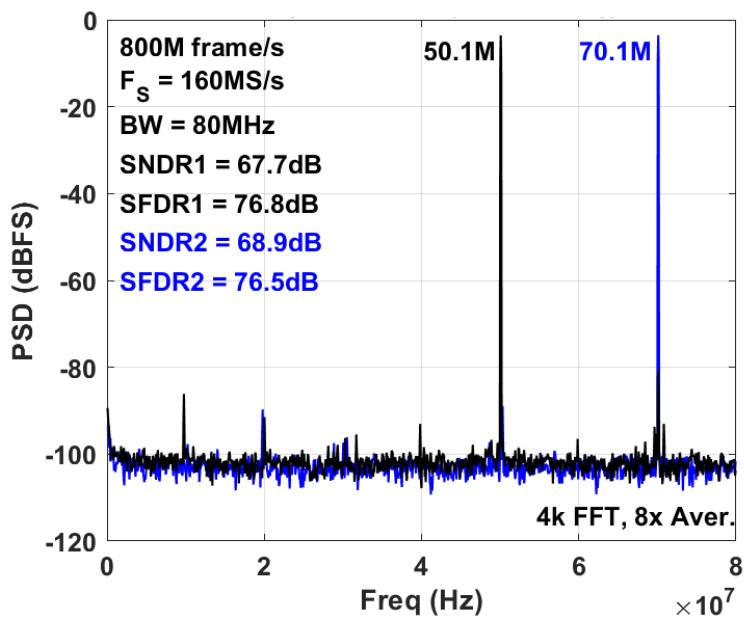
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	1	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	1	0	1	0	0	0	0	0
LSB	1	0	1	0	0	0	0	0
SAM	0	1	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	1	1	0	0	0	0	0	0
SRT	0	1	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	0	0	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 16] : Pipe-SAR (multitasking)

Measured spectrum at lab environment



Timing Matrix (CB 1)

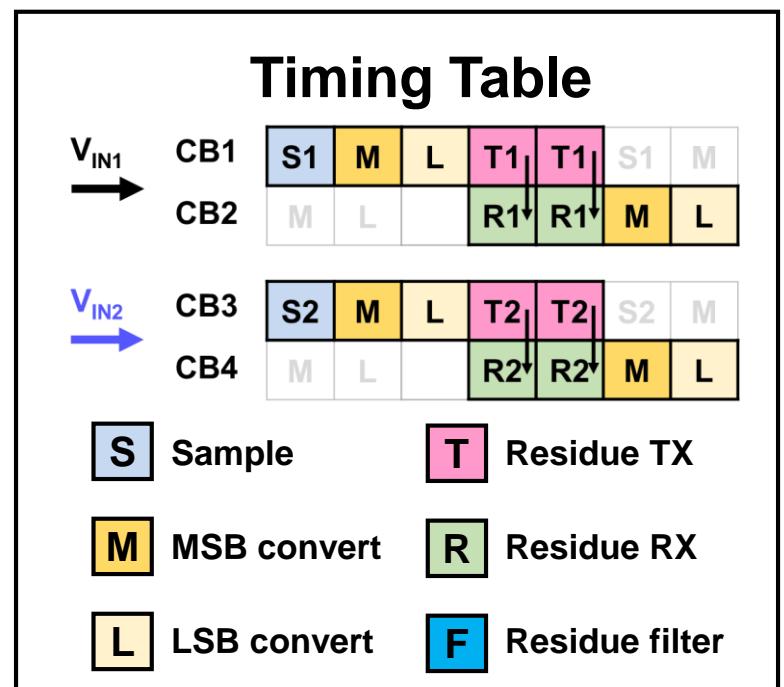
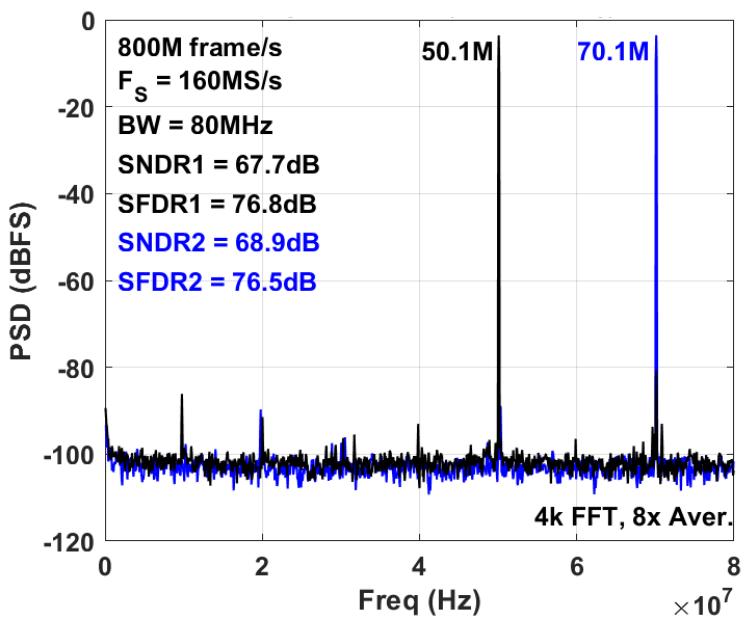
Frame	1	2	3	4	5	6	7	8
DISPATCH	1	0	0	0	0	0	0	0
RESET	1	0	0	0	0	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	1	0	0	1	1	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	1	1	0	0	0
CON	0	0	0	1	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	1	1	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

Timing Matrix (CB 2)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	1	0	0	0	0
RESET	0	0	0	1	0	0	0	0
MSB	1	1	0	0	0	0	0	0
LSB	1	1	0	0	0	0	0	0
SAM	0	0	0	1	1	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	1	1	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	1	1	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	1	1	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	1	1	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# [Example 16] : Pipe-SAR (multitasking)

Measured spectrum at lab environment



Timing Matrix (CB 3)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	1	0	0	0	0	0	0
RESET	0	1	0	0	0	0	0	0
MSB	0	0	1	1	0	0	0	0
LSB	0	0	1	1	0	0	0	0
SAM	0	1	0	0	0	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	0	0	0	0	0	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	1	1	0	0	1	0	0	0
SRT	1	1	1	1	1	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	0	0	0	0	0	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	0	0	0	0	0	0	0	0
EN RX	0	0	0	0	0	0	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	0	0	0	0	0	0	0	0
EN TX	1	0	0	0	1	0	0	0
CON	1	0	0	0	1	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	1	0	0	0	1	0	0	0

Timing Matrix (CB 4)

Frame	1	2	3	4	5	6	7	8
DISPATCH	0	0	0	0	1	0	0	0
RESET	0	0	0	0	1	0	0	0
MSB	0	1	1	0	0	0	0	0
LSB	0	1	1	0	0	0	0	0
SAM	1	0	0	0	1	0	0	0
FLIP IN	0	0	0	0	0	0	0	0
MUX IN 0	1	0	0	0	1	0	0	0
MUX IN 1	0	0	0	0	0	0	0	0
MUX IN 2	0	0	0	0	0	0	0	0
SRT	0	0	0	0	0	0	0	0
CS 1	0	0	0	0	0	0	0	0
CS 2	1	0	0	0	1	0	0	0
RS 1	0	0	0	0	0	0	0	0
RS 2	1	0	0	0	1	0	0	0
EN RX	1	0	0	0	0	1	0	0
HBW	1	1	1	1	1	0	0	0
MUX RX 1	0	0	0	0	0	0	0	0
MUX RX 2	1	0	0	0	1	0	0	0
EN TX	0	0	0	0	0	0	0	0
CON	0	0	0	0	0	0	0	0
FLIP TX	0	0	0	0	0	0	0	0
LOOPBACK	0	0	0	0	0	0	0	0
MUX TX 1	0	0	0	0	0	0	0	0
MUX TX 2	0	0	0	0	0	0	0	0

# References

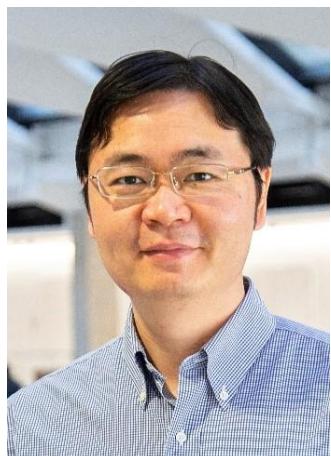
Z. Zhang, Z. Gao, S. Huang, N. Sun and L. Jie, "A 1GS/s6-Core Programmable A/D Converter Array Supporting Architecture Restructuring and Multitasking," 2023 IEEE Custom Integrated Circuits Conference (CICC), San Antonio, TX, USA, 2023, pp. 1-2  
doi: [10.1109/CICC57935.2023.10121311](https://doi.org/10.1109/CICC57935.2023.10121311).

Z. Zhang et al., "Programmable Analog-to-Digital Converter Array Supporting Architecture Restructuring and Mode Concurrency," in IEEE Transactions on Circuits and Systems I: Regular Papers  
doi: [10.1109/TCSI.2025.3533539](https://doi.org/10.1109/TCSI.2025.3533539).

# Programmable A/D Converter Array



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Lu Jie

