

# ***1Msps 8-Bit Cyclic ADC IP Marketing Brief***

***Epoch Microelectronics, Inc.  
Valhalla, NY***

# 8-Bit 1Mps Cyclic ADC: Features/Deliverables

## Features:

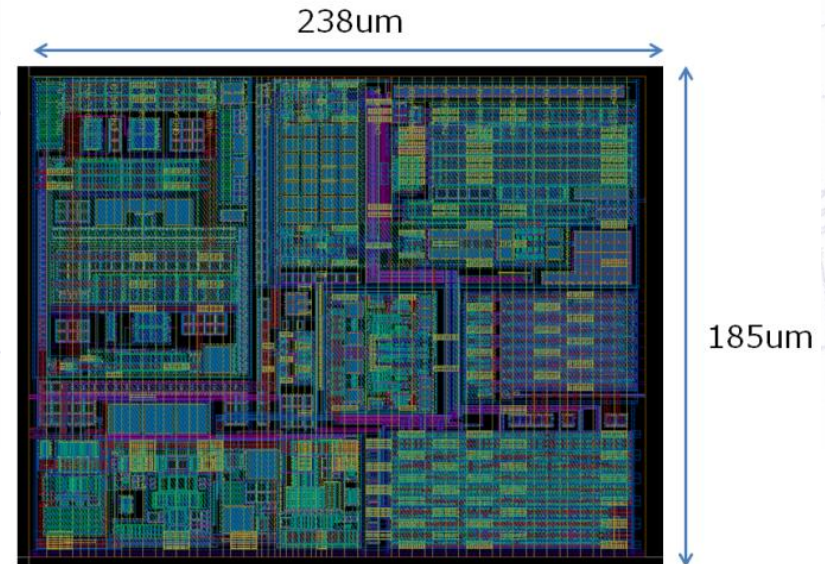
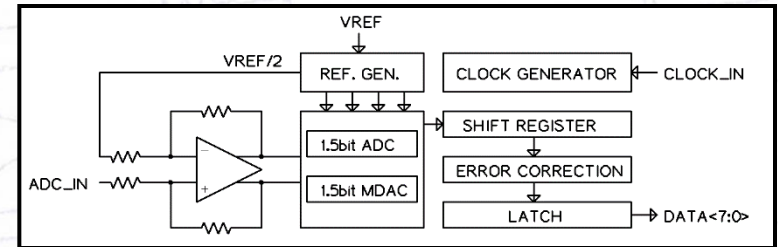
- Single to differential ADC driver amplifier
- Fully differential Cyclic ADC with bit controllable unsigned or signed output
- 1.5bit MDAC/ADC architecture with error correction.
- Internal reference buffers and generator from single 1.45V voltage reference
- Small Die Area

## Deliverables:

- White Box:
  - Cadence library including schematics, layout, and test benches
  - GDS2, CDL netlist, DRC/LVS/ERC reports
  - Verilog and .LIB files
  - Evaluation report
- Black Box:
  - GDS2, CDL netlist, DRC/LVS/ERC reports
  - Verilog and .LIB files
  - Encrypted SPICE netlist
  - Evaluation report

# 8-Bit 1Msps Cyclic ADC

|                        |                                      |
|------------------------|--------------------------------------|
| Technology             | Global Foundries<br>40nm CMOS        |
| Process Options        | 6L1x_1T6x_1T18x_LB                   |
| Analog Supply Voltage  | 1.8V                                 |
| Digital Supply Voltage | 1.1V                                 |
| Sampling Rate          | 1Msps                                |
| Input Voltage Swing    | 1.45V <sub>pps</sub>                 |
| ENOB                   | 7.7bit                               |
| SNDR                   | 47.9dB                               |
| Active Chip Area       | 0.044mm <sup>2</sup>                 |
| Power (Analog)         | 1.6mW                                |
| Power (Digital)        | 0.003mW                              |
| Status                 | GDS2 ready<br>(evaluation completed) |

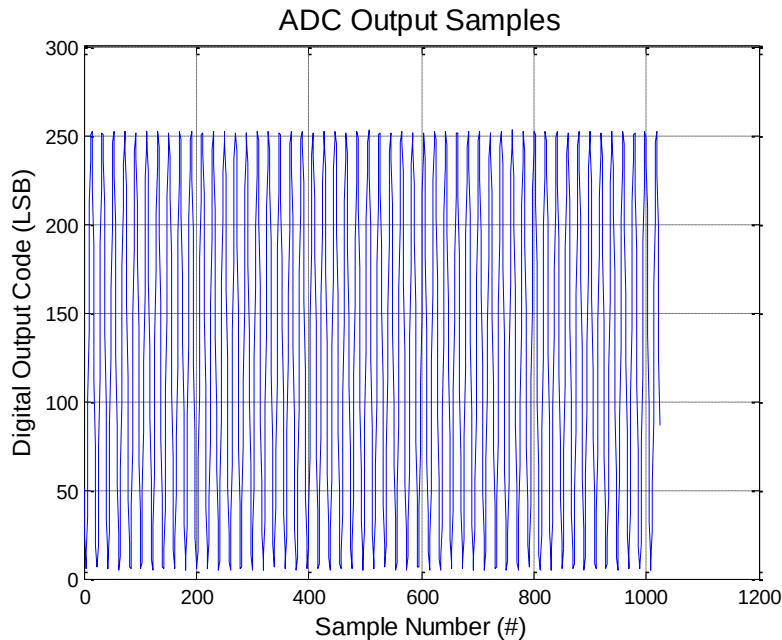


## Measured Summary (TT, SS, FF Samples)

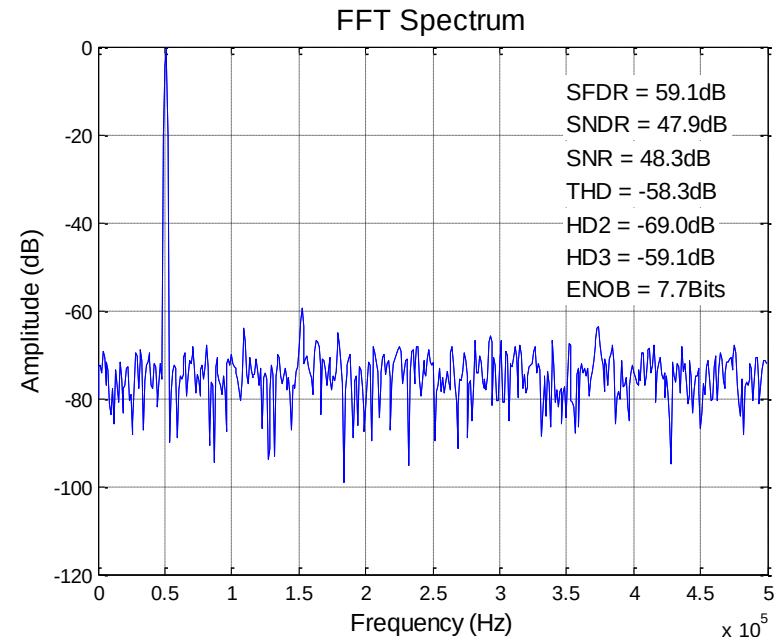
| Measured Item | TT Sample     | SS Sample  | FF Sample     |
|---------------|---------------|------------|---------------|
| HD2           | -69.0         | -65.8      | -66.6         |
| HD3           | -59.1         | -61.4      | -60.9         |
| THD           | -58.3         | -58.4      | -58.4         |
| SFDR          | 59.1          | 61.4       | 60.9          |
| SNR           | 48.3          | 48.2       | 48.4          |
| SNDR          | 47.9          | 47.8       | 48.0          |
| ENOB          | 7.7           | 7.7        | 7.7           |
| DNL           | -0.17 / +0.13 | -0.2/+0.12 | -0.17 / +0.12 |
| INL           | -0.3 / +0.2   | -0.3/+0.17 | -0.3 / +0.18  |

# Measured Spectrum: TT Sample

Output Samples



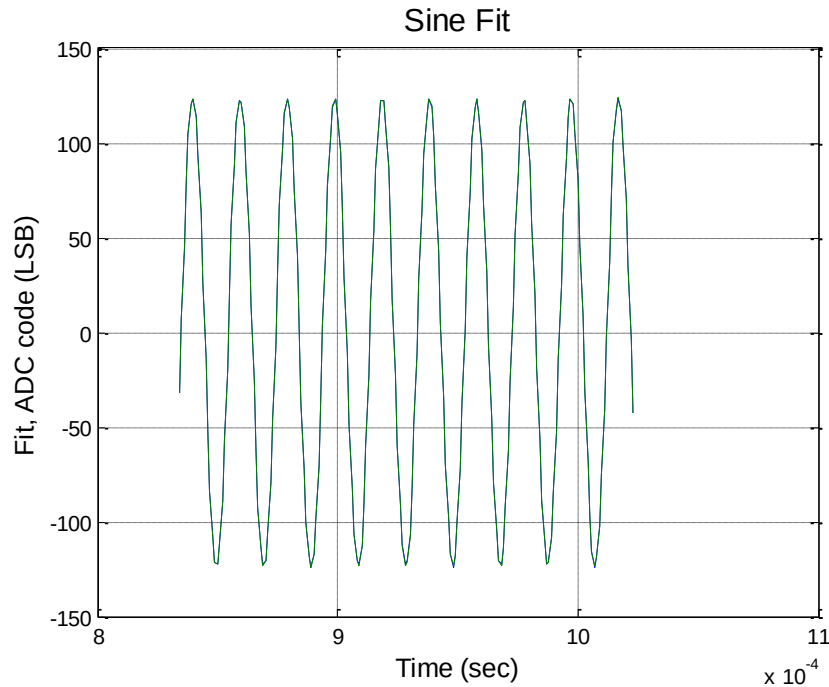
MaximFFT [blackman,1024pts]  
Signal Span=5bins, Harmonic Span=2bins



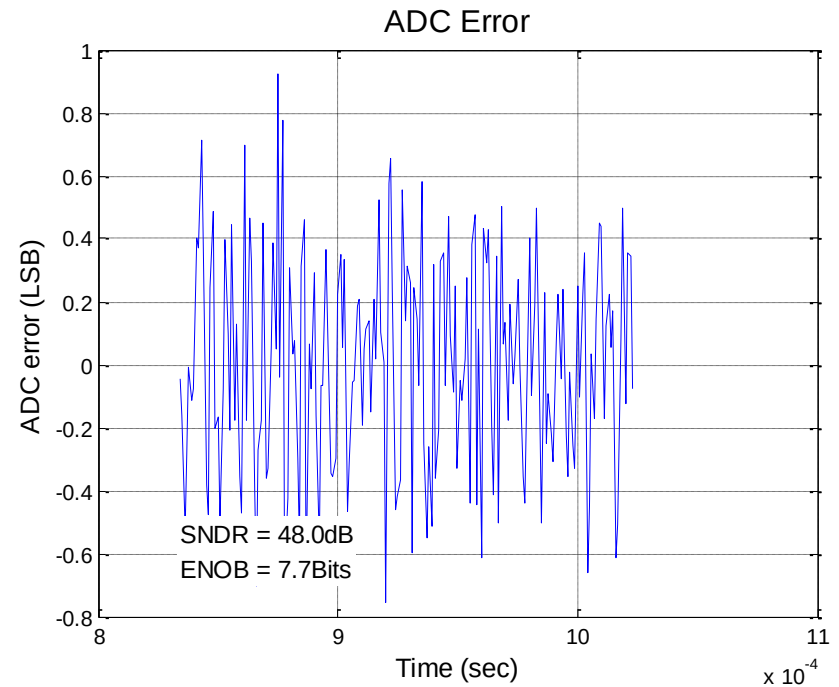
ENOB = 7.7 (blackman window)

# Measured Sine Fit: TT Sample

Sine Fit & ADC Output

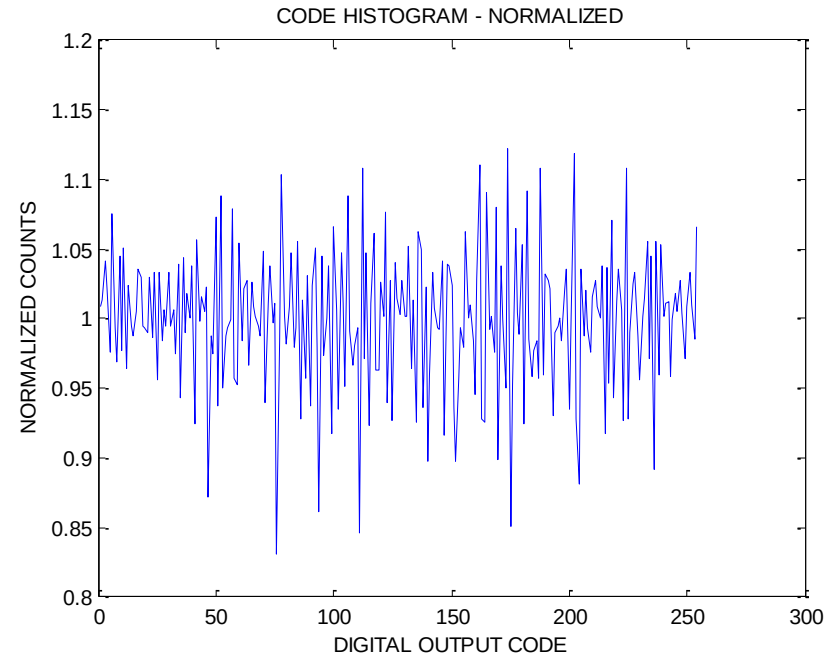
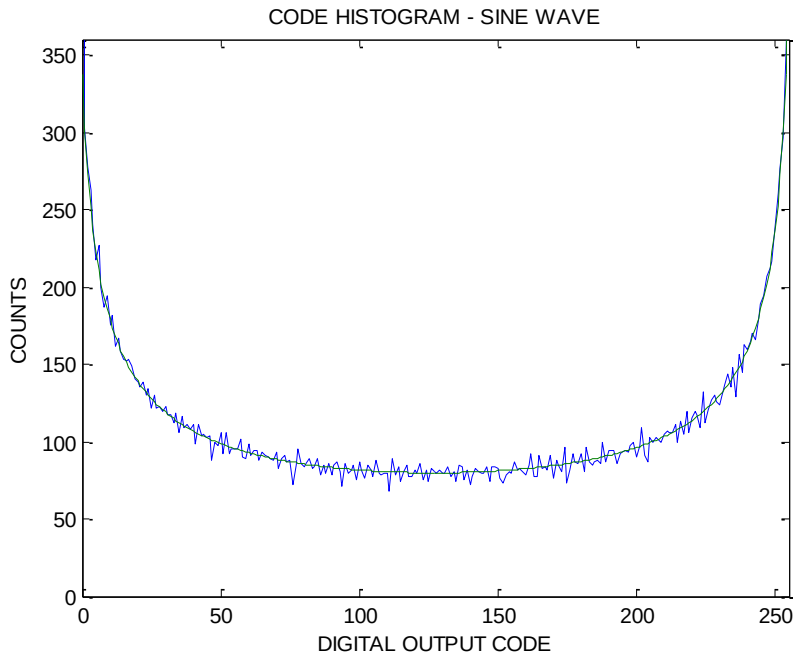


ADC Error



ENOB = 7.7 (10 sine cycles)

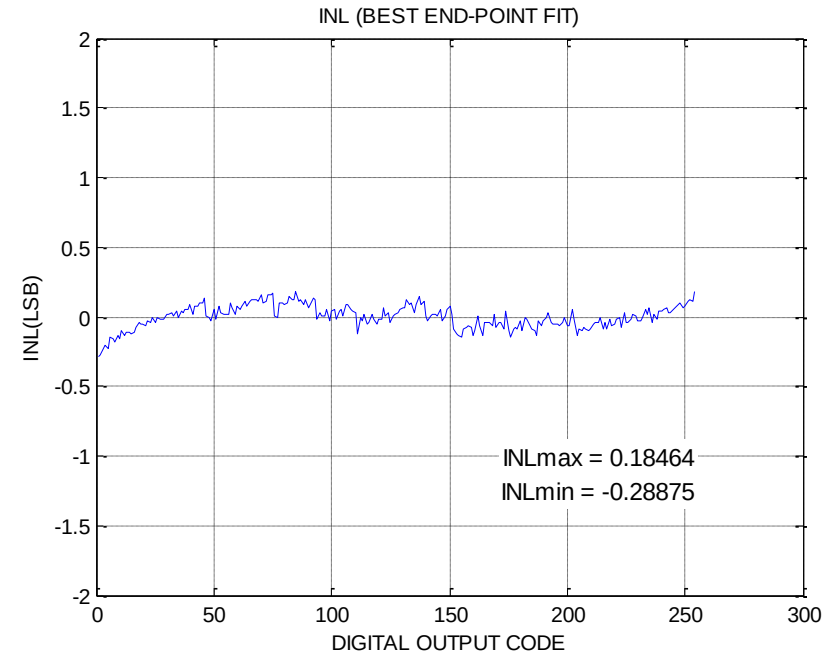
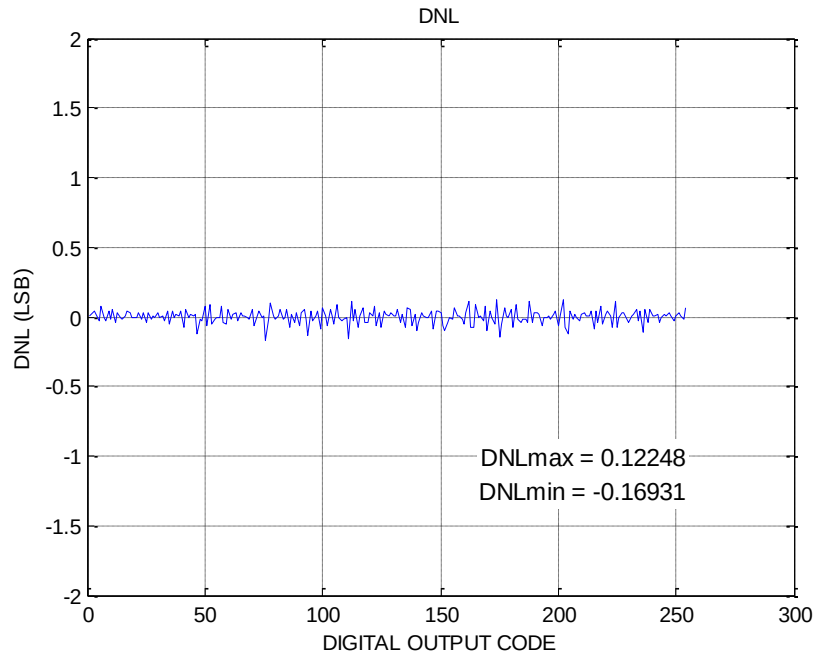
# Measured Histogram: TT Sample



Histogram shows all codes hit (no missing code)



# Measured DNL/INL: TT Sample



DNL = -0.17 / +0.13 LSB

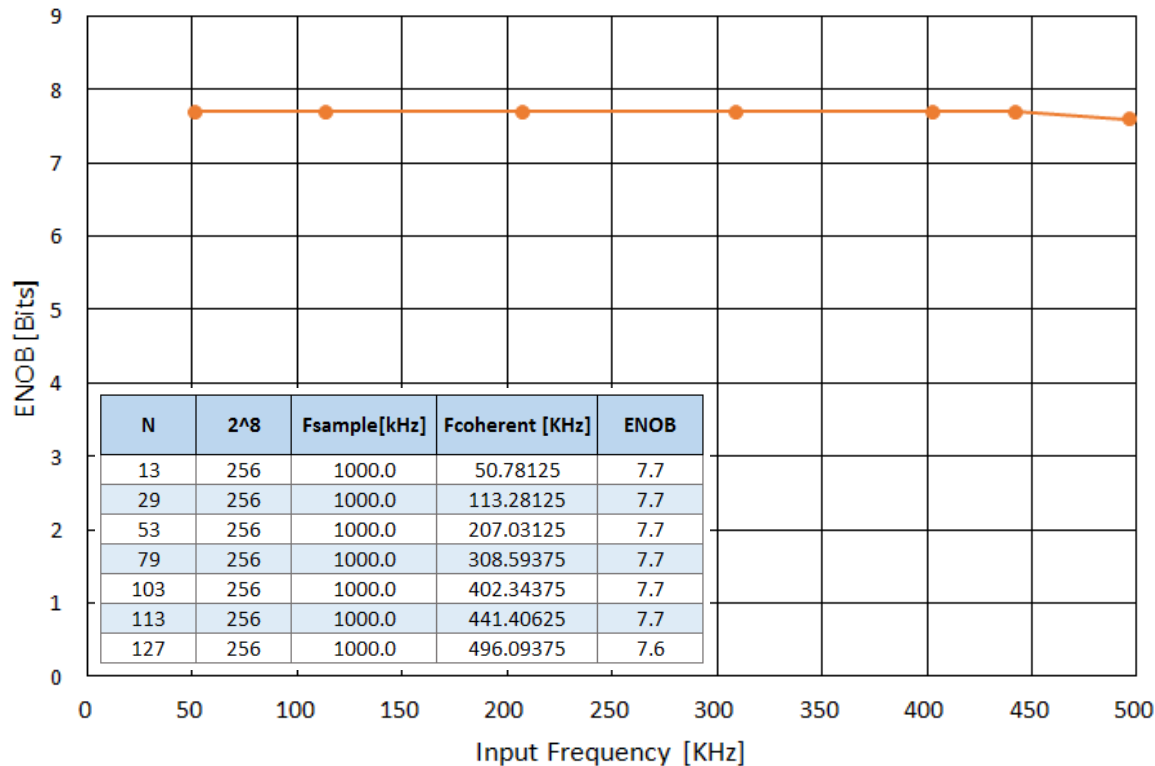
INL = -0.3 / +0.2 LSB

SFDR =  $20\log(2^N/\text{INL}) = 58.6\text{dB}$  (consistent with measured SFDR)



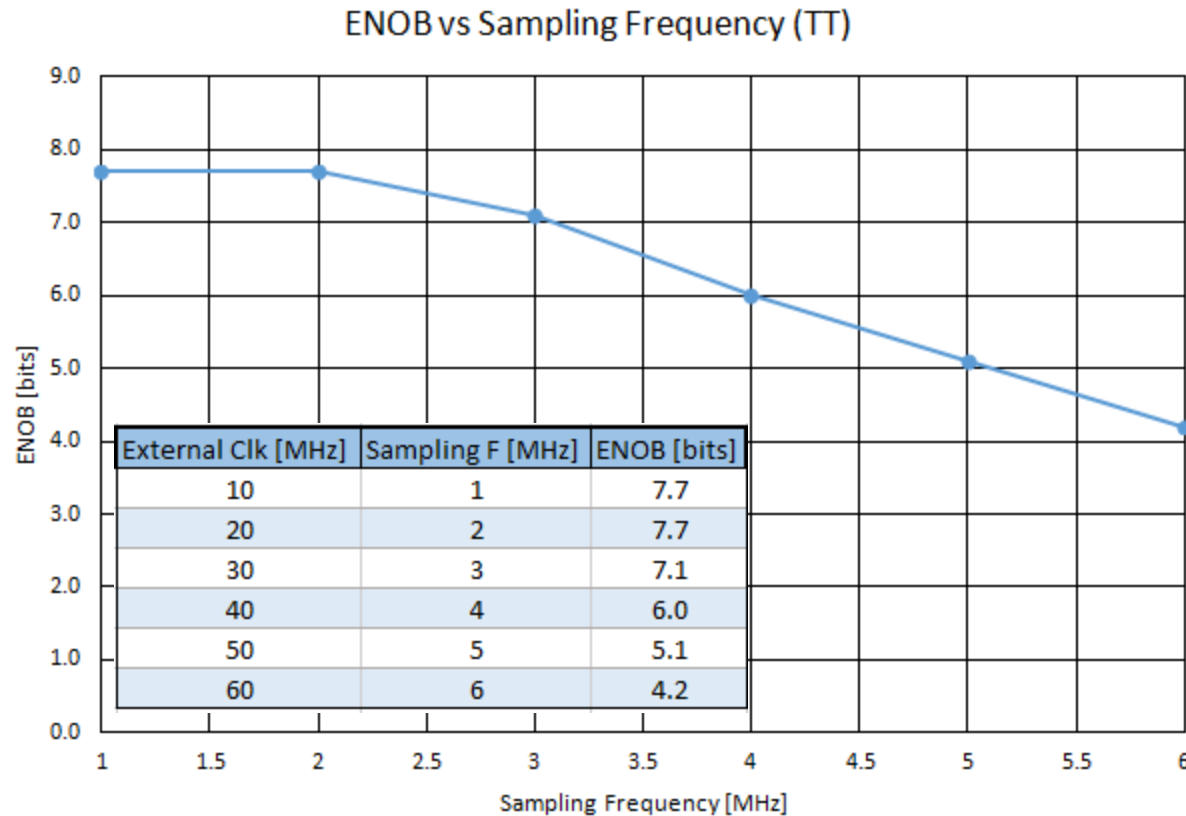
# ENOB vs Input Frequency: TT Sample

ENOB vs Input Frequency [Fs=1Msps]



No Meaningful ENOB Degradation Up To Nyquist ( $F_{in}=F_{sample}/2$ )

# ENOB vs Sampling Frequency: TT Sample



No ENOB Degradation @ 2Msps

# ENOB vs Supply & Temperature: TT

| N   | Fcoherent [KHz] |
|-----|-----------------|
| 13  | 50.78125        |
| 29  | 113.28125       |
| 53  | 207.03125       |
| 79  | 308.59375       |
| 103 | 402.34375       |
| 113 | 441.40625       |
| 127 | 496.09375       |

Input Frequency:  $(N/256) * 1\text{Mps}$

| Measurement Item                                                                           | Temperature | Vdd11_digital | Vdd18_analog | Units | TT-sample |        |        |        |         |         |         |
|--------------------------------------------------------------------------------------------|-------------|---------------|--------------|-------|-----------|--------|--------|--------|---------|---------|---------|
|                                                                                            |             |               |              |       | N = 13    | N = 29 | N = 53 | N = 79 | N = 103 | N = 113 | N = 127 |
| <b>ENOB vs Fin</b><br><i>Fsample = 1MHz</i><br><i>Vin = 1.45Vpps</i><br><i>Fin = sweep</i> | 25C         | 0.99V         | 1.62V        | bit   | 7.7       | 7.7    | 7.7    | 7.6    | 7.6     | 7.6     | 7.7     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.7     | 7.7     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.7     | 7.6     |
|                                                                                            | -40C        | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.7     | 7.6     | 7.6     |
|                                                                                            | +85C        | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.7     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.7     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.6       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            | +105C       | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.6    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            | +125C       | 0.99V         | 1.62V        |       | 7.6       | 7.6    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.6    | 7.6    | 7.6    | 7.6     | 7.6     | 7.5     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |

**TT Sample** measurements over supply & temperature show no meaningful ENOB degradation for input frequencies up to  $F_{\text{sample}}/2$

# ENOB vs Supply & Temperature: FF

| N   | Fcoherent [KHz] |
|-----|-----------------|
| 13  | 50.78125        |
| 29  | 113.28125       |
| 53  | 207.03125       |
| 79  | 308.59375       |
| 103 | 402.34375       |
| 113 | 441.40625       |
| 127 | 496.09375       |

Input Frequency:  $(N/256) * 1\text{Mps}$

| Measurement Item                                                                           | Temperature | Vdd11_digital | Vdd18_analog | Units | FF-sample |        |        |        |         |         |         |
|--------------------------------------------------------------------------------------------|-------------|---------------|--------------|-------|-----------|--------|--------|--------|---------|---------|---------|
|                                                                                            |             |               |              |       | N = 13    | N = 29 | N = 53 | N = 79 | N = 103 | N = 113 | N = 127 |
| <b>ENOB vs Fin</b><br><i>Fsample = 1MHz</i><br><i>Vin = 1.45Vpps</i><br><i>Fin = sweep</i> | 25C         | 0.99V         | 1.62V        | bit   | 7.7       | 7.7    | 7.7    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.7     | 7.6     | 7.7     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.7     | 7.7     | 7.7     |
|                                                                                            | -40C        | 0.99V         | 1.62V        |       | 7.8       | 7.7    | 7.7    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.7     | 7.7     | 7.7     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.7     | 7.7     | 7.6     |
|                                                                                            | +85C        | 0.99V         | 1.62V        |       | 7.6       | 7.7    | 7.6    | 7.7    | 7.6     | 7.7     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.6    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.7     | 7.7     |
|                                                                                            | +105C       | 0.99V         | 1.62V        |       | 7.6       | 7.7    | 7.6    | 7.6    | 7.6     | 7.7     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            | +125C       | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.6       | 7.7    | 7.6    | 7.6    | 7.6     | 7.6     | 7.5     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.6       | 7.7    | 7.6    | 7.5    | 7.6     | 7.6     | 7.5     |

**FF Sample** measurements over supply & temperature show no meaningful ENOB degradation for input frequencies up to  $F_{\text{sample}}/2$

# ENOB vs Supply & Temperature: SS

| N   | Fcoherent [KHz] |
|-----|-----------------|
| 13  | 50.78125        |
| 29  | 113.28125       |
| 53  | 207.03125       |
| 79  | 308.59375       |
| 103 | 402.34375       |
| 113 | 441.40625       |
| 127 | 496.09375       |

Input Frequency:  $(N/256) * 1\text{Msp}$ s

| Measurement Item                                                                           | Temperature | Vdd11_digital | Vdd18_analog | Units | SS-sample |        |        |        |         |         |         |
|--------------------------------------------------------------------------------------------|-------------|---------------|--------------|-------|-----------|--------|--------|--------|---------|---------|---------|
|                                                                                            |             |               |              |       | N = 13    | N = 29 | N = 53 | N = 79 | N = 103 | N = 113 | N = 127 |
| <b>ENOB vs Fin</b><br><i>Fsample = 1MHz</i><br><i>Vin = 1.45Vpps</i><br><i>Fin = sweep</i> | 25C         | 0.99V         | 1.62V        | bit   | 7.8       | 7.7    | 7.7    | 7.6    | 7.7     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.6    | 7.6    | 7.6     | 7.7     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.6     | 7.6     | 7.7     |
|                                                                                            | -40C        | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.6     | 7.7     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.8       | 7.7    | 7.7    | 7.6    | 7.6     | 7.6     | 7.7     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.8       | 7.7    | 7.7    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            | +85C        | 0.99V         | 1.62V        |       | 7.8       | 7.7    | 7.7    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.6     | 7.7     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.8       | 7.7    | 7.7    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            | +105C       | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.7     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.7    | 7.7    | 7.7     | 7.6     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.7    | 7.7    | 7.6    | 7.6     | 7.7     | 7.7     |
|                                                                                            | +125C       | 0.99V         | 1.62V        |       | 7.7       | 7.7    | 7.6    | 7.5    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.1V          | 1.8V         |       | 7.7       | 7.7    | 7.6    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            |             | 1.2V          | 2.0V         |       | 7.7       | 7.6    | 7.7    | 7.7    | 7.6     | 7.6     | 7.6     |
|                                                                                            | +150C       | 0.99V         | 1.62V        |       | 7.6       | 7.5    | 7.5    | 7.5    | 7.5     | 7.6     | 7.5     |

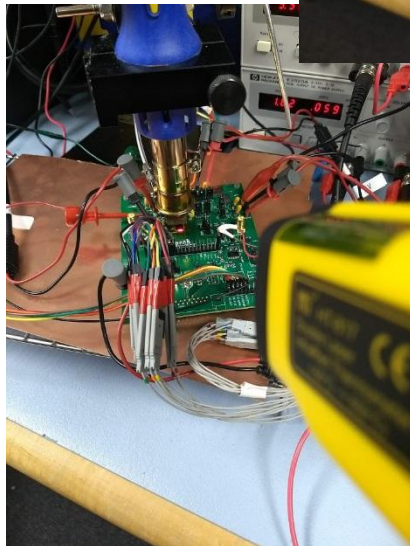
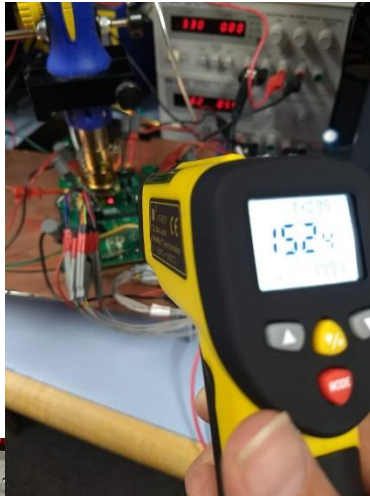
**SS Sample** measurements over supply & temperature show no meaningful ENOB degradation for input frequencies up to  $F_{\text{sample}}/2$

Note: -40C to 125C evaluation done in temperature chamber. 150C measurement done with heating up only the chip.

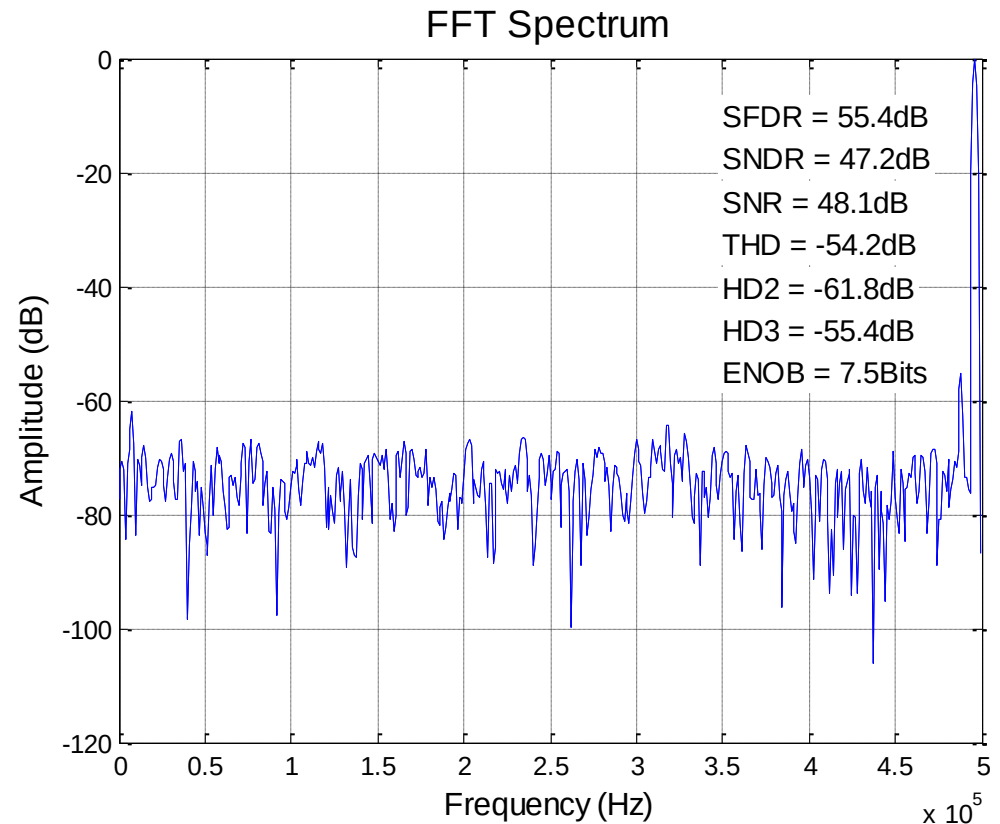
# Evaluation @ 150C: Worst Case

## SS/150C/0.99V/1.62V, $F_{in} = 496.09375\text{kHz}$

- (1) Chip heated up with Hakko hot air flow.
- (2) Chip temperature measured with dual laser infrared thermometer



MaximFFT [blackman,1024pts]  
Signal Span=5bins, Harmonic Span=2bins





# Thank you!



**epoch**  
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