# ADI助力半导体自动测试设备—ATE产品介绍

蔡振宇/黄健杰

# 主要内容

- **ATE设备市场**
- ADI ATE ASSP 产品介绍
- ATE产品基础应用介绍
- 参考设计方案

# ATE 测试分类及测试应用

SoC / 非存储器产品

## 数字芯片

- GPU
- CPU
- DSP
- Logic IC
- MIPI interfaces
- Video IC
- PCI
- High Speed Interface

## 混合信号

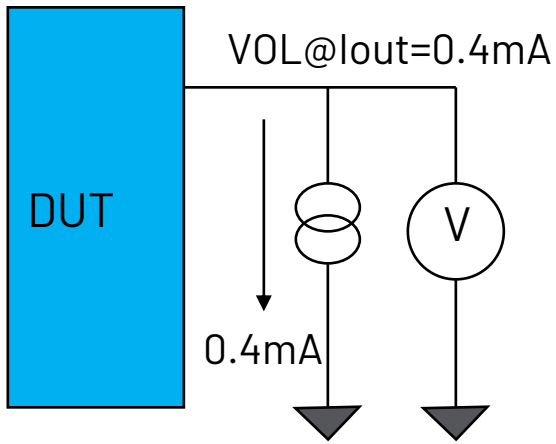
- Data converter
- IoT IC
- Power
- RF parts
- LCD / OLED driver
- Automotive IC
- SoC
- IGBT

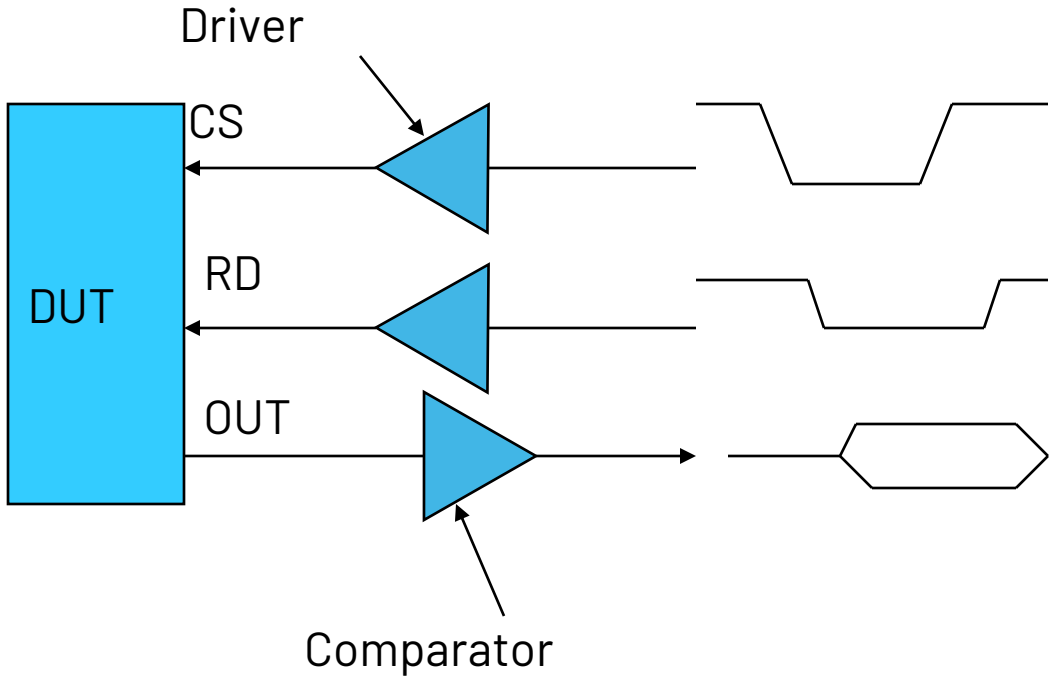
## 存储器

- DRAM / DDR
- SRAM
- EEPROM
- NAND/NOR Flash

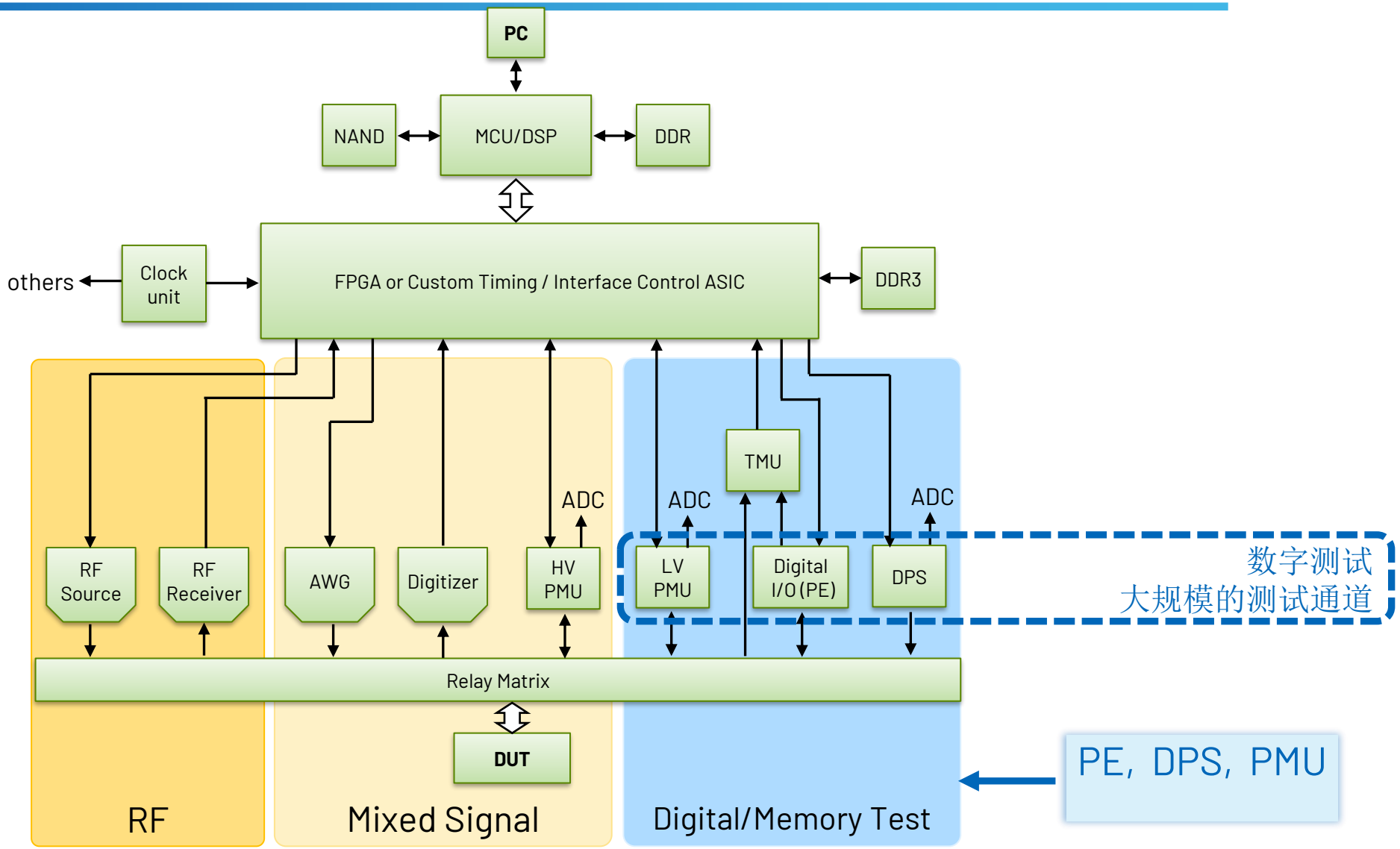
# ATE关于数字IO测试例子

- **功能测试：** 开路，短路
- **直流参数测试：** $V_{OH}$，$V_{OL}$，$I_{IH}$，$I_{IL}$，电源电压/电流
- **交流功能测试：** 读/写时序，真值表，建立时间/保持时间等



# ATE系统



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# PE vs PMU vs DPS

## 通常用于ATE术语

**PE （Pin electronic）**

- 用于产生和接收DUT的数字信号
  - 高时域精度
- 工作频率高
  - 10MHz–X GHz
- 每个测试机的通道多
  - 集成度高

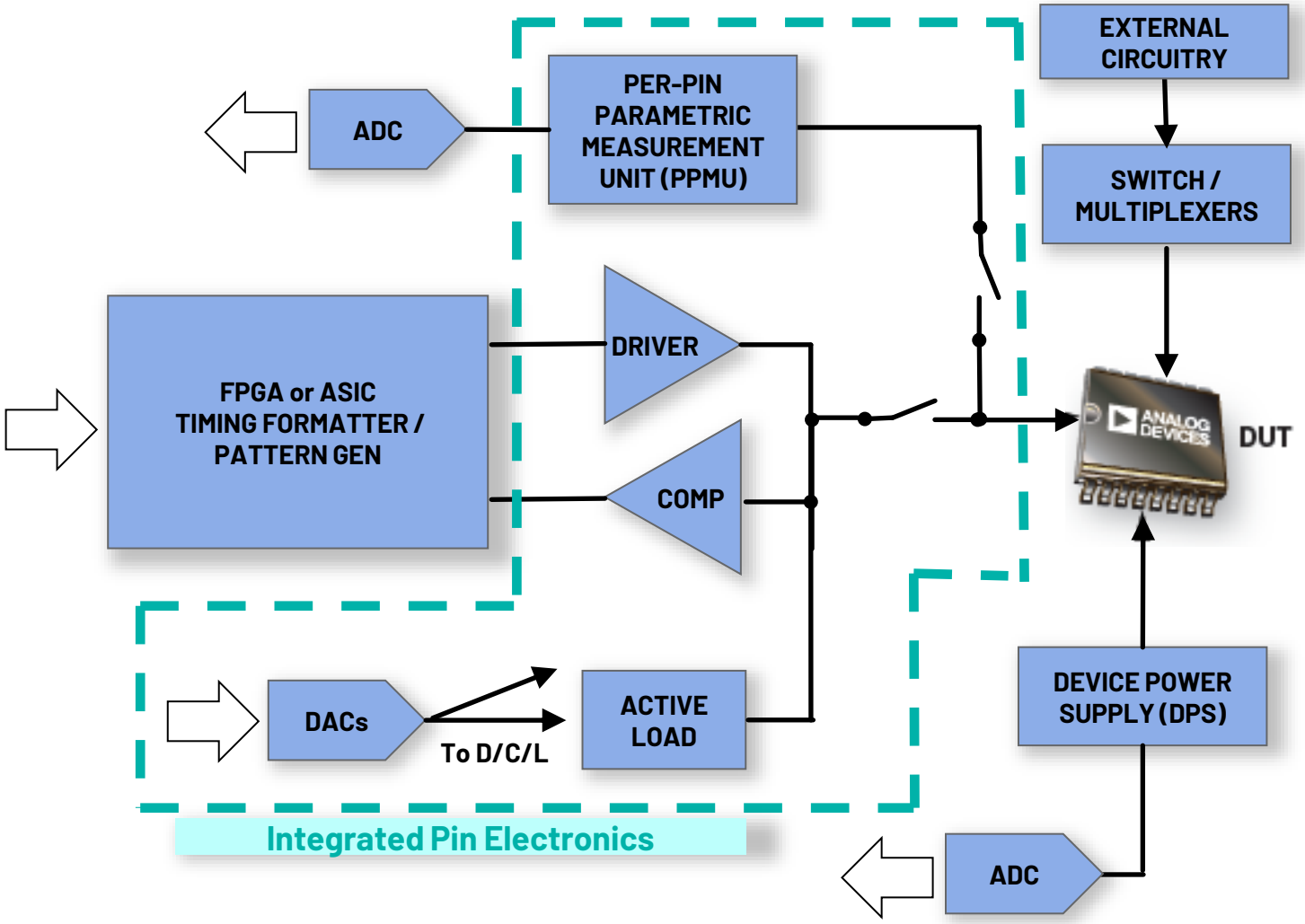
**PMU (Parametric Measurement Unit)**

- 用于输出和测量电压和电流
- 需要较高的测力和测量精度
- 电流范围高达100 mA
- 电压范围高达25V

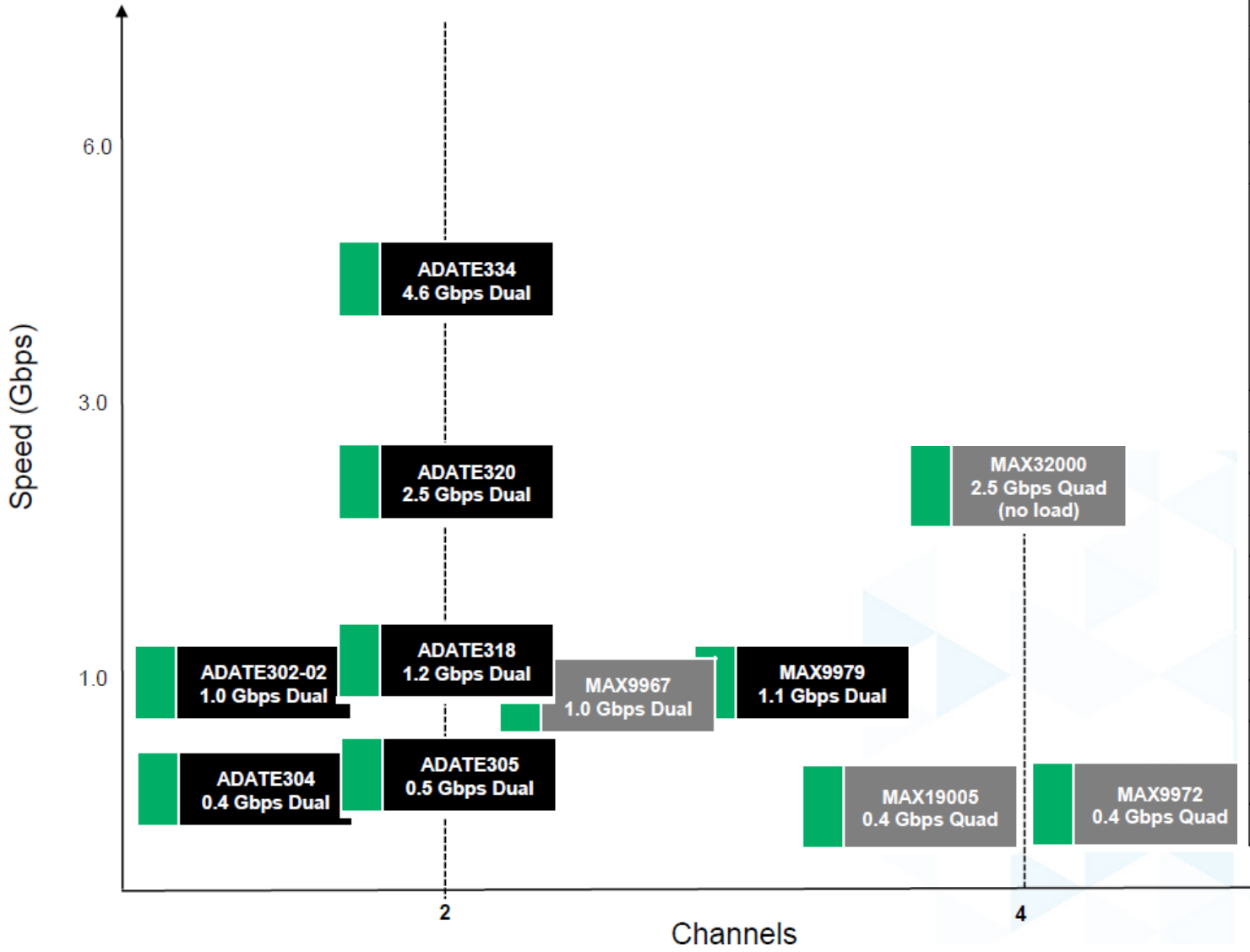
**DPS （Device Power Supply）**

- 对DUT（待测物）提供可编程的电源
- 电压输出，测量电流
- 需要良好的测量精度
- 电流范围： A级别
- 电压范围：25V
- 更高的电流
- 稳定地驱动更高的电容负载

# 数字 I/O 信号链



# PE roadmap




| ● = Include<br>o = Not Included | | Production | |
|---|---|---|---|
| | | ADATE318 | ADATE320 |
| Channels | | 2 | 2 |
| Speed (Gbps) - max | | 1.2 | 2.5 |
| Speed (Gbps) - min | | 0 | 0 |
| Driver | V range (unterm) | -1.5V to 6.5V | -1.5V to 4.5V |
| | Vswing max (unterm) | 8V | 6V |
| | Differential Drive | ● | ● |
| | Tri Level | ● | ● |
| | Hi Z | ● | ● |
| VHH pin | | 13.5V / device | o |
| Deskew | | o | o |
| Window Comparator | | ● | ● |
| Differential Comparator | | ● | ● |
| Cable Compensation (CLC) | | ● | ● |
| Active Load | | 25mA | 25mA |
| PMU | | 60mA | 40mA |
| Clamps | | ● | ● |
| Power / ch | | 1.1W | 1.2W |
| Level Setting DACs | | 16B | 16B |
| Package (mm) | | 10x10 LFCSP | 10x10 LFCSP |

# ADATE3xx 框图及参数

**PPMU**
- 50mA high current range
- 2uA low current range
- FvMi, FiMv

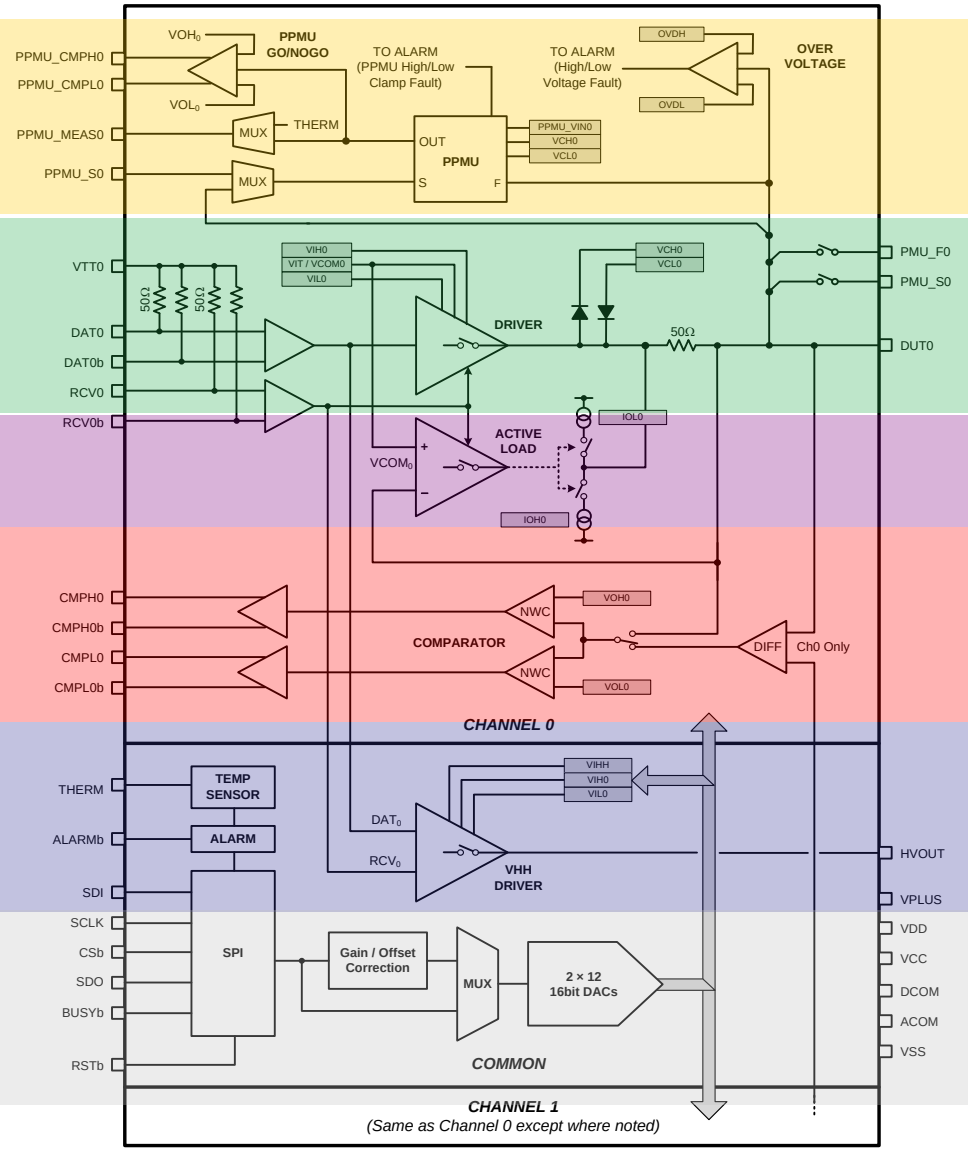
**PIN DRIVER**
- ~ 3Gbit/sec toggle rate
- - 2V to + 6V output range
- 50ps edge placement accuracy

**ACTIVE LOAD**
- 100uA to 25mA range
- High speed switching

**COMPARATORS**
- 1.2Ghz bandwidth
- SE and DIFF operation
- 50ps edge timing accuracy

**High Voltage Driver**
- 200ns rise time
- 0 to 14V output range
- 60mA current limit

**DACs and Digital**
- 16bit 500uV INL
- 0 to 5V output range
- Gain / Offset calibration
- Six pin SPI

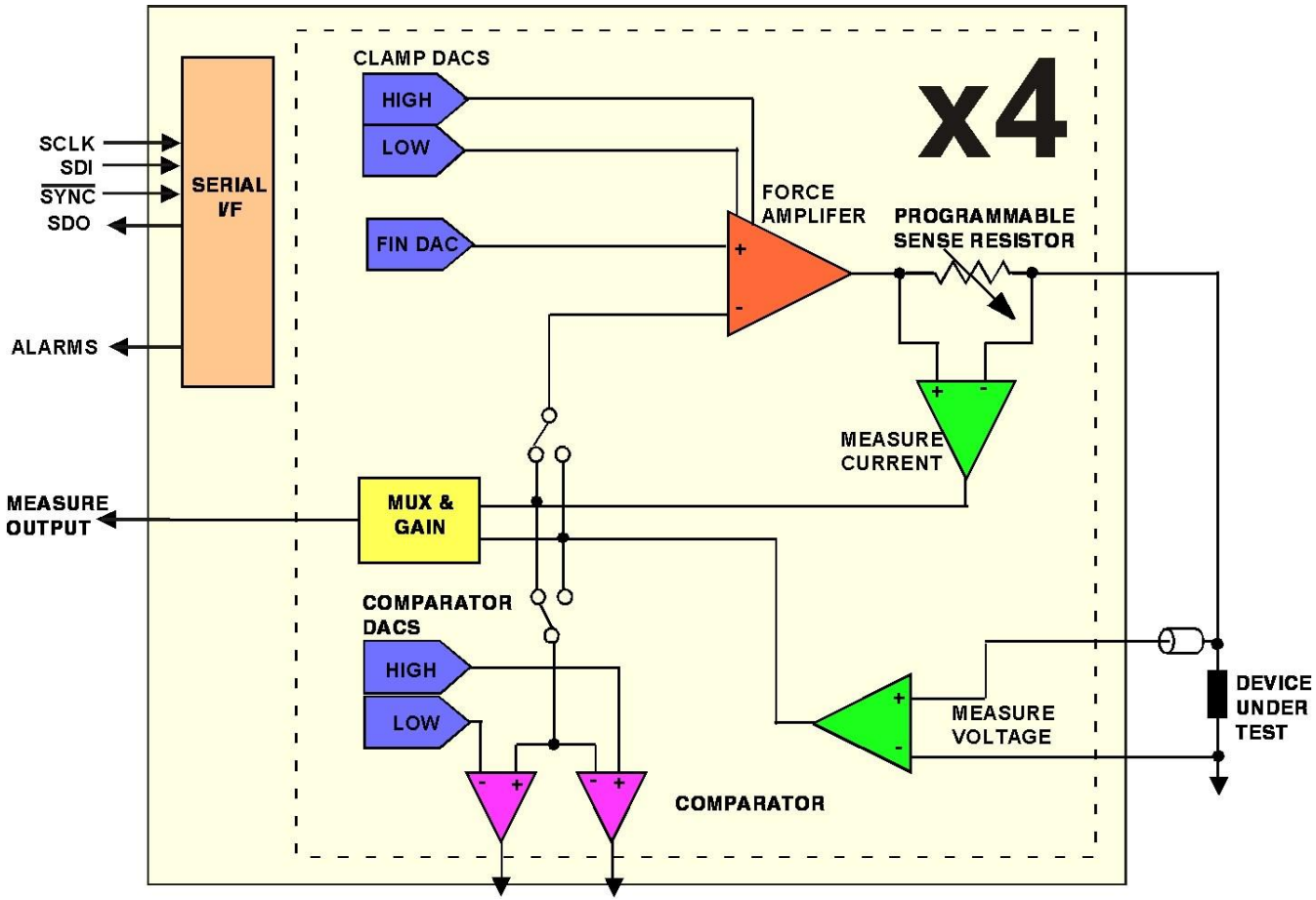



**2 to 8 channels per device**

# DSP/PMU road map

# AD5522(PMU)框图

- **四通道PMU-4个独立通道**
  - 电压或电流
  - 满量程电流范围5uA至80mA
  - 满量程电压范围为-16.25V至+ 22.5V
- **集成测量电压和电流的仪表放大器**
- 比较器，用于比较V或I
- **钳位电路在输出电流模式下限制电压**
- 每个通道5个DAC，总共20个DAC
  - 1用于设置输出电压或电流
  - 2个用于高/低压钳位
  - 2个用于高/低比较器
  - 用户针对增益和失调进行校准



# AD5560(DPS)框图

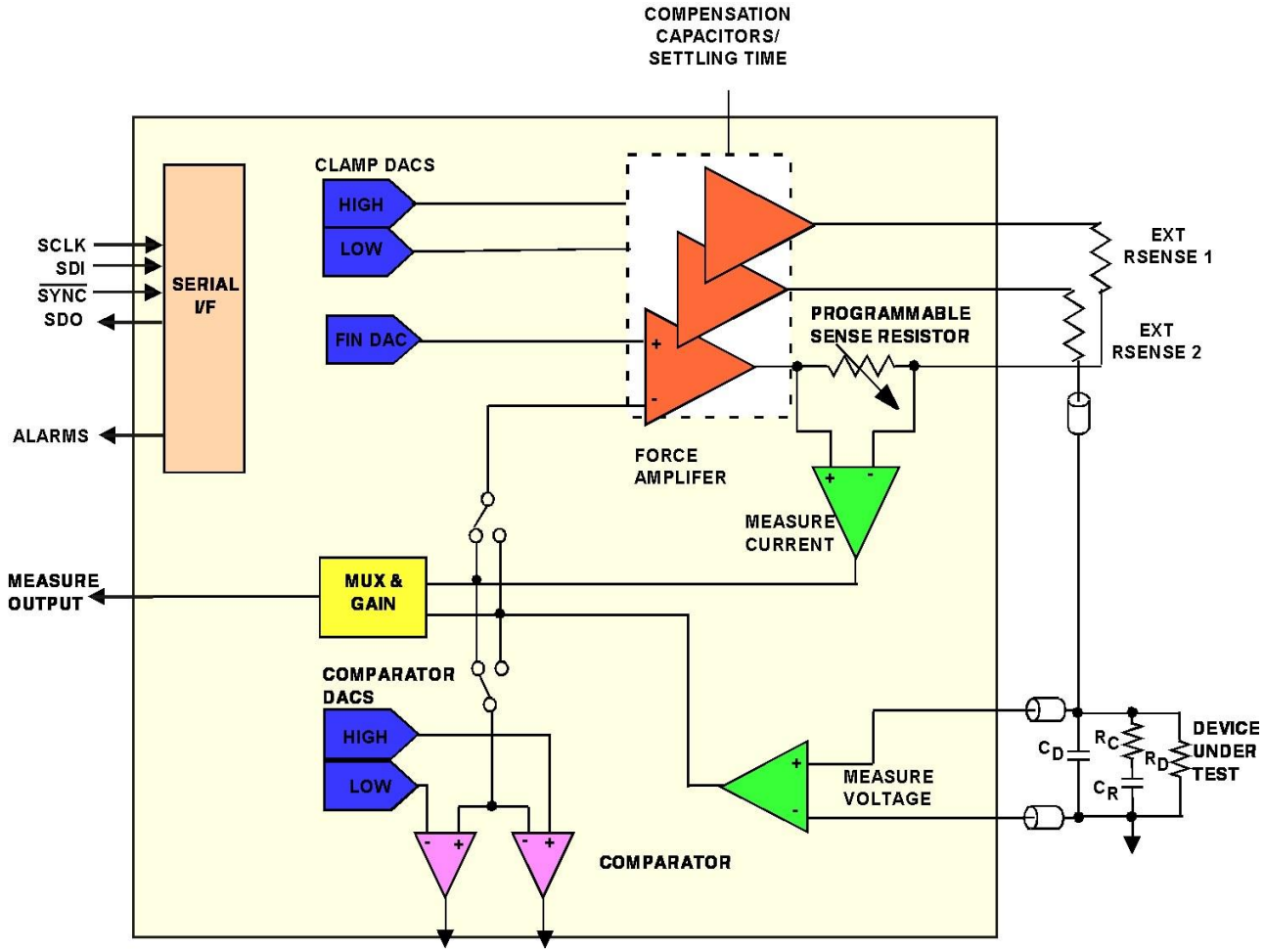
- 高集成度并可提供精确的电压

  - **FV/MI 功能**
    - 输出电压跨度：25V, 可扩展+可偏置
    - 5 档电流范围：
      - 5 uA, 25uA, 250uA, 2.5mA, 25mA (Rsense on-chip)
    - 2 档高电丁输出
      - 500mA and 1.2A max (Rsense off-chip)

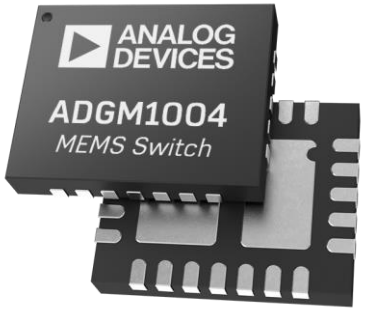
  - **测量电压功能**
    - 用于测量待测物电压

  - **片上偏置及增益校准**

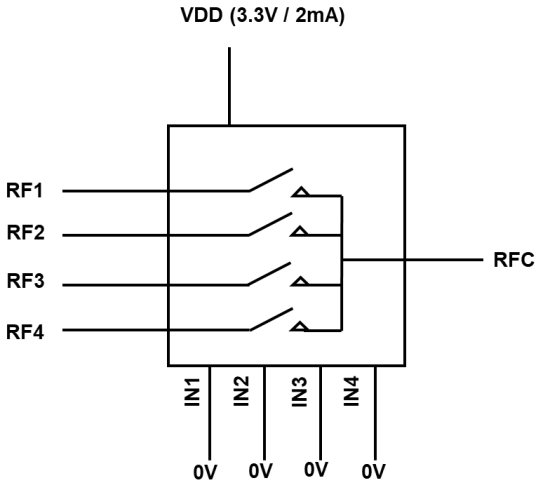
  - **工作模式**
    - 输出电压/测量电流
    - 支持并联输出



# ADI's MEMS Switch 技术




***ADGM1004***
***0 Hz/DC to 13 GHz, SP4T***
***2.5 kV HBM ESD***




**DC + Wide Bandwidth**
**20x Smaller SP4T**
**Relay Replacement**


## 在 ATE 中使用 MEMS 开关的好处

| 特点 | Benefits |
|---|---|
| 可用范围 DC 至13GHz高频 | 通过单程测试提高测试效率 |
| SP4T 更小封装尺寸(5x4x0.95mm) | 增加每个测试板的 DUT 和测试功能 |
| 10 亿次循环寿命 | 提高系统可靠性 |
| 3.3V易于使用的电源 | 简化解决方案实施 |

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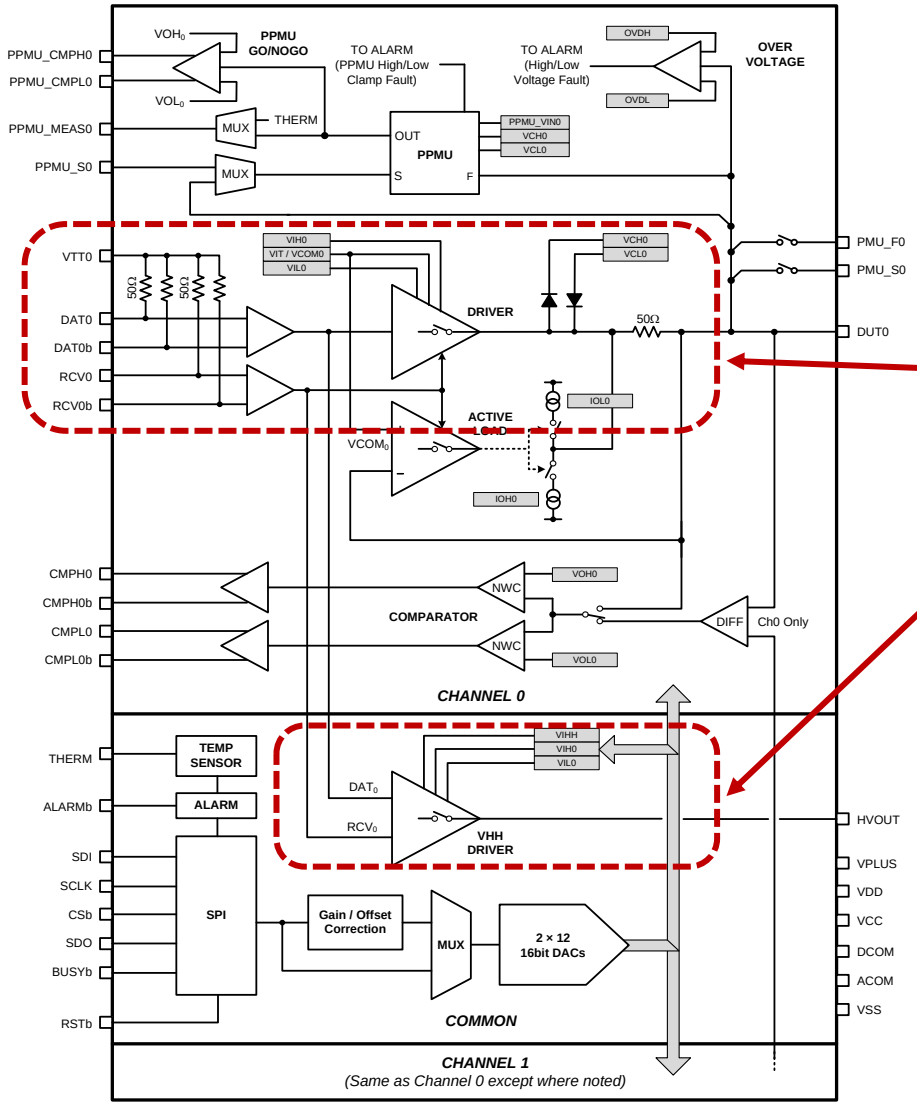
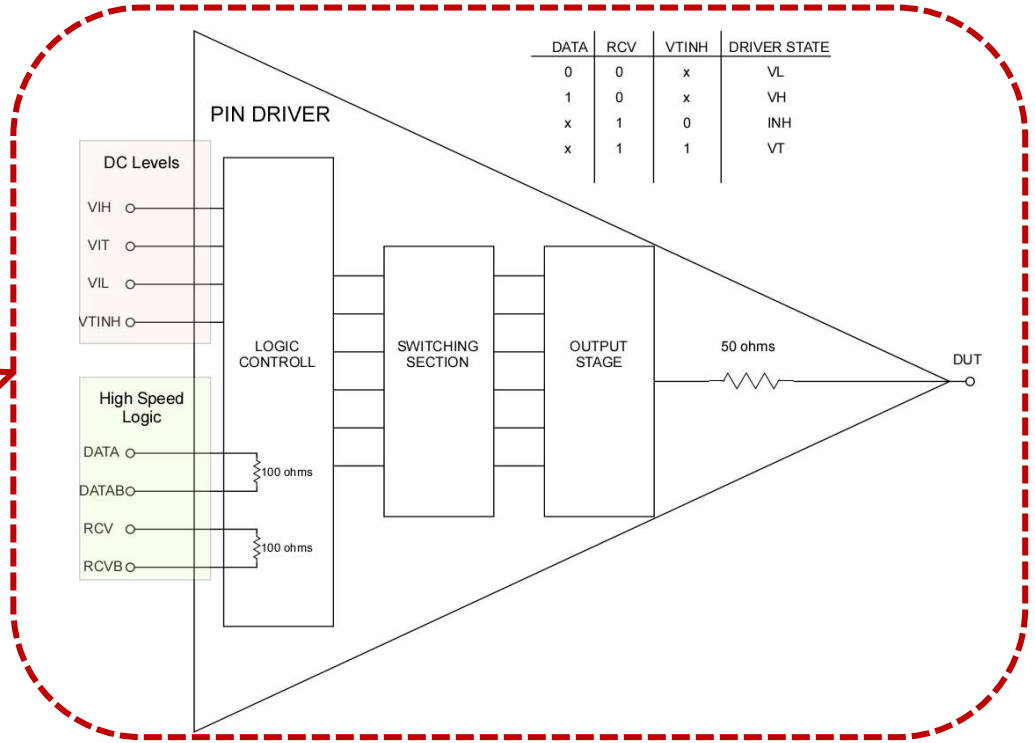
# 数字pattern发生器--- ADATE320 Driver



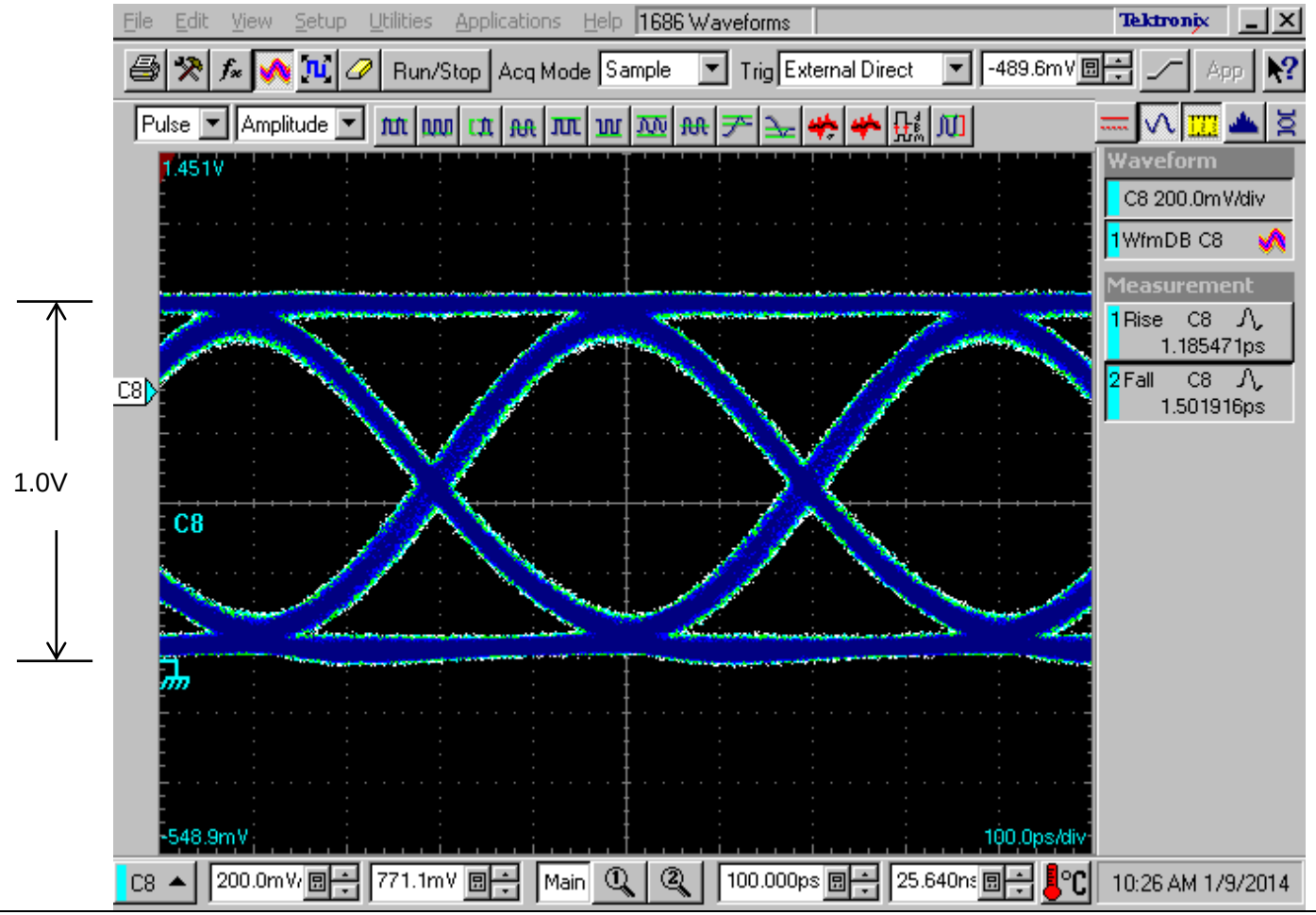




## Function of Driver

- Output Level Setting
- High Analog Performance
- Clamp function

# 数字pattern发生器--- ADATE320 Driver Eye Diagram

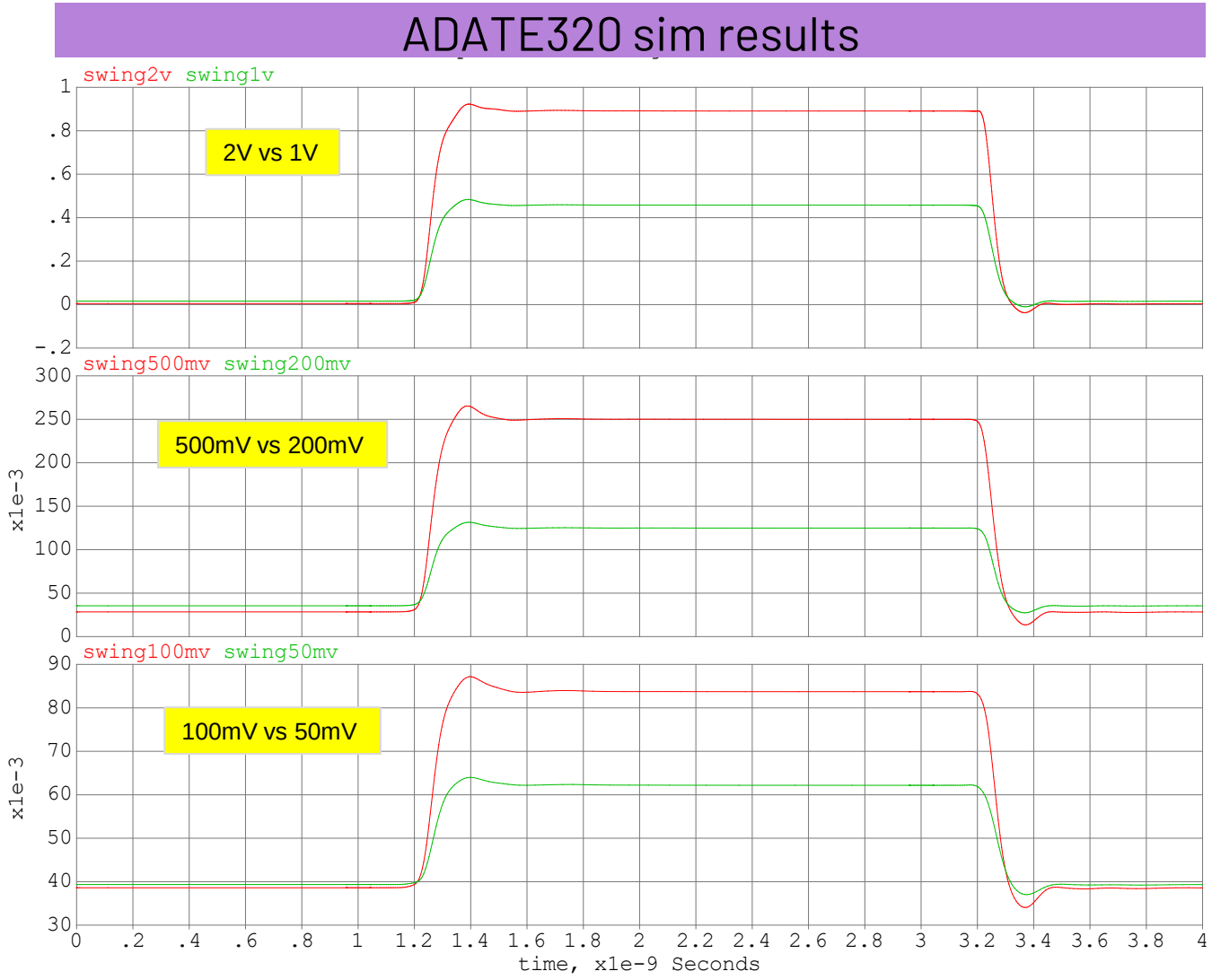
**Driver Eye Diagram 2.5Gbps PRBS $2^{31}$–1, 2.0V prog**




## Driver Eye Diagram

- Clear eye: Good jitter performance
- Good SI: No special overshoot and distortion.

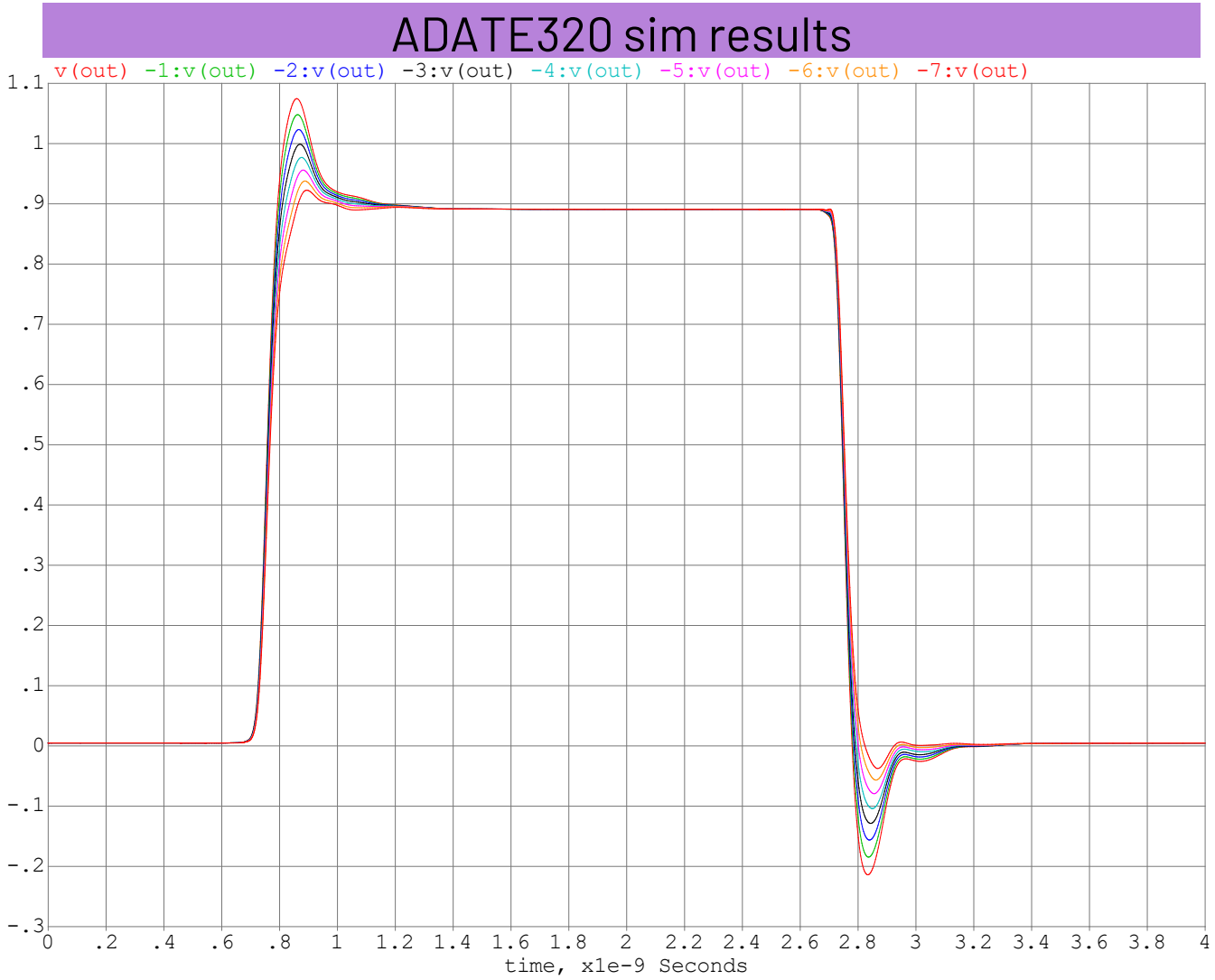
# 数字pattern发生器--- ADATE320 Rise/Fall Edge




Function of Rise/Fall Edge

- Fidelity : Keep same performance at different Amplitude output.
- Don’t concern about rise/fall time change at different situation.

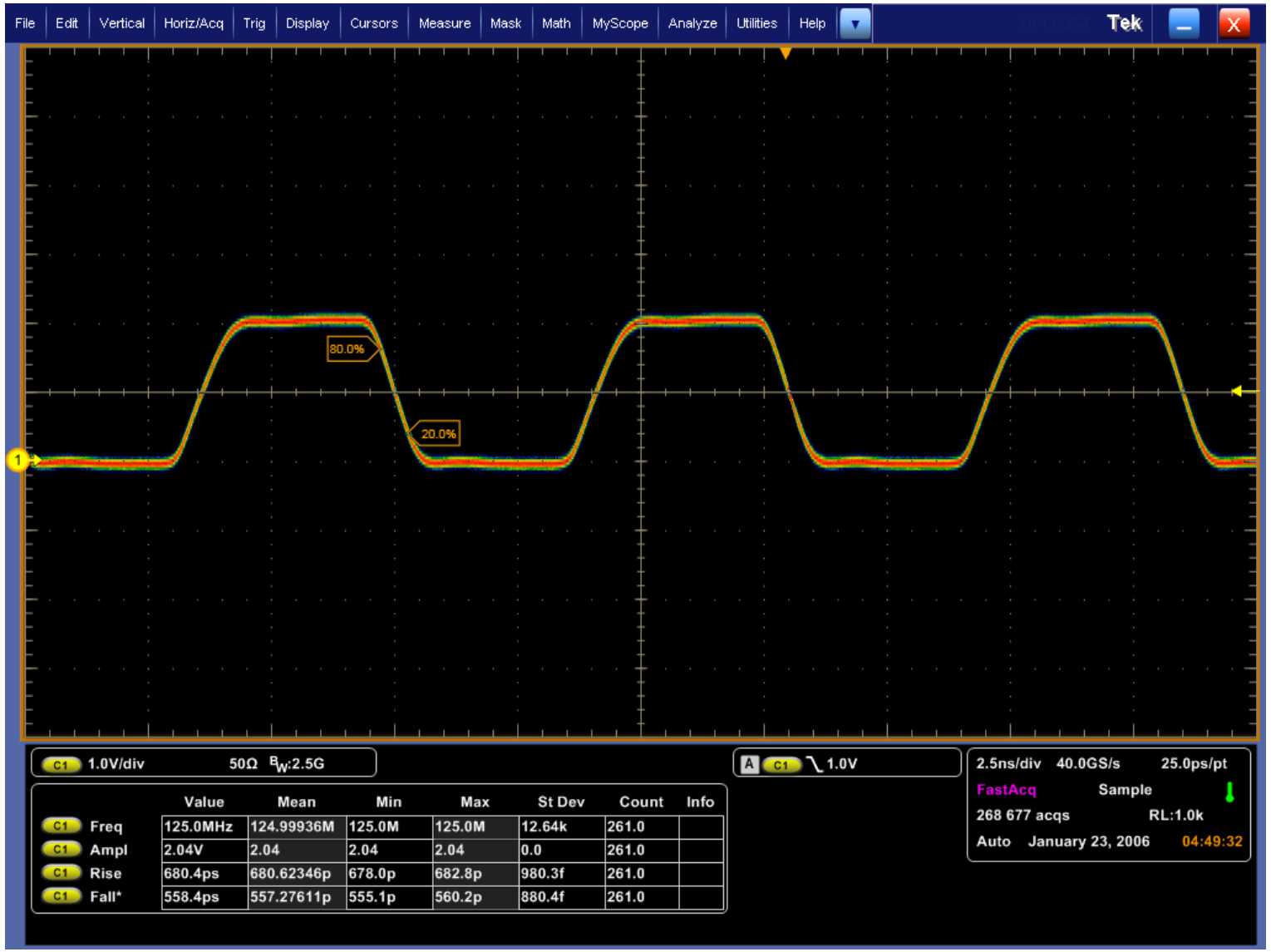
# 数字pattern发生器--- Pre-Emphasis（CLC）




Function of Driver CLC

- Cable loss compensation
- SI adjustment
- Balance overshoot and rise/fall time

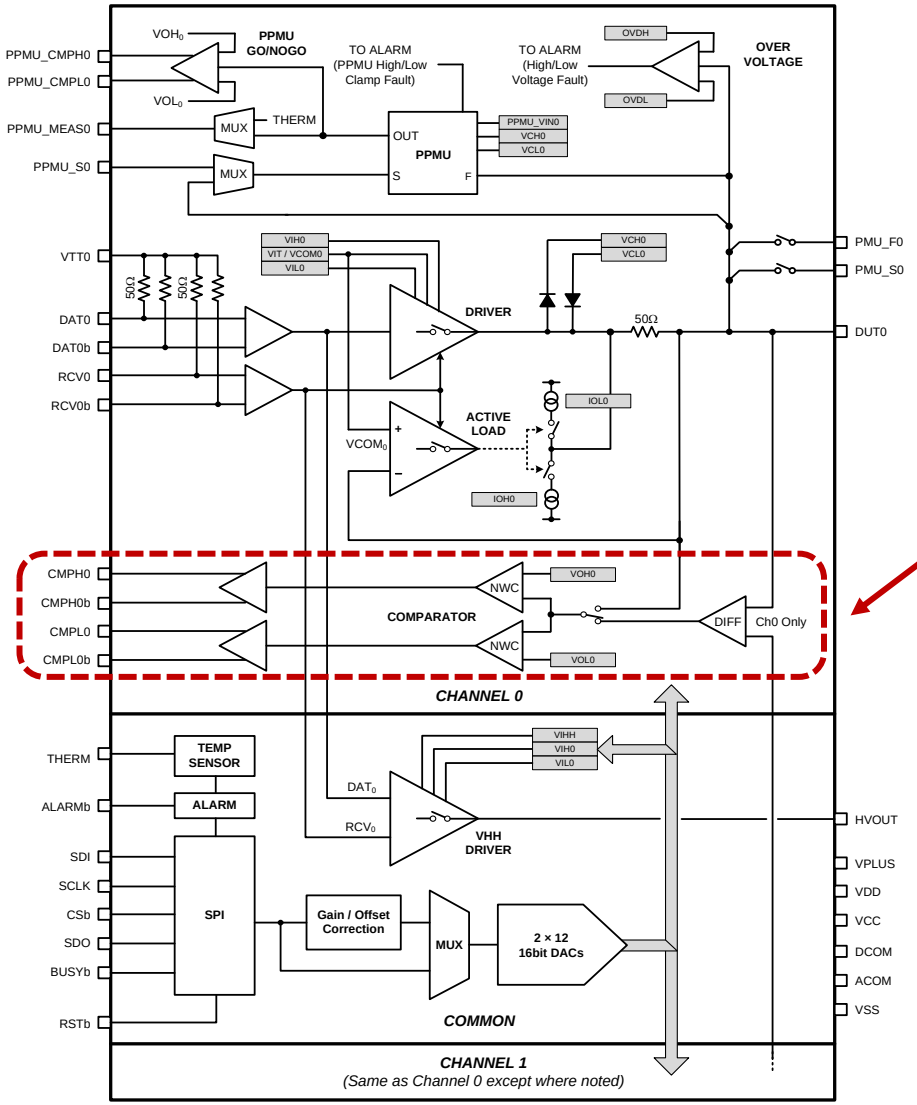
# ADATE318 LV Driver 测试

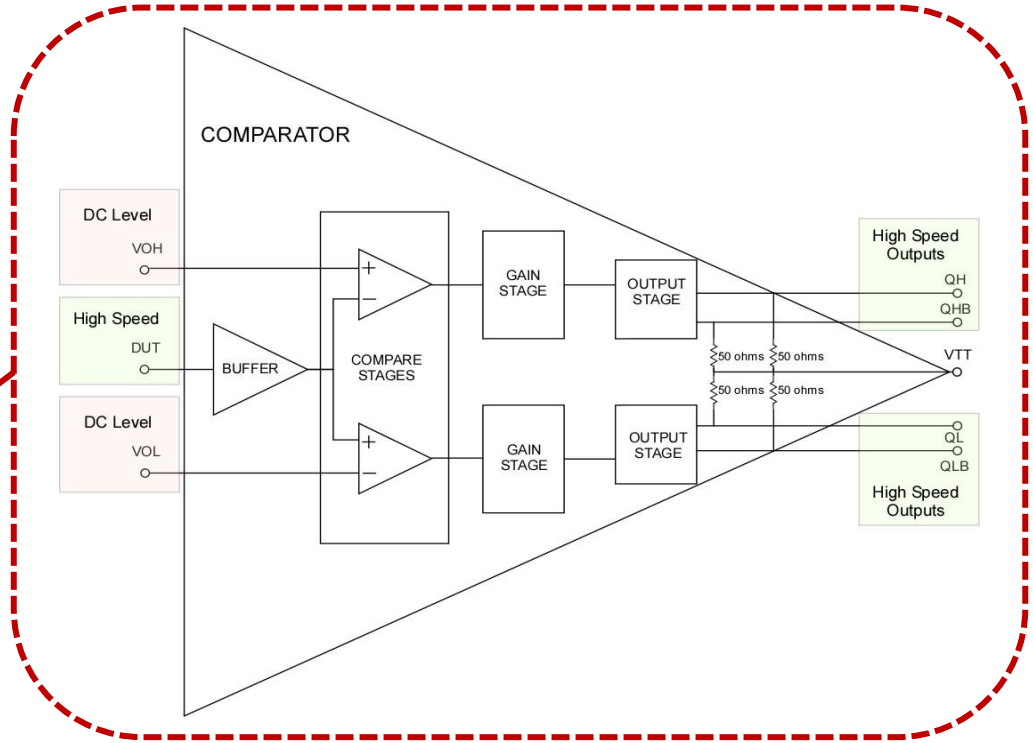



测试环境：

1. VIH：4V
2. VIL：0V
3. Frequency：125MHz
4. CLC: off
5. Load: 50ohm
6. Scope: 2.5G BW
7. Cable：RG316 1m
8. RLC Band stop filter：added

# ADATE3xx --- 比较器

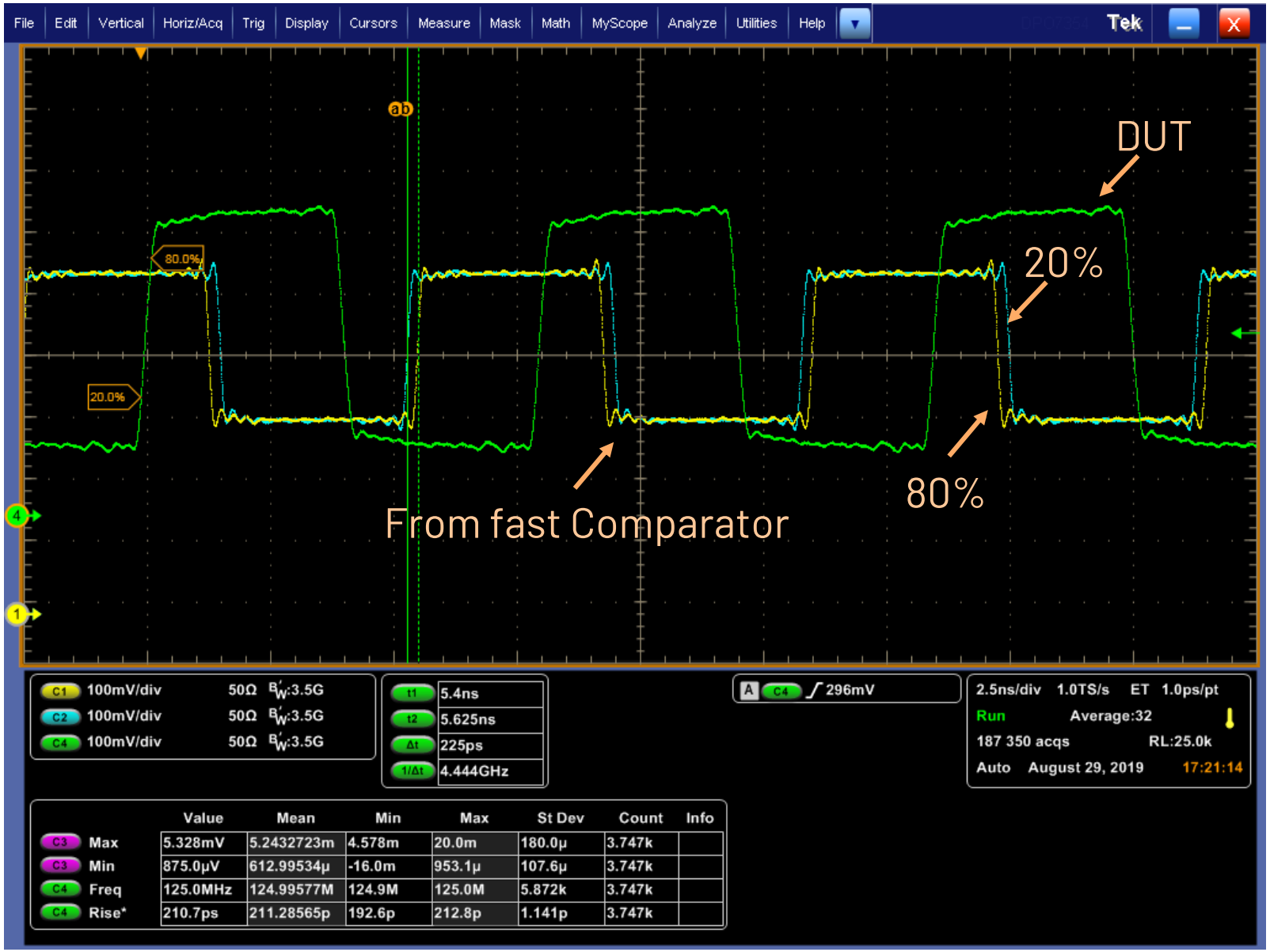


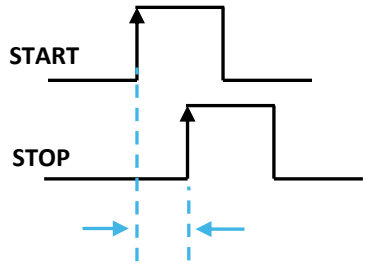

## Function of Comparator

- 2 triggered signal for TMU
- Level conversion
- DC voltage pass/fail

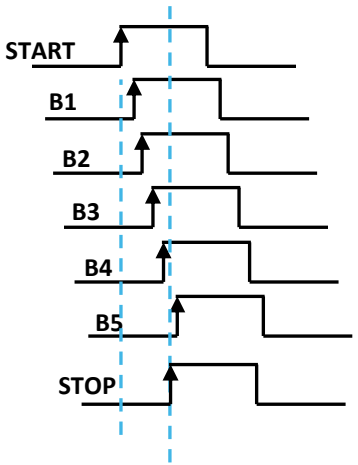
# 样例 ---- Rise/Fall Edge 测试



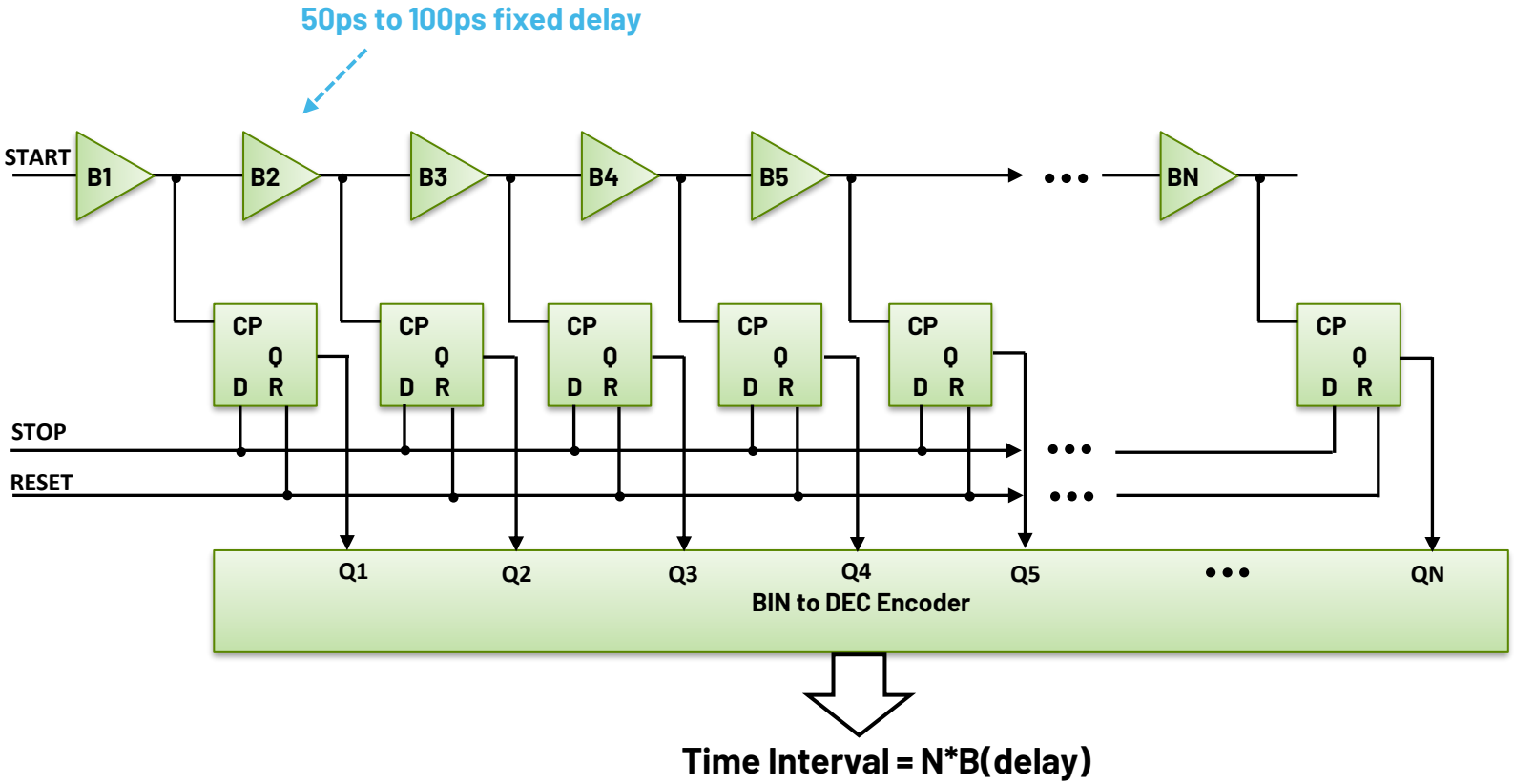
# 时间测量单元--- Digital Time Encoder in FPGA




Time Interval for Measurement




Interval Q = 000011111…




**Notes:**

1) Edge of signal is not sharp enough in FPGA, it cause jitter and uncertainty.
2) Temperature cause gate uncertainty.
3) Must add constraint and map to fixed area of FPGA.

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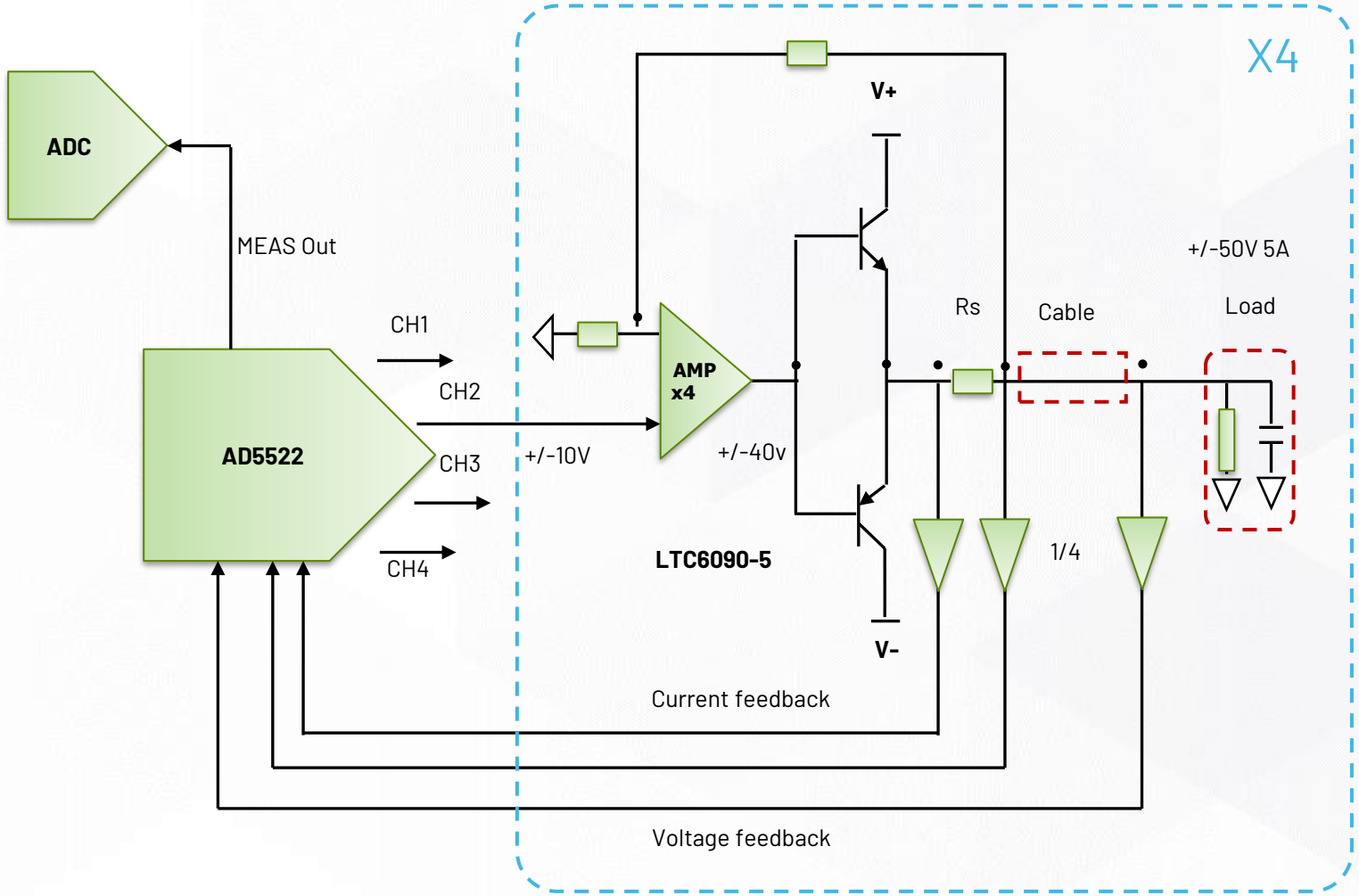
# 高功率范围 DPS/SMU解决方案




## 主要特点：

支持4象限V / I

AD5522支持4ch DPS / SMU

电压：+/- 50V

电流：5A

最小化DC / DC纹波

支持脉冲输出（高带宽）

浮动输出（非通道间）

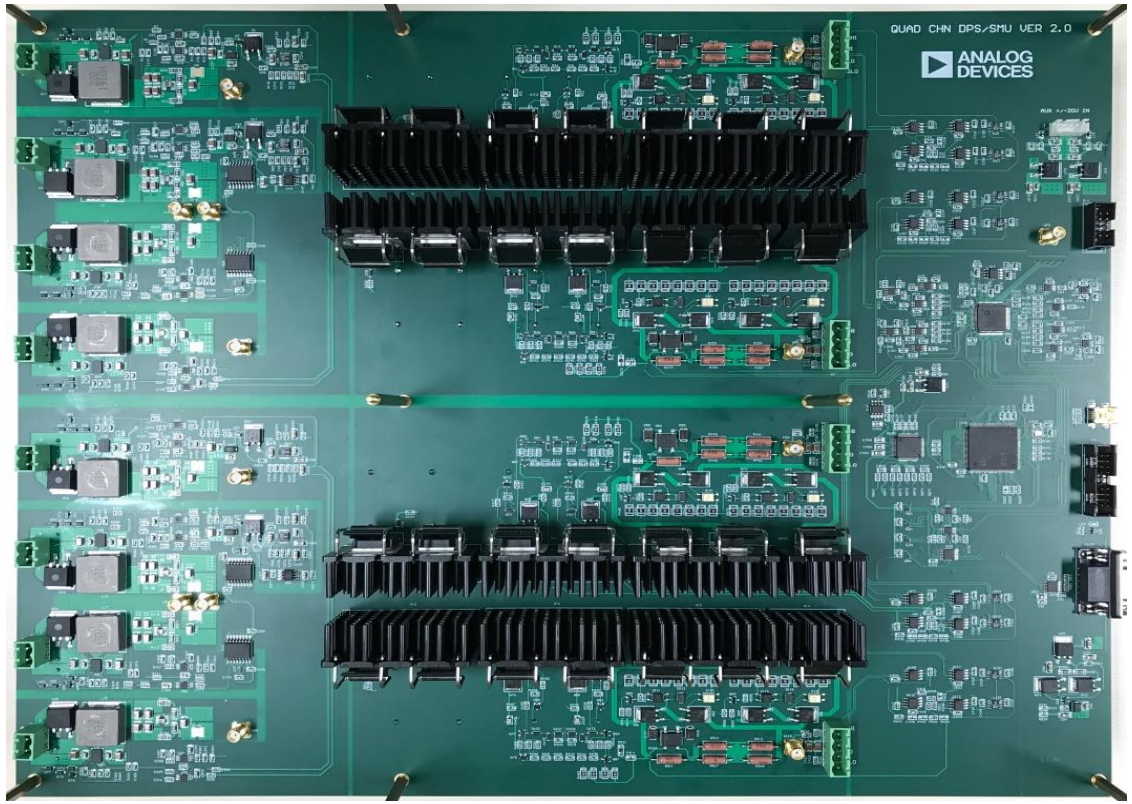
片上电压/电流钳位保护

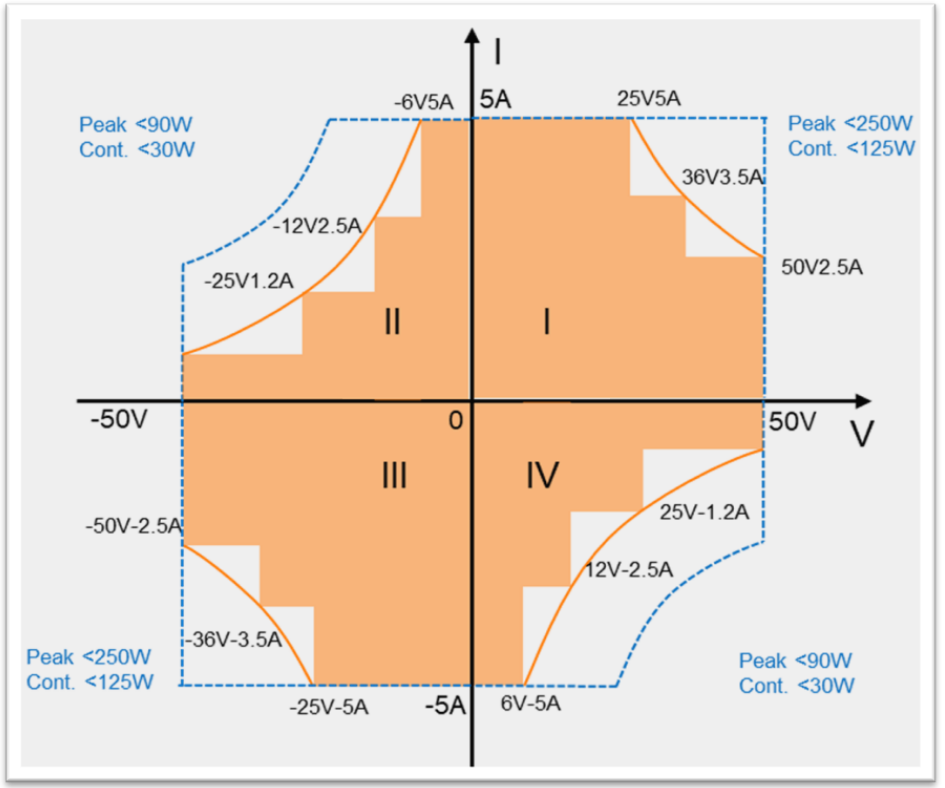
片上电压/电流窗口比较器

与整体线性驱动器相比，效率更高

支持可编程增益V / I测量

# 参考设计图片



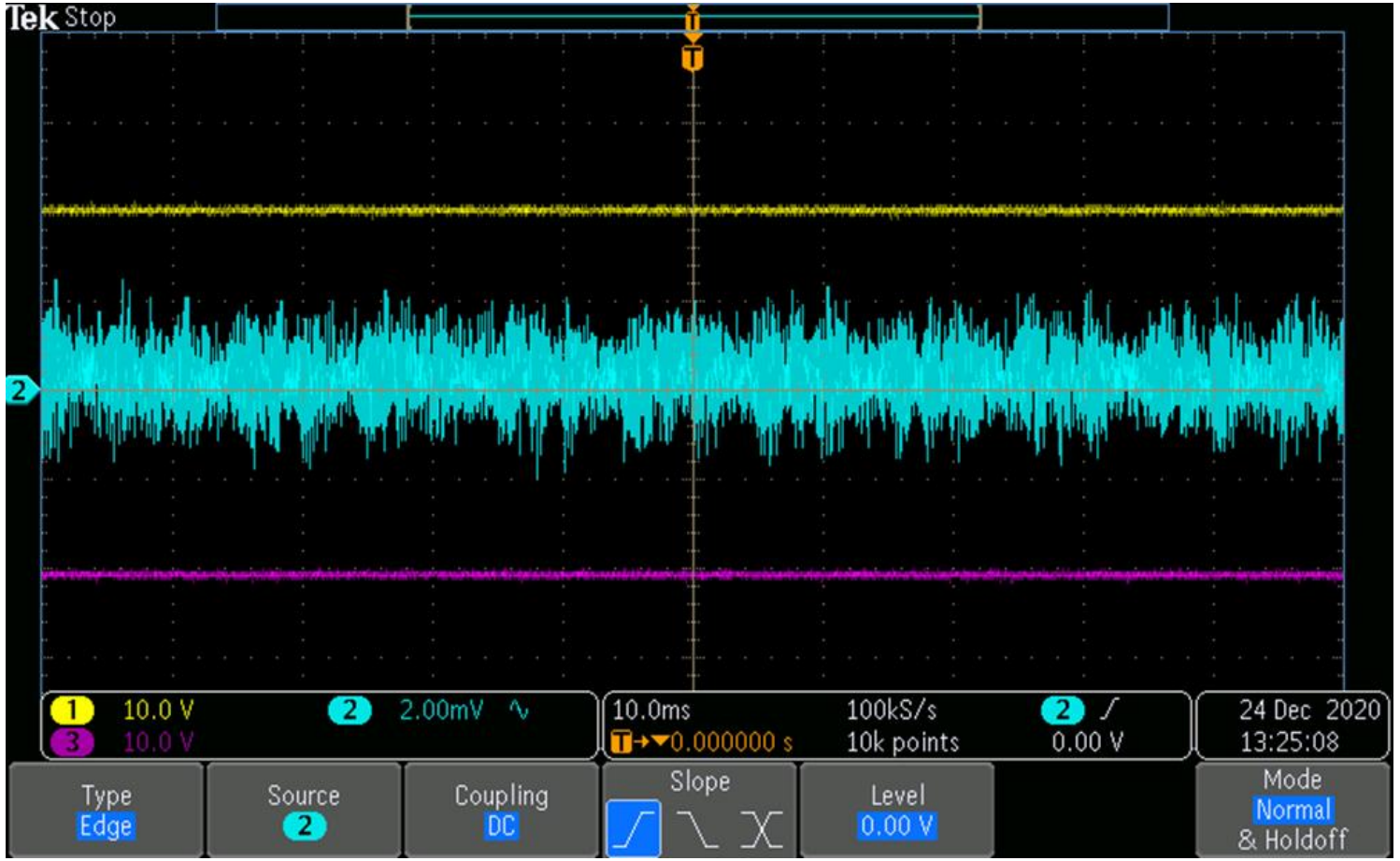

4 quadrants

Max 250W per Channel

+/-50V 5A x4 Channels

# FV扫描输出波形

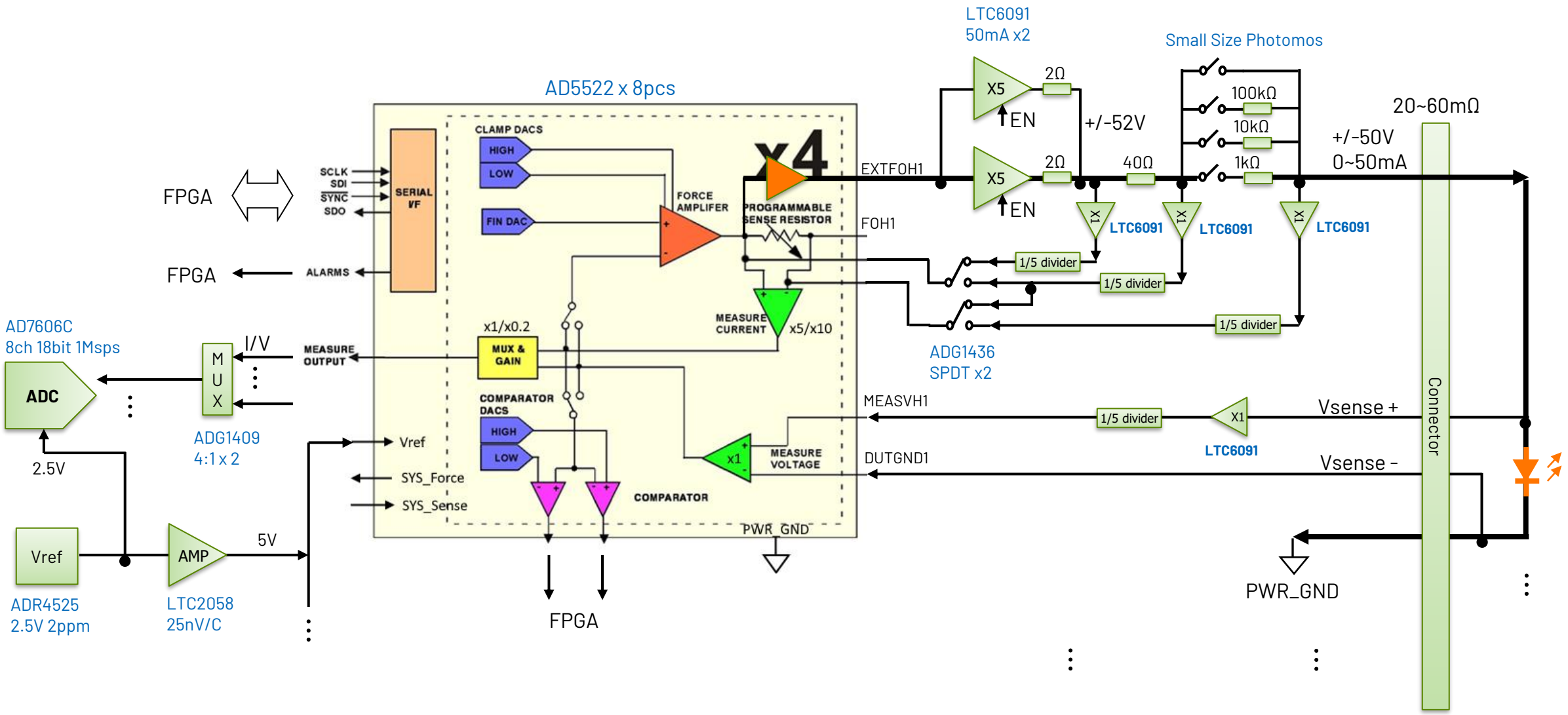
# FV 模式--- 噪声性能, VO=+/-10V




Red – postive main
Blue – SMU output
Yellow – negative main

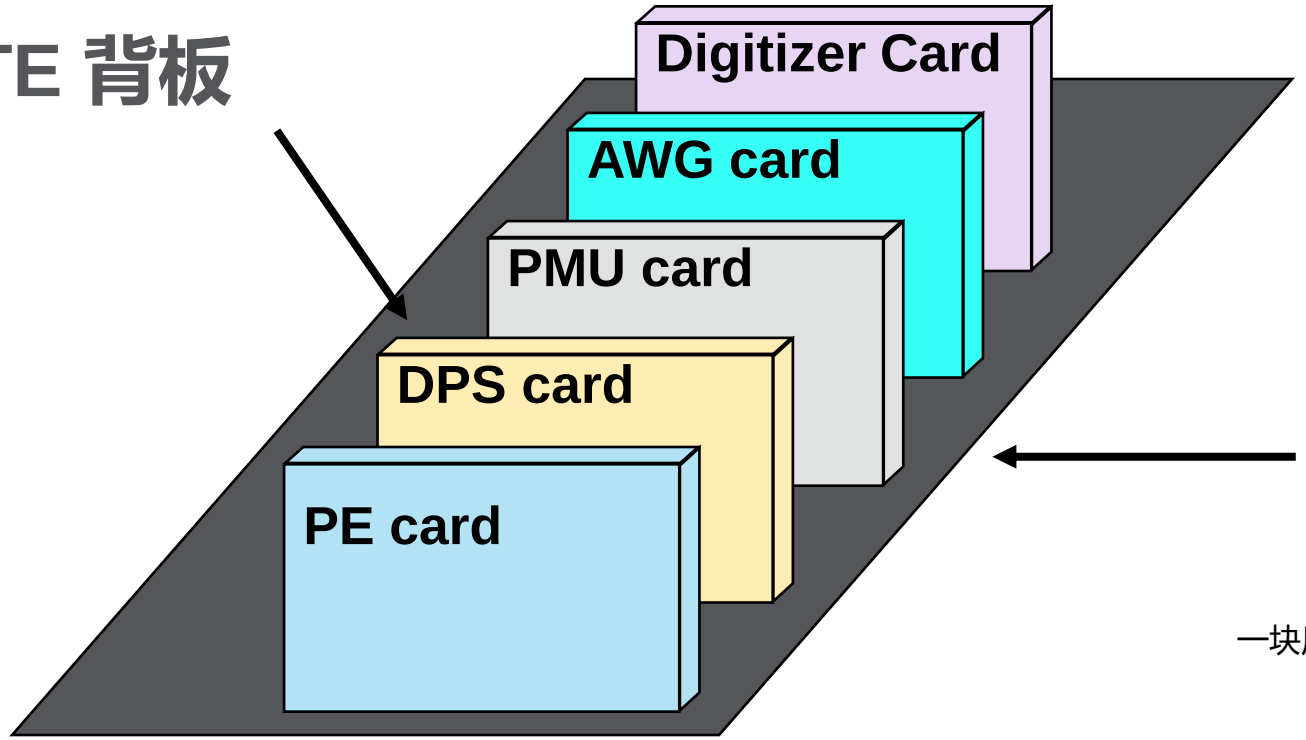
10nF compensation
5A current range
10uF + 10ohm load

# 32CH SMU Block Diagram --- +/-50V 50mA



# ATE使用中的小困扰

ATE 背板

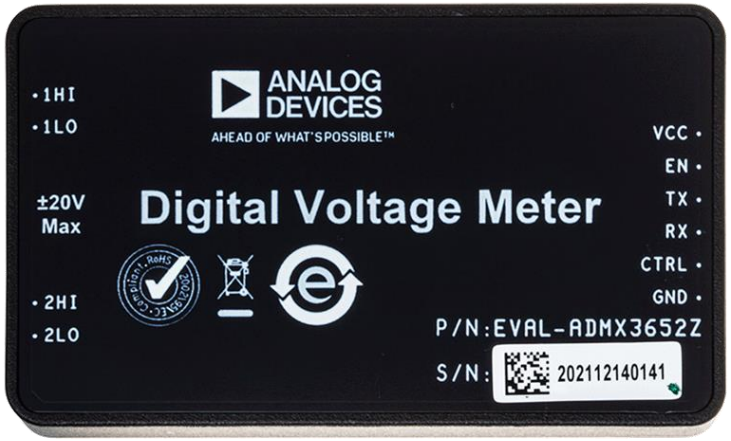




校准板

一块用于校准ATE卡的校准板

# 6.5 DVM模块

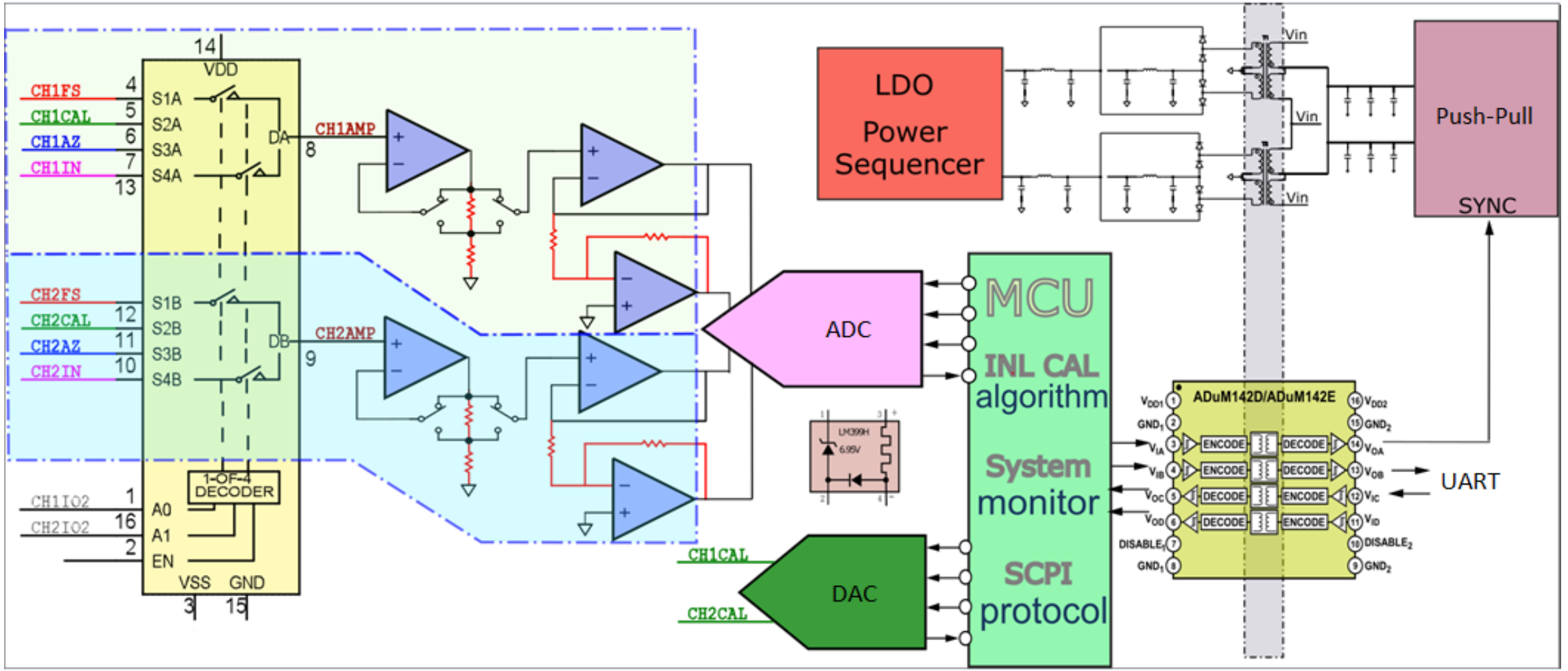




**Application:**

- ATE
- BFT
- ICT / FCT Test
- Small Signal Test
- Precision voltage/current measurement

# 6位半DVM解决方案（超高精度电压DAQ模块）



# DVM模块的主要参数

## 主要功能

- 双通道
- 精准度
  - 自动归零和满量程校准
  - 同步开关电源
- 高速
  - 最高10ksps数据速率
- 健壮性
  - 隔离电源和数字接口
  - 电源序列和监控器，输入保护
  - 信号链诊断
- 易用信
  - 5V电源，UART接口
- 兼容性
  - 支持SCPI协议
  - 扩展的模拟输入通道
  - 输出高精度基准电压

## DC 参数

- 范围：±20 V, ±2 V, ±0.2 V
- 90 days Accuracy (+/-3 Sigma, cover 99.7%)

  ±20 V Range: 12ppm + 4ppm

  ±2 V Range: 17ppm + 8ppm

  ±0.2 V Range: 98ppm + 40ppm
- 1个PLC时0.3 ppm rms噪声，1000点
- 超低增益漂移
  - 保证0.5ppm /℃
- 超低漂移
  - 自动归零功能
- 高输入阻抗和低漏电
  - 输入偏置电流<1nA @ 25℃
  - ±20 V，±2 V > 10G Ω
  - ±0.2 V > 300M Ω

# ATE产品的中文数据手册

**AD5522：** https://www.analog.com/media/cn/technical-documentation/data-sheets/AD5522_cn.pdf

**AD5560：** https://www.analog.com/media/cn/technical-documentation/data-sheets/AD5560_cn.pdf

**ADATE318：** https://www.analog.com/media/cn/technical-documentation/data-sheets/ADATE318_cn.pdf

**ADATE320：** https://www.analog.com/media/cn/technical-documentation/data-sheets/ADATE320_cn.pdf

# Thanks