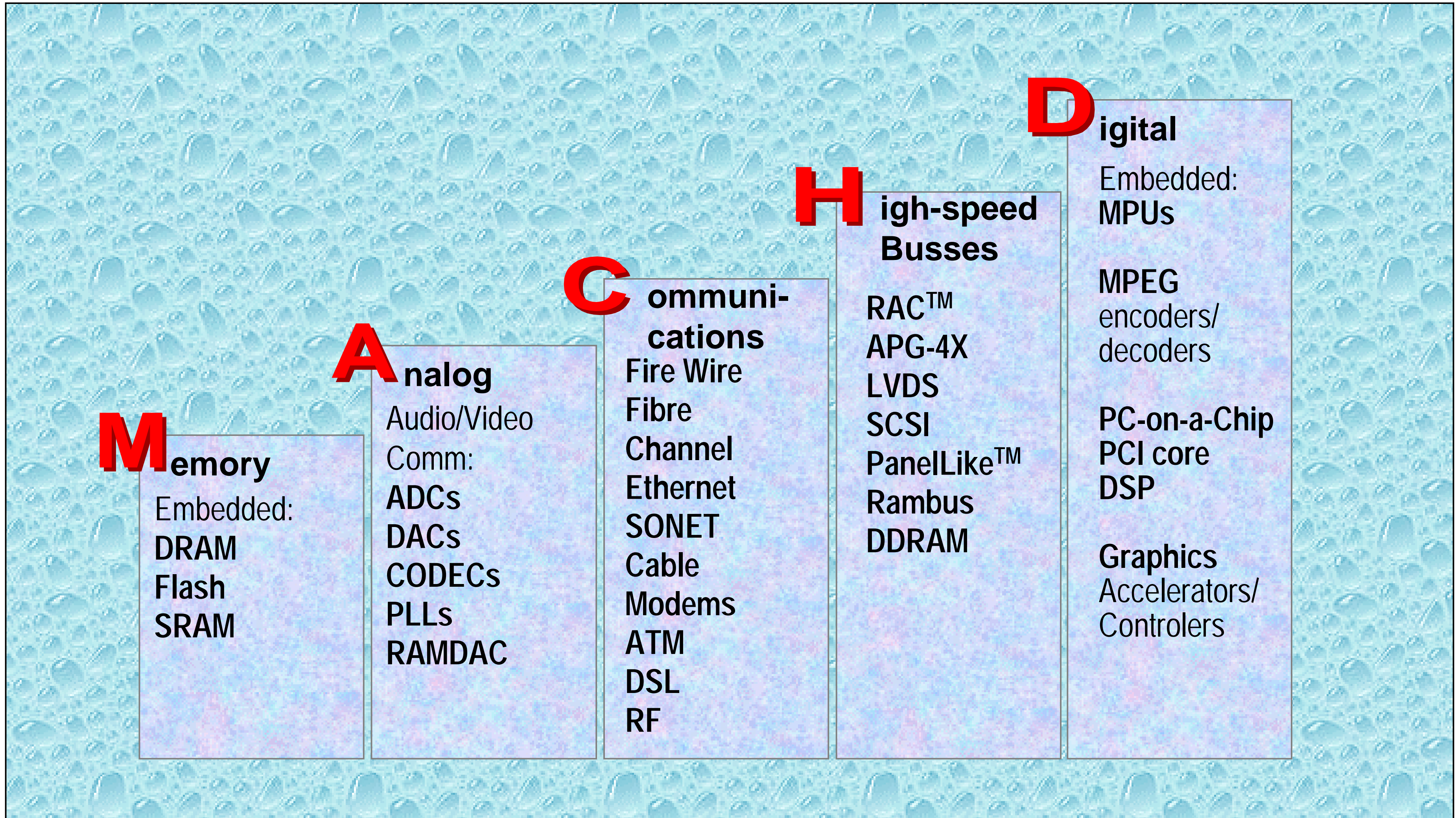
Automatic Test Equipment

- General introduction
  - -- IC category
  - -- Tester category
- ATE Hardware system
- Tester example -- DRAM

IC category



Tester category

Category	Devices
Digital	**DSP, ASIC, CBIC, ASSP, High pin-count gate Array, MPU, ASIC, SOCRISC, CISC…..**
Mixed-Signal +DC Parameter	**Communications、Converters、Interface、Integrated Signal Processing、Smart Power、and Specialty……**
Memory	**DRAM, ROM, SRAM, SDRAM, Flash Memory, DDR RAM, Rambus,………………**

Tester category & Examples (Advantest)

SOC Test System - MPU, ASIC, SOCRISC, CISC……**T6682 SOC Test System**

VLSI Test System - ASIC, CBIC, ASSP, High pin-count gate array……**T3347B VLSI Test System**

Memory Test System - DRAM, DDR, RDRAM, SLDRAM, PBSRAM…… **T5591 Memory Test System**

Flash Memory Test System - Flash Memory….. **T5721 Flash Memory Test System**

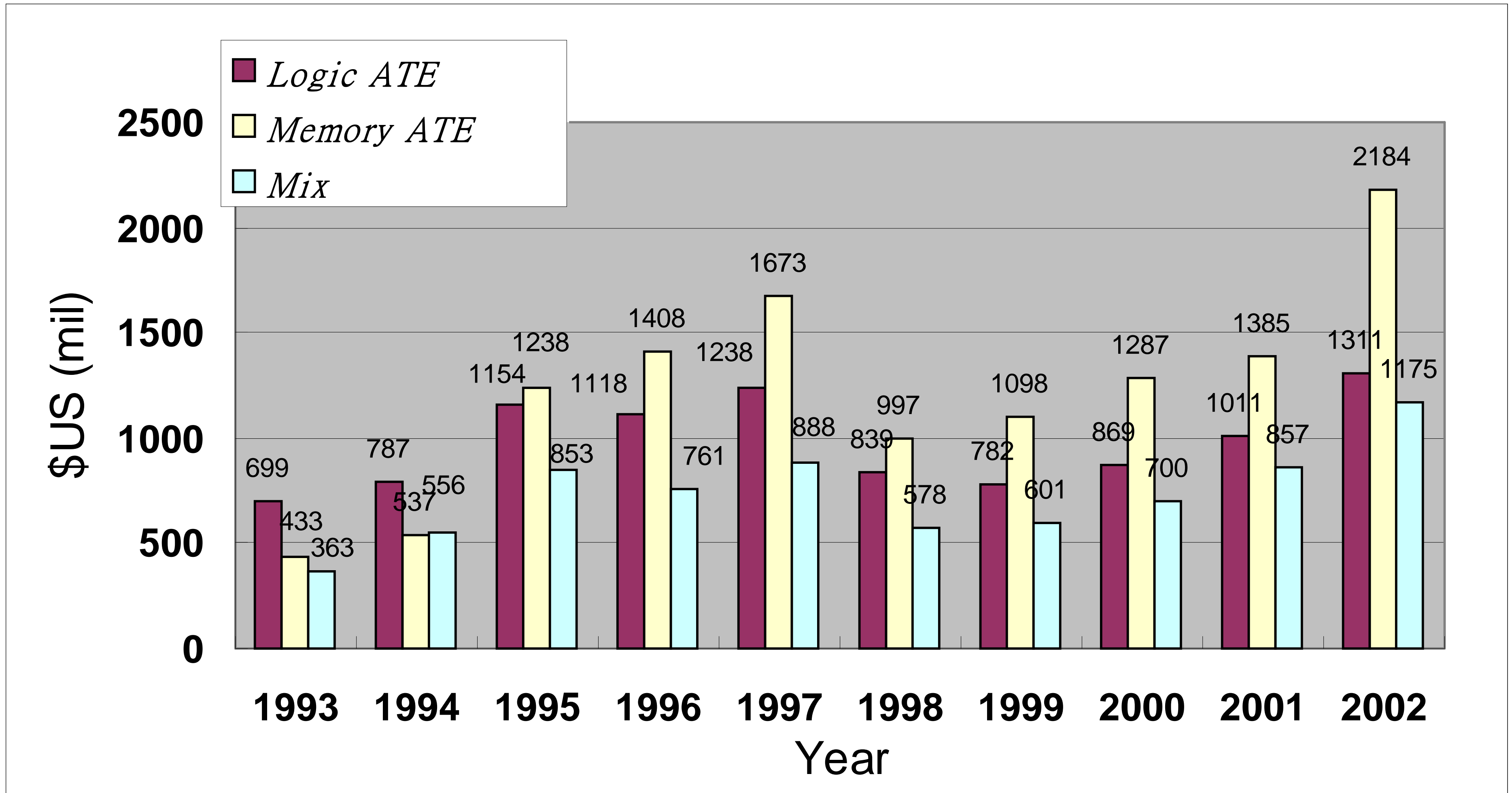
Mixed-Signal Test System - Mixed-Signal devices for audio/video, CD-ROM or other PC peripherals, mobile telephone system…... **T7323 Mixed-Signal Test System**

RFIC Test System - RFIC used in various types of radio communications…... **T7610 RFIC Test System**

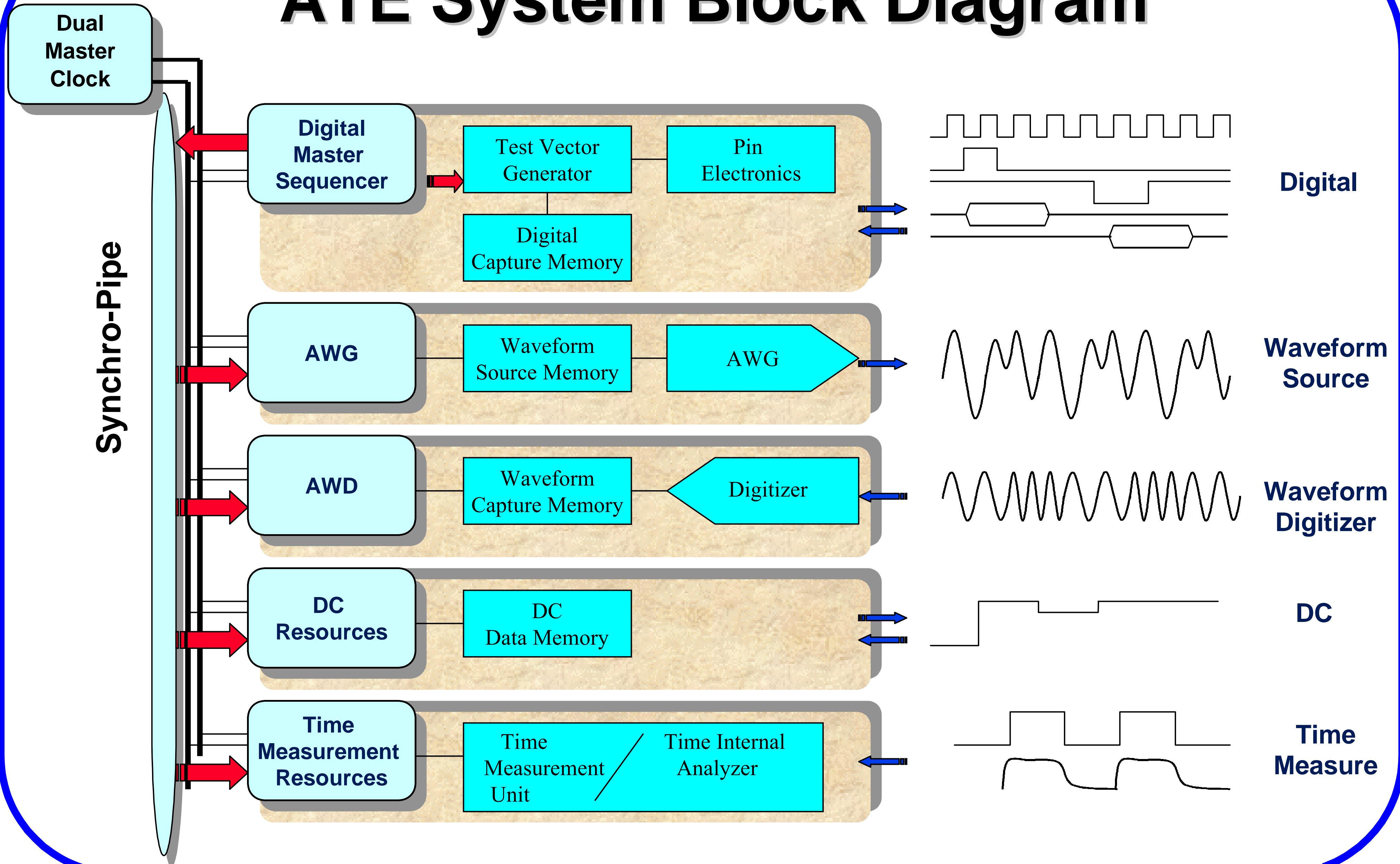
LCD Drive/Panel Test System - LCD Drive IC, Looking straight type…... **T7313 LCD Drive/Panel Test System**

E-Beam Test System - …… **E1380A E-Beam Test System**

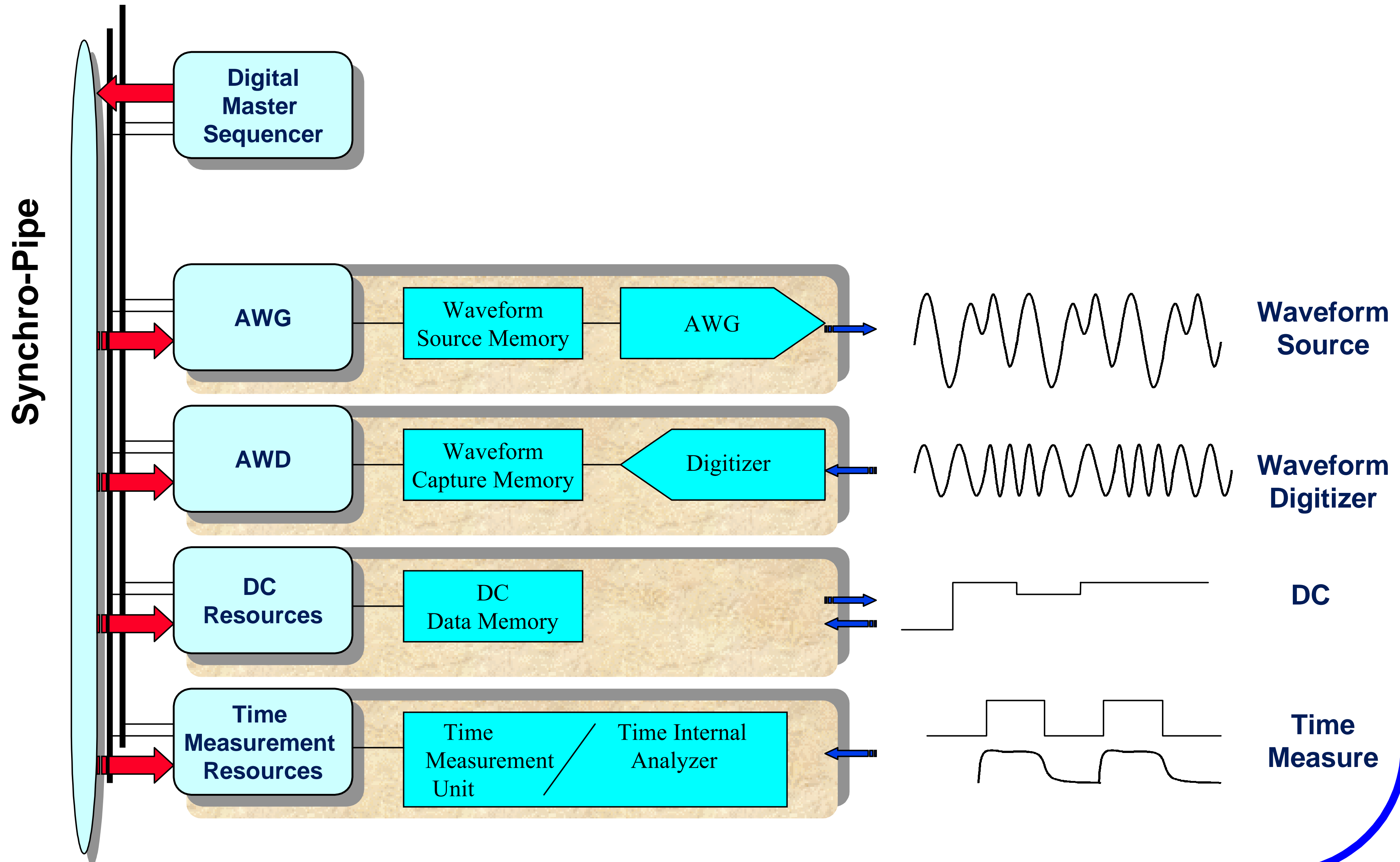
Market share of Testers



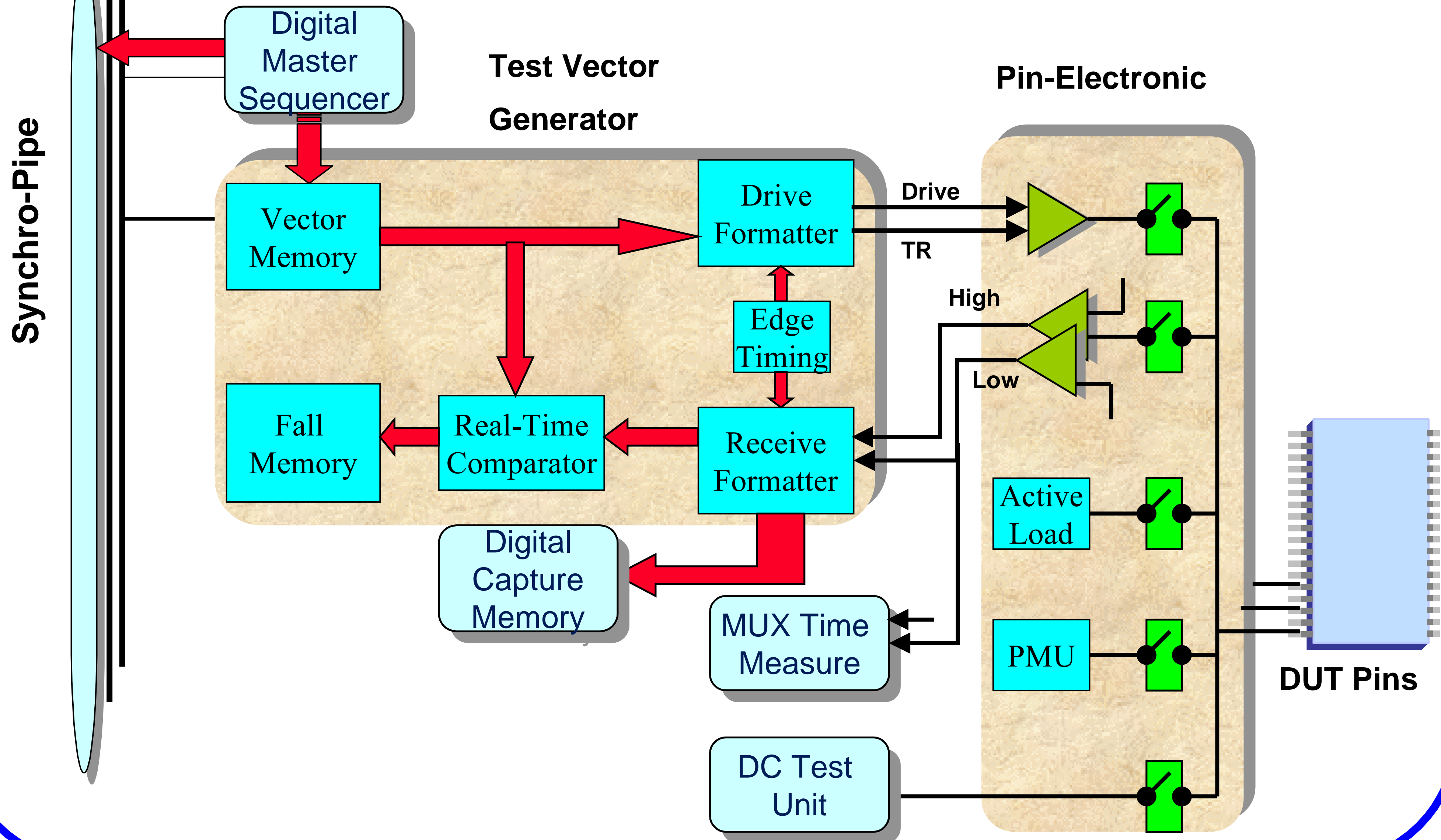
ATE System Block Diagram



Digital Test function Diagram



Digital Test function Diagram



DC Resources

Resource	Count	Range	Notes
PPU Per-Pin-DC Test Unit	8-256	-7 to +8V +/-30mA -2.1 to +7V +/-30mA	Fast Compare
PPU Parametric Measurement Unit	0-4(+1)	+/-40V 50mA or +/-20V 100mA	MUX to Pin or Direct
PPU Wide Range DC Test unit	0-3	+/-200V +/-50mA to +/- 2V +/- 1A	Low 1 Measure High V Force
DPS DUT Power Supply	1-2p Head	+/-6 to +/-24V 600mA +/-2 to +/- 8V 2A	DUAL Supplies
PVS Precision Voltage Source	0-1	+/-10V +/-100mA	23 bit Resolution
PVM Precision Voltage Measure	0-1	+/10nV to +/- 200V	28 bit Resolution

Analog Waveform Generation

Synchro-Pipe

Clock

AWG Sequencer

AWG

Waveform Source Memory

Dual Clock

SFG

DC Offset

Amp/ Filter

Mux

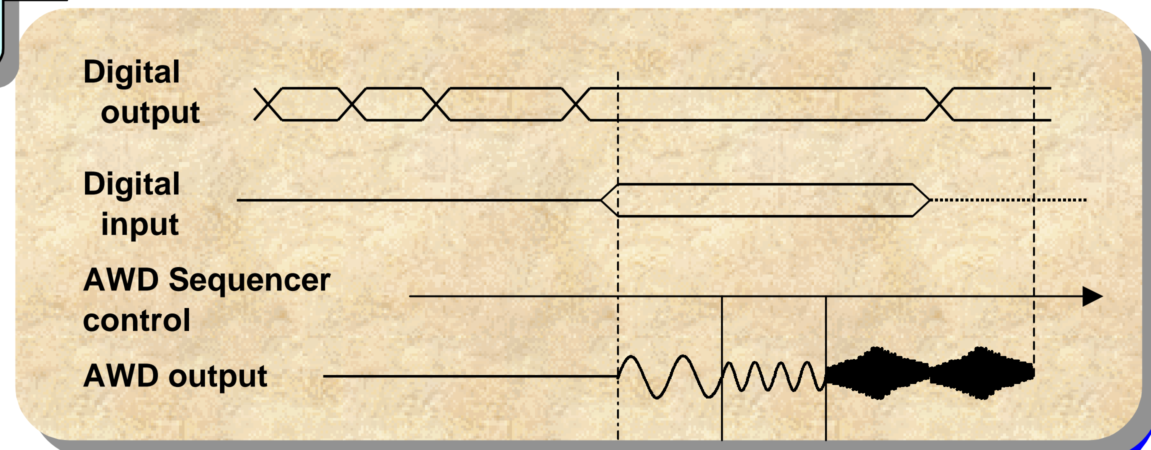
For 30MHz / 1MHz / 100KHz AWG

Testhead

For 128MHz AWG

Testhead #1

Testhead #2



Full Feature Set

- Synchronous or Asynchronous Clocking
- Triggering
- Waveform Sequencing
- Single-Ended or Differential
- Filters
- Offset
- Real-Time DSP

Analog Waveform Digitization

Clock

Synchro-Pipe

Digitizer Sequencer

Waveform Digitizer

Amp/ Filter

Mux

Waveform Capture Memory

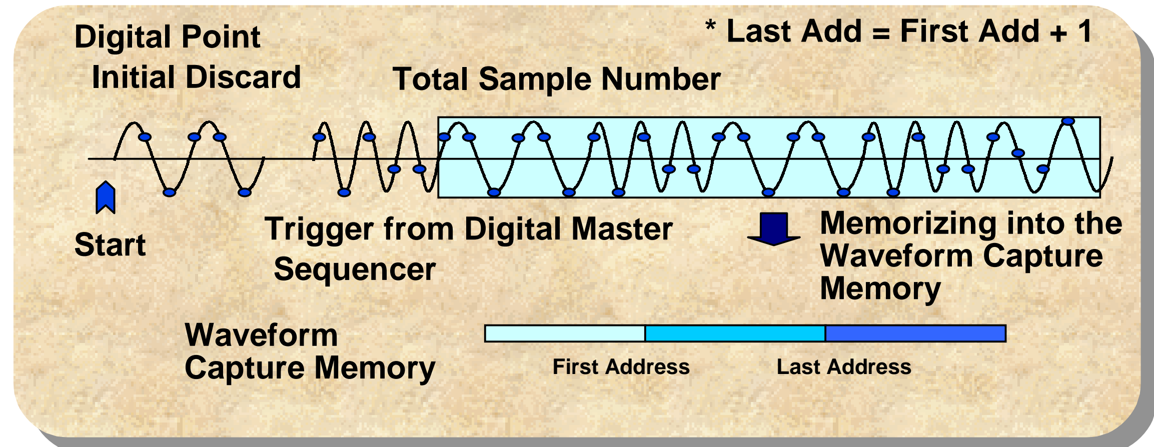
Dual Clock

Testhead #1

Filter Sampler

Testhead #1

Filter Sampler

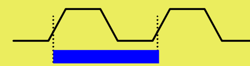


Time Measurement Resources

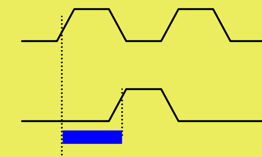
TM
Time Measurement Unit

Measurement:
- Max. 100MHz interval/period
- Max. 10ps resolution (interval)
- Max. 10fs resolution (period)
- One shot or averaging

Single Channel



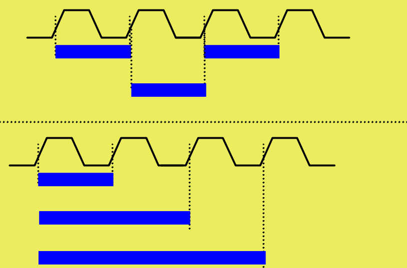
Dual Channel



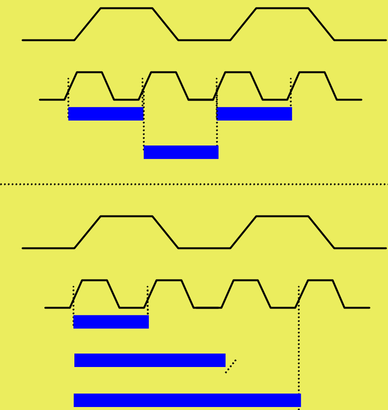
TIA
Time Interval Analyzer

Measurement:
- Max. 80MHz interval
- Max. 50ps resolution
- Multiple sequential(max. 2nd)
- Hardware histogram functions

Single Channel

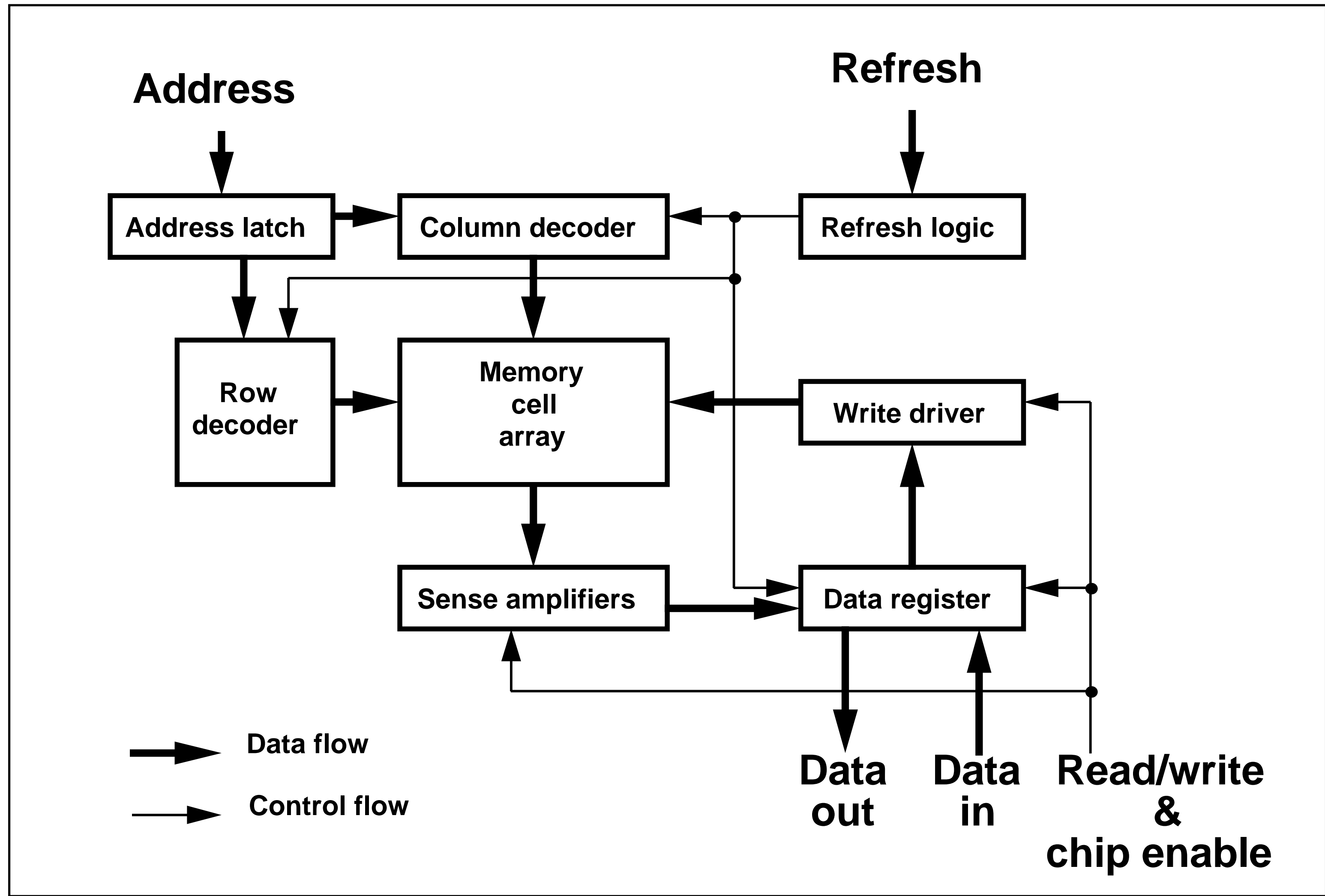


Dual Channel



Test Example -- DRAM

Architecture of DRAM



Test Program / Test Flow

- **Main program**
  - **Set Test Conditions**
    - » **Timing setup**

      Test Rate, Drover Clock, I/O Drive Enable clock….
    - » **Voltage setup**

      Driver, Comparator, Terminator, Program Load, Device power, DC Measure Unit…..
    - » **Pin Status setup**

      Pin => Voltage, Timing, Waveform, Pattern Assignment
  - **Control Test Sequence**
    - » **Timing Setup Hardware Unit Starting Flow**
    - » **Path Pattern Program to PG**
    - » **Read Control Data**

Test Program / Test Flow (Cont.)

    - » Call PBDATA
    - » Timing guardband
    - » Setting Category and Sort Table
  - – Start Program
    - » Measure DC
    - » Measure AC
    - » Functional Test
- Pattern program
  - – Edit ALPG micro-code to process Test Pattern
- Socket program
  - – Parallel Test Setup

Test Principle / Test Module

Items to Test for Memory IC

- **DC Parametric Test**

  Measure IC's DC Voltage or current

- **AC Parametric Test**

  Measure IC's AC Timing for Specification

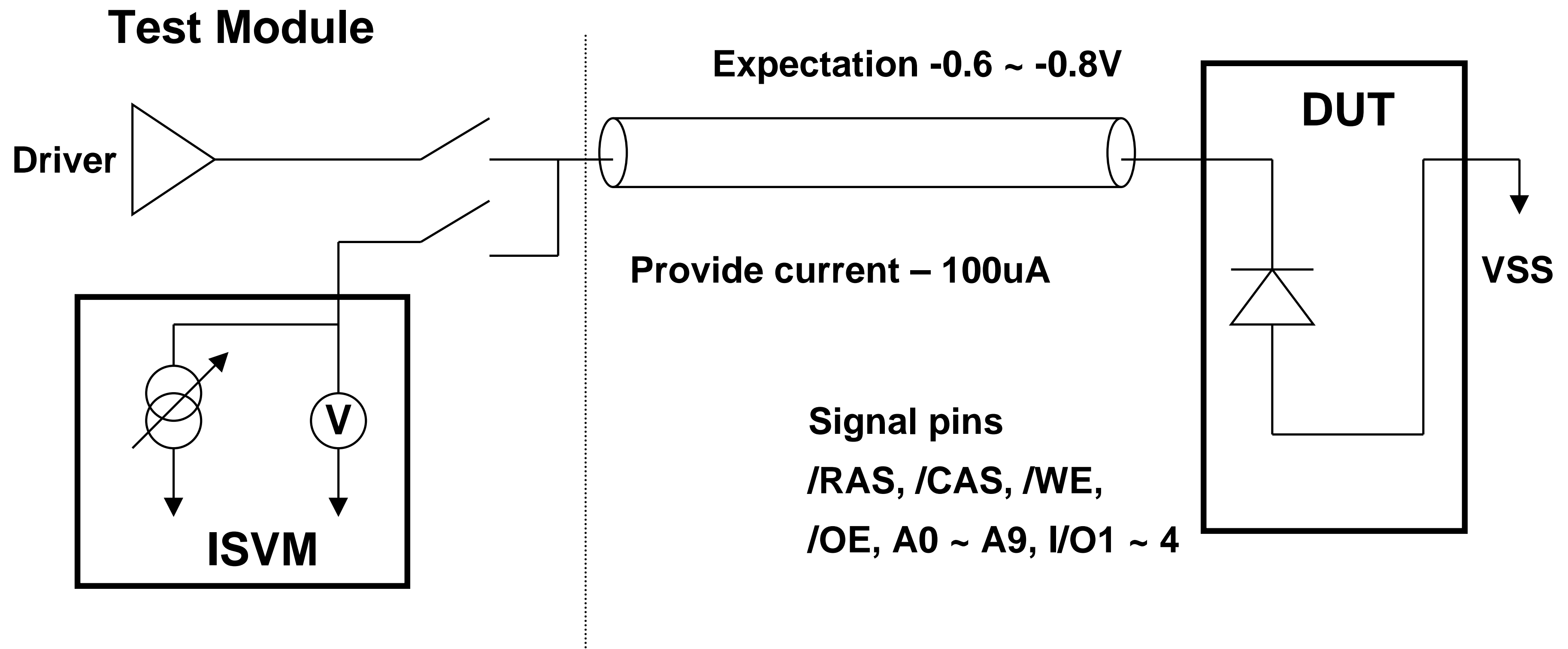
- **Functional Test**

  Verify IC's operation functions

DC Parametric Test

1. Open/Short Test (Contact Test)

a. Signal Pin Open/Short Test



DC Parametric Test (Cont.)

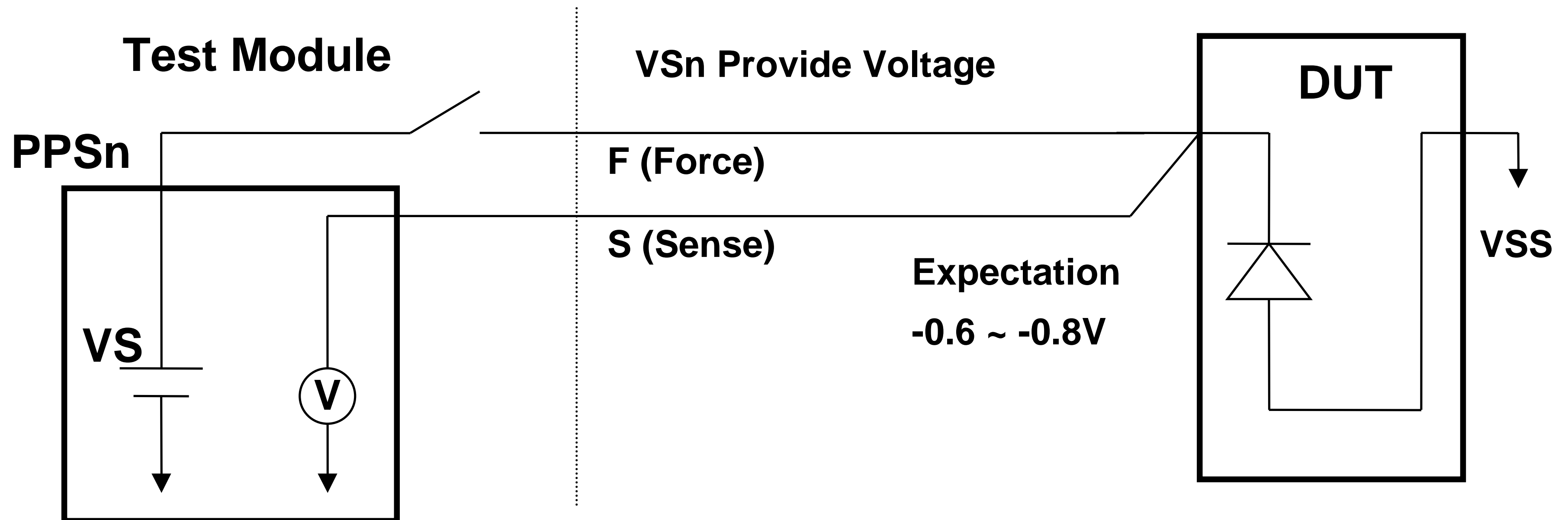
Program Example

```
;OPEN/SHORT TEST (SINGAL PINS)

PCON= 0                ; 10uF Bypass Capacitor is disconnected
VCON= I (or VSI)       ; The Relay of PPS is disconnected
LCON= 0                ; Power Supply of Load Module is disconnected
ISVM= -100UA,R800UA, M8V, 1V, -5V
LIMIT DC=-O.OIV, -2V
TEST 10
MEAS/T DC(pin number)
```

DC Parametric Test (Cont.)

b. VCC Pin Open/Short Test



;OPEN/SHORT TEST (VCC PINS)

VCON= I ; The Relay of PPS is disconnected

VS1=VSVM, -1V, R10V

LIMIT VS1=-O.3V, -0.7V

TEST 20

MEAS VS1

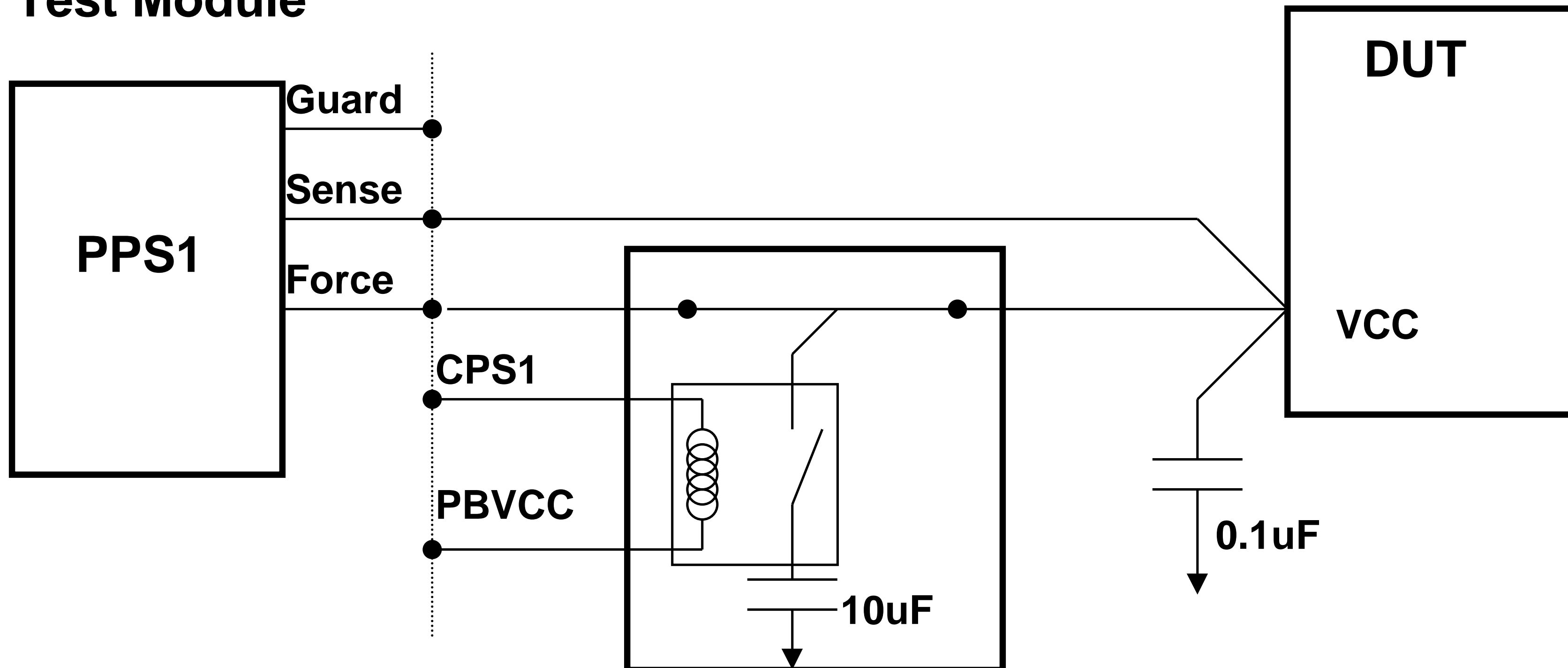
DC Parametric Test (Cont.)

2. Standby ICC Current Test

Test Status

/RAS : High level, /CAS : High level I/O pins : Open,
10uF C : OFF, Limit : 2mA

Test Module



DC Parametric Test (Cont.)

Program Example

```
; STANDBY CURRENT ICC(ICC2)
PCON=0                          ;10uF Capacitor is disconnected
VCON=0                          ;The relay of PPS1 is connected
LCON=0                          ; Power Supply of Load Module is disconnected
TIMEI?MS: VSI
TIME2?MS: INI
;*****************************Power Supply Setting & *Pin Condition Setting
VS1=5.5V,R8V,M400MA             ;Vcc maximum value
LIMIT VS1= 1MA,0                ;Maximum value of ICC2
INI=5.3V,OV                     ;CMOS interface(High level=VCC-0.2V)
RAS=IN1,FIXH                    ; /RAS is high level
CAS=IN1,FIXH                    ; /CAS is high level
ADR=IN1,FIXH                    ; Address Pins Level is "don't care"
WE=IN1, FIXH                    ; /WE level is "don't care "
OE=INIJIXH                      ; /OE level is "don't care"
IO=OPEN
;*************************Test Item & Measure Start
SRON                            ; Sequential Reference On happens
WAIT TIME 1MS                   ; Wait until Vcc Current becomes stable
TEST 100
MEAS VS1                        ; ICC2 value is measured
```

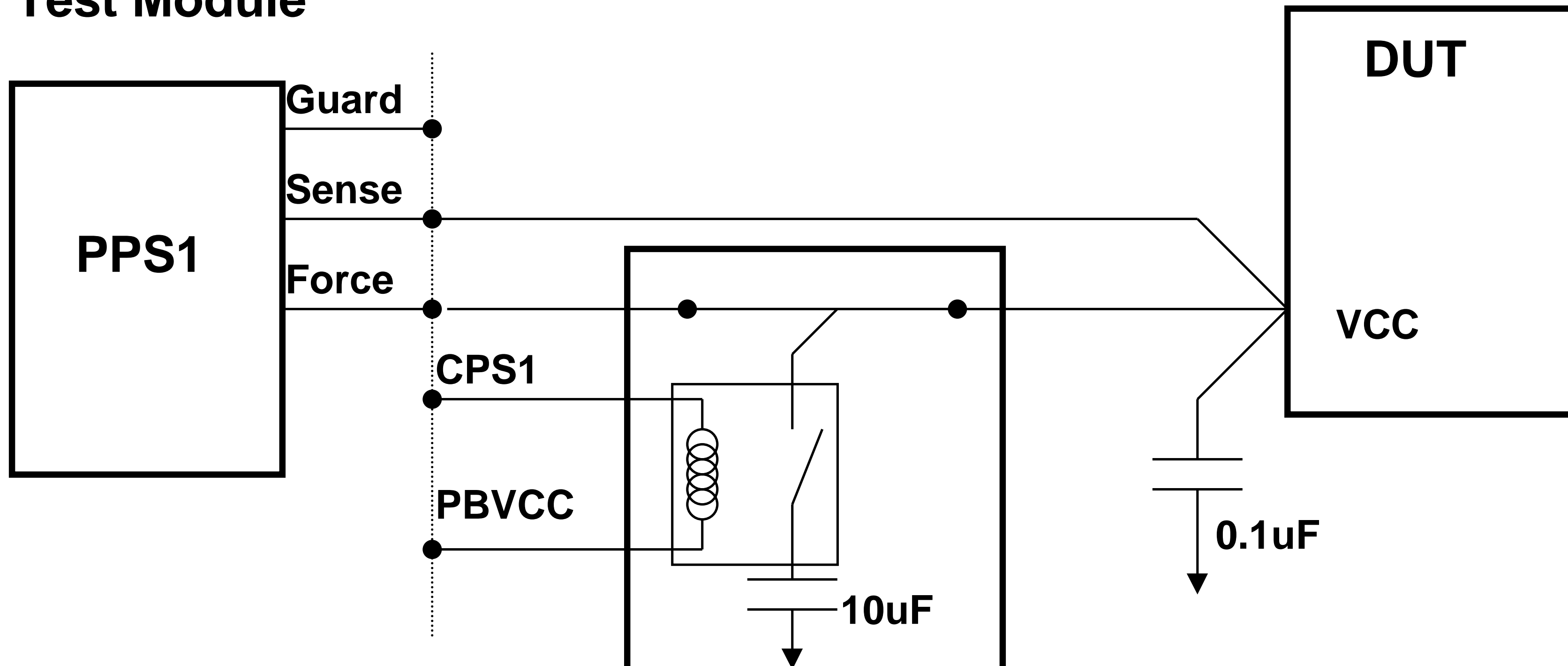
DC Parametric Test (Cont.)

3. Operating ICC Current Test

Test Status

/RAS : As SPEC, /CAS : As SPEC I/O pins : Open,
10uF C : ON, Limit : 2mA

Test Module



DC Parametric Test (Cont.)

Program Example

```
;OPERATING CURRENT ICC(ICC3)
;*********************pm Condition Setting
ADR=IN1, FIXL
RAS=IN1, /RZO,BCLK4,CCLK4,<CO>        ; /RAS Signal Definition
CAS=IN1, /RZO,BCLK5,CCLK5,<C1>        ; /CAS Signal Definition
WE=IN1,FIXL
OE=IN1,FIXH
IO=OPEN
;*********************Power Supply Setting, PG Start & Test Item Set
PCON=1                                ;10uF Bypass Capacitor is connected
VSI=5.5V,R8V,M400MA,200MA,-200MA      ;Vcc maximum value
LIMIT VS1=100MA,0                     ;Maximum value of ICC1
REG MPAT PC=#***
SEND MPAT filename                    ;Send the patterp program to ALPG
START MPAT *                          ; ALPG start to run
WAIT TIME 1MS                         ; Wait until Vcc Current becomes stable
TEST 120
MEAS VS I                             ;ICC I value is measured
SROF& STOP MPAT
```

DC Parametric Test (Cont.)

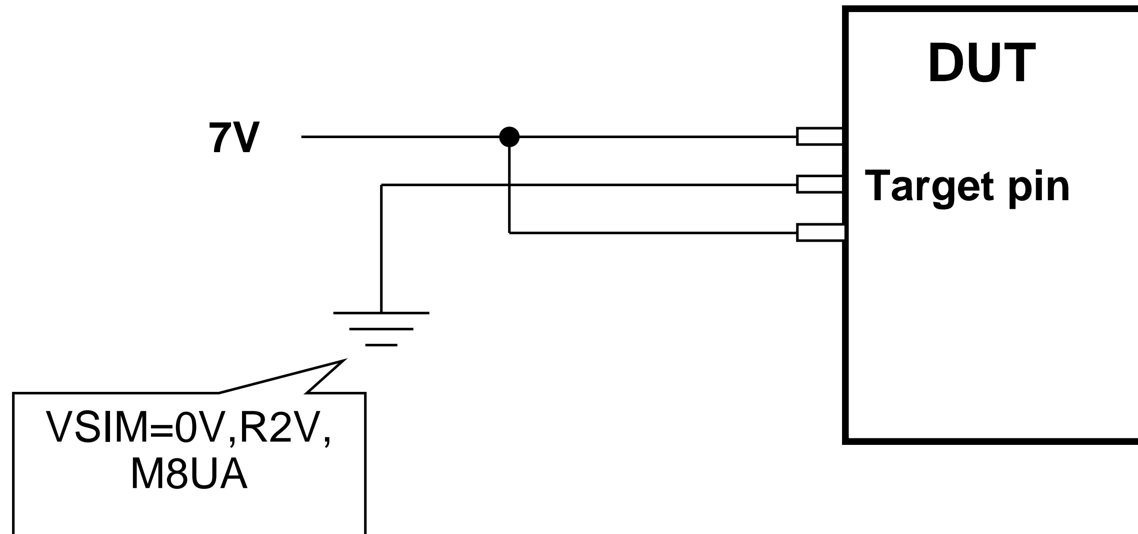
4. Current Leakage Test

a. ILIL (Input Leakage / Input Low)

Test Status

Vcc : 5.5V, 10uF C : OFF, Target input pin : 0V

The other input pins : 7V, I/O pins : Open, Limit : -10 ~ 10uA



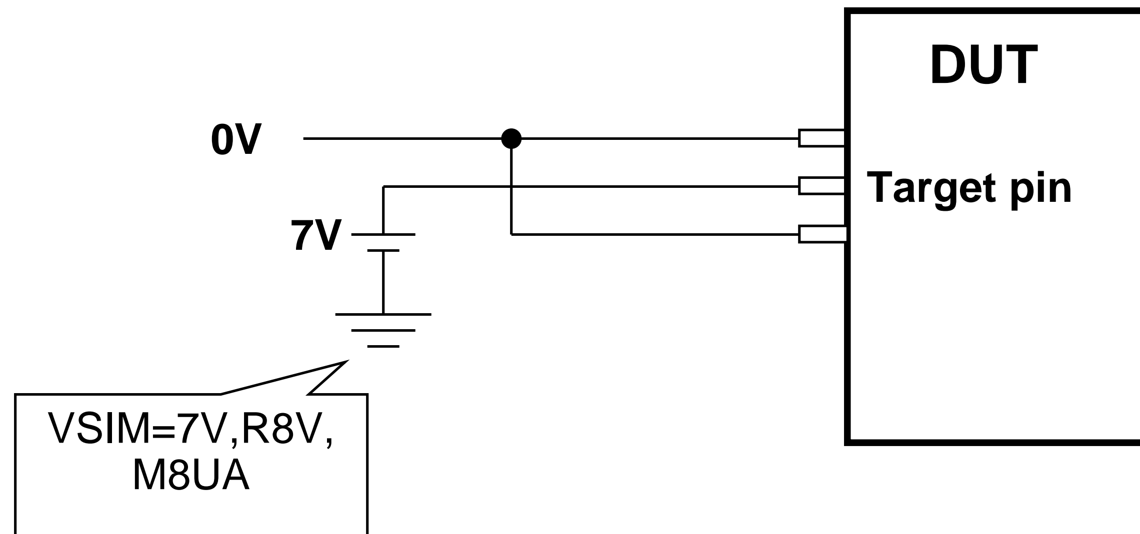
DC Parametric Test (Cont.)

b. ILIH (Input Leakage / Input High)

Test Status

Vcc : 5.5V, 10uF C : OFF, Target input pin : 7V

The other input pins : 0V, I/O pins : Open, Limit : -10 ~ 10uA



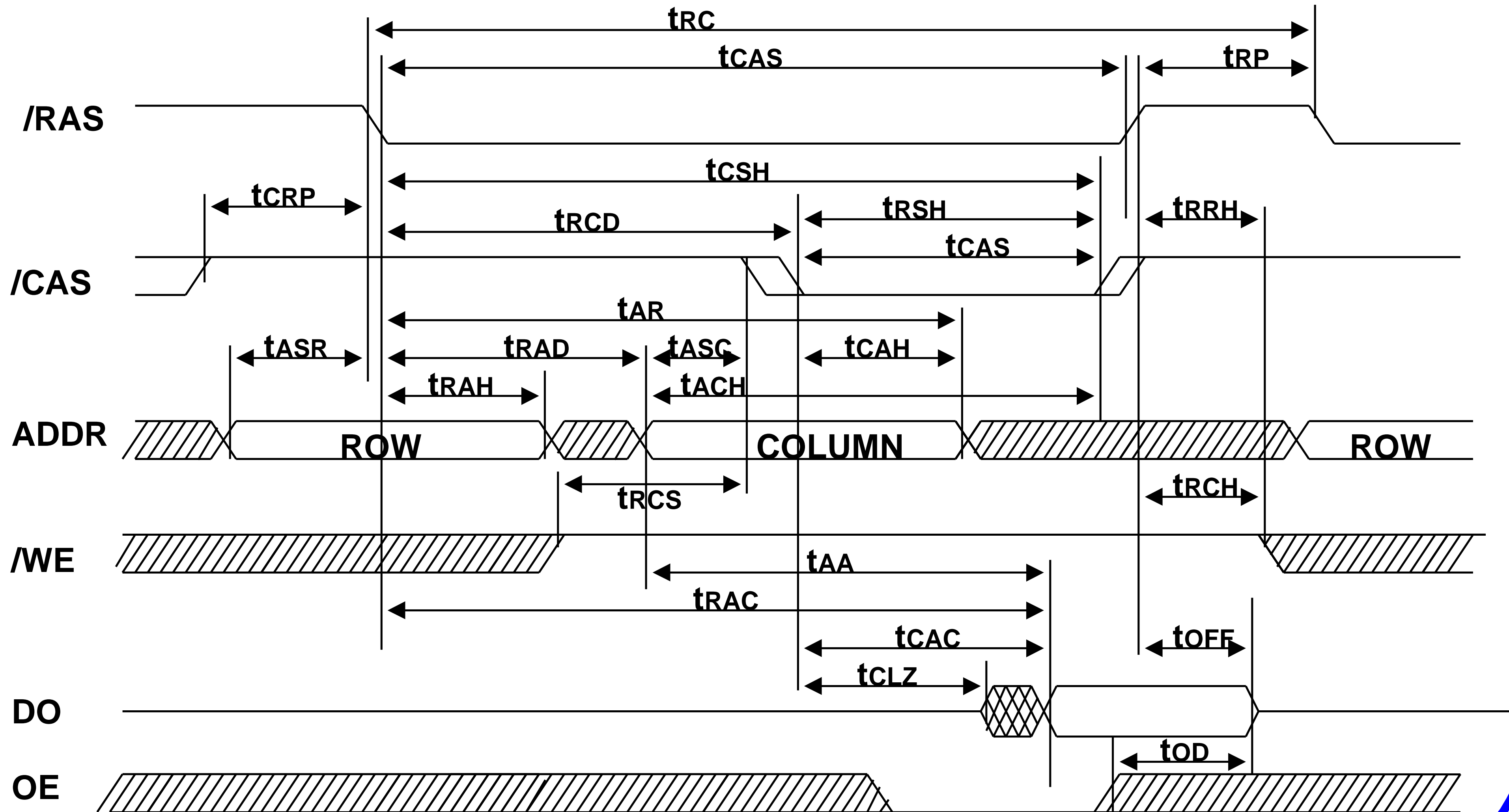
DC Parametric Test (Cont.)

Program Example

```
; INPUT LEAKAGB CURRENT TEST
VSI=5.5V
INI=7V,OV
10=OPEN
VSIM=0V,R8V,M80UA,+112UA,-112UA        ;Low level for a target input pin
LIMIT DC=IOUA,-IOUA
INP=IN1,FIXH                           ;High level for other input pin
TEST 140
MEAS DC(INP)                           ;ILIL is measured
VSIM=7V,R8V,M80UA,+112UA,-112UA        ;High level for a target input pin
INP=IN1, FIXL                          ;Low level for other input pin
TEST 150
MEAS DC(INP)                           ;ILIH is measured
```

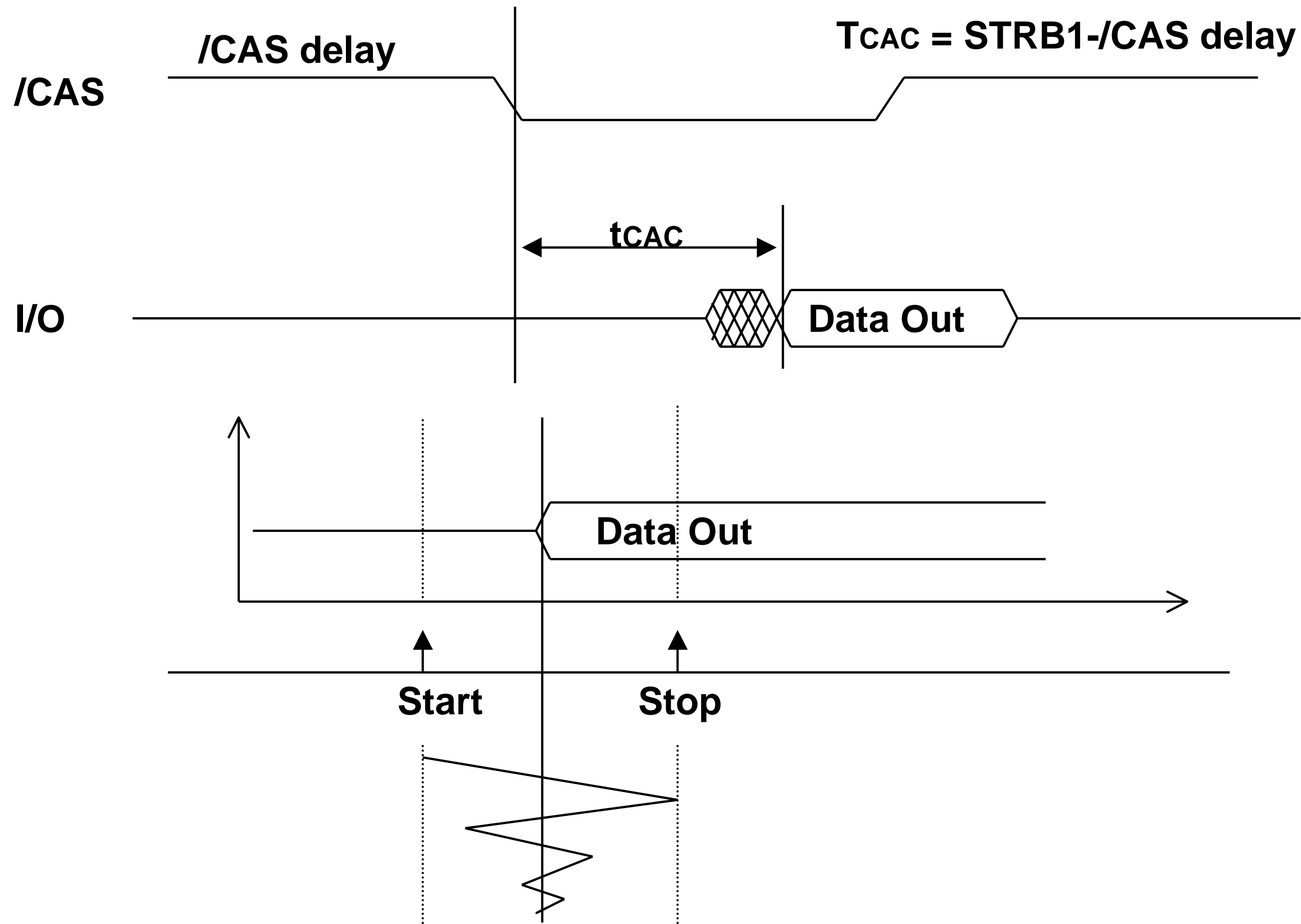
AC Parametric Test

Example : TCAC Test



AC Parametric Test (Cont.)

Example : TCAC Test



AC Parametric Test (Cont.)

```
;TCAC MEASUREMENT
DIM ARG(11)     ;Elcvcn array variable arc required for the TMEAS utility.
;*********************Voltage Setting
VSI=5.5V
OUTI=2.4V,0.8V
IN1=3V,OV
;********************* Timing Edge Setting
RATE=260NS
ACLK1=30NS & BCLK1=45NS & CCLKI=70NS
ACLK2=75NS & BCLK2=80NS & CCLK2=115NS
ACLK3=0NS & BCLK3=80NS & CCLK3=115NS
ACLK4=0NS & BCLK4=50NS & CCLK4=190NS
ACLK5=0NS & BCLK5=85NS & CCLK5=190NS
ACLK6=0NS & BCLK6=50NS & CCLK6=190NS
ACLK7=0NS & BCLK7=80NS & CCLK7=115NS
DREL1=80NS & DRET1=115NS
STRB1=120NS
SELECT DCLK ACLK1, BCLK1, CCLK1
```

AC Parametric Test (Cont.)

```
;*************************Pin Condition Setting
PADR=IN1,XOR, ACLK1,BCLK1,CCLK1 ,SDM,<X0-9,Y0-9>
PRAS IN1, /RZ0, BCLK4,CCLK4,<CO>
PCAS =IN1, /RZ0, BCLK5 ,CLK5,<CI>
PWE = IN1,/RZ0, BCLK7, CCLK7,<WT>
POE = IN1,/RZO,BCLK6,CCLK6,<RD>
PIO IN1, XOR,ACLK3,BCLK3,DRERZ,IOC,OUT1,STRB1,LOD,<D0-3>
;**************************parameter Setting
ARG(1 )=0NS          ;Start value of ARG(3)'s unit
ARG(2)=120NS         ;Stop value of ARG(3)'s unit.
ARG(3)=21            ;Unit number (21;STRBI).
ARG(6)=1             ;Timing set number 1;TS!
ARG(7)=#0            ;Start PC value of ALPG.
ARG(8)=O             ;Tracking unit number.
ARG(9)=0             ;Tracking value for ARG(8).
ARG(10)=0            ;Timing set number of the tracking unit defined by ARG(8)
ARG(11)=1            ;DUT number.
;**************************Test Item Set & Call Utility Function
REGMPATPC=#0
SEND MPAT filename
TEST 200
ASM TMEAS(ARG)     ;TCAC is measured.
```

Functional Test

1. Gross function Test

- Read Cycle Test
- Write Cycle Test
- Fast Page Mode / EDO Mode Check
- March Column / March Row

2. Special Pattern Test

- Checkboard Pattern
- Butterfly Pattern
- Diagonals Pattern
- Moving Inversion Pattern

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