Proposed changes for improving IEEE Std 1149.1

CJ Clark, Intellitech

Intellitech

Call for participation & WG formed at ITC 2009

Elections 12/2010

- CJ Clark, Intellitech, Chair
- Carol Pyron, Freescale, Vice Chair
- Carl Barnhart, SiliconAid, Editor
- Bill Tuthill , Raytheon, Secretary
- Roland Latvala, Freescale, Friday secretary

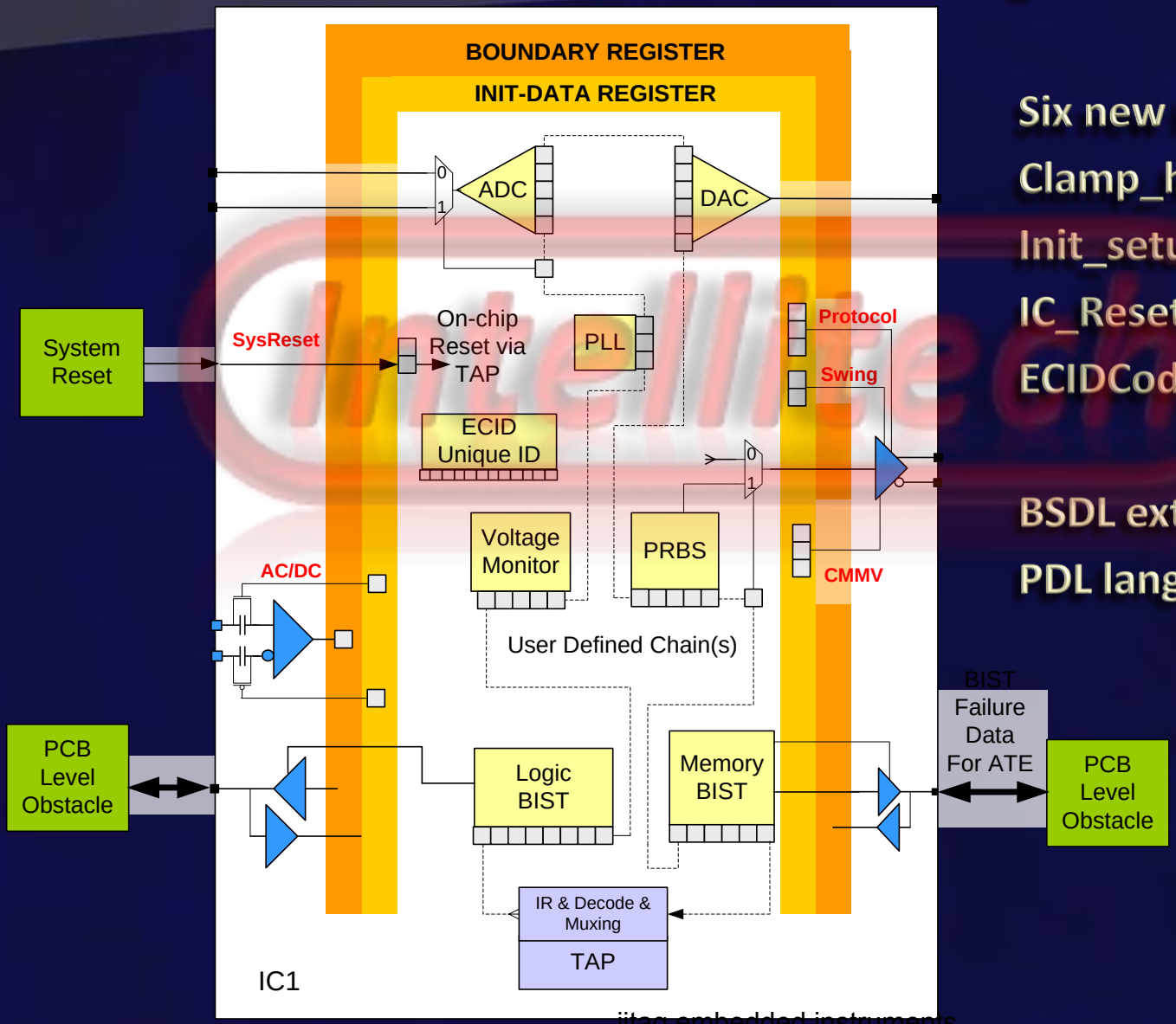
Great group of dedicated users/IC/DFT/ICT
Approx 14-19 people on weekly conferences
Tuesday call - 11AM EST
Friday - 11:30-1PM EST

IEEE 1149.1WG website

http://grouper.ieee.org/groups/1149/1/

Join WG or IEEE reflector

P1149.1-2012 at a glance



Six new instructions:

Clamp_hold/release

Init_setup/Init_run

IC_Reset

ECIDCode

BSDL extensions

PDL language

Design Specific Test Data Registers always in standard

BSDL lacked definitions

Since 1990s many

Vendor/Proprietary BSDL extensions devloped

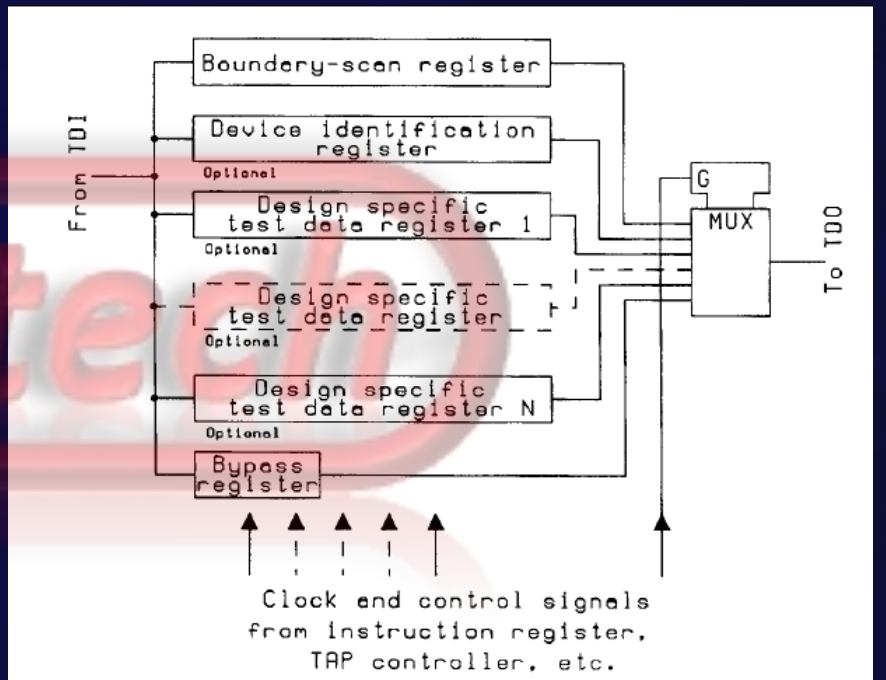


Figure 9-1—An implementation of the group of test data registers

BSDL extensions and languages supported high level operation (vendor specific)

```
attribute REGISTER_NAME of exinit : entity is
      "mbist-csr[1]      (INIT_DATA[101,101]),"&
      "alg[5]        (INIT_DATA[205,201]),"&
      "done[1]         (INIT_DATA[101,101]),"&
      "Status[2]       (INIT_DATA[101,100]),"&
      "fail_row[8]     (INIT_DATA[117,110]),"&
      "fail_col[8]     (INIT_DATA[127,120])";
```

```
--  format register/bus:MNEMONIC (bit pattern,
       data, data)
```

```
attribute TDI_MNEMONIC of exinit : entity is
      "mbist-csr:Start    (1)," &
      "mbist-csr:Stop     (0)" &
```

Dotted heirarchy

```
setTDI  u1.mbist-csr start
setTDI  u1.alg          walk1
drscan
runtest 10000
set result [getTDO status]
If  {$result != pass}
    puts “memorybist failed”
```

Re-usable Script to operate on Mbist registers

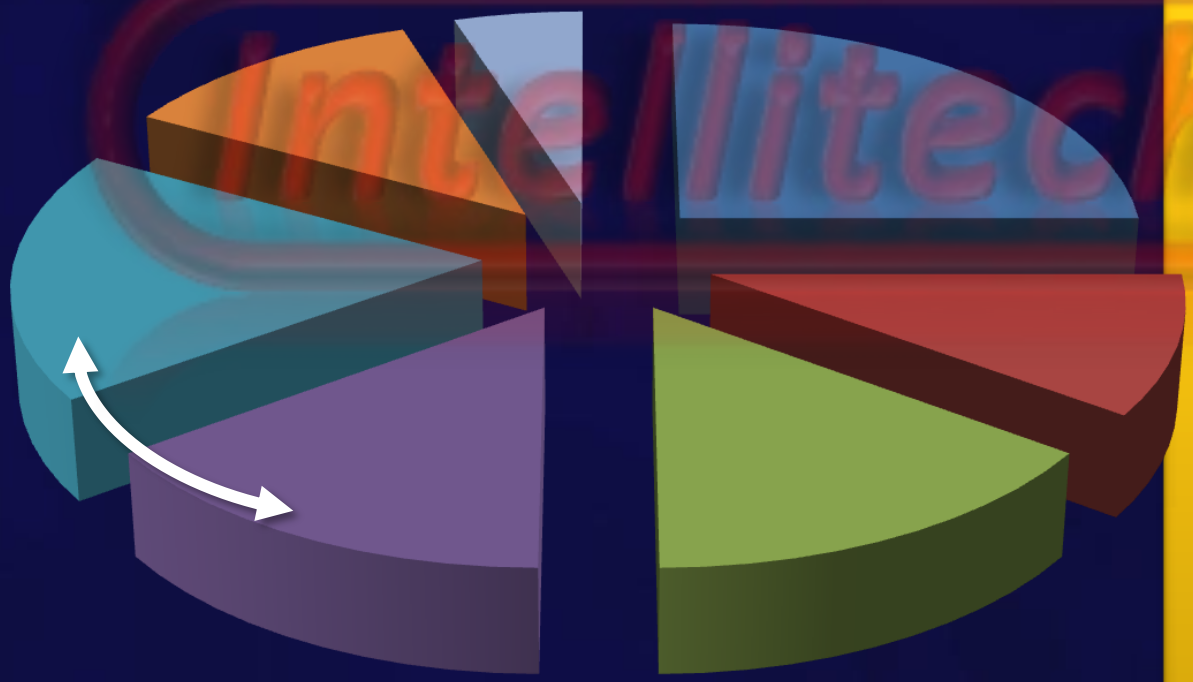
Fast forward to today

Critical Elements for Successful use of JTAG Assisted Functional Tests

1) Standardized languages and BSDL constructs
2) Ease of use/Re-use
3) Minimal ecosystem requirements
4) Minimize false failure mechanisms (see 2 & 3)

Reduce Cost of IC for the System Integrator

- IC is good, price is right, cost to deploy system with IC is high



Correlation

IC Tester

IC in System

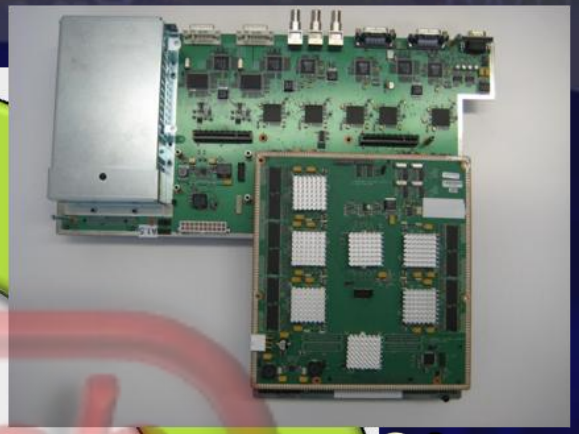
- Stable temperature
- 50ohm Z_T DUT card design, dedicated
- Low noise Power, DC/DC converters
- Perfect Low jitter, 50/50 duty clocks
- BIST/Compression vectors, delay test

- Changing temp
- Std. FR4, multi-IC signals
- Commodity LDOs, DC/DC
- Tin Can Osc, System origin clocks
- JTAG assisted Functional/BIST

On-Chip test via IEEE 1149.1 - the lowest common denominator

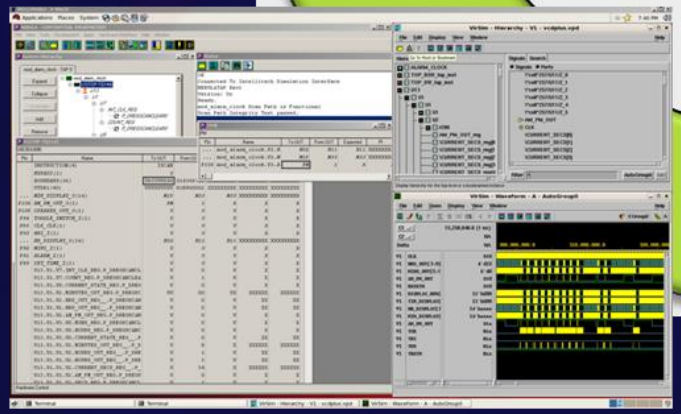
IC Tester

TEST
DEBUG
CONFIGURATION
With 1149.1/JTAG

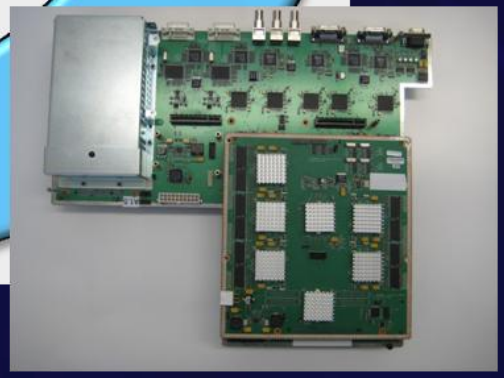


System Test

Simulation



Field

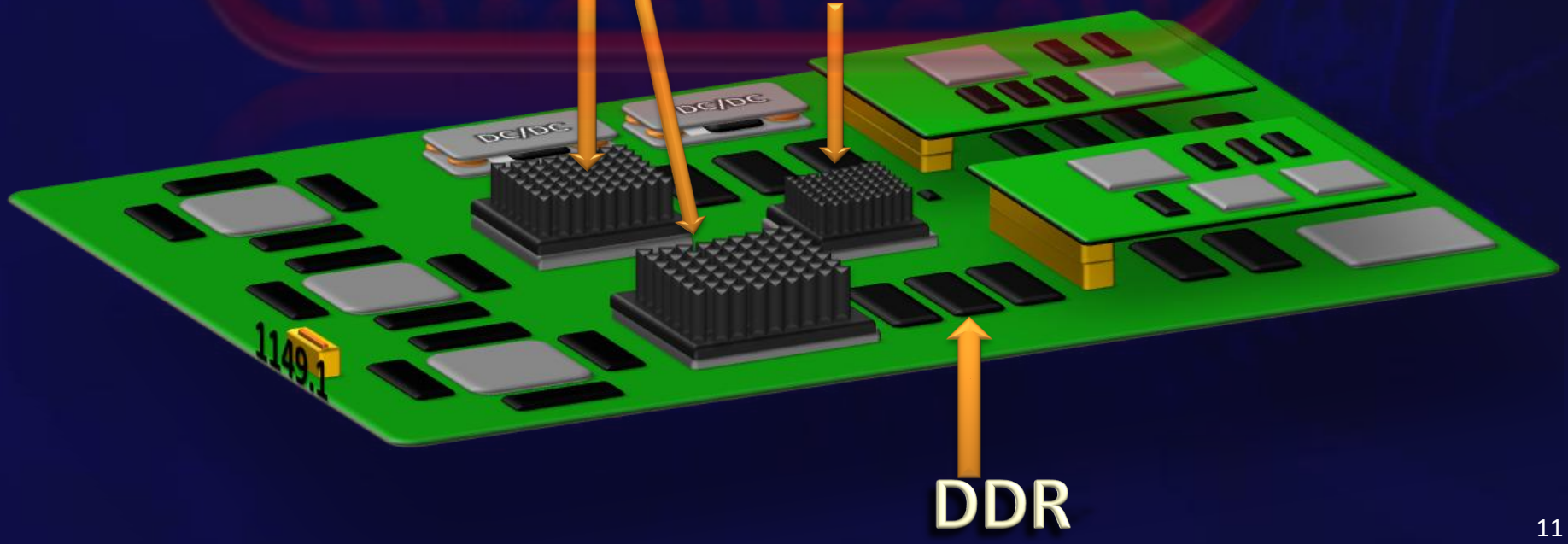


Board Test Complexity

Need help in testing Ecosystem around IC : DDRs, SERDES I/O

May require powering down/up system between BIST tests

What system knowledge is required to understand
how to operate on-chip Infrastructure IP?

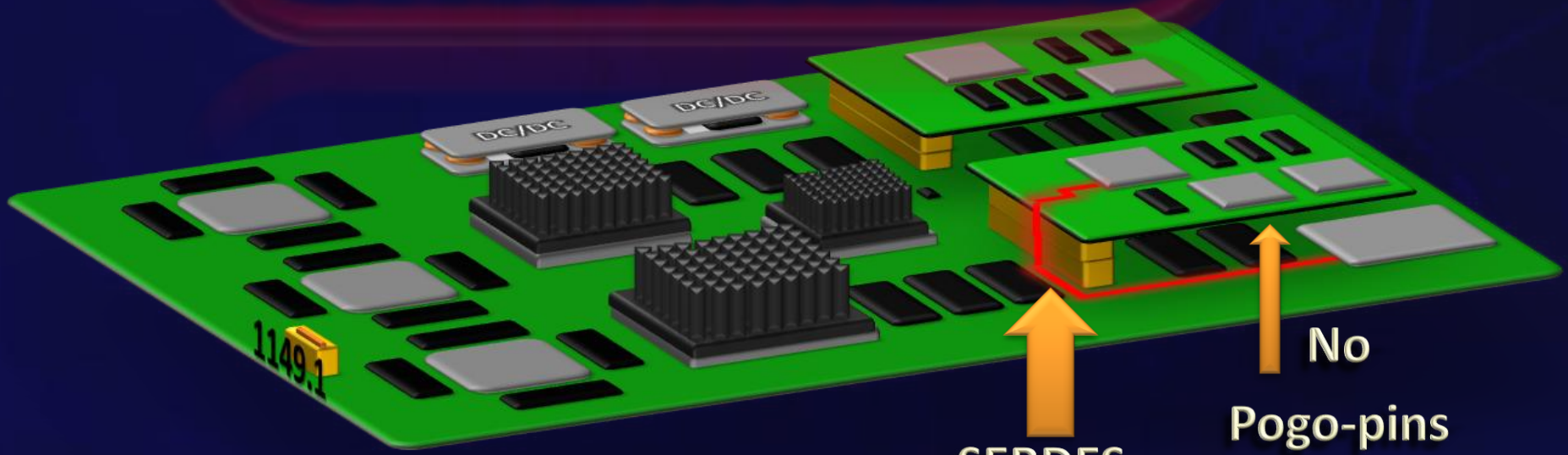


Need simple JTAG assisted functional tests

- small bite-sized at-speed test
- ex.: using on-chip PRBS/BER test

Remove need for entire system to boot

Enable in-field structural test (no external tester)



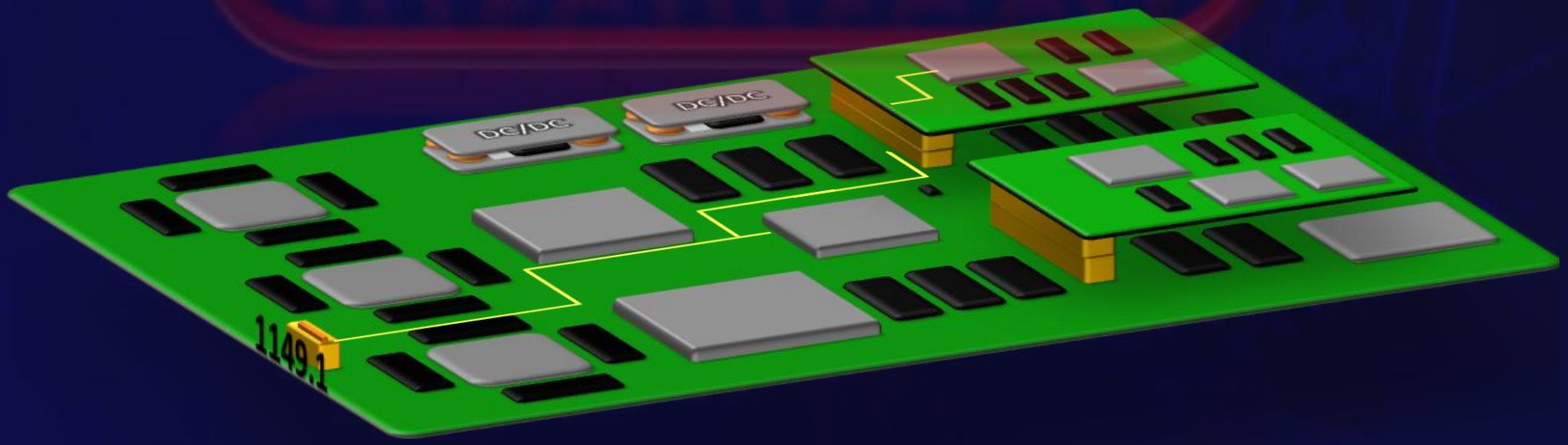
Board Test Complexity

Heat Sinks may not be present at board test

On-chip PLLs need to be controlled (safe and cool)

Access to system reset of IC critical

- power up/down is costly in terms of time
- many resets (and not always routed for JTAG test)



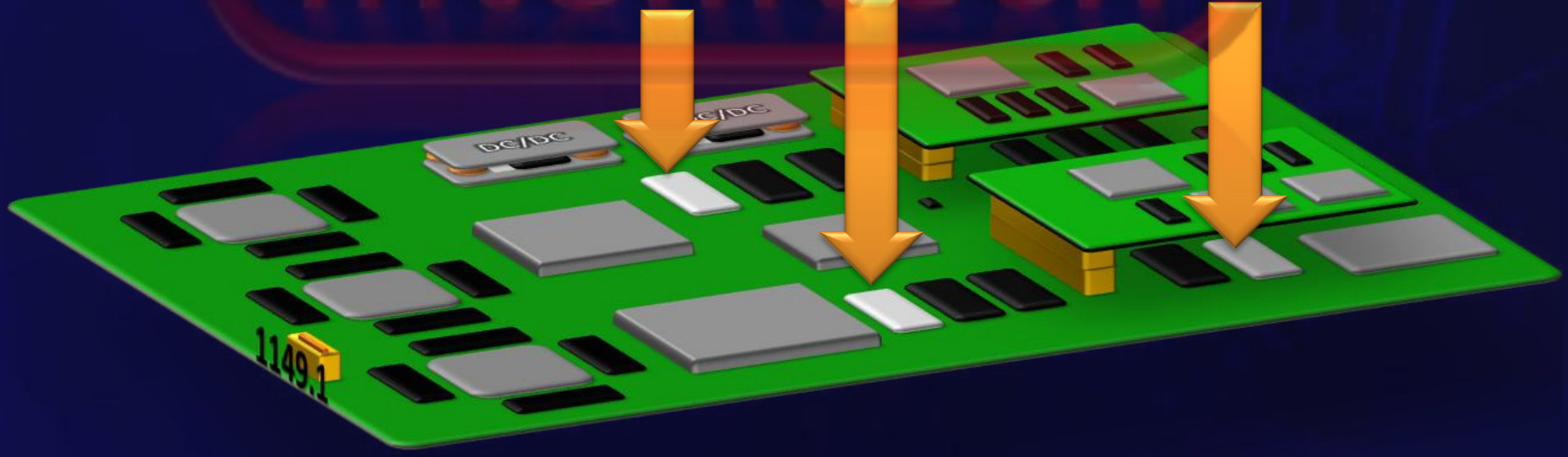
CPU may not have ecosystem to initialize I/O

-Clocks, code, resets, watchdogs

PLDs unprogrammed

-Inputs to ASICs perhaps undriven

Flash un-programmed

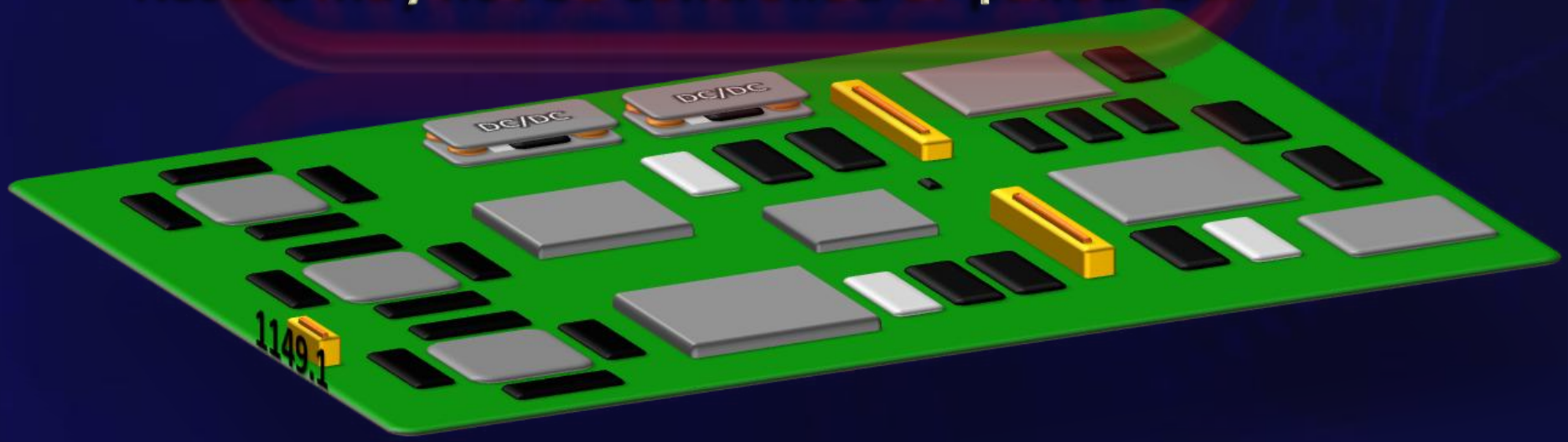


Board Test Complexity

COTs CPU modules missing

IC I/O may be uninitialized

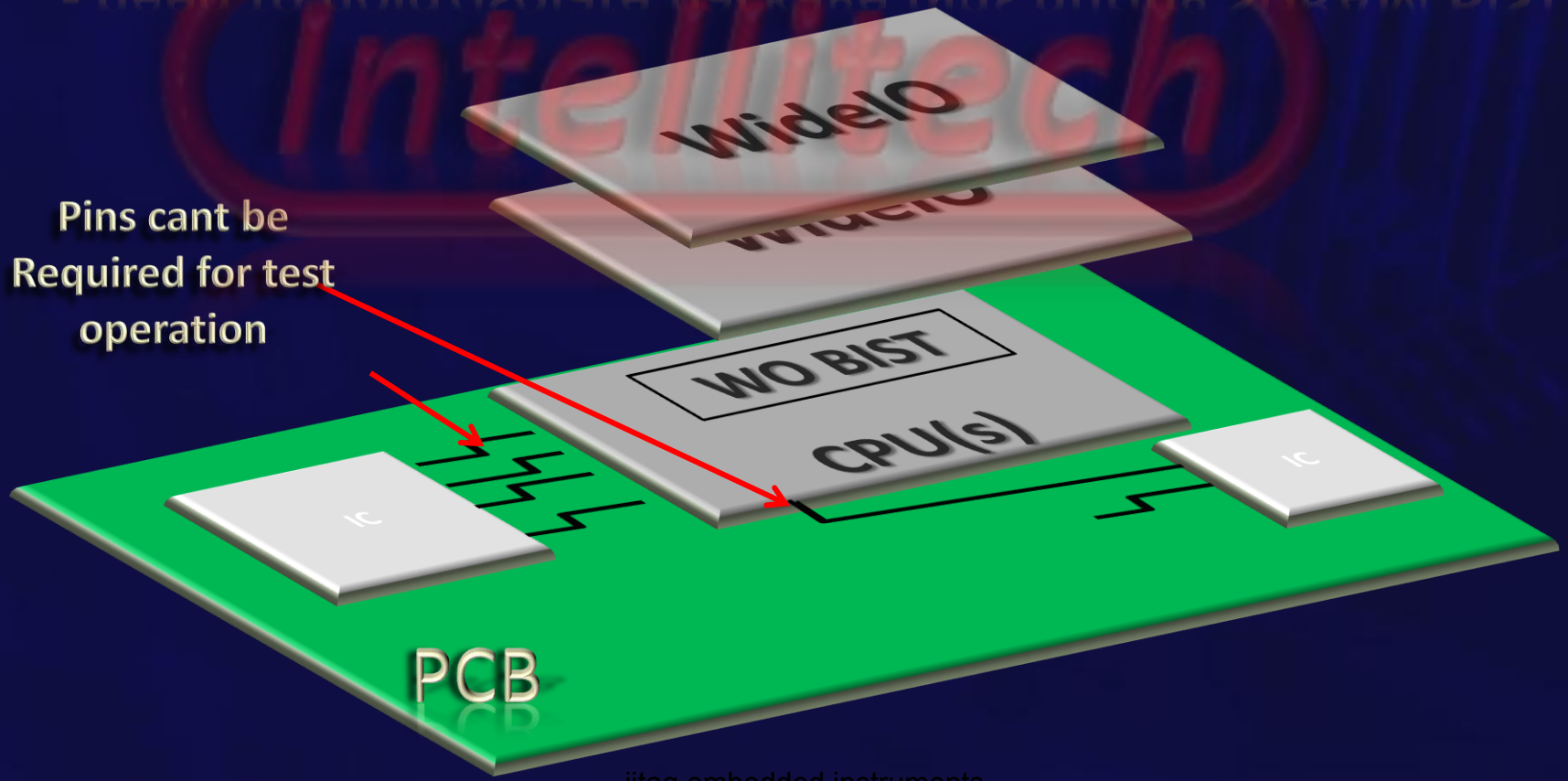
Resets may not be controlled or pulled-low



Isolation critical for reliable Test & F/A

1149.1 accessible SDRAM BIST in 3D package

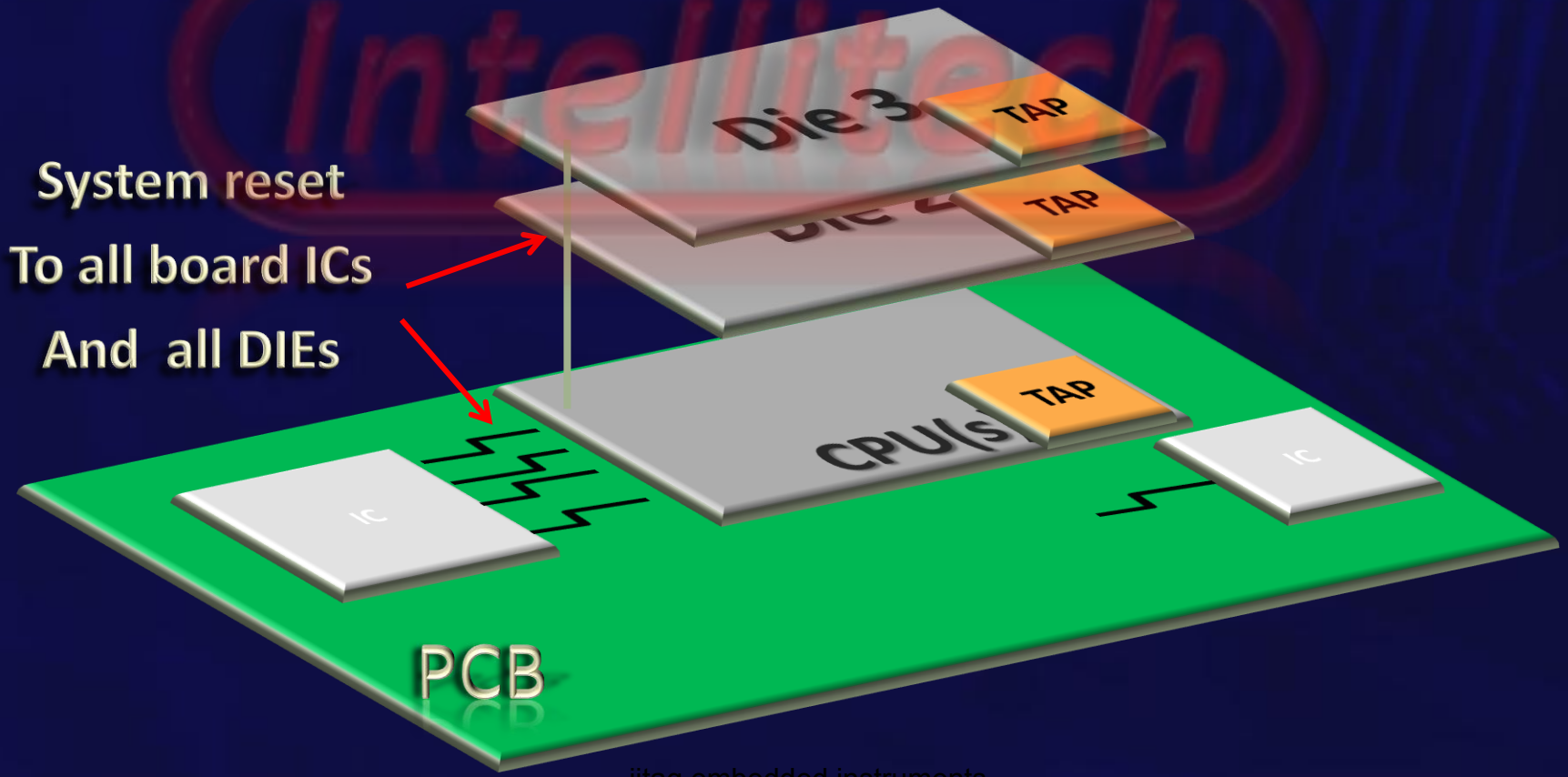
- can't fail good SDRAM due to system design/fault
- need to hold/isolate package pins during SDRAM BIST



JTAG controlled IC RESET needed

- **LogicBIST, memoryBIST, etc - all need IC reset after execution**
- **Need to isolate the reset from all the other ICs**
  - Save time -hold reset internally to IC/DIE so IP based test can run

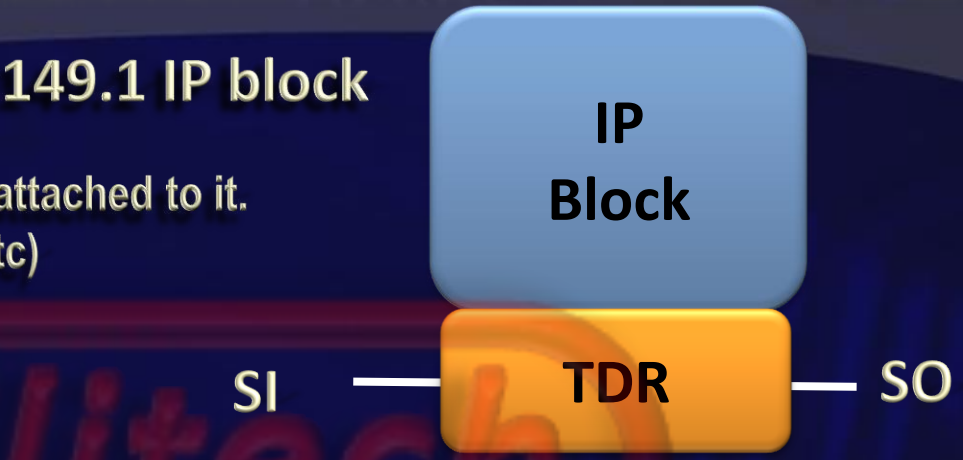
after reset each IC has to potentially be re-INIT, re-configged for next test



IEEE 1149.1 IP block

An IP block has a TDR segment directly attached to it.
-Purpose built IP block (PLL, SERDES, etc)

Broad industry applications
- microcontrollers, FPGAs, ASICs



IP blocks which don't have a TDR segment currently, will
In the future as the ecosystem around the standard develops

CLAMP_HOLD / CLAMP_RELEASE / IC_RESET needed for guaranteed operation of IP based tests

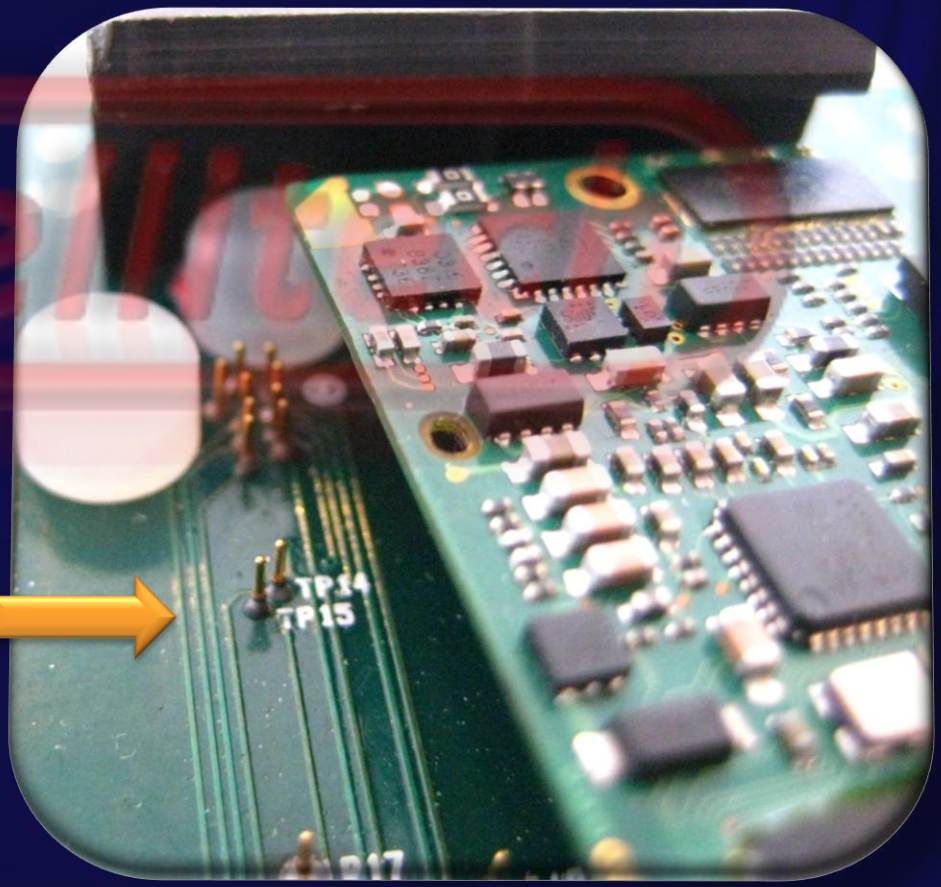
Focus on ecosystem to isolate IP block or IC such that no system or ecosystem faults can prevent IP from working

Document IC power/ground and system clock pins
use REGISTER_PIN_ASSOCIATION attribute

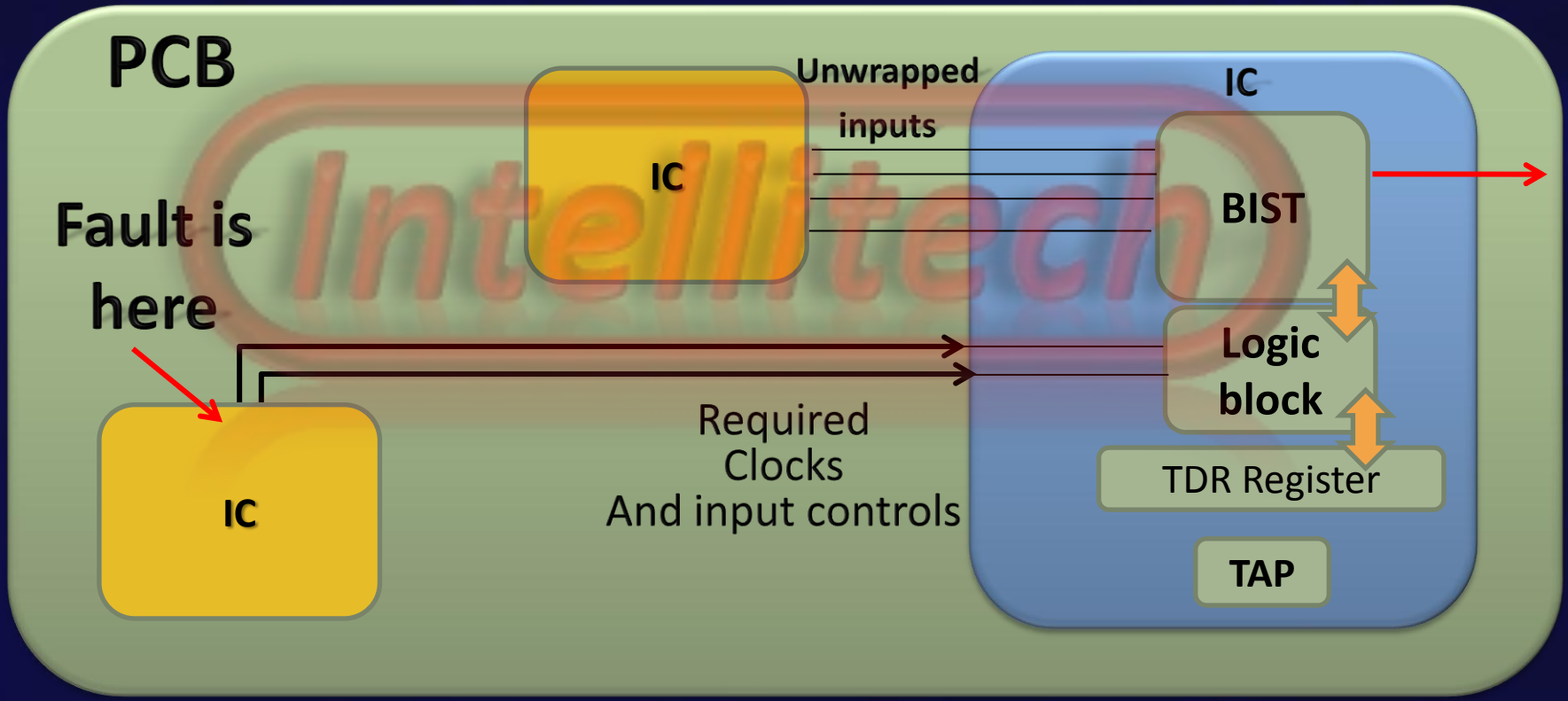
Ideally less reliance on external digital I/O to prepare IC for tests or execute on-chip IP for board test

Small features
- High Density
-Difficult to probe
Typical .035”

.017”



Prior to IEEE 1149.1-2012

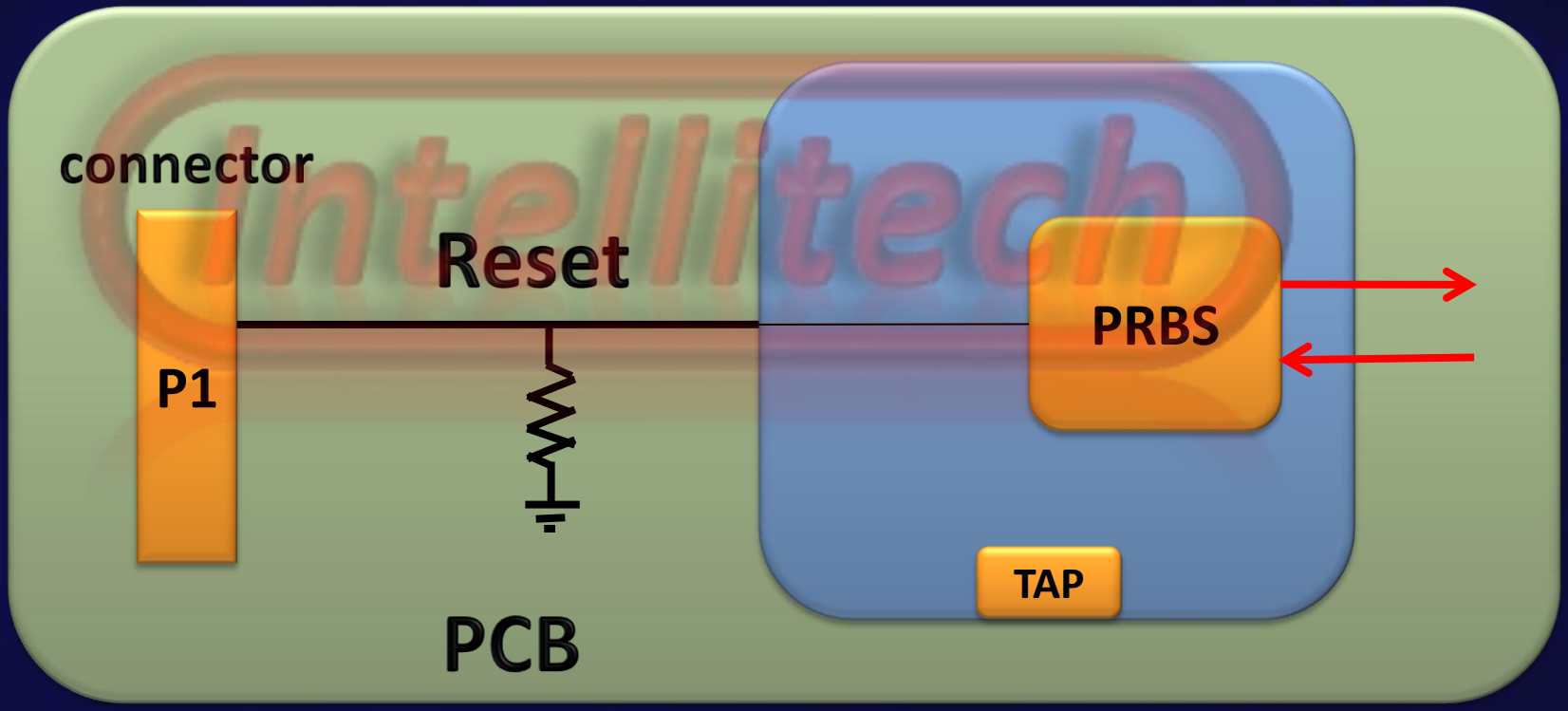


If you can control your ASIC design flow as the System design is being done – perhaps possible to manage And avoid – but at what cost/risk. How is it diagnosed?

On-chip JTAG based tests require stable system resets

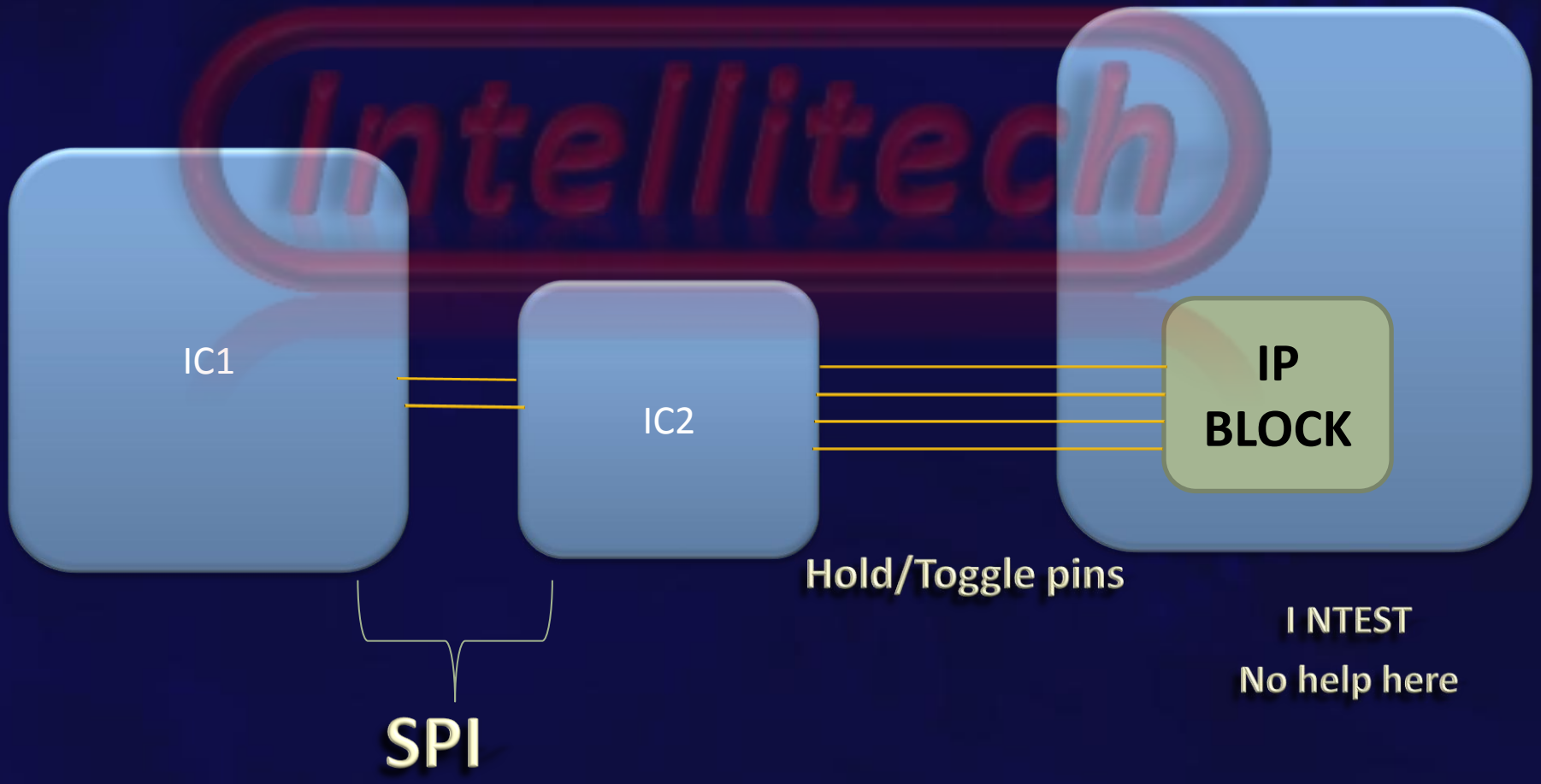
Without System reset control – IP block tests will fail mysteriously

(open, toggling, non-driven RESET inputs) - Difficulty for CM to find root cause

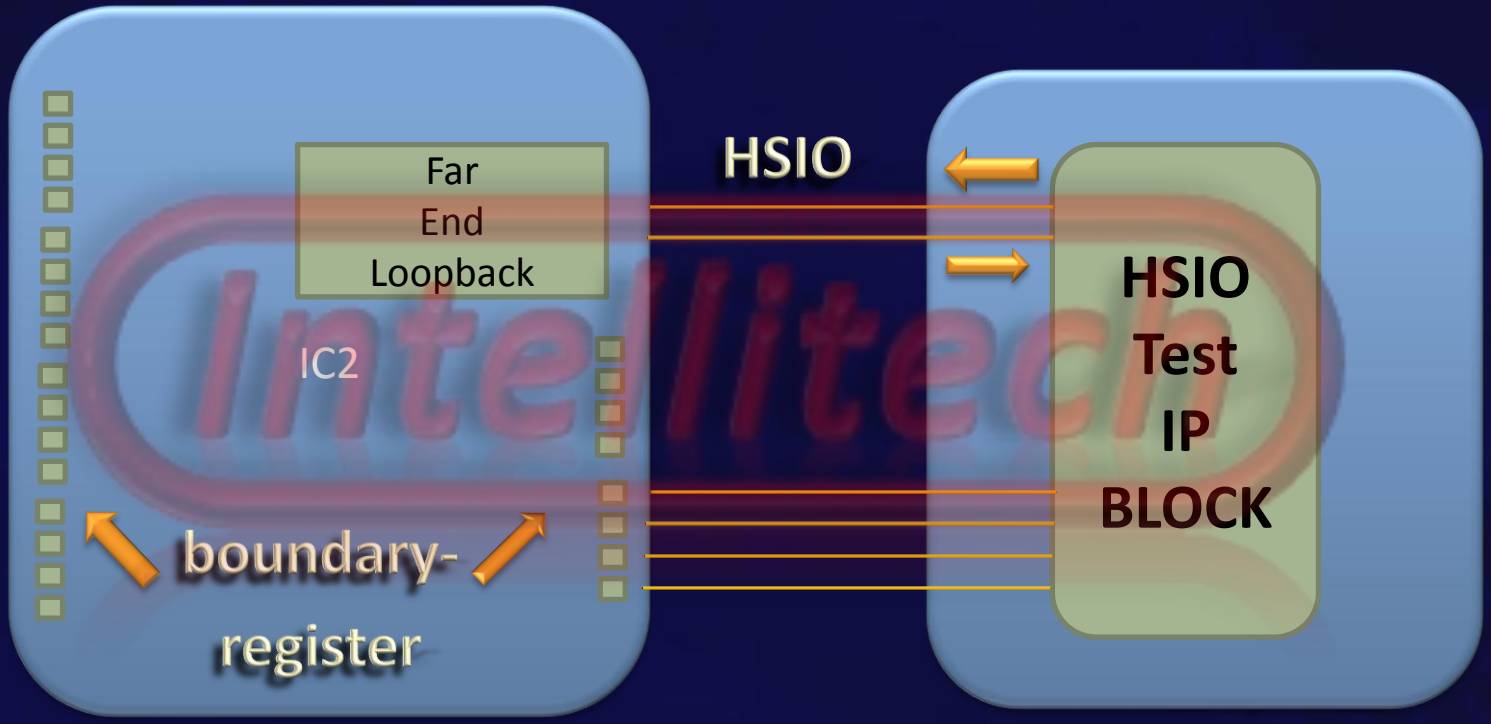


This is managed in 1149.1 with IC_RESET instruction

Need to reduce dependencies on ecosystem



IP cannot count on external ecosystem



Need EXTEST to Hold/Toggle pins

-3000 cells causes large test time increase

-(compared to direct access)

-IC2 no longer in functional mode

Where the big money is

IP Domain Expertise

HDL

"I know my infrastructure IP" "I don't want To know the entire system to make it work"

"I know my IC" "I don't want to support the infrastructure IP or the entire system"

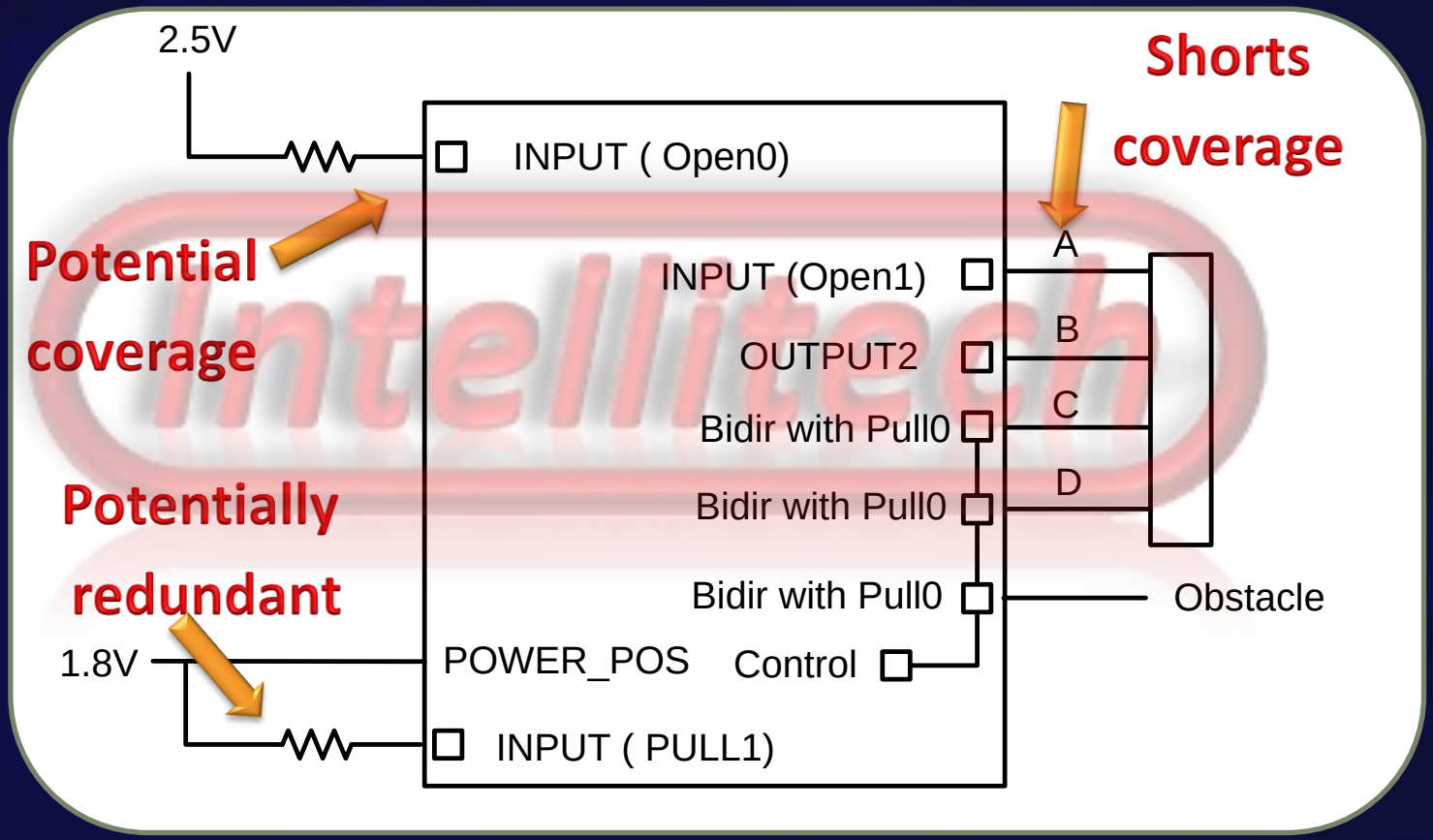
"I know my system design" "How Does this Infrastructure IP work?"

EMS

"I know board test and assembly" "How does this Infrastrucure IP work?"

What IEEE 1149.1-2012 is proposing (still unapproved/unballoted)

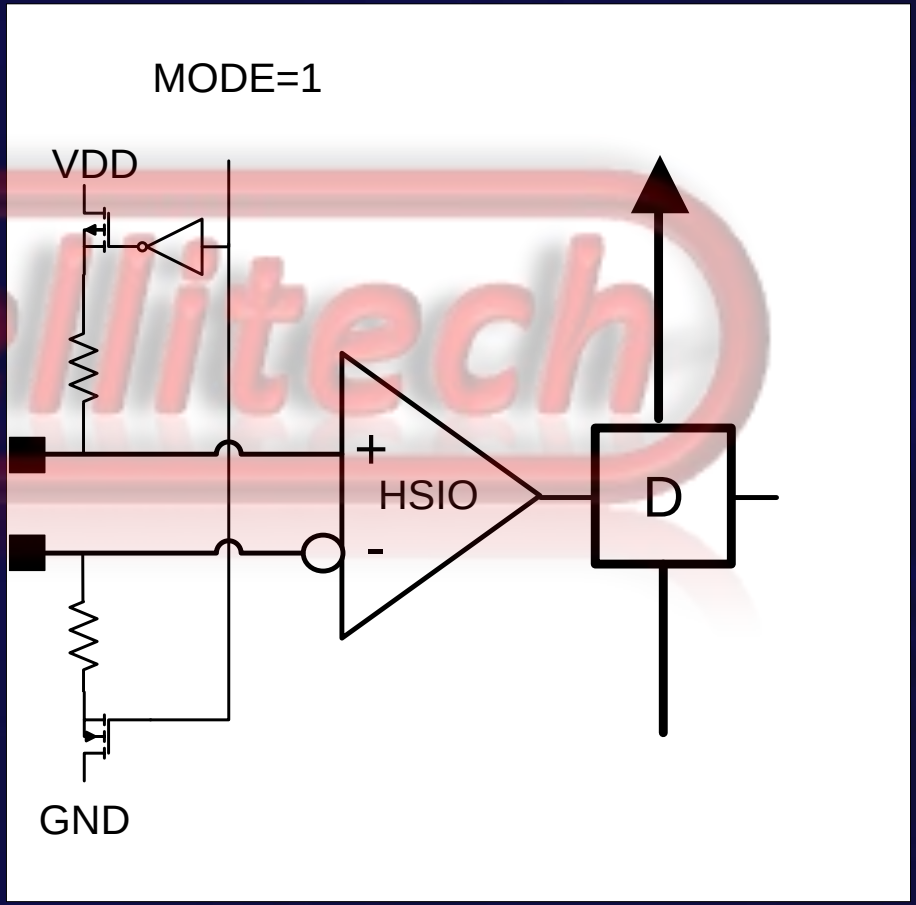
New <input spec> = Open1/0/X, Pull1/0, Keeper




```
"8  (BC_1,  in1,   input,   open0)," &
"7  (BC_1, out2, output3, X,  16, 1, PULL1)," &
```

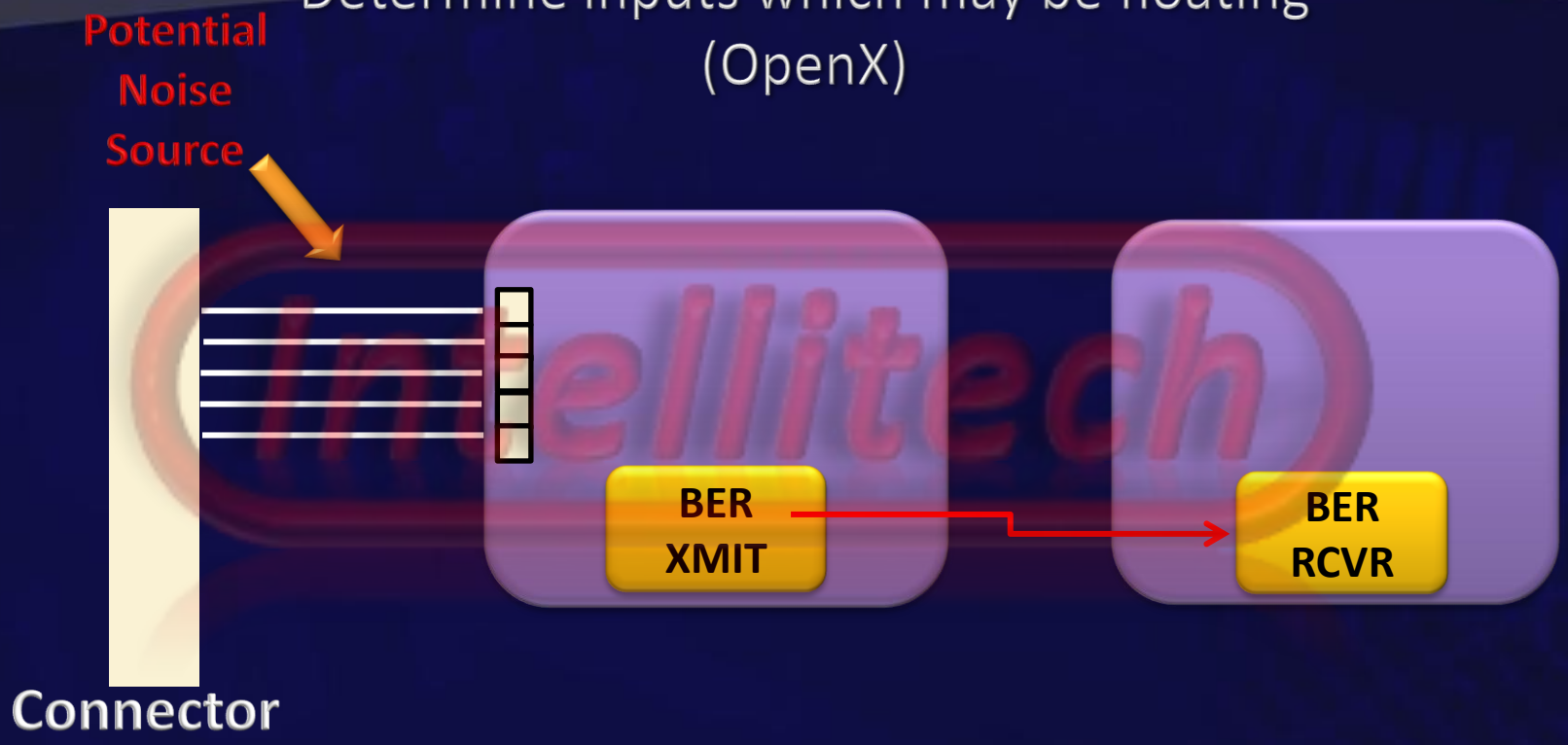
PULL may occur only in test modes

LVDS
And other
Standards
Require
Differential
Receivers to
produce ‘1’ on open
connection



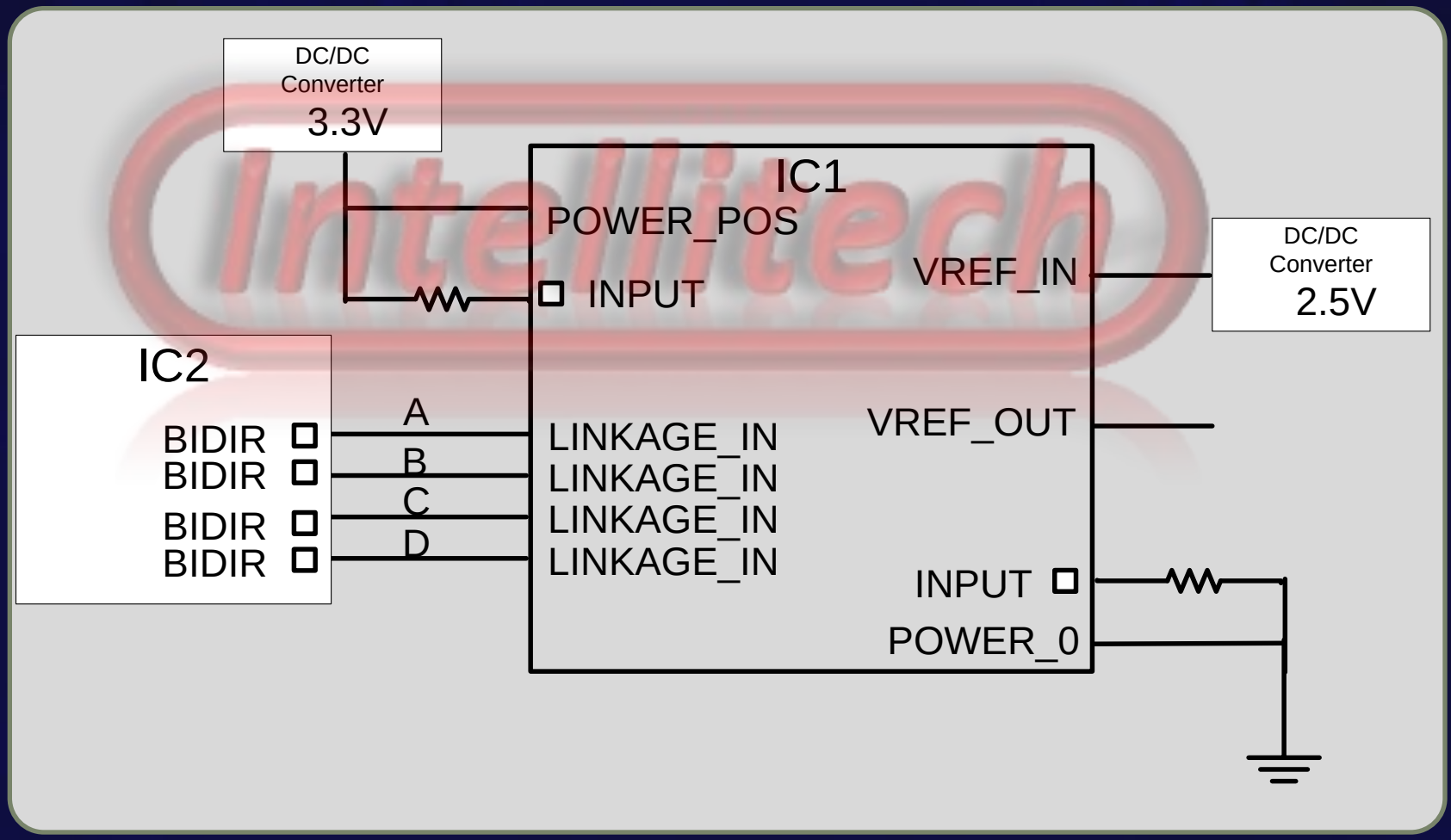
"8 (BC_1, in1, input, PULL1)," &

Determine inputs which may be floating (OpenX)



During board test, input s may not be driven due to connectors

New descriptive port types for linkage



New descriptive port types for linkage

linkage_out	A non-boundary scan analog port capable of sourcing/sinking significant current that has a disable method.
linkage_in	A non-boundary scan analog input that does not source or sink significant current
linkage_inout	A non-boundary scan analog bidirectional
Linkage_buffer	A non-boundary scan analog port capable of sourcing/sinking significant current, but does not have a disable method.
linkage_mechanical	A non-electrical port used for positioning, heat sinks or other non-electrical use. There is generally no connection to the chip silicon.
vref_in	A non-boundary scan input reference voltage port
vref_out	A non-boundary scan output reference voltage port
power_0	Zero volt Ports. These are ports which are normally associated with GROUND. Keyword GROUND or GND is not used here in order to leave these words for signal names.
power_pos	Power supply ports which receive a constant potential with respect to power_0 that is greater than zero volts.
power_neg	Power supply ports which receive a constant potential with respect to power_0 that is less than zero volts.

Six new Instructions:

IC_RESET

- reset IC and power domains through JTAG

INIT_SETUP/INIT_RUN

- configure I/O on-chip resources for

CLAMP_HOLD/CLAMP_RELEASE

- hold pins for in-situ on-chip tests

ECIDCODE

- read unique die/TAP ID value

BSDL for Internal JTAG TDR registers

- for BIST/PLLs/SERDES IP blocks

MNEMONICS for JTAG registers

- Easy to remember words

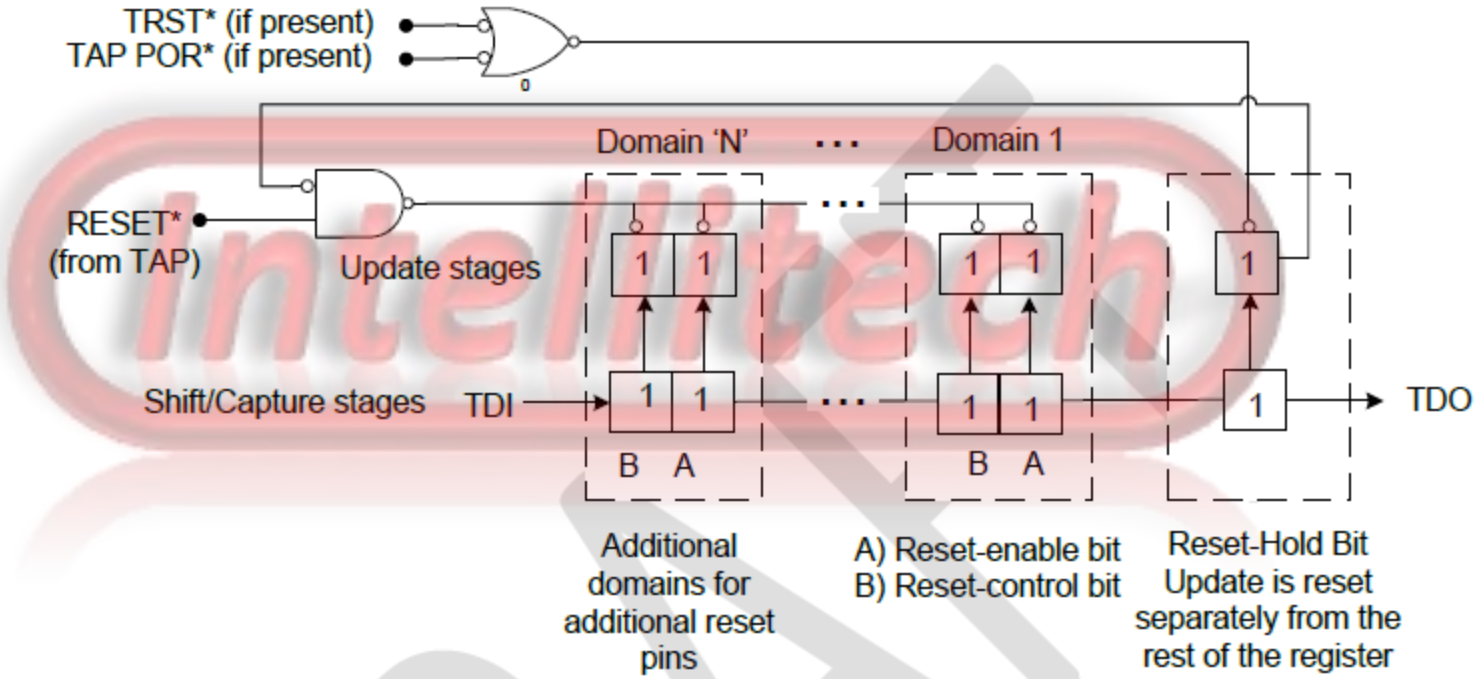
Package files for on-chip Infrastructure IP blocks

- self-contained definitions for IIP

PDL Script files for device initialization and IIP access

- operates on registers, packages, Mnemonics

4783 **16.1 Design and operation of the Reset-Select Register**



4784

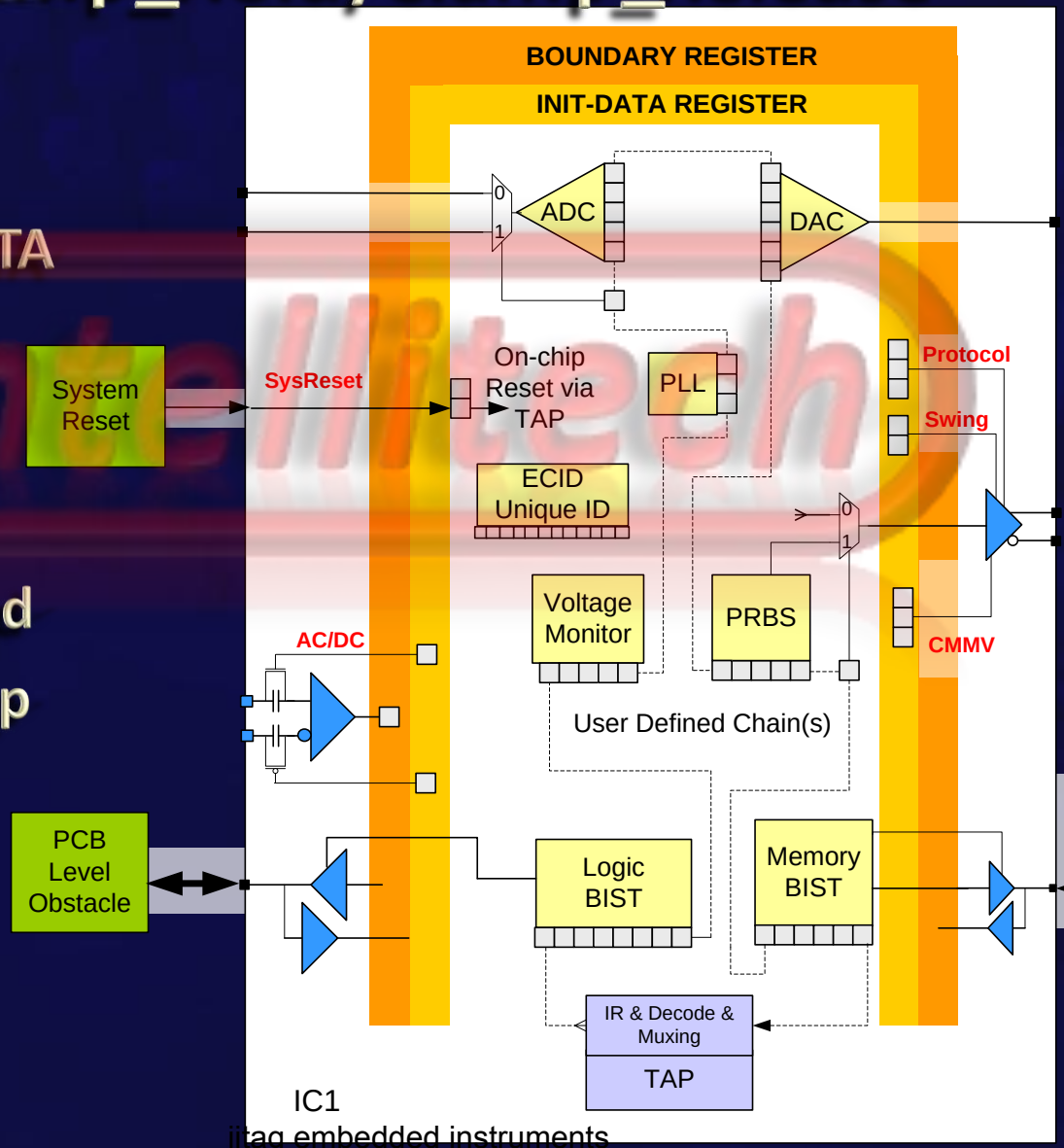
4785 **Figure 16-1 Reset-Select register overview**

Clamp_Hold/Clamp_Release

Two purposes:

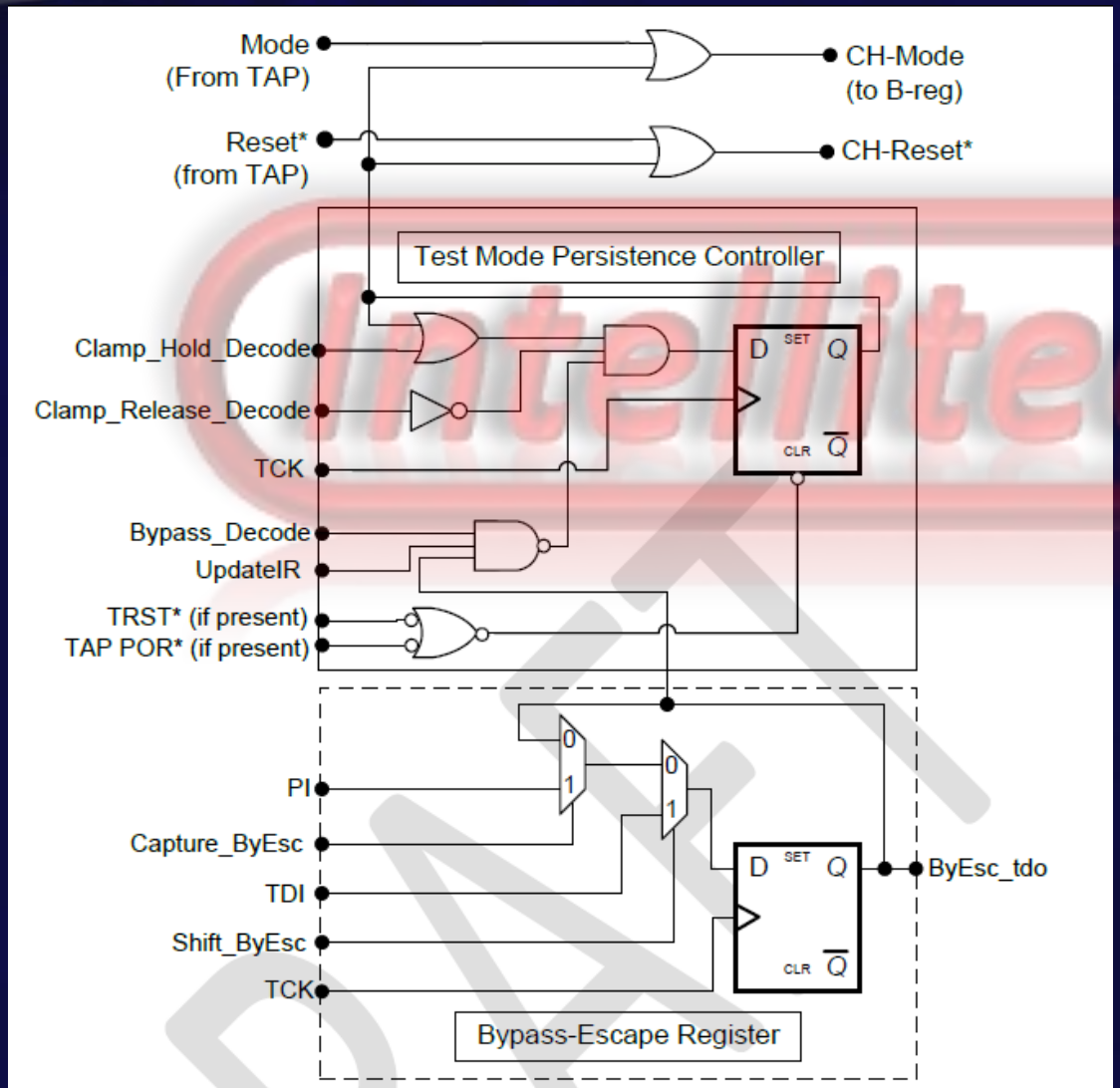
1) Hold INIT-DATA Across chip and TAP reset

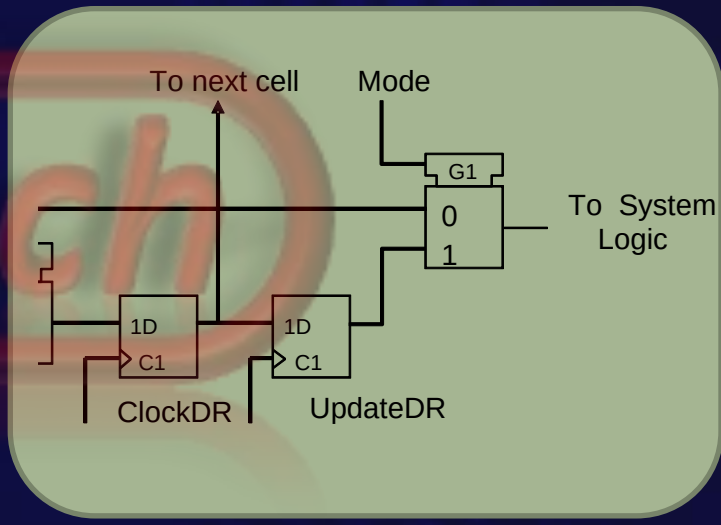
2) Enable in-situ Test - isolate/hold I/O during on-chip tests



Protect Against PCB Obstacles

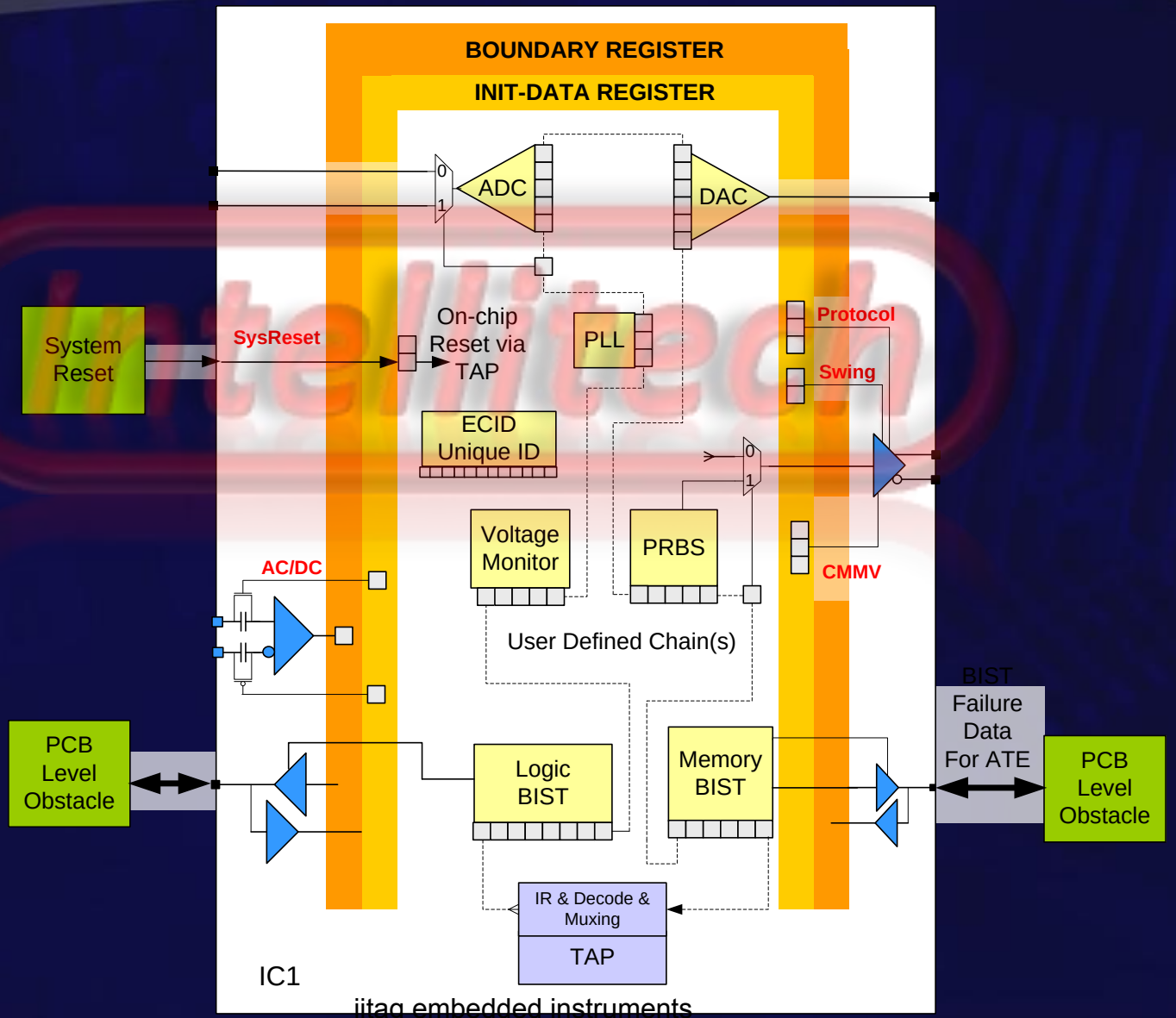
CLAM_HOLD (intercept mode/reset to TDRs)





gure 15-1—Example TMP Controller and Bypass Escape Register (non-gated clocks)

Intel embedded instruments



jtag embedded instruments

Recommendations for user TDRs
- Enable IP blocks TDRs to plug together

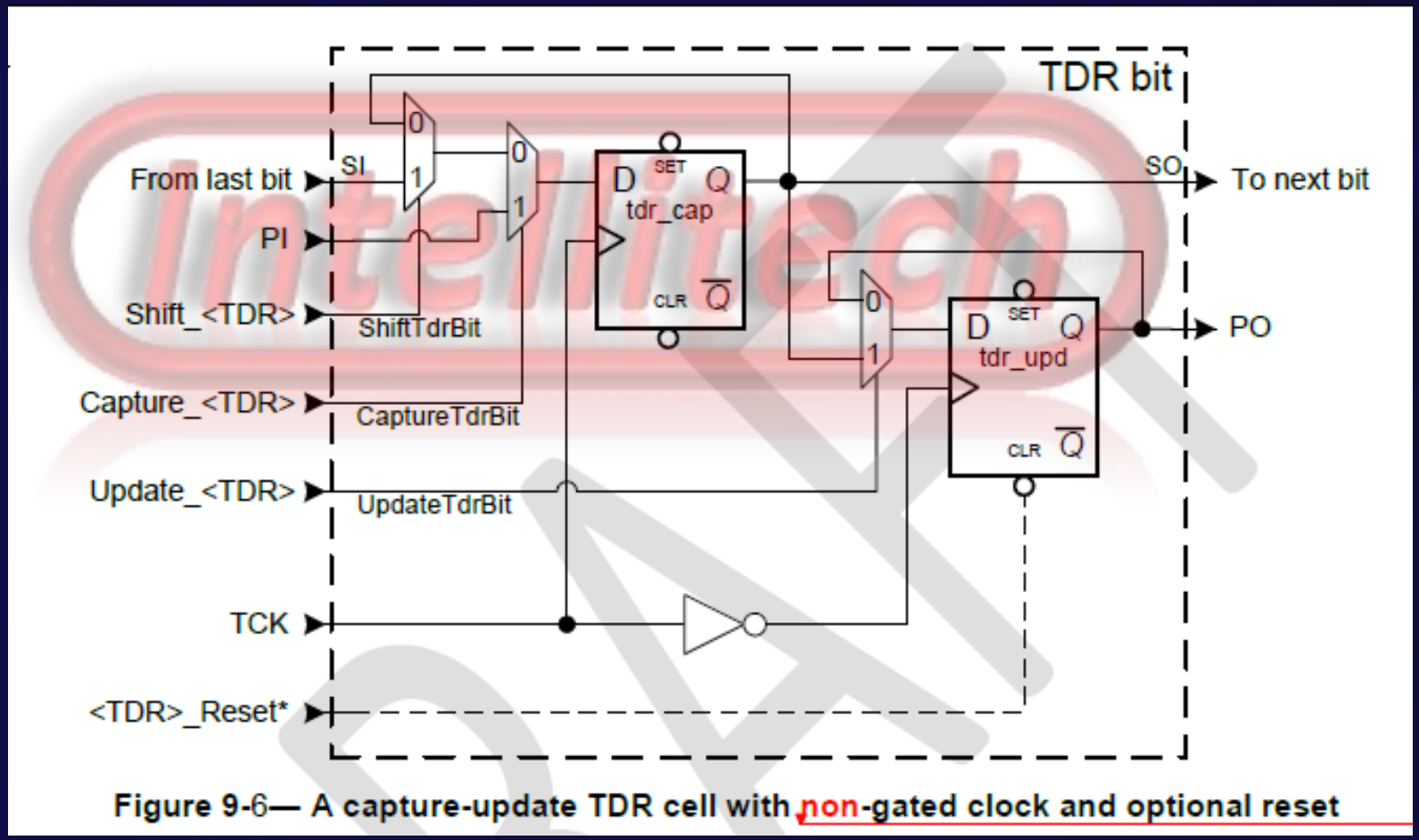
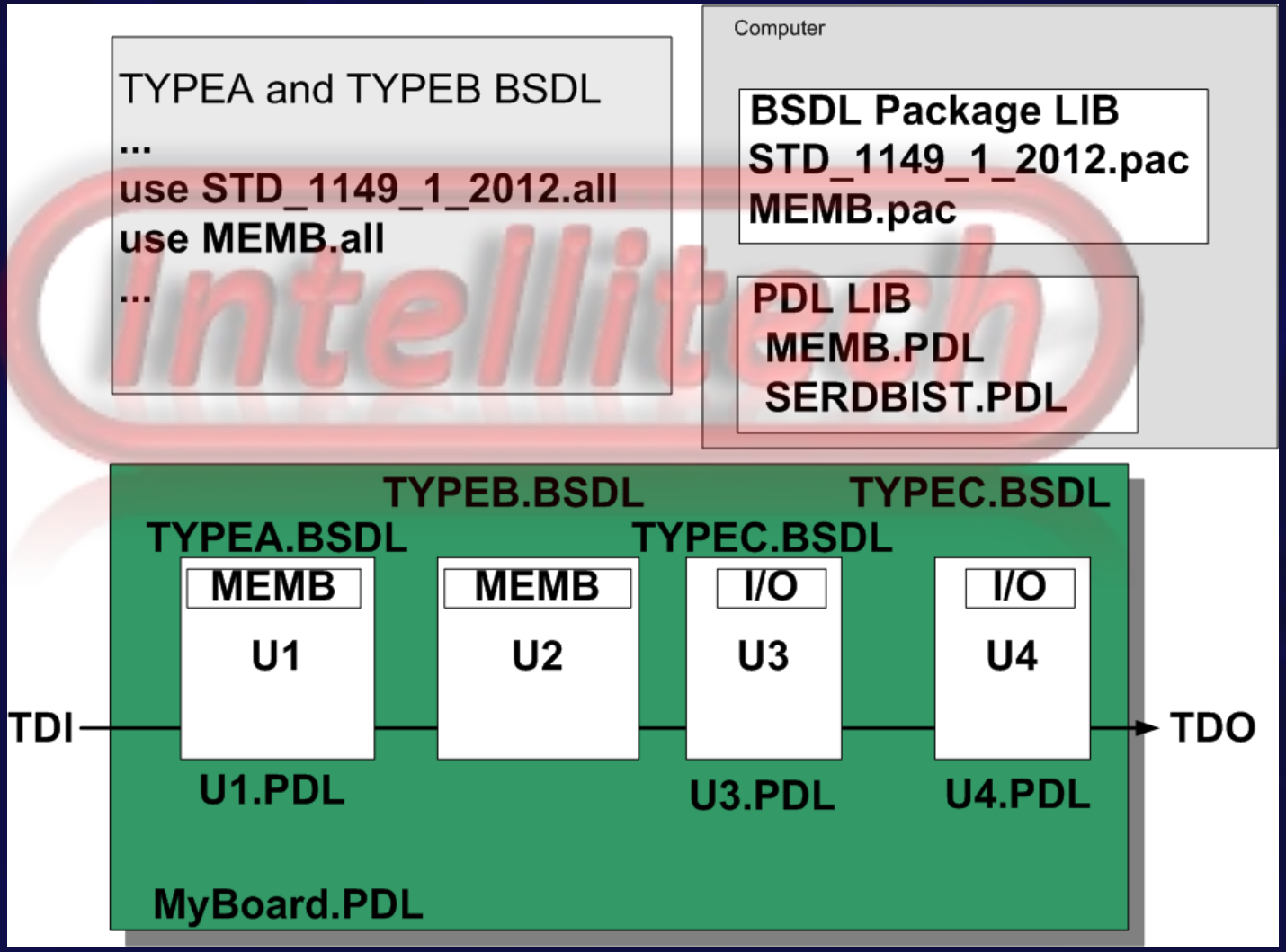


Figure 9-6— A capture-update TDR cell with non-gated clock and optional reset

Hierarchy supported through package files



New standard INIT_DATA & INIT_STATUS TDRs

New instructions, INIT_SETUP/INIT_RUN

-Use between PRELOAD and EXTEST - Turn off PLLs

-Setup I/Os (Vcm, Vswing, protocol….)

INIT_SETUP access INIT_DATA

- Uses TAP, CE, power
- INIT_DATA bits control the above

INIT_RUN access INIT_Status register. Can clock TCK in RTI.

- Pass/Fail, Done – other bits as needed

Why can't I/O settings be delivered in BSDL?

U3.PDL

```
iProc init_setup {} {
iWrite IO1  PCIe
iApply
}
```

U4.PDL

```
iProc init_setup {} {
iWrite IO1  SRIO
iApply
}
```

Board Test Engineer Developed via Software or from Templates from IC Vendor

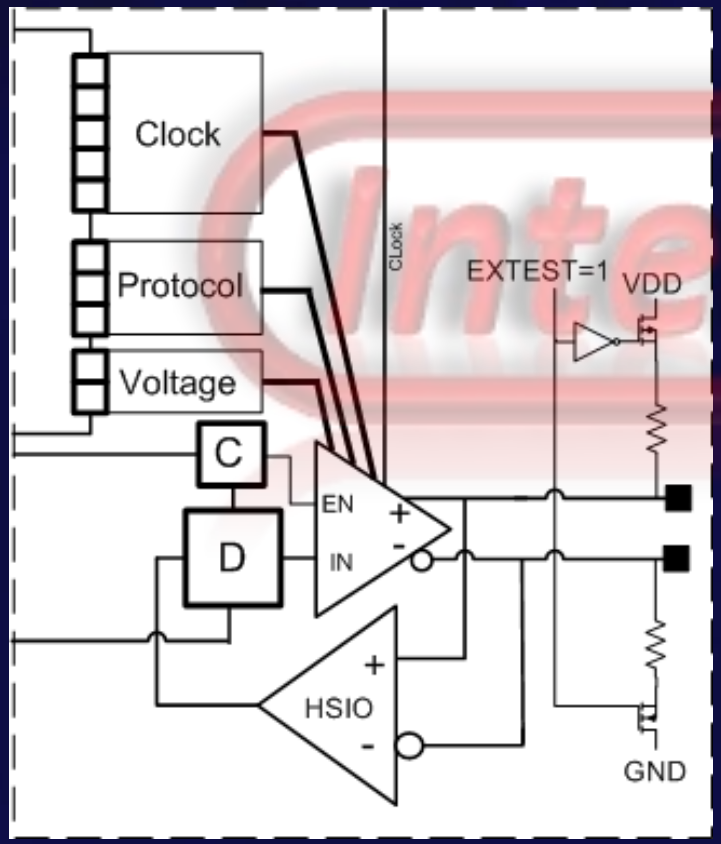
Board.PDL

```
iCall U3.init_setup
iCall U4.init_setup
```

Board Test Engineer Developed via Board Test Software, Automatically, assisted or manually

Basic Register Fields

TDR

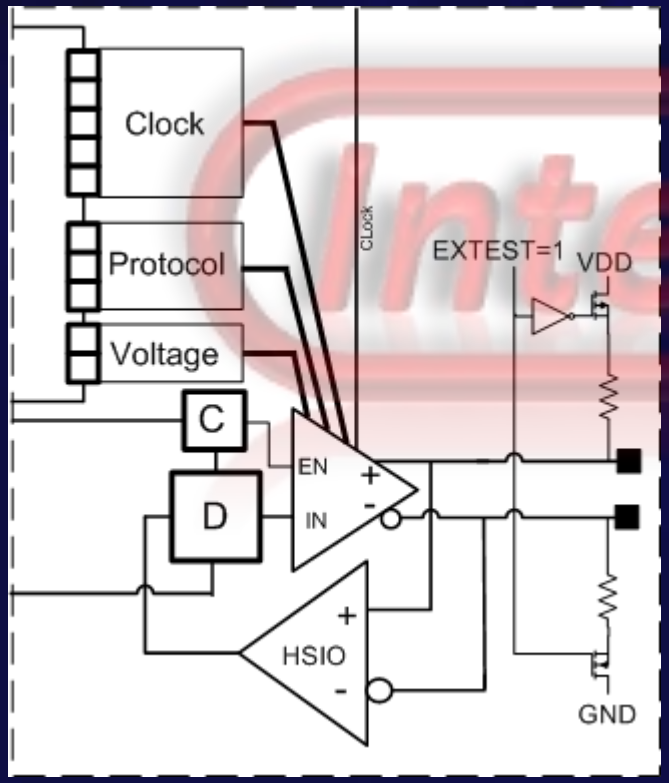



```
attribute REGISTER_FIELDS of INIT_Example :
entity is
"init_data ( "&
"(Clock[5]       IS (504 DOWNTO 500) ), "&
"(Protocol[3]    IS (302 DOWNTO 300) ), "&
"(Voltage[2]     IS ( 101 DOWNTO 100) ), "&
"(Reserved [20] IS ( 19 DOWNTO 0) ) "&
");"
```

BSDL syntax for “INIT_DATA” and For Clause 9 user defined TDRs

MNEMONICS

TDR




```
attribute REGISTER_MNEMONICS of SERDES :
package is
" Protocol ( " &
"  OFF (000) <I/Os powered down>, "&
" PCIe (001) <PCI Express>, "&
" SATA (010) <SATA>, "&
" SRIO (011) <Serial RapidIO>, "&
" XAUI (100) <XAUI>, "&
" Rsvd1 (101) <Undefined, do not use>"&
)," &
"Clockset ( " &
" F125Mhz (00111), "&
" F100Mhz (10101), "&
" Illegal (00000) <Do not use!>)";
```

Basic Register Fields with Mnemonics

```
attribute REGISTER_FIELDS of INIT_Example : entity is
"init_data ( "&
"(Clock[5]   IS (504 DOWNTO 500)  Default(Clockset(100Mhz) ), "&
"(Protocol[3] IS (302 DOWNTO 300)  Default(Protocol (off) ), "&
"(Voltage[2]   IS ( 101 DOWNTO 100)  RESETVAL(11) ), "&
"(Reserved [20] IS ( 19 DOWNTO 0))"&
")" &
“myTDR ( "&
"(Addr[64] IS (163 DOWNTO 100) ), "&
“(Data[64]  IS (227 DOWNTO 164) ), "&
“(WE[1]      IS (228) RESETVAL(1)   ), "&
“(TempMON[7]  IS (236 DOWNTO 229)) "&
);”
```

Sparse definitions compared to register length

Software reads BSDL & used for PDL generation

PROTOCOL1(10)	OFF	0000000000	0000000000
PROTOCOL2(10)	OFF	0000100000	0000100000
SWING(2)	SRIO	00	00
PLL(2)	PCIE	10	10
CAMBIST(2)	XAUI	00	00
CAMSTATUS(2)	00	10	10
LBIST(2)	RUN	00	00
LBISTSTATUS(1)	0	PASS	PASS
MODESTATUS(1)	0	0	X
STATUS1(1)	0	PASS	PASS

Device PDL (Procedure Definition Language) - Board specific

```
Proc  init_setup {} {

iWrite  Clock       F125Mhz      # use of mnemonics
iWrite  Voltage     0H01         # use of values
iWrite  Protocol    PCIe
iApply
}

Proc  init_status {} {

iRead   Status(1)   Pass         # use of mnemonics
iApply
}
```

Some PDL Commands

```
iWrite   <reg>  <value>       | mnemonic
iRead    <reg>  <expected>  | mnemonic

iApply                                  # perform DR scan RTI-RTI
iPrefix  <dotted path>            #  iPrefix bank0.serdes
iReset                                  #   Test Logic Reset
iEndState   RTI | PDR             #   set end state
iRunloop    <TCK-Count>          #   Loop in RTI
iCall     <iproc name>
itarget  <instance>
```

```
iPrefix U1              #  U1.LBIST

# run some basic tests on registers
iWrite LBIST RUN        # bit-position independent regs
iApply
iRunLoop 300000
iRead  LBISTSTATUS PASS  # check that LBIST passed
iApply
iWrite SWING S400MV     # set differential Swing to
400mv
iWrite PROTOCOL1 SRIO   # set protocol to SRIO
iApply
iWrite CAMBIST RUN      # execute CAM BIST
iApply
iRead  CAMSTATUS DONE
```

Association of ports (pins) to registers for diagnostics

attribute REGISTER_PORT_ASSOCIATION ("&

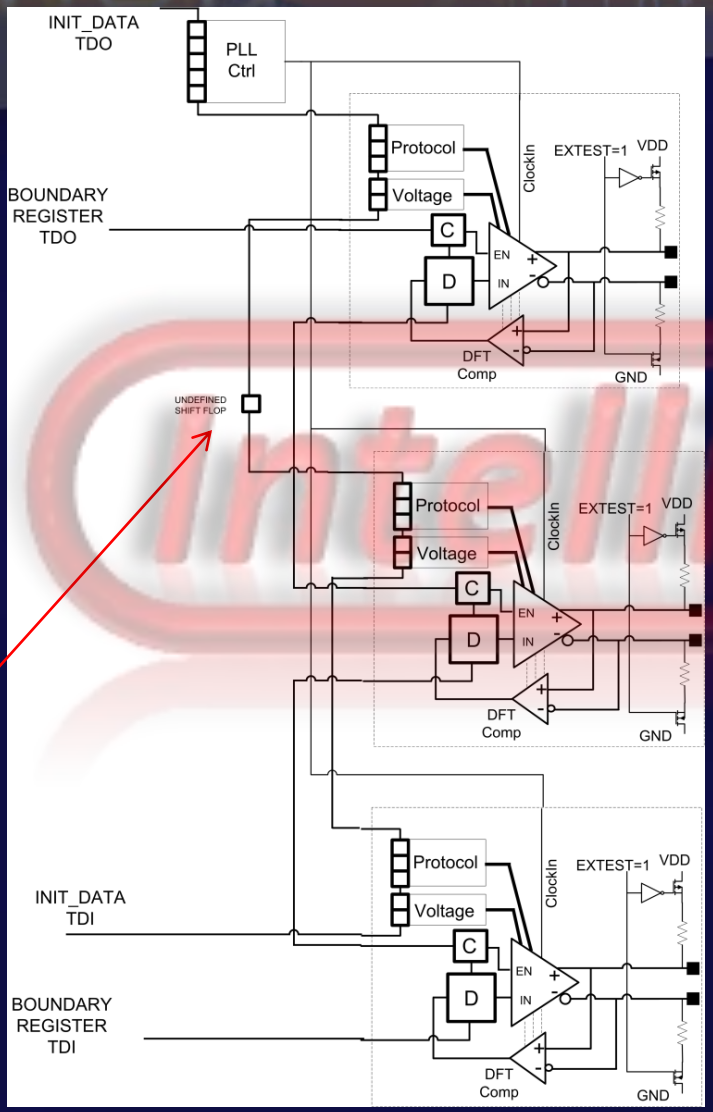
"SerDes00_PRBS (SD_RX(0), SD_RX_B(0), SD_TX(0), SD_TX_B(0)),"&
"SerDes01 (SD_RX(1), SD_RX_B(1), SD_TX(1), SD_TX_B(1)) ";

Register Field

Pins associated with Register Field

Diagnostic and automated fault coverage reports

Support for IP blocks



3 SERDES with init_data Registers

Common PLL

Extra Bit

```
------------------------------------------------------------
-- Package file including single SERDES segment
-- and a 3 SERDES plus clock segment.
-- Copywrong of the XYZ corp.
------------------------------------------------------------
PACKAGE XYZ_IO IS

   USE Std_1149_1_2012.all;

   attribute REGISTER_MNEMONICS of XYZ_IO : package IS

      "SerDes_Protocol  (off  (000) <Powered down>, "&
      "                  PCIe (001) <PCIExpress>, "&
      "                  SATA (010) <SATA>, "&
      "                  SRIO (011) <Serial RapidIO>, "&
      "                  XAUI (101) <XAUI>, "&
      "                Resvd1 (100) <Undefined behavior - Do Not Use>, "&
      "                Resvd2 (11X) <Undefined behavior - Do Not Use>), "&

      "SerDes_TX_Outputs (off (00)   <Powered down>,  "&
                                        -- Output driver swing level
      "             Full_Swing (01)    <100% Swing>, "&
      "              Swing_p75 (10)    <75% Swing>, "&
      "             Swing_p527 (11)    <52.7% Swing
                                  -- Not legal if XAUI is protocol>), "&
```

BSDL Package

For re-useable IP Block

Local Mnemonics

Package File Cont'd

Local Register Segment Names

```
   attribute REGISTER_FIELDS of XYZ_IO : package IS
      "Channel [5] ( "&
      "Protocol[3] (2, 0, 1) IS DEFAULT (SerDes_Protocol (PCIe)) "&
      "                          RESETVAL(SerDes_Protocol (off)), "&
      "TX_Swing [2] (3, 4) IS DEFAULT (SerDes_TX_Outputs (off)) "&
      "), "&

END XYZ_IO;

-------------------------------------------------------------------------
---

PACKAGE BODY XYZ_IO IS

   USE Std_1149_1_2012.all;

END XYZ_IO;
```

Local default/reset values

Register assembly – bits predefined defined – length calculated by BSDL reader

REGISTER_ASSEMBLY

3 serdes ip blocks – 1 PLL block

```
Use XYZ_IO.all;
Use XYZ_PLL.all;

--   stuff removed for brevity

attribute REGISTER_ASSEMBLY of INIT_Example : entity is
  "init_data ( "&
 " (USING XYZ_PLL), " &
 " (   P1  is    Settings), " &
 " (  USING XYZ_IO ), " &
  "(  Array SerDes(1 TO 2) is Channel), " &
  "(  dummy[1] ),  " &
  "(  SerDes( 0)  is  Channel ), " &
  "(   reserved[105] )" &
");"
```

TDR NAME FROM XYZ_PLL

Array

Conclusion

Infrastructure IP Providers:

Encouraged to use recommended TDR interface

For I/O related IP (SERDES etc) – provide INIT_DATA TDR interface

Encourage customer to design IC with

- CLAMP_HOLD/CLAMP_RELEASE, IC_RESET

IC Designer:

Provide INIT_SETUP/INIT_RUN

-Enables I/O initialization by non-system means

-Control PLLs via INIT_SETUP

-Use IC_RESET

-Enable customer to use in-situ JTAG based tests via CH/CR

Software

Free BSDL parser supporting IEEE 1149.1-2012 BSDL constructs

http://www.intellitech.com/bsdl

Free NEBULA software tool

1) Supports PDL and BSDL register fields/mnemonics
2) Interfaces to ModelSIM, VCS and Xilinx JTAG Pod

http://www.intellitech.com/ijtag