DESIGN VERIFICATION WAVEFORM ANALYSIS THROUGH MACHINE LEARNING SOLUTION

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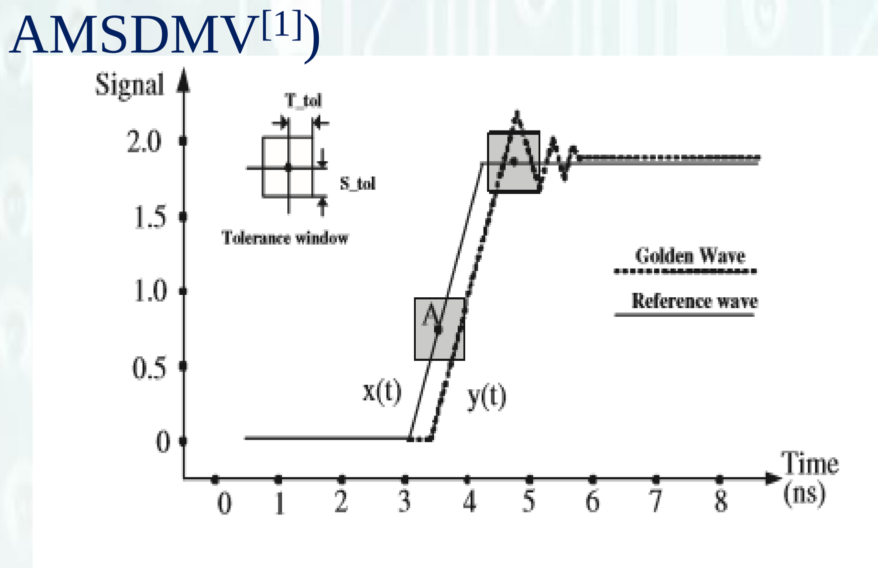
1. Motivation & Problem Statement (1/2)

Manual Waveform review in analog space is largely error-prone due to

- Gaps in top level understanding of chip in various system use-cases
- Possibility of missing subtle outliers while reviewing 1000s of jobs across corners
- Human errors because of saturation owing to repetitive effort of waveform review
- Difficulty in writing analog checkers that are compliant across corners–which only flag real errors and not variations which are acceptable within spec limits

Existing Design Verification Techniques

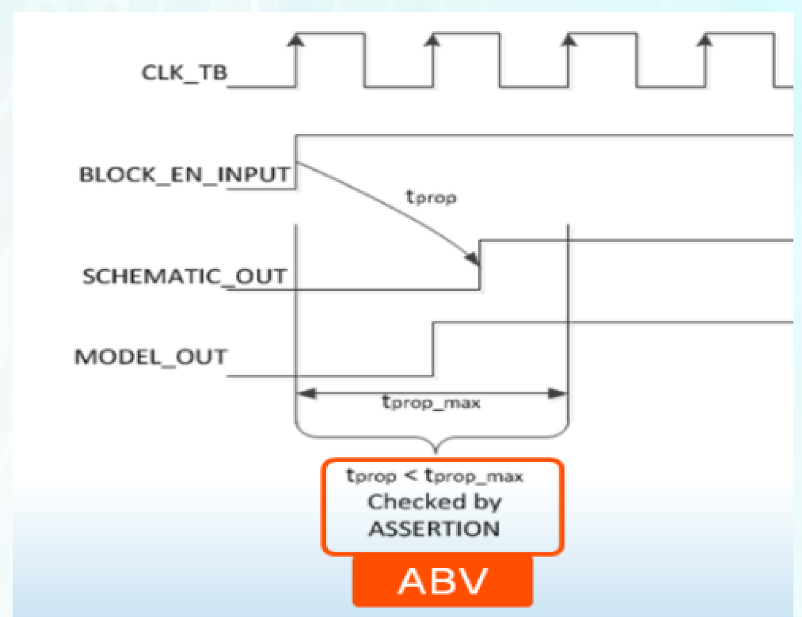
Waveform Comparison (Cadence® AMSDMV[1])



ig. 4. Point-to-point comparison with time tolerance window

- × It's a simple a point to point graphical comparison.
- × Cannot learn device behavior
- × Error prone and high manual effort involved
- × Time-shift comparison using WCOMP

Assertion Based Verification[2,3]



- × Too many assertions for complex designs needed to comprehensively verify the complete functionality

2. Motivation & Problem Statement (2/2)

Summary

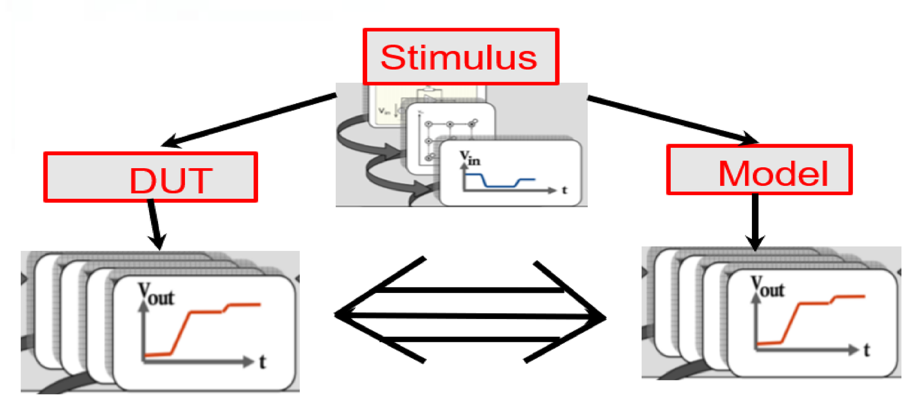
Achieve automated waveform review in analog design verification space in order to

1) To speed up manual review process without compromise on quality
2) To increase number of cases to be reviewed without any impact on schedule
3) To catch any anomalies in device behavior where chances of miss from manual review are high
4) To generate expected DUT response

3. Proposed Solution(1/3)

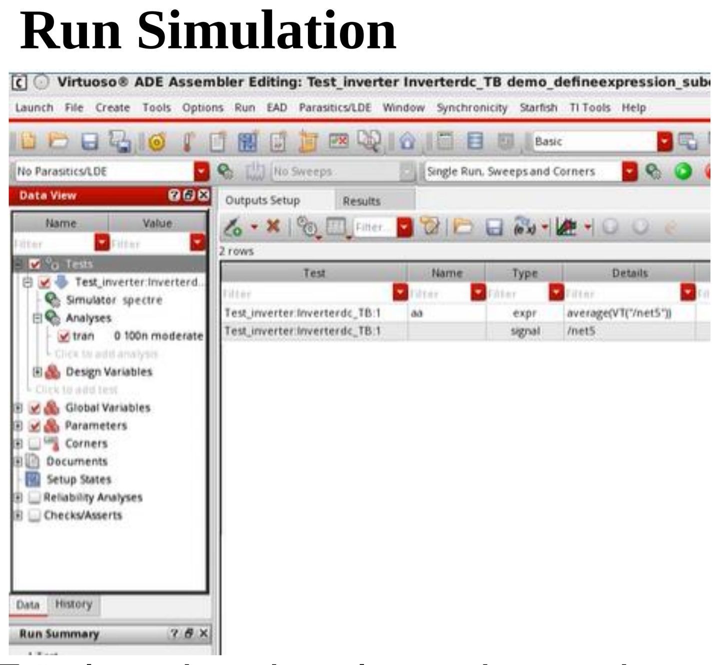
A probabilistically approximately correct (PAC**) ML Model is our solution** :

- which is based on simulation data
- can generate reference waveform data for new testcases to flag bugs
- leads to reduction in time and human effort and a significant improvement of quality in the verification process



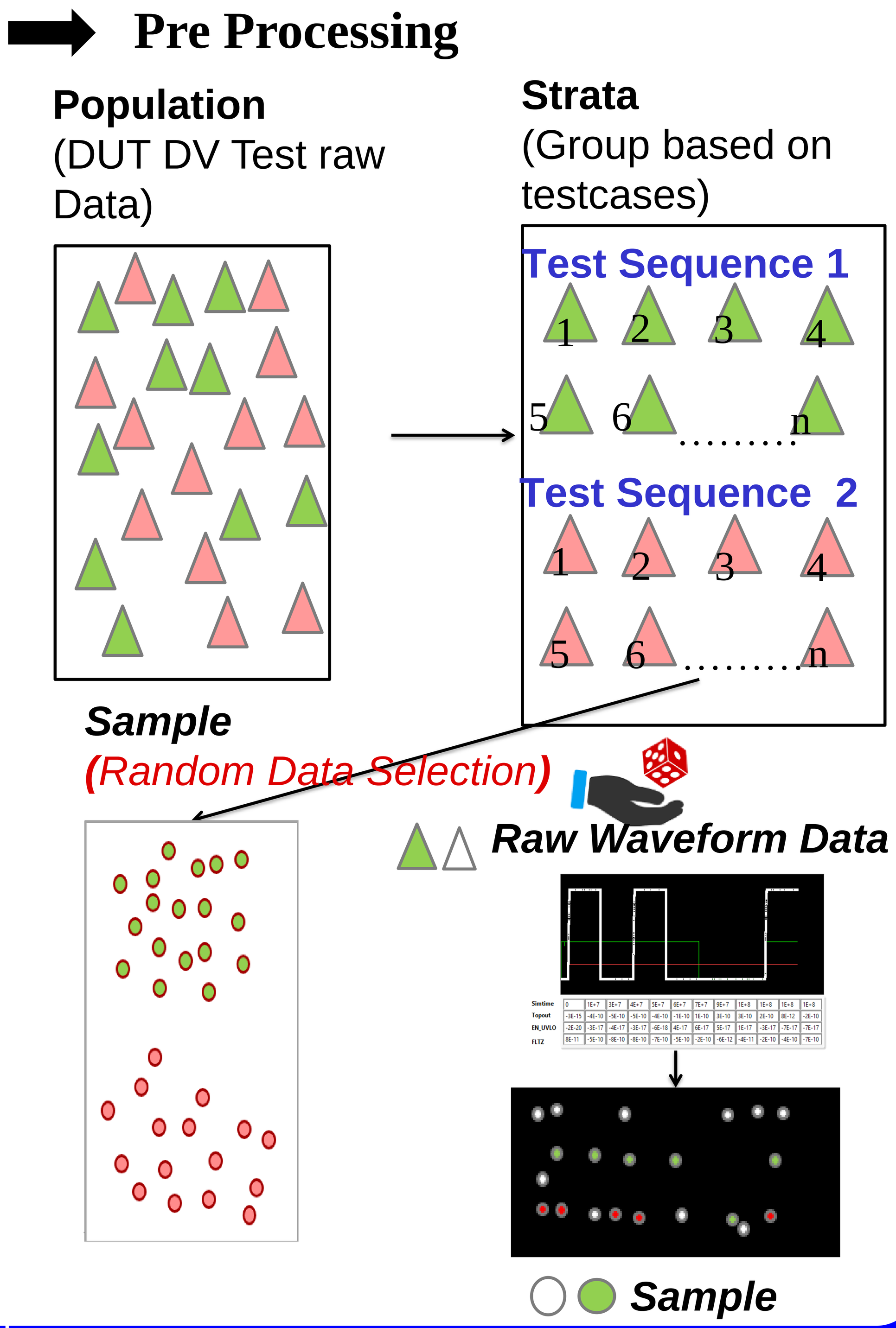
4. Proposed Solution(2/3)

Run Simulation

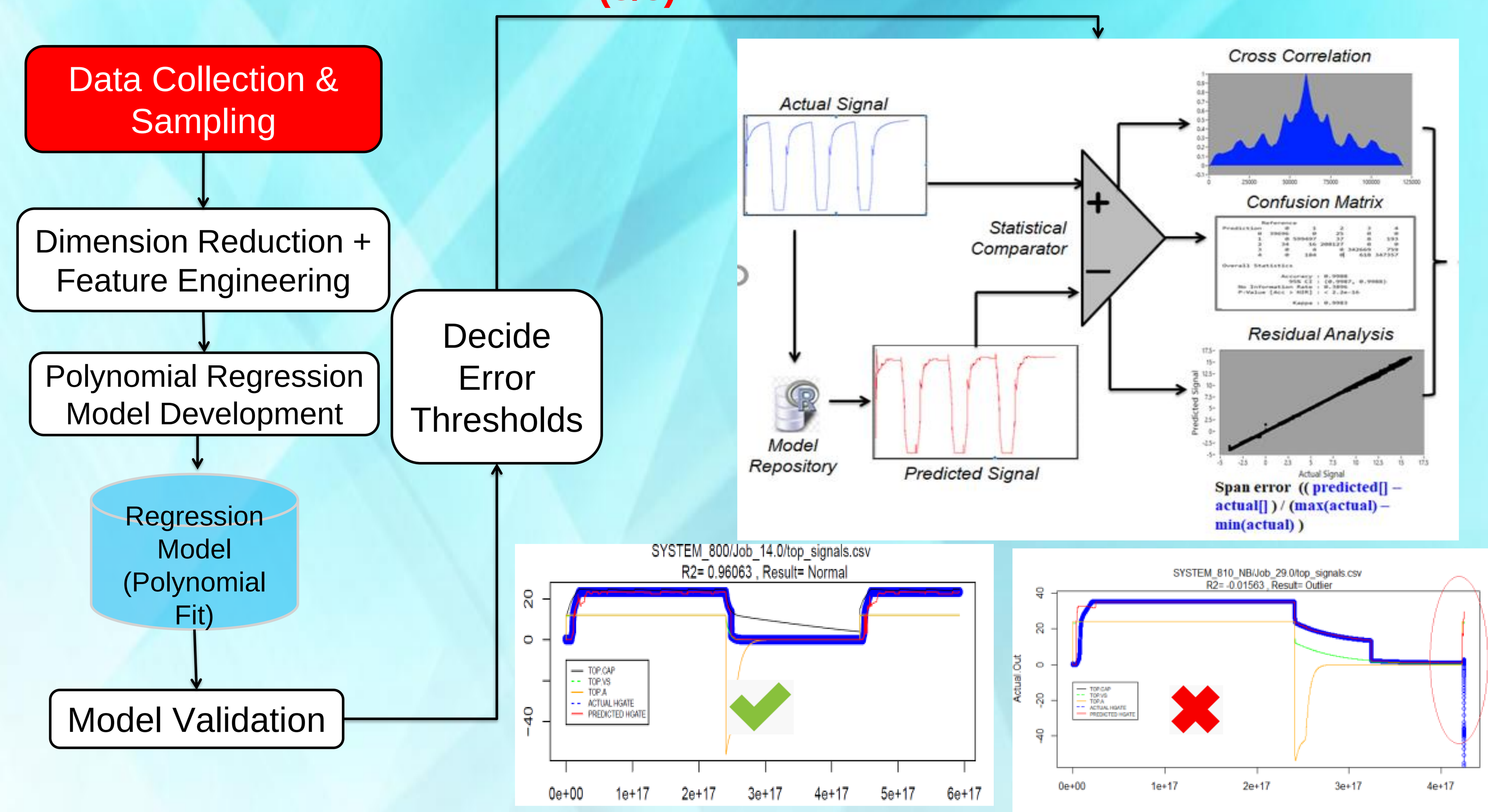


- ❑Select the signals on the testbench to be extracted for ML based verification
- ❑Select waveforms across testcases to be used for generating model
- ❑Strata - Sort data based on test scenarios (testcases)
- ❑Random Data Selection – From every sorted testcase data, data is selected in random method.
- ❑This randomized approach ensures that bias is randomized and not systematic
- ❑Final Sample is generated for model creation

Pre Processing



5. Proposed Solution(3/3)

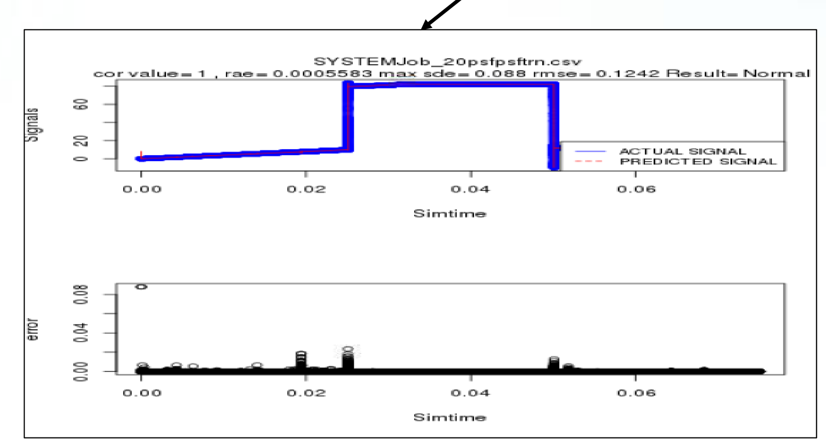


6. Evidence and Results – Industrial Case Study

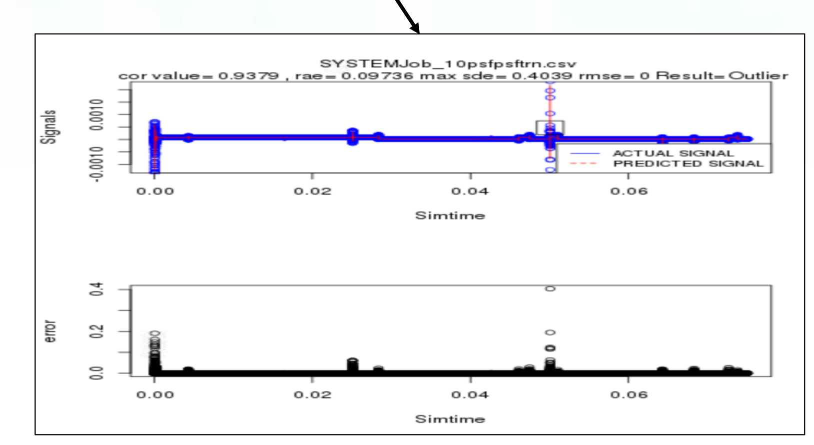
Bug Detection Demo: This demo was conducted on high side switch which is a power path protection design and has features such as overcurrent protection and overtemperature protection. The following is a summary (called heatmap) of correlation scores across different test conditions, where color coding is used for easy identification of outliers.

Pin 1 Model / **Pin 2 Model**

A	B	C	D	E	K	L
Jobs	DIG.X_MC	DIG.X_MC	sim_TPS481XXQ1_top.BST_DUT	sim_TPS481XXQ1_top.CSm_DUT	sim_TPS481XXQ1_top.GND_DUT	sim_TPS481XXQ1_top.G_DUT
	kappa	kappa	cor	cor	cor	cor
SYSTEMJob_10psfpsftrn.	0.9979	0.9998	1	1	0.9627	1
SYSTEMJob_20psfpsftrn.	0.9991	0.9997	1	1	0.9568	1
SYSTEMJob_30psfpsftrn.	0.997	0.9996	1	1	0.9485	1
SYSTEMJob_40psfpsftrn.	0.9986	0.9995	1	0.9999	0.9256	1
SYSTEMJob_50psfpsftrn.	0.9975	0.9998	1	1	0.9742	1



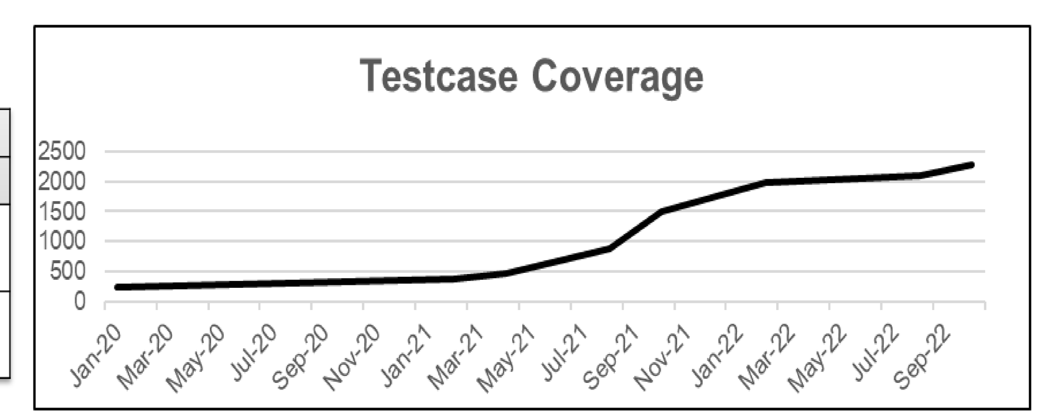
High Correlation (0.99-1) between predicted and actual signal



Poor correlation (0.937) between predicted (expected) and the actual signal and high standard error of 400mV

7. Model Statistics

CONFUSION MATRIX		Waveform Reference Model	
		Normal	Outlier
Actual	Normal	1920/2290	240/2290
	Outlier	0/229	130/2290



8. Conclusion

How is it better than Prior Art?	Novelty Aspects
Manual effort greatly reduced based on point to point waveform comparison between reference and actual simulation	Generates waveform reference model by learning from simulation data
Higher confidence and quicker turn-around time with repeated regressions of verification activity	Bug detection capability because of instant outlier detection post simulation
Much better visualization and reporting capabilities	Heatmap approach provides concise summary of outliers which is easy to review

Limitations
ML regressions are computation intensive thus demand high number of CPU and GPU cores
High model development time if the waveform data to be used for training is huge

Acknowledgements

Rubin A Parekhji of Texas Instruments (India) Pvt. Ltd. and **Gopika Geetha Kumar** of Carnegie Melon University (Ex-TI).

TEXAS INSTRUMENTS