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High Current Test Contactor – Divide and Conquer

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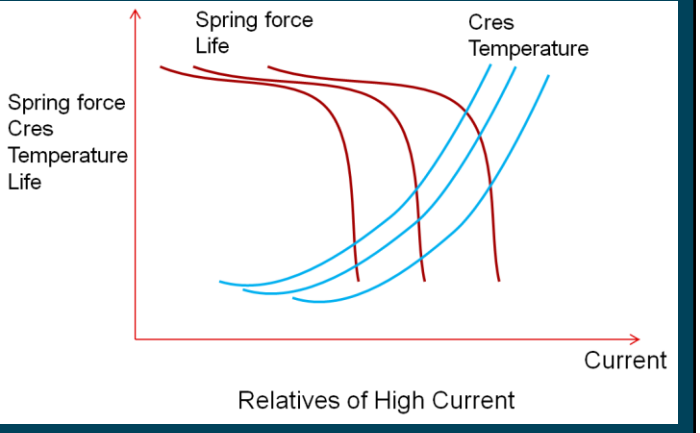
Overview

- Background
- Problem Statements
- Road To METS Test
- MET CCC Test
- Contactor Design for Reliability
- High Current Contactor Performance
- Does Current Equally Split?
- High Current Test Methodologies
- Summary

Background

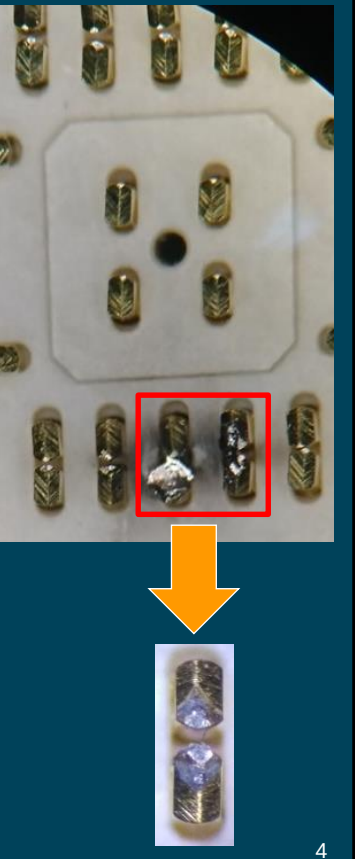
- Semiconductor devices become smaller ➔ smaller pitches and smaller pad/lead (land area) ➔ need smaller contactor to test
- The application of the devices become more complex
  - Low RDSon and High current testing on the same device pads
  - Extreme Tri-temp testing
- Need contactors
  - Small enough to handle small pitch and pad sizes
  - High Current Carrying Capability (CCC)
  - Low Contact Resistance (Cres)
  - Extreme Tri-Temp Capability
  - >1M Insertions Reliability
  - High Multi-site → low spring force requirement



Relatives of High Current

Problem Statements

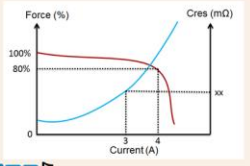
- Mismatch between Contactor Spec. vs. Actual Test
  - Contactor Spec.: ISMI (International Sematech Manufacturing Initiative) and Temperature rise methods ➔ use Continuous Current, New Pins, Room Temp,….
  - In test application: use various pulse current, tri-temp, degrade over time, foreign materials,….
- Inadequate hardware/circuit implementation
  - High continuity/FuncPara ➔ Low Yield
  - Depressed pin, burnt pins, melting pin block,… ➔ High Maintenance
  - Low throughput ➔ High Cost of Ownership (COO)

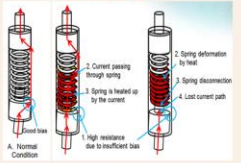


Road To METS Test

Force/Cres Reduction Method

- Modified ISMI Method ➔ Measure and monitor not only force, but also Cres
- Set Cres limits at maximum xx mΩ
- Why does Cres increase, but force stays within the 20% reduction ➔ Biasing?

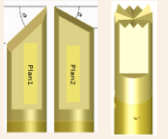




Pin Life vs. CCC

- CCC decreases along with increasing insertions
- Aged pin's Cres becomes unstable ➔ causing low CCC
- Reliable contact at DUT side and maintaining internal contact resistant are essential

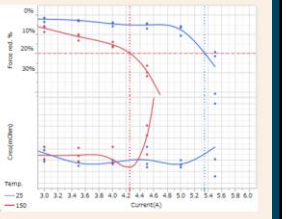
Test Condition	Modified ISMI	
	CCC (A)	CRES (mΩ)
Initial	4	54
250K Insertions	4	62
500K Insertions	3.5	66
750K Insertions	2.5	69
1M Insertions	2	73



Test Temperature vs. CCC

- Pin CCC dramatically reduces while testing under high temperature
- Cres of the pin increases with an increase in temperature
- Thermal stresses significantly affect the structural strength and stability of the pin

Pogo Pin Under High Temperature

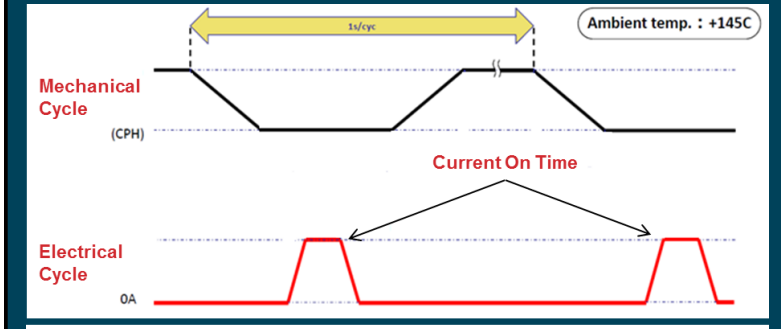


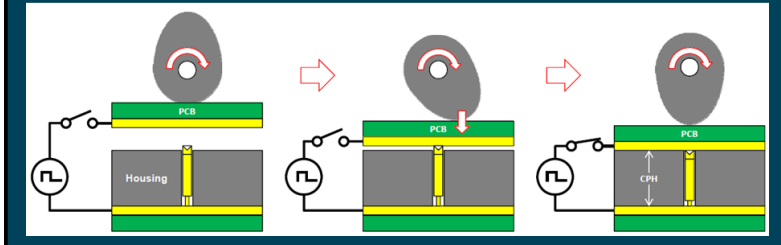
Reference from 2017 BiTS

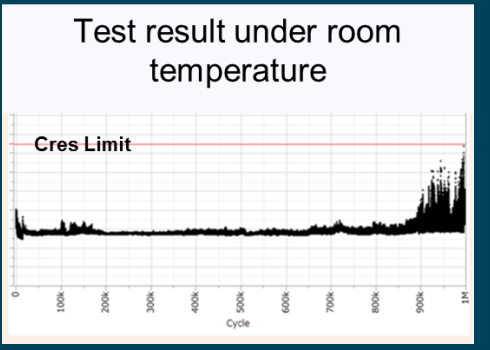
- METS: Mechanical, Electrical, and Temperature stress test.

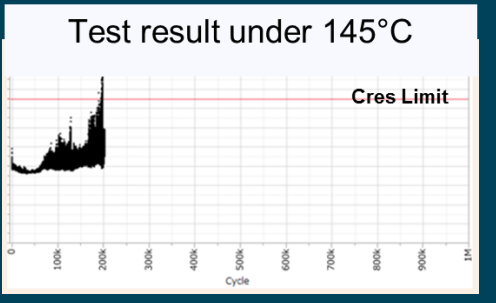
MET CCC Test

- Test Procedure: Apply Mechanical, Electrical, and Temperature stress on the same setup and observe contactor Cres.









- Performance degrades with life (insertions) of the pin
- Life of the contactor is significantly reduced on High temp run

Contactor Design for Reliability

- Develop Pin CCC calculation table using Temperature rise study and METS Tests data
  - Inputs
    - Max Current
    - On Time
    - Off Time
    - Test Temp
  - Outputs
    - # of Pins Needed
- Design right hardware during design stage

Input Conditions		
Pin count	2	pc(s)
Max Current	30	A
Current On time	8	ms
Index time	300	ms
Ambient	25	C
Need more pins		

Input Conditions		
Pin count	6	pc(s)
Max Current	30	A
Current On time	8	ms
Index time	300	ms
Ambient	25	C
Working		

High Current Contactor Performance

Vendor in-house METS Test Data Comparison

Vendor	Base Line	A	B	C	D
METS (Room)	x	10x	10.3x	0.75x	3x
METS (High Temp)	x	2x	2.1x	N/A	1.1x

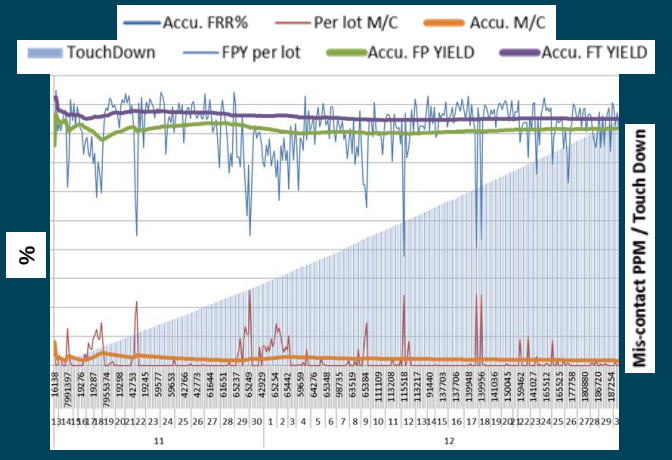
METS result is use to rule out under perform pin design

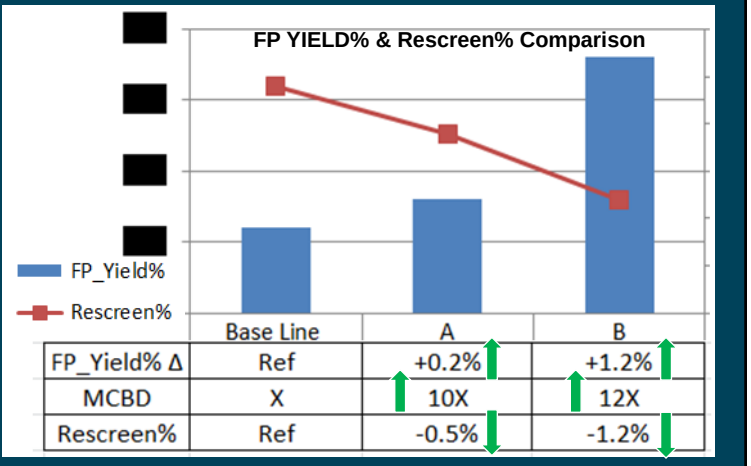
Internal Production Eval. Data Comparison

Acronyms

Accu.: Accumulated
FRR: Failure Recovery Ratio
M/C: Accumulated Mis-Contact
FPY: First Pass Yield
FP YIELD: First Pass Yield
FT YIELD: Final Test Yield
PPM: Parts per Million

MCBD: Mean Count Between Depressed

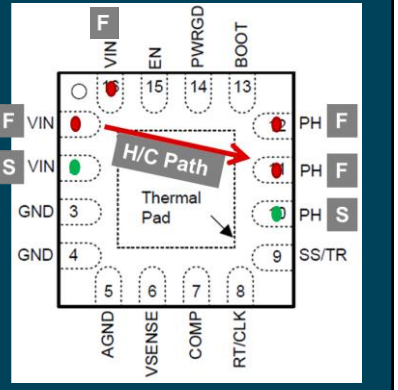


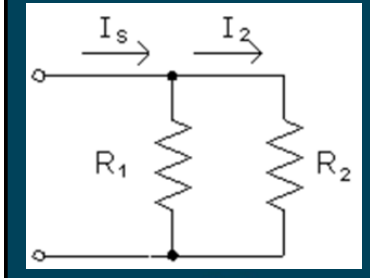


	Base Line	A	B
FP_Yield% Δ	Ref	+0.2%	+1.2%
MCBD	X	10X	12X
Rescreen%	Ref	-0.5%	-1.2%

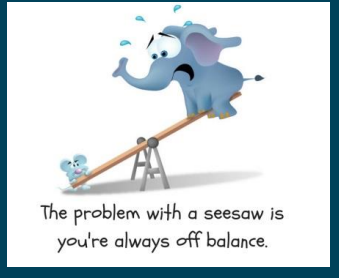
Does Current Equally Split?

- 15A through VIN to PH (2F & 1S)
- Theoretically 15A shares two VIN pins ➔ 7.5A each
- The total resistance varies with one insertion to another due to alignment, biasing of the pin, foreign material, and so on… ➔ **Managing current/pin**
- More current flows through lower resistance path and downgrades the pin ➔ **See-saw effect**





Assumed all other variables are constant.				
Total I= 15A		Cres (mΩ)	Total Resistance	Current (A)
Case 1	Pin 1	50.0	25.0	7.5
	Pin 2	50.0	25.0	7.5
Case 2	Pin 1	75.0	30.0	6.0
	Pin 2	50.0	30.0	9.0
Case 3	Pin 1	150.0	37.5	3.8
	Pin 2	50.0	37.5	11.3



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High Current Test Contactor – Divide and Conquer

High Current Test Methodologies

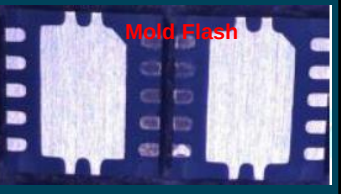
- Kelvin Check
- Managing max current clamping
- Balancing the current flows to all force pins
  - Add resistor
  - Add relay (gang sense pin for use as force pin during non-kelvin test sequence)
  - Split current path

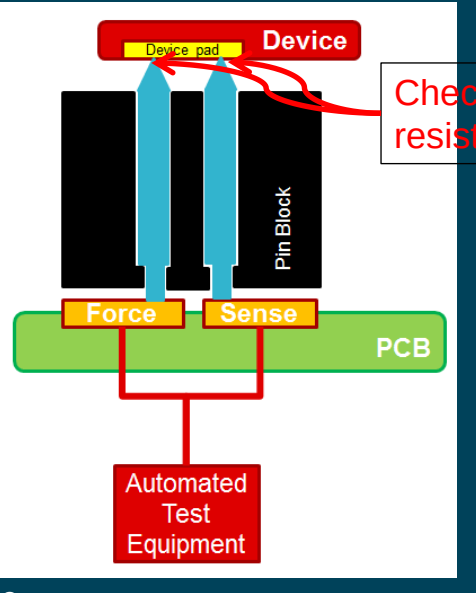
Kelvin Check

- Debris, Foreign material on the device and contactor
  - ❖ **Debris** causes high contact **Resistance** between pin and device ➔ Hot spot
  - ❖ The higher the **Resistance**, the higher the **Power** ➔ the higher the **Energy**

$$P = I^2 * R\ (W) \qquad W = P * t(WSec\ or\ J)$$

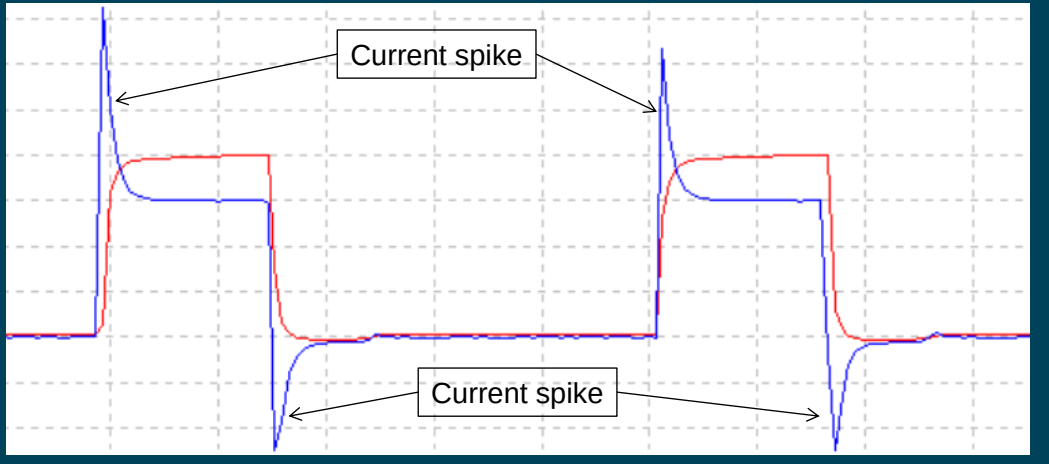
- Check the contact resistance between pin tip to the DUT pads before high current testing





Managing Max Current Clamping

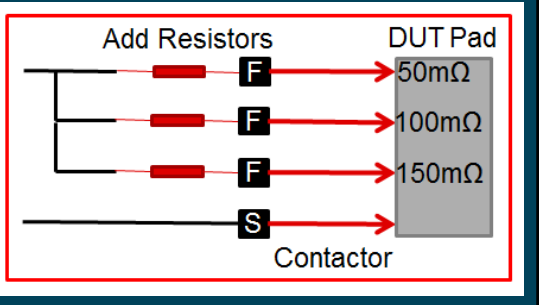
- Current or voltage surge could cause early failure of the contactor
- Choosing right clamping (program & hardware) current or voltage to prevent unwanted current spike

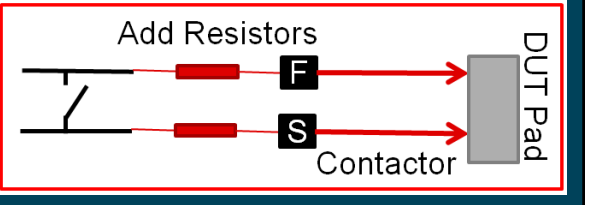


High Current Test Contactor – Divide and Conquer

Balancing The Current Flows

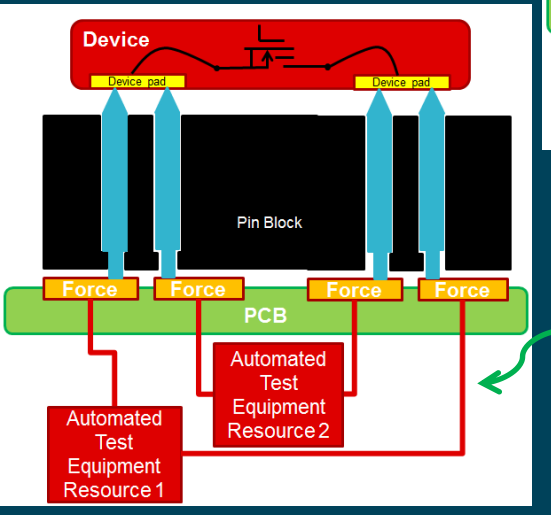
- Add series resistors in the high current path and split all Force PCB pads to eliminate the unbalance current effect due to small contact resistance variabilities.
- In case of having one Force and one Sense contact, add relay to short F & S for high current testing.

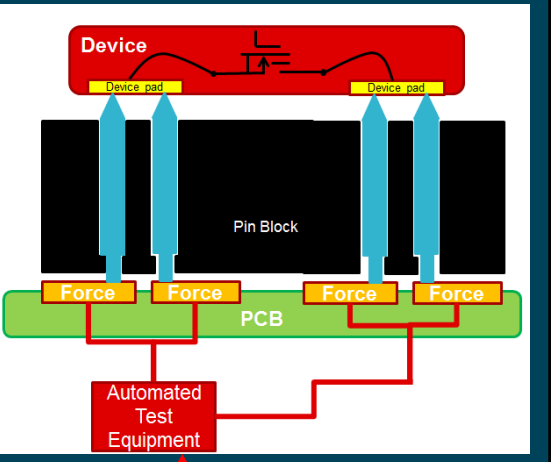




Split Current Path

- Slight contact resistance between two force pins ➔ imbalance current split ➔ **See-saw effect**
- Using multiple ATE resources to ensure balanced current condition even with resistance differences between the paths.





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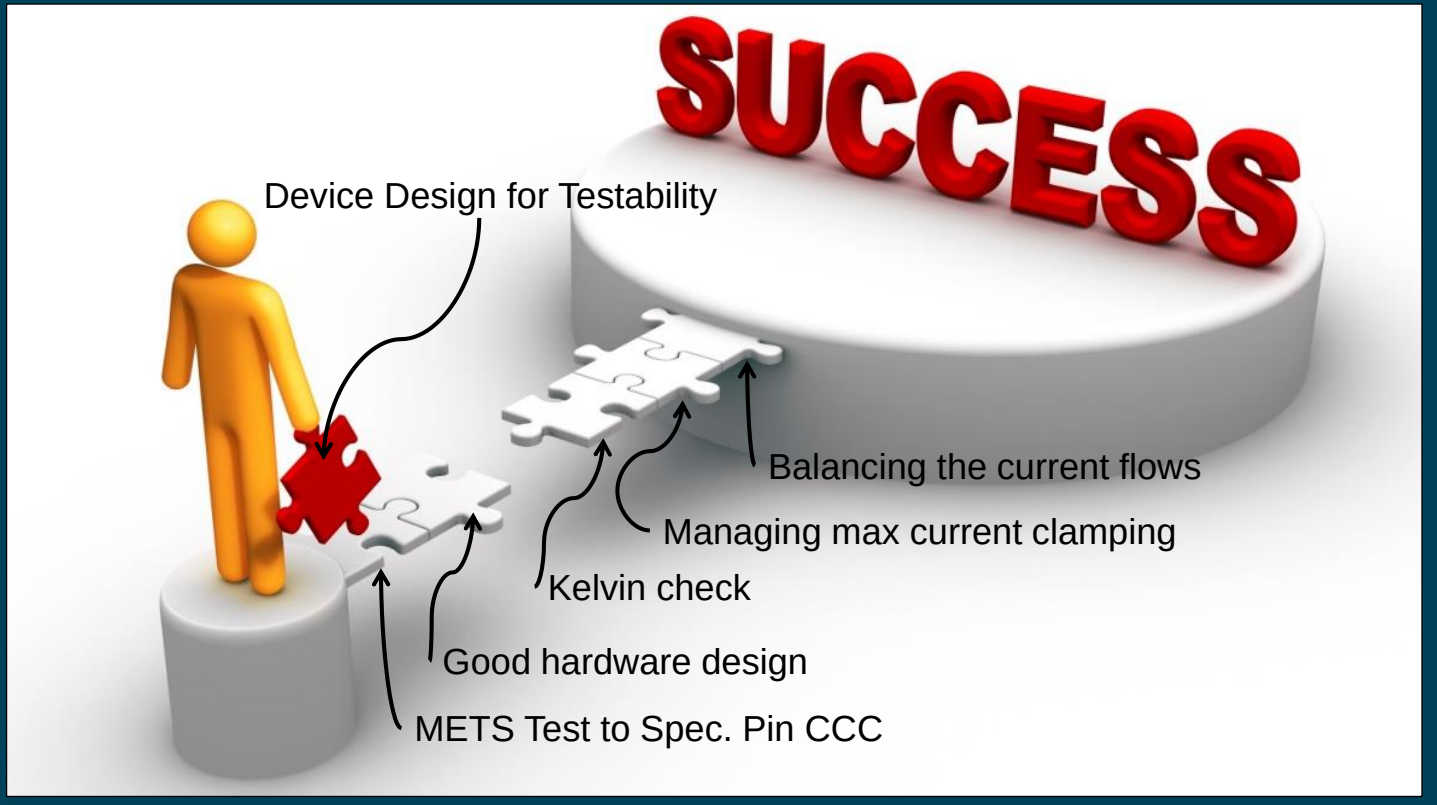
Summary



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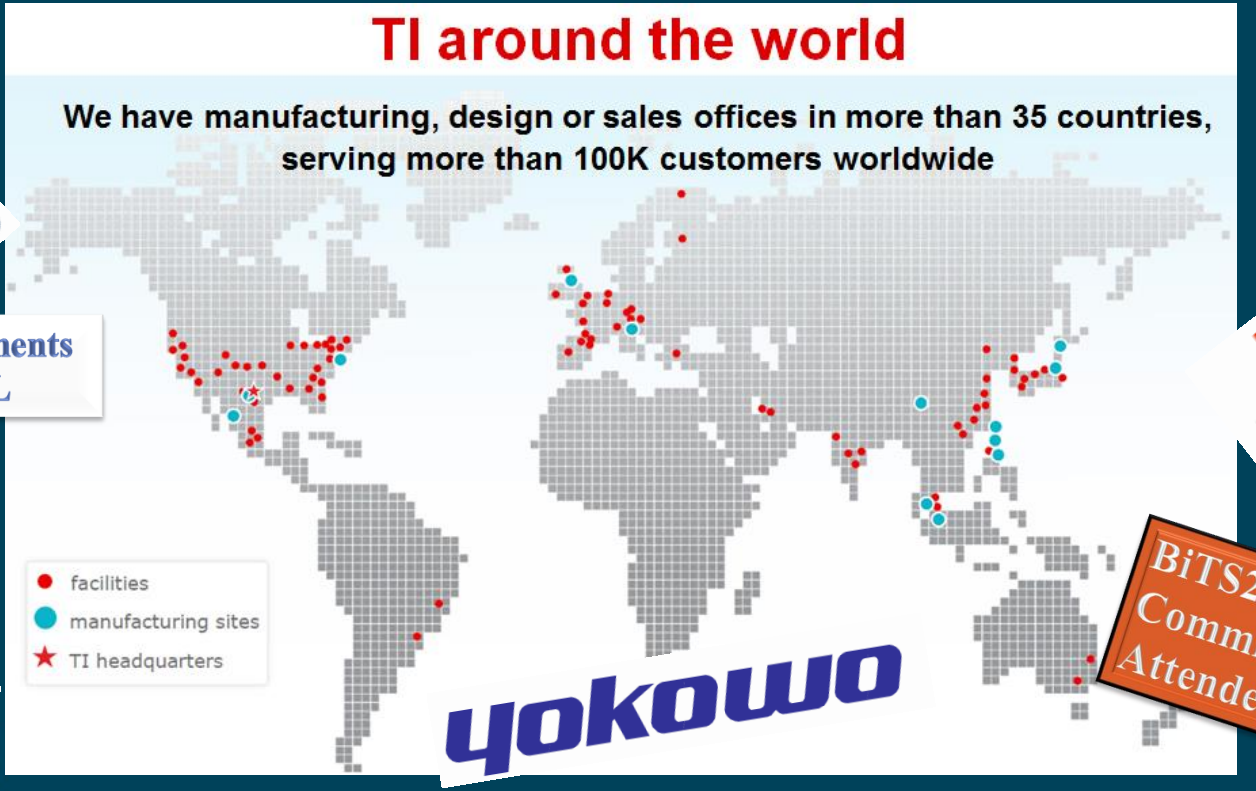

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