Efficient ramp up of an industrial volume products

Etteplan test day 2018

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Title: Development engineer / roles why I'm involved on PCB testability

- Worked on Metso since 2005
- As NDX series valve controller development program's supply chain work package manager
- As positioner factory's technical NPI engineer
- As positioner factory's supplier quality engineer

Metso Flow Control as part of Metso Oyj

A short summary

Minerals	Flow Control
(2017 orders received 2308 MEUR)	(2017 orders received 675 MEUR)

- Metso Flow Control is the other of the Metso Oyj's 2 business segments and our product offering consists:
  - "Valves, pumps and related services for chemical industries, mines, pulp and paper and other process industries."
- Our factory network spans to 4 continents and major operations are on 7 countries
- Our service center network covers most of the globe
- All digital valve controllers are end-assembled at Helsinki plant, Hakkila, Vantaa.

Definition of digital valve controller as product and process

- Digital valve controller is the third major module of industrial control valve
  - Communicates with factory automation system (HART, Foundation Fieldbus, Profibus or 4-20 mA current loop)
  - Measures the position of the valve and drives to correct position by releasing pressurized air to pneumatic actuator's cylinder
  - Continuously runs active diagnostics to valve's health and provides feedback to customer's condition monitoring
- Scale of production is 60 – 70 000 manufactured digital valve controllers annually
- Helsinki plant performs only end-assembly from sourced parts and modules from global network of suppliers.
- Production is divided to 3 major product groups
  - ND9000 series / current high volume product family, launced to markets at 2003
  - VG/SG9000 series / product family build on top of ND9000 platform, released c 2010
  - NDX series / New next generation digital valve controller product family. On rampup-phase - Single acting released to market 2016, double acting Ex d 2017, 2-A Ex i + basic later this year.
- Significant number of accessories / customer tailored niche solutions
  - Local control panels
  - Isolators
  - Barriers

Product features that have a special impact to desing and testing

- Limited power budged of loop (4-20mA) powerd product
  - Device shall be operational with 3,8 mA loop current. (Including Controller PCB, Local user interface / display included, I/P converter pneumatic pre-stage that drives mainstage pneumatics)
  - Provides detailed current consumption test cases to test plan with different load levels. Lots of switching, waiting times etc.
  - It's often seen that component datasheet values do not always provide enough information.
- Desing rules of ATEX / IEC Ex Ex i protection scheme
  - Mandatory test cases derivated from IEC 60079-11
  - Provides several test cases to test plan for multipled protective blocks of schematics that must be tested one by one.
  - Product documentation is controlled by notified bodies, change management must be systematic and there are ofter procedural delays in schedules.
- End customer applications that are covering the whole temperature range of industrial electronics (-40 - +85C & for Arctic versions: -53 - +85C)
  - Provides strict control limits at room temperature for several test cases to ensure neccesary margin to temperature extremes.
  - Any component changes must be validated with well-covered design testing.
  - When combined to power-budget issues it's often seen that the component datasheets are not fully reliable on the performance extremes.

An anatomy of a typical product ramp up on our product line

- Concurrent desing process
  - The 1st desing round is usually lab-tested and prototype manufactured but R&D wish is to produce 2nd round sampes with final EMS and test with production tester.
  - Thus the tester project is usually started with limited product knowledge
- Pressure for time to market
  - In some cases product variant is promised to customer before desing project have started so date of delivery is fixed.
  - Or then a preliminary contract is made with an OEM customer and then there are pressure to build full production capability due the date when the design is finally finished.
  - Or at least need to provide final marketing and/or customer test samples.
  - Thus usually no spare time to hone the process and test limits
- Limited in-house resources for process support.
  - When HW design is outsourced on R&D side and on opertions side the in-house resources are limited on the project management / product ownership like roles a competent suppliers for test solutions are needed.
- Concurrent challenges
  - Ramp up of PCB design is just one topic. Simultaneously we are usually ramping up our own end product tester(s), several assembly jigs, injection molding tools, pressure die casting tools, validating precision macined parts etc etc. So the amount of spare time to focus an individual problem is limited and thus proactive suppliers for test solutions are needed

Where we have succeeded

- Initial yield
  - Usually the very first production samples have passed the process quite easily
- Level of on site support
- Implementation of SkyWATS have reduced significantly our response times for problems

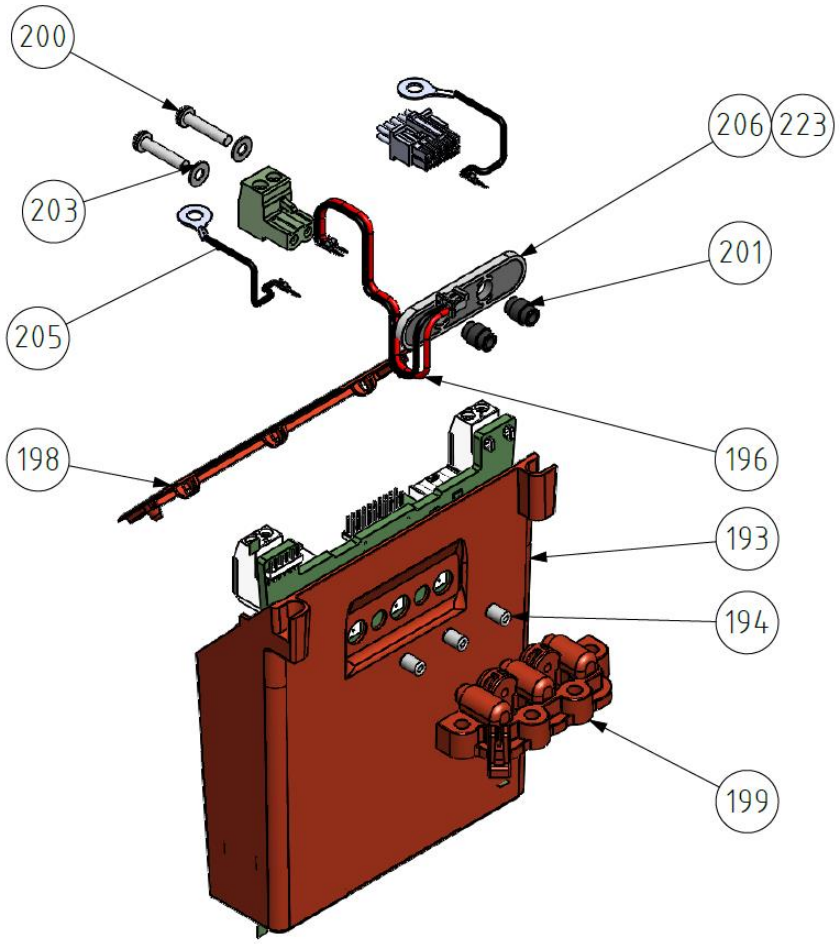
- Level of tecnical challenges have been solved
  - Magnetic references for position measurement sensors
  - Tightness of pressure sensor calibration conduits

Weak points

- Process yield after initial launch
  - Test plan limits are often based on the initial samples which are often assembled from same component lot’s
  - When lot to lot variation is added to process and alternative component manufacturers are used then the process variation starts to increase
- Timing and timeout effects are not tested and documented
  - Part of the lot-to-lot variation is not due nominal differences on components but just due small variation of the speed how signal levels changes when load is added or removed.
  - When this effect is not understood, this leads also problems in the production

Successful ramp up / Lessons learned

- Complete 1st revision of purchased BOM asap on ERP level. (item names, structure, etc..)
  - While our new products might be familiar to us, our supply chain does not recocgnise nick-names or work names.
  - Supplier’s NPI process is usually started not until we are able to deliver a proper item data, BOM and Purchase order.
  - Also help’s product’s identification when test application is developed
- Release 1st component BOM candidate as soon as possible
  - Component lead times are currently long so purchases at supply chain shall be started as soon as possible to achieve needed inventory levels due product launch



What could be improved

- Product design phase
  - Desing sensitivity to component level part to part variation within accepted tolerances should be simulated to see if there are risks of exceeding test limits
- Production test plan:
  - For each test 3 separate things should always be available.
    - Background for the limits (Ex desig, power budget limitation etc)
    - Technical desing limit that shall not be exceeded
    - Selected control limit that is based on actual measurement and product behaviour
  - Immediate benefit: Stakeholders would be immediately aware about the nature and criticality of process changes.
- Test SW design:
  - When signals are changed, the significances of timeouts should be always tested to see tests which are sensitive for small differences.
- Traceability of control limits at test plan
  - It would be helpful if test limits are based on measured parts to have about info and lot data of those samples.
- Product verification
  - Design verification samples should always be manufactured from all BOM-accepted component variants, not just the 1st choices to see potential performance related changes when component vendors are changed.

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