

Houston! We have a Transformer problem!

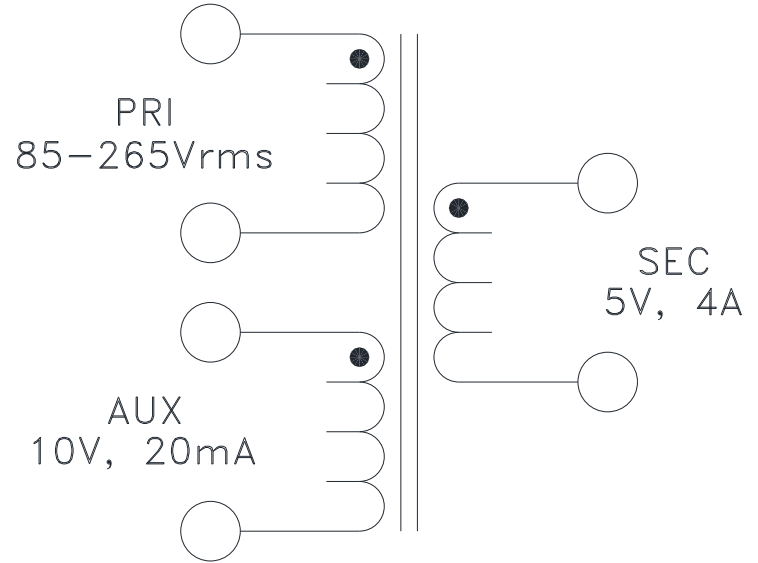
Adam Sullivan
Wurth Electronics
Design Engineering Manager



Transformer Request

Typical request might that seem simple:

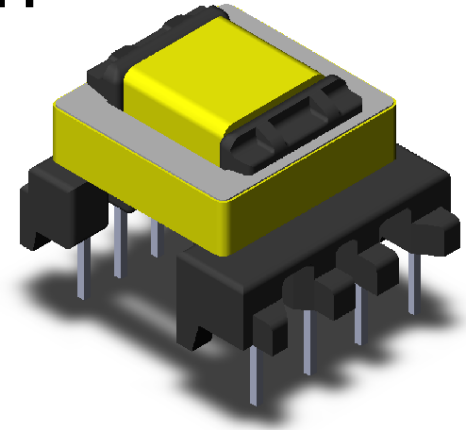
- Input voltage
- Auxiliary wind voltage
- Output voltage
- Output current
- Safety requirement
 - Reinforced Insulation
- Other
 - Topology
 - Frequency
 - ...



Package Selection

Considerations include:

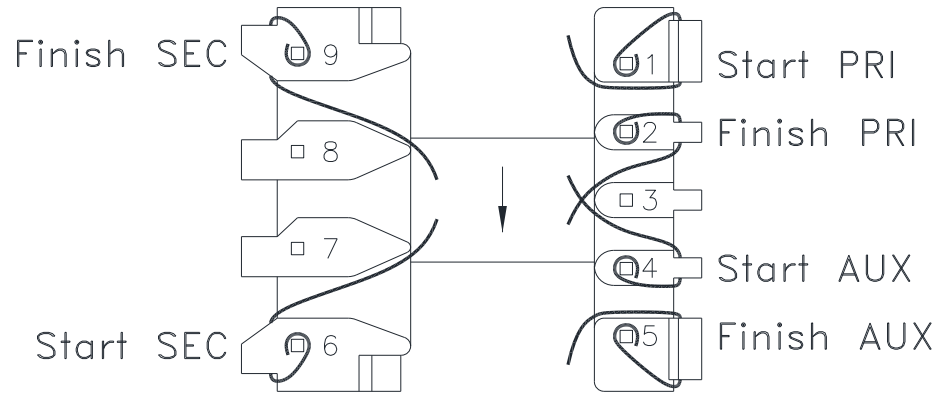
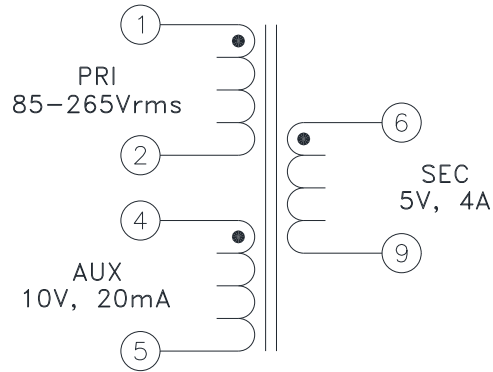
- Power level
- Size limitations
- Mounting style
- Safety requirements
- Balance Cost vs Reliability vs Performance vs EMC



Download the Custom Capabilities Catalog for package style selection tips and options:

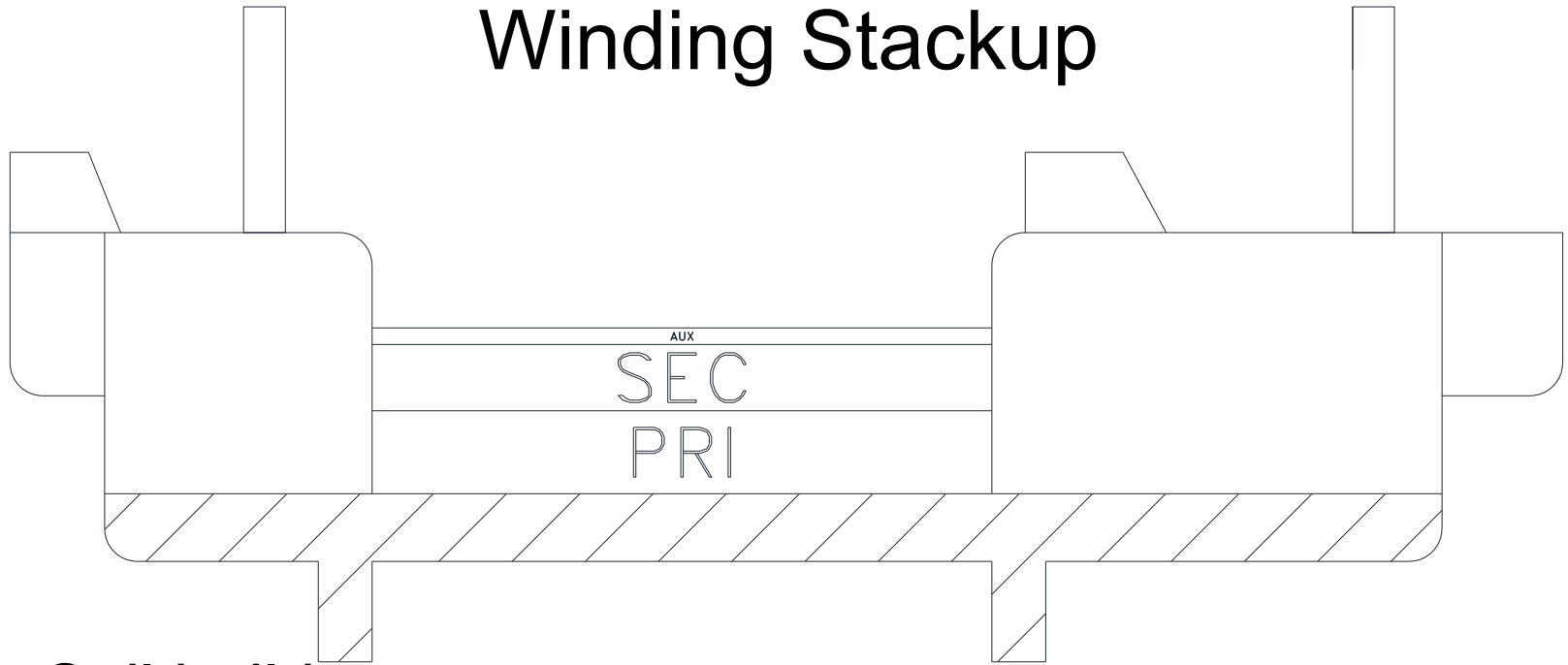
https://www.we-online.com/web/en/index.php/download/media/06_passive_components_-_custom_magnetics/toolbox/Custom_Capabilities_Catalog.pdf

Initial Pinout



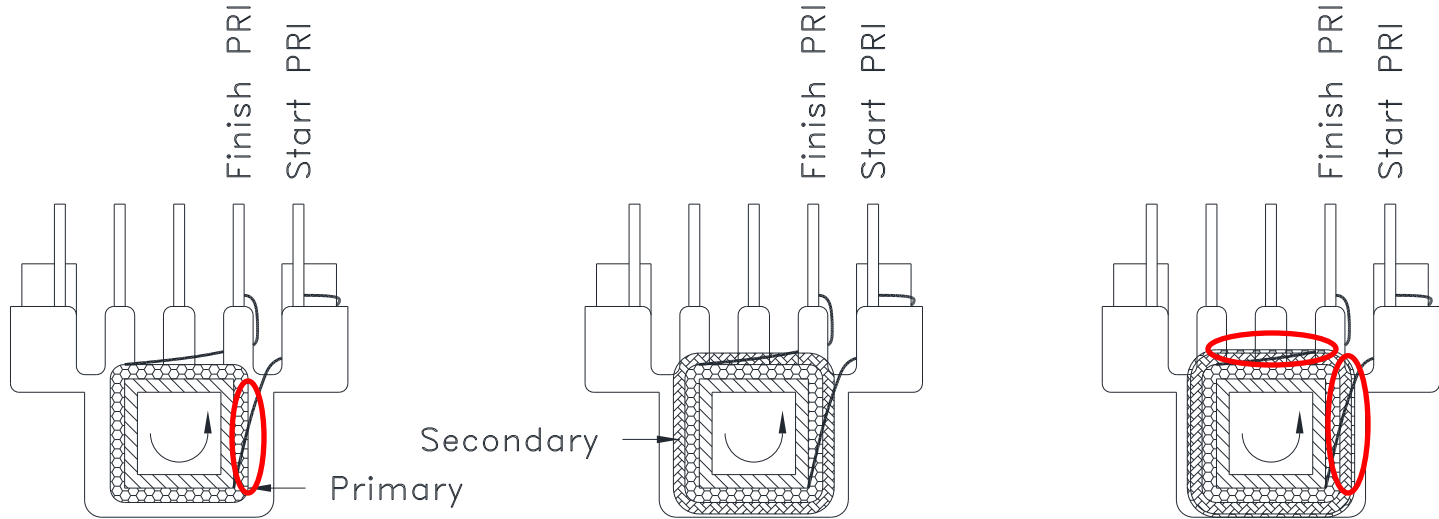
- **Routing Knobs**
 - Leads in slots
 - SEC extended rail & insulation burn back
- Direction of wire into the coil opposes the direction that the bobbin is turning
- SEC leads crossing

Winding Stackup



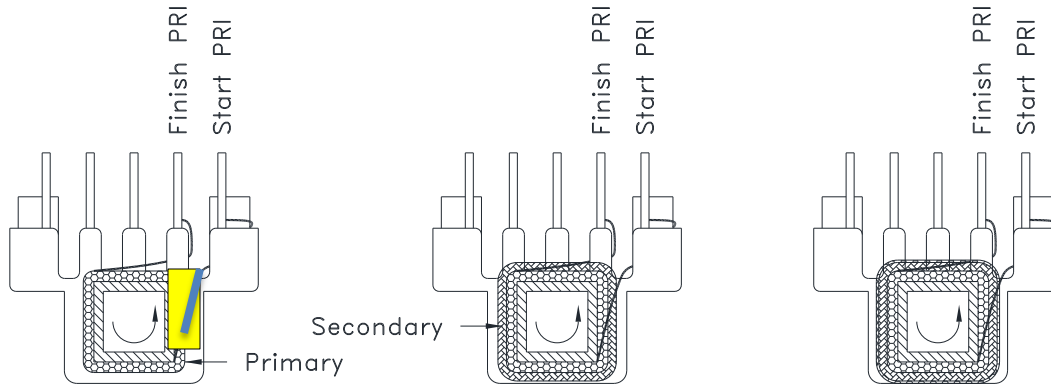
- **Coil build**
 - 50% Primary wound first
 - 40% Secondary wound second
 - 10% Auxiliary

Termination to Coil Lead



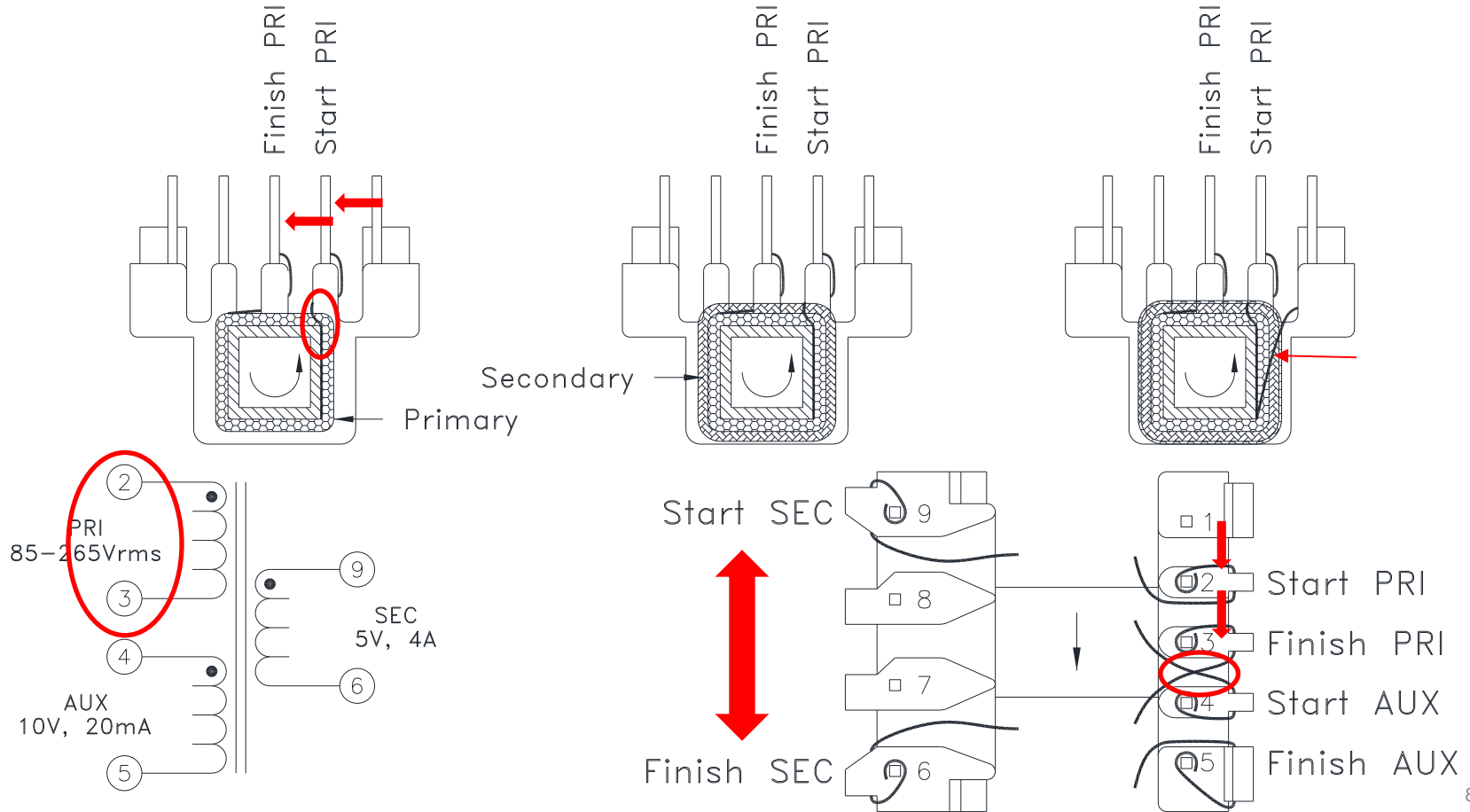
- Start of Primary lead-in:
 - Volt-turn stress between lead-in and each layer of Primary
 - Do we need to isolate the primary turns from its own lead-in?
 - How to isolate the lead-in from the other windings?

Termination to Coil Lead (Isolation)

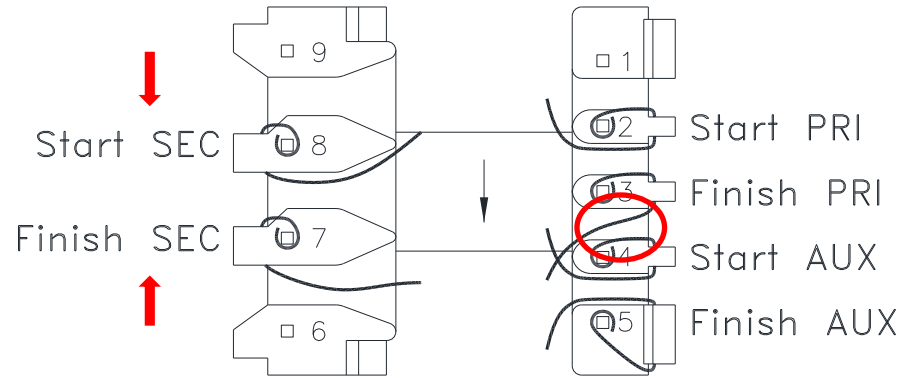
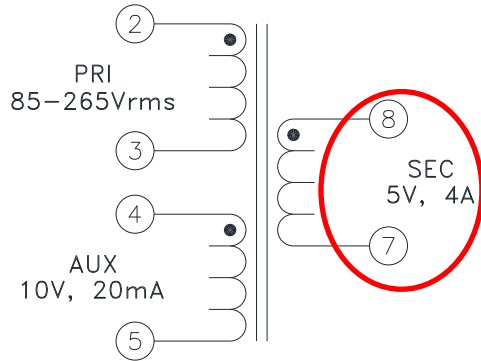


- **Start of Primary lead-in isolation:**
 - Teflon tubing
 - Narrows winding window
 - Manual application; manual termination
 - Insulation tape
 - Manual application
 - Integrity; after subsequent windings, after solder process

Reliability Improvement (Pinout V2)

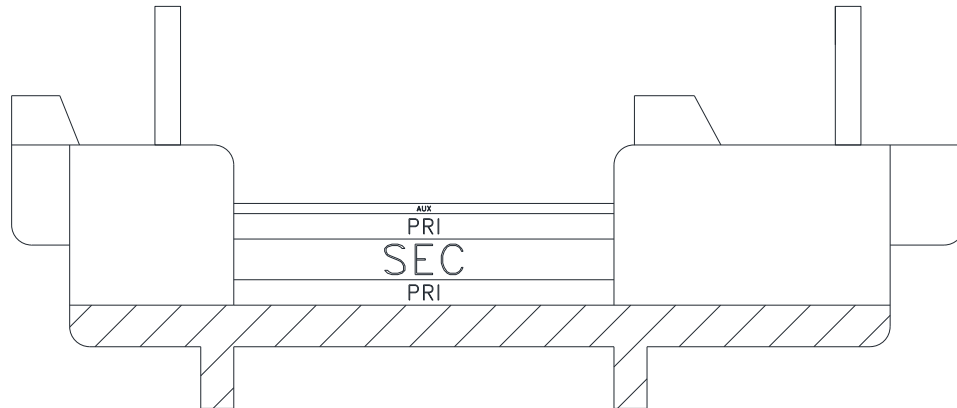
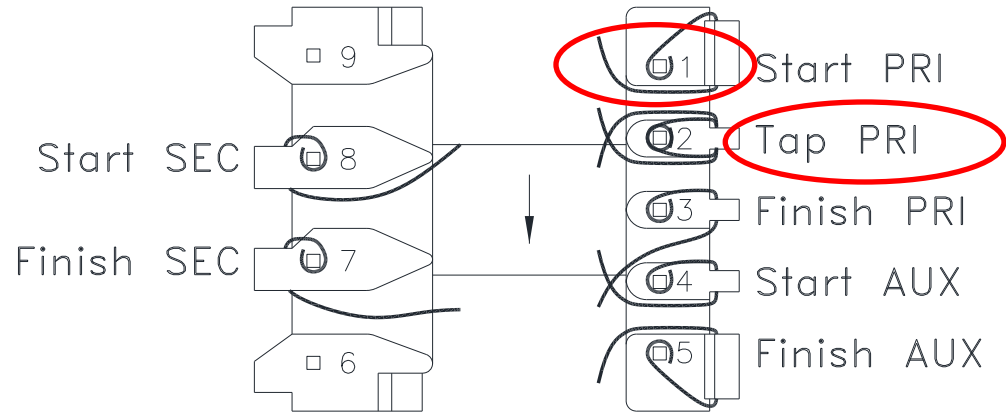
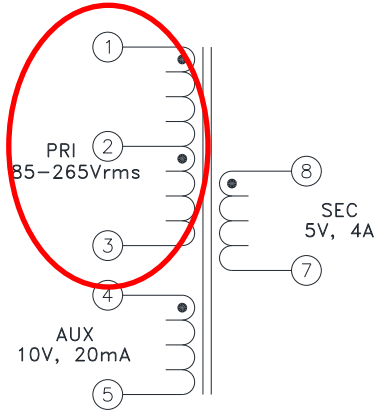


Reliability Improvement (Pinout V3)

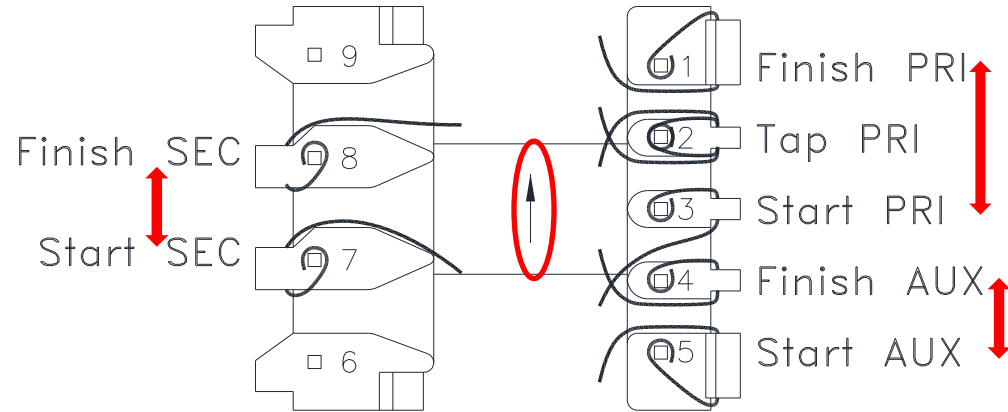
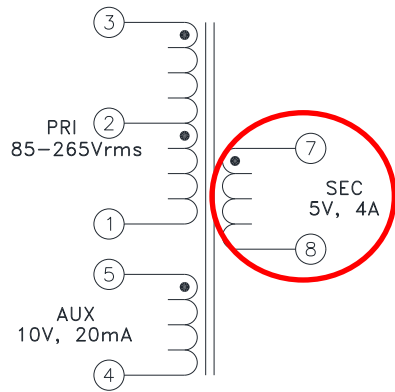


- Primary shifted down one terminal (from before)
- Secondary moved to center terminals
 - Both eliminate the need for crossover tape or tubing
- Start Aux re-routed
 - Eliminate Finish PRI and Start AUX sharing the same slot
- What can we do to improve coupling?

Coupling Improvement – Split PRI (Pinout V4)

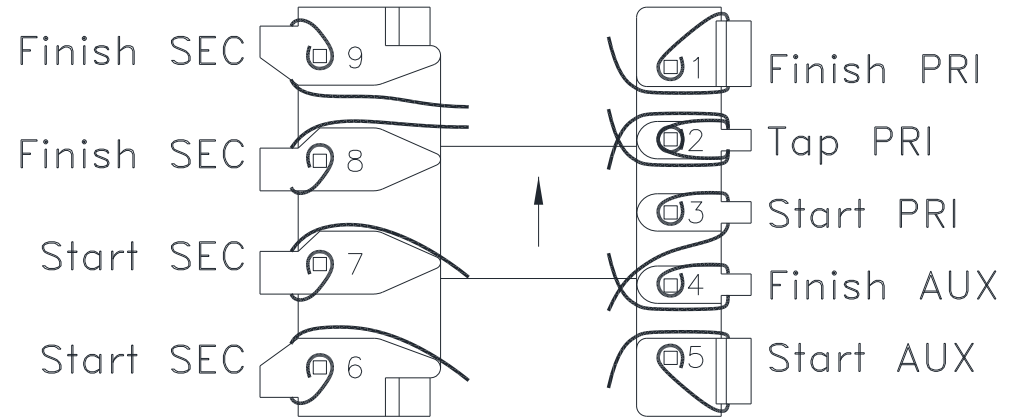
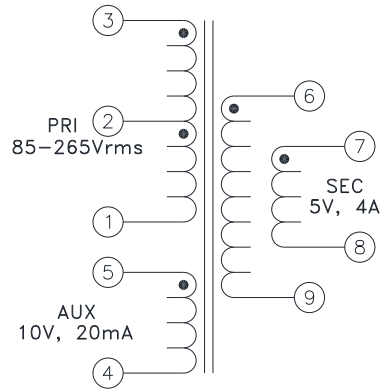


Coupling & Reliability Improvement (Pinout V5)



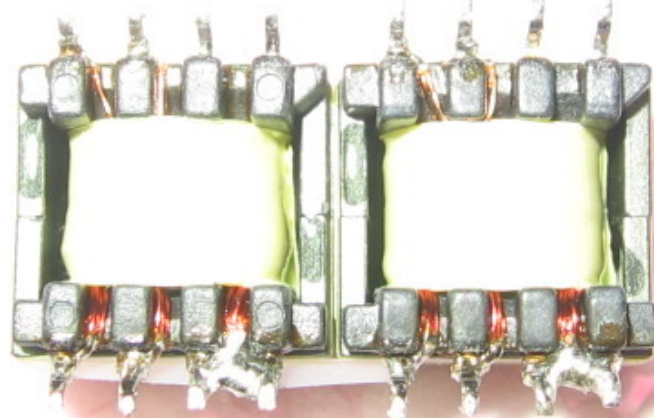
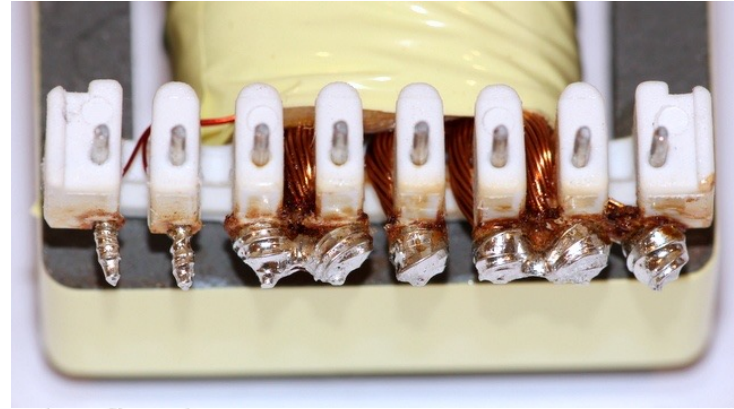
- Winding direction
- Starts and finishes swapped to fix lead-in problem (pin 3 first)
- What else could we do?
 - Perhaps put more emphasis on the 4A Secondary.
 - Large diameter wire, low turn coil, lumpy coil, terminations

Coupling, Reliability & Manufacturing (Pinout V6)

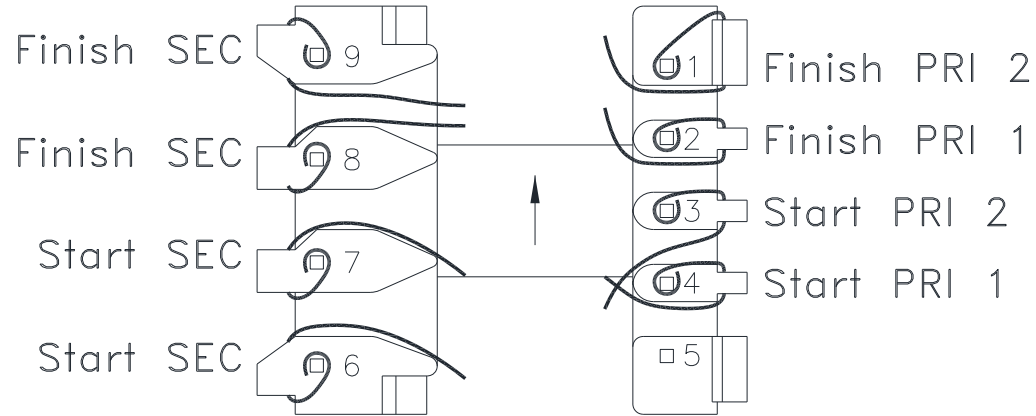
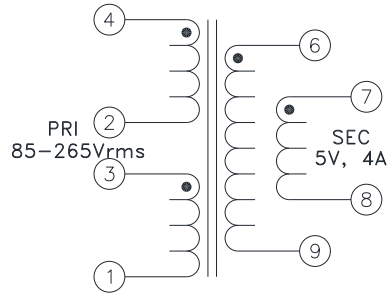


- **2x wire smaller wire vs single strand of large wire**
 - Improved termination & soldering processes
 - Improved fill factor of low turn high current single layer
 - Reduce finish drag back lump
 - Improve coupling and cross regulation
 - Improve the foundation for the next winding
- **Secondary options**
 - Parallel secondary as shown
 - 2 independent secondary
 - Share slot to share a common ground.
 - Share slot to create a series tap and 2x voltage option

Strategic Solder Bridging

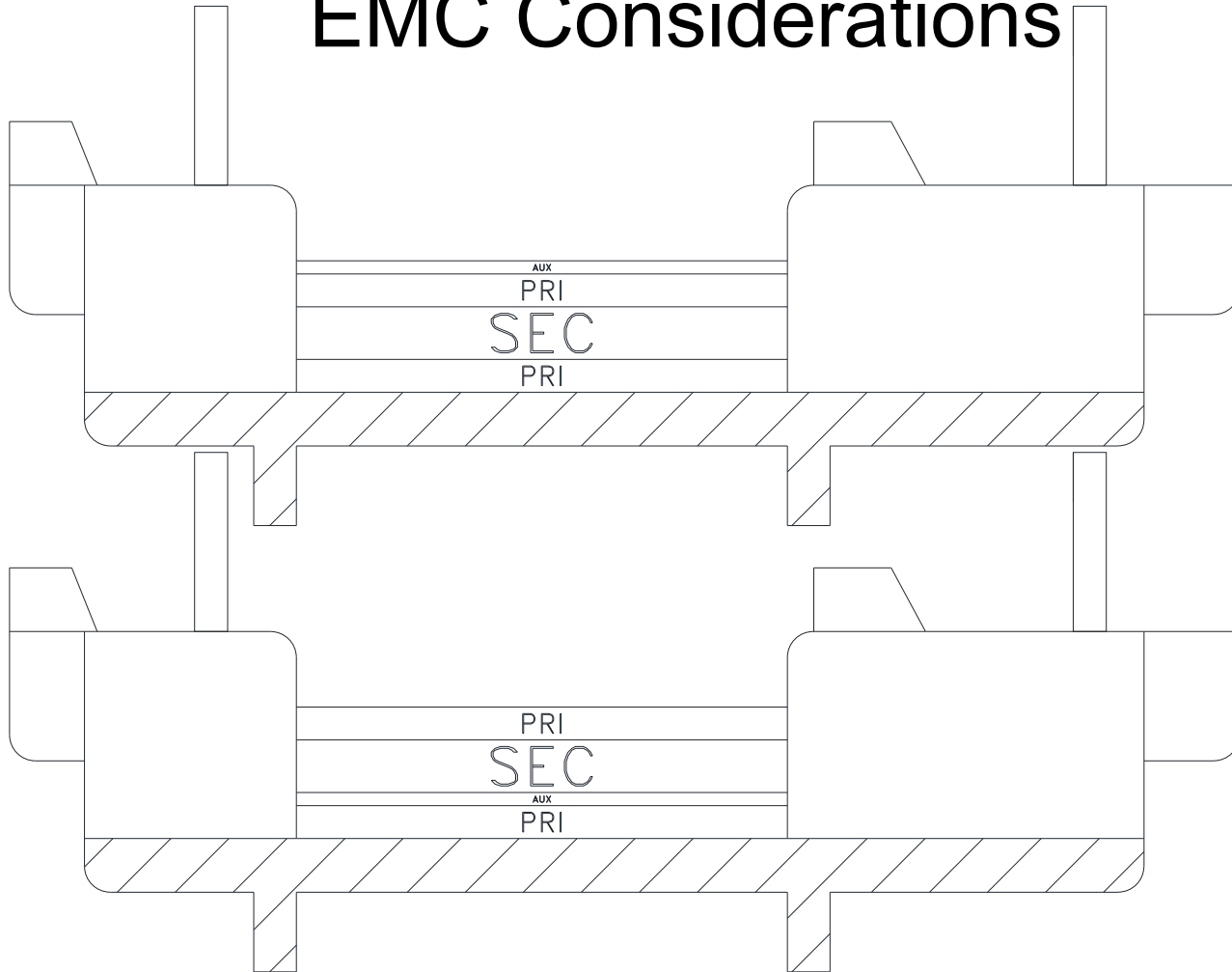


Coupling, Reliability & Manufacturing (Pinout V7)

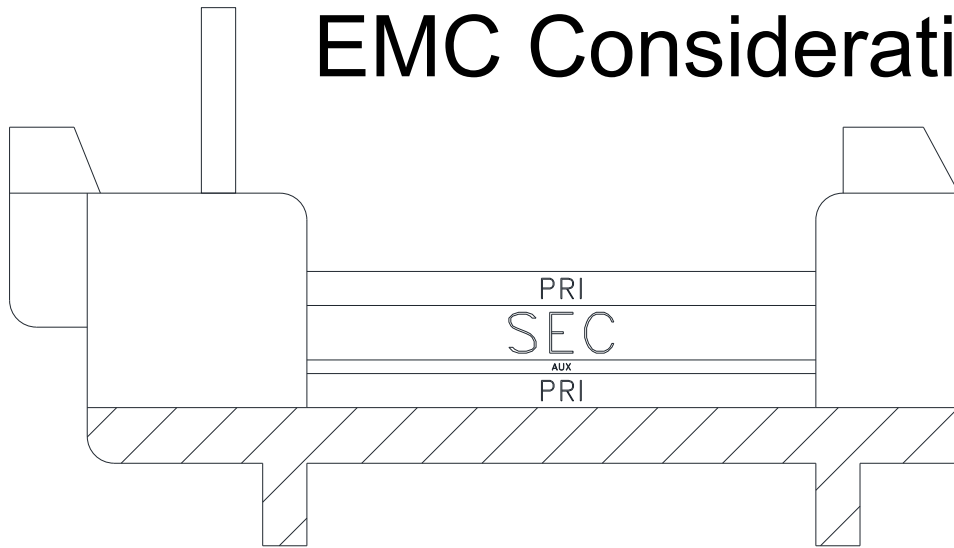


- Tapped Primary on PCB instead of the transformer
 - Termination & soldering processes much easier if one winding on a bare terminal
 - Solution for mounting plane interference (wire beyond standoffs)
 - Possibly reduce standoff height / overall height
- EMC?

EMC Considerations



EMC Considerations



- Foil Shields, Wire Wound Shields, External Flux Band?
- Winding Order / Connection?
 - Auxiliary to separate (shield) noisy Primary from Secondary
 - Which Primary lead is connected to IC
- Unbalanced Split Primary?
 - Adjust turns for 2 near perfect layers
 - Second layer self-shield the noisy inner layer

Cost Considerations

- Machine vs Manual processes
- Easy vs Difficult
- Wind PRI & AUX back to back
- No tape between PRI & AUX
- Same wire for PRI & AUX
 - Minimize setup and possibly eliminates a handling
- Single winding PRI instead of Split PRI
- Eliminate tapes or tubing over lead-ins
- Extruded insulated wire
 - Large coils & mean length turn windings
 - Multiple strands windings; x the length
 - Stripping and termination processes



Pinout and Stackup

- Terminating wire to pins methods and impact on
 - Terminal straightness
 - Mounting plane
 - Coplanarity
 - Soldering
- Safety insulation burn back control and inspection
- Layering impact on cross regulation of multiple outputs
- Core assembly topics related to full coils or wires in core window areas
- Tape width and failure modes
- Visible solder wicking in coils, visible heat damage into coil
- Other Volt - Turn stress reduction techniques
 - Interlayer tape
 - Z-winding
 - Multi-section coil
- Vertical core orientation packages

**What's
Missing?**

How Can You Help?

- The Power Supply Design Specialists can benefit by leaving the transformer specifics as open and as flexible as possible for the Transformer Design Specialists.
- A transformer designer will work with you to balance Cost, Performance, Reliability, EMC and even Size.
- Understand that Safety Requirements will play a significant factor in the package selection, bill of material, and construction of a Transformer.
- Stop back at 11:30 for a Safety specific presentation.