Check before you freeze that design!

Here's a master checklist that just might ward off disaster some day. Use it while you work.

Critical examination of each design before release can minimize design and schedule slips.

Here is a master checklist that can save you time and money. Check your designs against it. Better yet, refer to the list during each phase of your design. One corrected item—an item that might have gone unnoticed without the checklist—can sometimes save a project from disaster.

No list like this can be all-inclusive. But it does present often-overlooked points of broad interest. You may wish to add your own entries based on your specialty.

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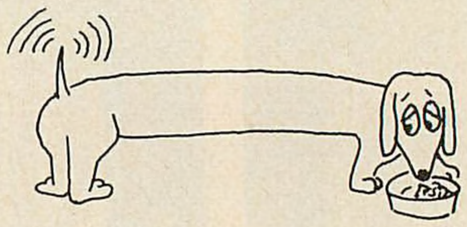
Amplifiers

1. Are inputs and outputs physically and electrically separated as much as possible?

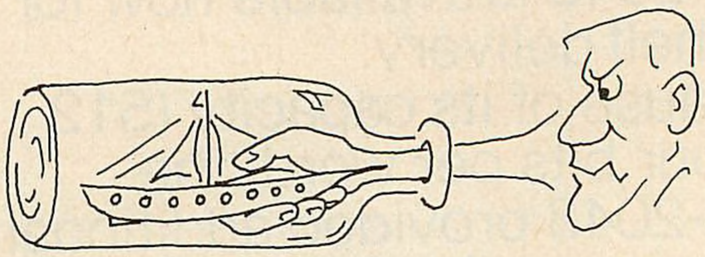


2. Are power sources decoupled close to high-gain, wide-bandwidth devices? Does each device have its own decoupling circuit?

General

1. Have U.L. requirements been considered, and do the designs conform?
2. Have all of these factors been considered in the design:
   - Power consumption?
   - Weight?
   - Size?
   - Cost?
   - MTBF, MTTR?
3. Are there anticipated requirements or options that may be satisfied by minor changes easily incorporated now? For instance, components that might be needed later can be put on the PC art work now. The parts can be left out and mounted when needed.
4. Is the module easily tested? Has test equipment been designed? Have test personnel examined the design?
5. Are parts selected from the company's standard parts list where possible? Are parts available from second sources? Are the parts in this design in common use in other products of the company?
6. Has producibility been considered? Has production seen the design?
7. Has the module been "operator proofed" against the following:
   - Simultaneous and contradictory commands?
   - Damage from insertion or removal with power applied?
   - Backward power connections?

   Use your imagination here. The operator certainly will.



8. Are assemblies easily removed and replaced?
9. Does failure of a module cause "domino" failures elsewhere?
10. Can interlocks be defeated accidentally?

Capacitors

1. Are surge currents within the rated limits of the capacitor? Can associated components safely handle the surge?
2. Are capacitors operated at less than half rated voltage for maximum MTBF?
3. Are electrolytics bypassed for high frequencies with a small, solid-dielectric, noninductive capacitor?
4. Are large capacitors bypassed by bleeder resistors?
5. Are capacitors operated within their temperature limits?

3. Can linear amplifiers be driven into nonlinear modes and do they automatically restore to linear operation?
4. Do nonlinearities generate sidebands that remain and appear as distorted data?
5. Have the effects of offset, bias voltages and currents to op amps been considered?
6. Is the slew rate adequate for high-frequency and fast-switching performance? Is the maximum output swing available at the highest signal frequency?

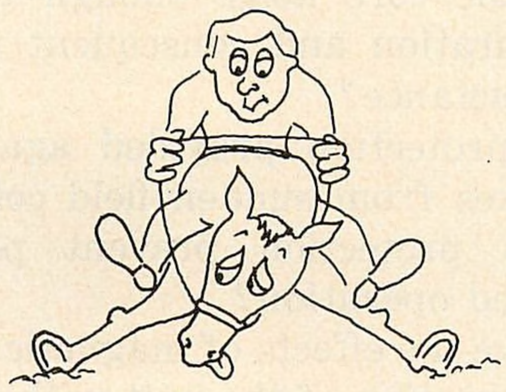
Cost

1. Is the circuit free of special parts (custom transformers, specially machined sinks, special specification op amps, selected resistors, etc.)?
2. Is the variety of parts at a minimum?
3. Is the module easy to assemble and test? Is it easy to repair?
4. Are low-cost parts used where possible?
5. Are ICs, LEDs, ROMs, and other parts with declining prices being used where possible?
6. Have expensive parts been submitted for competitive bidding?
7. Is hand-wiring eliminated where possible? Does the design use PC boards as male connectors, group I/O connections for flat cable wiring and wave soldering?

   (Plastic power transistors can be mounted so that they overhang the PC card, thereby allowing transistors to be fastened to heat sinks with single screws.)

Interfacing

1. Are standardized nomenclatures and pin assignments used?
2. Are decoupled power busses clearly identified and separated from the regulated but noisy power busses?
3. In the layout of the PC board have pins not assigned to standard and critical circuits been left unassigned to permit layout flexibility?
4. Can the interfacing cables be driven without degrading performance? Have sufficient steps been taken to protect against noise pickup on the cables?



5. Are all loads compatible with their sources?
6. Will failure or the disconnecting of one or more power sources cause damage? If yes, what steps have been taken to prevent damage?
7. Is any special sequence required for removing or applying power?
8. Are interlocks provided to insure against improper power sequencing?
9. Can an open or shorted lead produce a harmful action? Is the circuit behavior fail-safe when an interface lead is opened or shorted?
10. Is circuit initialization—an automatic or manual reset or a warm-up time delay—required?
11. Have time race conditions been designed out of the circuits?

Semiconductors

1. Have both voltage and current thyristor rate effects been considered in designing with thyristors?
2. Are transistors operated at less than 80% V_{ce} and V_{be}? Are power limitations observed? Are capacitive and inductive loads properly treated?
3. Is the thermal impedance to the heat sink and to the ambient air low enough?
4. Are matched pairs used where needed? Are they adequately coupled thermally?
5. Are spare circuits identified on the schematic?
6. Have multitransistor arrays been considered to reduce cost or save PC space?
7. Are FET leads properly connected? (The gate is often not in the middle.)

Inductors and transformers

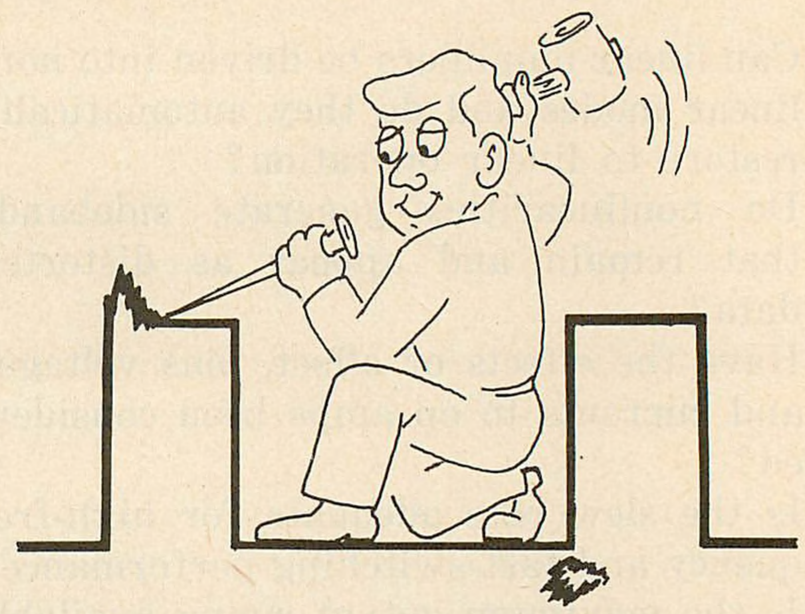
1. Can the unit support the highest possible input voltage at the lowest possible frequency without saturation?
2. Is dc current carried by the unit? If yes, is the core large enough to withstand saturation and consequent reduction in inductance?
3. Is protection provided against voltage spikes from sudden field collapse? Does this protection prevent proper high-speed operation?
4. Have the effects of magnetic and thermal orientation of the unit within the assembly and in the next higher assemblies been considered?
5. Can worst-case core and copper losses be dissipated?
6. Are taps provided for required impedances or drive voltages?

Resistors

1. For reliability, are all resistors operated at less than 75% of their rated power? Are they operated within their voltage rating?
2. Are noninductive resistors used in high-frequency and high-speed circuits?
3. Have the needs for precision, stability, linearity and noise-free performance of resistors been evaluated?

Noise

1. Are critical component positions and sensitive cable routings securely fixed in place?
2. Is rf decoupling used in each module?
3. For low-level critical signals, are power driver and receiver circuits used with twisted, shielded-pair lines?
4. Are high-current, noise producing leads, such as those to motors and solenoids, isolated and shielded from signal circuitry?



5. Are the signals used for edge-triggering "clean" and free of multiple transitions?
6. Are filters used for both reducing line noise pickup and preventing noise broadcasting?
7. Are all wires large enough to carry worst-case loads?
8. For critical signals, has the common-mode-rejection method of reducing response to noise been considered and properly implemented? Are low-level leads as short as possible?
9. Are grounds returned to a single point? Are separate ground leads provided for low-level signals and kept separate from high-current and high-frequency ground leads?

Testing

1. Are tests points provided so they are still accessible in the final assembly?
2. Can test points be shorted to ground without circuit damage?
3. Are test points labeled and conveniently placed for any corresponding adjustments?
4. Has a test specification and procedure been prepared?

Adjustable components

1. Is the adjustment really necessary?
2. Are adjustments adequately labeled? Do clockwise adjustments produce an increase in the controlled quantity or move the operating point to the right in visual displays?
3. Is each adjustment independent of other adjustments? Are adjustments independent of power supply levels?
4. Is there sufficient range and resolution in the adjustment? Are the adjustment end stops strong enough to protect against overzealous turning?
5. Are adjustments still accessible when the module is mounted in the full assembly? Can the adjusted parameter be monitored from the module's final position?
6. Are factory-adjusted components sealed? Are they mounted so that tampering is discouraged?
7. Are variable resistors wired with the wiper connected to one end, thus preventing a completely open circuit should the wiper contact fail?

PC cards and packaging

1. Are PC cards keyed and does the keying prevent reversed insertion?
2. Are power and ground busses labeled on the art work? Are diode directions shown? Are capacitor polarities marked?
3. Are pin-number labels provided for connectors, ICs and transistor sockets?
4. Are standardized pins used for power and ground? Are alternate pins left blank where possible to minimize accidental shorts while troubleshooting?
5. Are the adjustable components labeled?
6. Are sockets used for fuses and lamps?
7. Are low-level signal runs as short as possible? Are high-current conductor widths on PC boards wide enough?
8. Are hot components raised above the card, for cooling and card protection?
9. In difficult or dangerous environments, has hermetic sealing been considered for the package design?
10. Are metal-cased parts protected so they don't cause accidental shorts?
11. Is some room allowed for future growth?
12. Does the module carry its part number and name in a visible area?

Relays

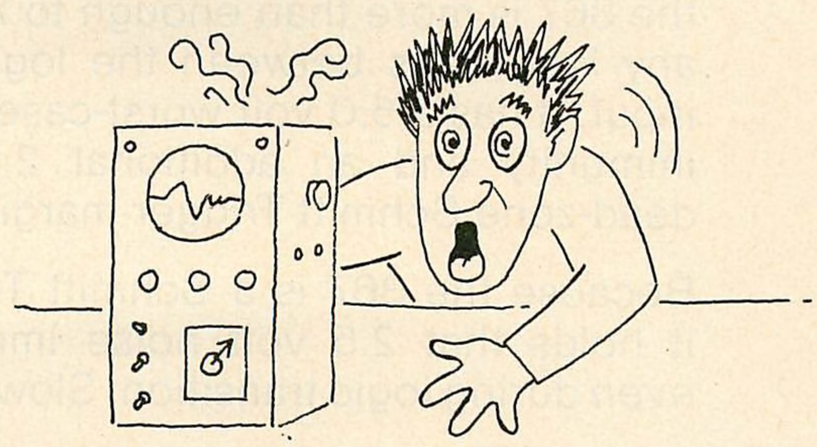
1. Has the relay driver been protected against voltage spikes? Does the protection increase dropout time too much?
2. Have operate, release and bounce times been considered?
3. Is arc suppression necessary. If yes, has it been tested for effectiveness?
4. Are contacts designed for the nominal load only? In "dry" circuits, are the proper contacts used? Have solid-state relays been considered?
5. Has circuit and contact timing been studied to eliminate sneak paths and momentary bridging of contacts?
6. Has the duty-cycle of the relay coil been considered?

Temperature

1. Is sufficient cooling airflow provided? Is cooling still present with the drawers pulled out? Can airflow be impeded by operator negligence, such as stowing manuals on the cabinet top? (A good rule of thumb is: Temperature Rise

$$(^\circ C) = \frac{1.7 \times \text{Power Dissipated (Watts)}}{\text{Airflow Rate (CFM)}}$$

2. Has the performance of the cooling system been checked?



3. Are personnel protected from contact with hot parts?
4. Are heat-sensitive parts (transistors, capacitors) protected and kept away from heat sources?
5. Are PC cards and other materials that easily discolor protected from contact with hot parts?
6. Are components still properly cooled when installed in the final assembly?
7. Has power dissipation been checked under worst-case conditions? (For instance, check zener regulator circuits with the load removed.)