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Baby steps stop the crying

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Sometimes, a seemingly insignificant part tempers the thrill of a technical accomplishment. That's what happened to me recently when I designed and built a Battlebot that I thought was verified and ready to run. Instead, repeated failures brought me to my knees. I know now that I should have guarded against the fault, but ESD problems attributed to mechanical elements can trip up anyone.

The TV show "Battlebots" hooked me. I thought I could build a competitive bot. Whereas a number of bot styles existed in the early days, I thought a wedge design with a lift arm would be a unique and promising approach. I envisioned "tank-control" steering in which independent motors drive the left and right wheels.

I sized both wheel motors for a 120-lb bot and selected motor controllers that were compatible with the PWM output of a model-airplane remote-control receiver. I found a golf-cart pc board that could drive the lift-arm motor but needed a way to connect the receiver's output and the golf-cart board's dc proportional to speed input. To connect the two, I designed a custom interface board with a PIC processor, an amplifier stage, and some gating logic. I prototyped the system with the electrical parts spread out on a workbench. I was happy to get the system running by remote control after making only a couple of tweaks on the custom interface board.

I next assembled the electrical components into the chassis raised on blocks; the bot was essentially complete with lift arm and wheels. I knew the chains connecting the axles would tend to throw grease, so I fabricated a plastic piece to cover the exposed interface board. Once in the bot, the left and right tank-drive circuitry worked perfectly. Surprisingly, after a couple of lift-arm actuations, the lift-arm electronics failed. Troubleshooting the interface board, I found a defective NAND gate. I replaced the IC and got the same quick failure.

Back to the bench. I disassembled the system. I replaced the faulty chip and began scoping various points in the circuit, looking for unusual voltages and motor transients. I found no transients, and every node measured just as expected. I encountered no electrical issues, and the lift-arm electronics worked many times without a failure. I did add transient-voltage-suppression devices to the supply lines just in case there was a sneaky transient I didn't see.

After reassembling the fortified electronics and motors back into the bot, the wheel motors worked perfectly, but my heart stopped when the lift arm failed after two actuations. Frustrated, I broke for lunch, approaching tears, and vented to my nonengineer wife.

I decided to again disassemble the system, prove it functional, and then incrementally reassemble it into the chassis. As expected, it worked on the bench. I mounted just the receiver into the chassis and successfully tested the outputs. Next, I successfully added the interface board. I added the wheel-motor controllers and ran them at a low speed because I hadn't yet mounted the protective cover. Finally, I added the golf-cart controller and lift-arm motor and ran multiple successful test cycles.

Finally, before running the wheel motors at full speed, I added the protective cover over the electrical section. After two actuations of the lift arm, the electronics failed. Bingo! The plastic cover was charged with ESD, and that charge was transferring onto the interface board when the cover brushed against the connecting wires. After I removed the cover and replaced the IC, the problem disappeared.

High-tech equipment inevitably has low-tech problems. A seemingly inconsequential component—a plastic cover—brought down my entire system. Methodically following a process-of-elimination troubleshooting path can be valuable. When I couldn't analyze the problem, I isolated it by taking baby steps from a known working system. ESD is often an underestimated problem that designers should always consider. EDN

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