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Electronic BSE

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9 Bracken View, Brocton, Stafford ST17 0TF T:+44 (0) 1785 660247 E:info@emcstandards.co.uk

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Eur Ing Keith Armstrong CEng MIEE, Cherry Clough Consultants

What BSE did to the beef industry, electromagnetic interference may do to the electronics industry.

The origins of BSE were in the large market for meat products, and the demands of the market for low prices. This led to the feeding of cows on anything that could be called protein, wherever it came from. The customers, in their quest for more meat and lower costs mistakenly assumed that the meat industry knew what it was doing, and had its customers interests at heart. The customers also could not know enough to question the health effects of the beef industry changes which were occurring as a direct result of customer pressure and business economics.

Compare this with today's evolving electronics industry. Digital processing and silicon wafer technology have advanced to the point where almost everything either now has, or will soon have an "electronic brain" in it, with a man-machine interface. An example of the type of "brain" involved is probably close to you as you read this - the humble PC.

How robust is your PC? How often does it crash? I have just had my PC motherboard upgraded and it now crashes at least twice a day, whereas before it might crash once a week. We all curse Bill Gates whenever this happens, but it turns out that many software crashes may in fact be due to low cost computer boards which suffer from poor signal integrity. I am about to have the errant motherboard replaced with one that should be more robust, but in the meantime I have lost useful worktime to the value of a couple of new PCs. It appears that many companies suffer similar problems with their computer technology, a slow bleeding that we trust will not turn into a fatal haemorrhage.

Signal integrity is an electromagnetic interference issue. The term EMC is usually reserved for electromagnetic interference caused or suffered by an electrical or electronic system with respect to its neighbouring equipment and general environment. But signal integrity can also be correctly viewed as electromagnetic emissions and immunity issues between the various parts in a single system.

From this viewpoint, the loss of 'squareness' of a clock signal as it travels around a PCB, or of a data signal in a PCB or a cable, is a problem of electromagnetic emissions - not all of its harmonics are reaching their intended destination. Some harmonic energies are lost by coupling into other PCB tracks and cables, and some are radiated away into the air. This is an in-system electromagnetic emissions issue.

Ground bounce and crosstalk in chips, sockets, PCB tracks, and cables leads to the erosion of noise margins and incorrect clocking and/or data. This is an in-system electromagnetic immunity issue. I spend a lot of my time showing digital designers that designing for the lowest-cost EMC compliance and the fastest time to market must address EMC at the signal integrity level, as this leads directly to fewer design iterations for the desired functional performance and robustness.

Usually though, good design at this level for modern digital signals requires additional PCB layers to allow good solid ground and power planes to be used, plus transmission-line techniques where necessary (by the way - if you can see any light shining through a PCB, it does not have a full ground plane in it).

Because of the pressure from the marketplace for low-cost electronic goods, designers and managers try to keep material costs low. This is good, as long as it is kept in the proper perspective - the real goals for any design and manufacturing company are to achieve the shortest financial break-even time and the greatest return on investment. But only a part of achieving these goals is concerned with the actual cost-to-manufacture, and only a part of that involves actual material cost. There is no point in saving œ1 in the bare-board cost by using two fewer layers if it is going to lead to an additional œ10 spent on external shielding so that the final product may be legally CE marked and sold. There is no point saving 20p on filter components if it is going to lead to an additional design iteration which causes the product to miss its window of opportunity in the marketplace.

Like the beef industry, or any other industry for that matter, an electronic company's business objectives usually do not include direct consideration of their customers' best interests. Most companies instead settle for the idea that as long as people keep buying its products they must be doing something right. This situation is a given, so what would be an acceptable number of PCB layers for a new product not to lead to a significant loss of customer confidence in the manufacturer?

The consequence of price pressures plus a lack of understanding of the true consequences of poor signal integrity is that we may get lowest-cost PCBs which lack the couple of layers, or a couple of components, that they need to provide the robust operation that customers need. Companies claim that they are doing there best to meet market demands for more processing power with lower costs, but both they and their customers may not fully appreciate the longer-term effects that this may have their economic health - the possibility of an electronic equivalent to the BSE situation. Some companies are better than others of course, and their products sell on quality rather than price, but even the highest-quality manufacturers feel a constant downward pressure on prices and are tempted to reduce quality to increase sales volume.

The final piece in the electronic BSE jigsaw is the very rapidly increasing use of digital electronics in areas where people have traditionally used mechanical or electromechanical technology. Motor cars are a particular case in point; with intelligent buildings and advanced highway systems following close behind.

3% to 5% of car owners who have radio controlled central locking can expect to suffer lock-out problems at some time. The AA and RAC attended 8,800 such breakdowns during 1996. What was the root cause? Keyfob radio-control is (like everything in a motor car) subject to intense cost pressure, so simple, cheap, small radio circuits are used - and these are not very good at rejecting out-of-band interference. Park near to a factory which uses RF induction heat-treatment, close to a private mobile radio base station, near to a beauty salon where someone is having unwanted hair removed, or in many other places, and you may not be able to get back into your car, or to disarm the immobiliser, simply because a circuit whose components cost a few tens of pence can't cope with its electromagnetic environment.

Your motor car manufacturer may have saved costs even further by eliminating the redundant mechanical locks and electromechanical switches, so all you can do is wait for the tow-truck to arrive to tow your car somewhere where the keyfob radio can cope with the electromagnetic environment.

Radio-control units similar to car keyfobs and using the same frequencies are used in other applications, such as the remote control of dockyard cranes, hi-fi, and vehicle winches. New guidelines from the Radio Activated Key Entry Committee (details from the AA or the RAC) recommend that such radio-control units are not used as the sole means of control for safety-critical systems, and also - when interfered with - such systems should fail to a safe condition. Wouldn't you have expected that the manufacturers of safety-critical systems would have already taken this into account? Don't you find it worrying that such basic advice needs to be given?

It was recently reported that someone giving a presentation on how Windows 97 will in the future have to be the operating system for medical equipment, because of the cost pressures on the healthcare industry, was unable to get his PC to reliably present his slides. So how should we feel about our possibilities of surviving a major operation or a period on life-support, following a car accident possibly caused by our immobiliser coming on unexpectedly when a passenger in our car used a handheld mobile phone (contrary to the warnings provided in our car's user manual), when we suspect that our surgeons and anaesthetists are using ordinary PCs for their life-critical medical tasks. What confidence can we have that the motherboards in these PCs have adequate signal integrity, when they were purchased from the lowest-price bidder for the Health Authority contract?

In a couple of years, when everything we do relies upon the correct functioning of digital "intelligence", when the mechanical or electromechanical means of doing whatever it is does not exist any more (and especially when we can't get at the power connector to perform a "master reset"), lowest-common-denominator electronic design could easily cause untold personal misery and economic damage. We could easily find ourselves suffering from the electronic equivalent of BSE, brought about by lack of industry knowledge of the long-term effects of poor signal integrity; customer pressure for ever-lower prices, and the inability of customers to know what they are letting themselves in for. Don't believe it? - the embedded digital system or computer you bought today will probably fail on or soon after 09/09/1999, for no good reason other than lack of understanding of medium-term consequences and price pressure from customers. Dates are an easy thing to understand and get right, so what does this imply for signal integrity and reliability due to in-system electromagnetic interference? Electronic BSE is a real possibility.

Keith Armstrong, Cherry Clough Consultants, phone 01457 871605, Email keith.armstrong@virgin.net

Archive Index

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NUTWOOD UK LTD

Eddystone Court - De Lank Lane
St Breward - BODMIN - PL30 4NQ
Tel: +44 (0)1208 851530 - Fax: +44 (0)1208 850871
nutwooduk@nutwood.eu.com