Some Contributions by Gordon Scott to CoolLED Ltd.

Over the 11+ years I've made far to many to mention, so I list a few significant ones.

First things first.

I devised, designed and implemented every single bit of electronics and software in and relating to every product that CoolLED sells, at least up until my forced departure.

Me and me alone.

I also devised all of the comms interface and protocols and most of the user interface, test and configuration software, PC application, SDK and some of the programming interfaces.,

Nick's contribution to that design process was little more than to say that he wanted a rotary encoder on a small separate control 'Pod' on precisExcite, the button-pad concept for pE-4000 and answering my question: "I can do this in several ways and wondered if you have a preference which way? ...". Most of the time the answer was "No preference, do what you think is best". The really obvious exception to that was regarding the change of direction to wanting simultaneous operation of multiple wavelengths, which he had previously declared "not wanted" to the now "must have", when it was no longer possible wirthin the existing product to do so and where neither Nick, Gerry nor Jim would give an answer for very many months to the question "which of these several possible compromises are most acceptable to both CoolLED and our customers".

Anyone who tells you otherwise is at best very seriously mistaken.

I shall make clear what "every single bit" means:

- It means ensuring that what I produce meets, or preferably, exceeds the expectations of the company, its customers and the regulatory authorities!
- It means aiming to be and planning to be "ahead of the game";
- It means the overall hardware and software architectures of numerous systems;
- It means choosing the power and CPU parts capable of delivering the performances we want;
- It means ensuring the CPUs have sufficient and adequate peripherals;
- I means the configuration of all of those peripherals on those CPUs;
- It means that the power supply designs must have the capacity, be compact, efficient and low-enough noise;
- It means everything from handling switch-bounce and pixel management on the Pod to applying the quadratic linearisation at the LED current drives. On the pE-4000, that's a million linearity adjustments a second each of the four channels when they're in linear mode;
- It means the communications protocol for the PC interface, parsing the messages, actioning them, avoiding race conditions;
- It means managing the output constant-current sinks for the LEDs, their power dissipation by the use of tracking power supplies, their voltages and temperatures, quietness and stability of light output and more;
- It means ensuring the control op-amps and their circuits have sufficient output power and speed to drive the current-sink transistors … for a sensible price.
- On precisExcite, pE-1 and pE-2 it meant managing the LED temperature within a fairly narrow margin;

- Allowing users to plug LAMs in wherever they want (“They can’t do that; That won’t work! Will it?” “Yes, it will work ... when I design things I try very hard to make them consistent and ‘orthogonal’.”.);
- It means allowing software integrators to choose which messages they receive via the protocol, from simple responses to commands right through to full telemetry … on a per-interface basis;
- It means meeting approvals for safety, EMC, EMI and more.
- It all too often means making workarounds for people’s lack of thought … like Nick’s decision to supply “end marker” indications on the pE-4000 LED movement, rather than the “reference point” for which I’d asked. He thought end markers would be helpful. He didn’t think how, if the LED was unexpectedly beyond one of the endpoints, I could work out in which direction we must go to get back to sanity.
- It means that if one plugs a ‘wrong’ Pod into a system, not only will it not smoke, in some cases, despite very different systems, the Pods will actually still control the light source to the limits of what’s present.
- It means designing products to meet cost expectations and time expectations, though both of those have to be sensible to be achievable.

Those products (Microscopy):

- Original precisExcite,
  - This was the point where Nick, Gerry and I sat in a huddle and asked “could we make a successful product for this market?”. There were just the three of us and we concluded “Yes we could”. The task was split three ways; Nick did mechanicals, Gerry specified optics, I did the electronics and software … acknowledged even then to be by far the largest task.
- pE-1 and pE-2 derivatives,
- Analogue derivative and custom versions for distributors and for special testing.
- pE-100,
- pE-100 module,
- pE-Integrator,
- pE-Integrator “In Vivo” version (may never have been sold),
- pE-300,
- pE-4000,
- pE-4000 module,
- PC application (platform agnostic),
- PC SDK,
- Test software for all the above,
- Configuration software for pE-1, pE-2, ELAMs, pE-4000,
- Tcl/Tk Applications library
- precisExcite generic simulator as an integration aid for implementers,
- Usage examples for ad-hoc user applications vie DDE and TCP/IP.
- Usage manuals and parsers for implementers.

Those products (Curing):

- UV2600 curing pen
- pC-100 (pE-100 custom derivative)
- pCx
- pC-1000
- pC-2000
- Redesign of Nick’s ITCM one-off for production use (never tested by me as they didn’t buy in the PCBs in time for me to test either hardware or software)

- Some stand-alone SMPSUs that may or may not have ever been used

All of the specifications for all of the above.

Not too bad a throughput for a decade. I’m alleged to have worked for 11+ years and produced all of those products whilst having “no respect”

The Microscopy Illumination Concept

The initial suggestion of an LED illuminator came, I believe, from Brad Amos.

During our[1] earliest discussions about the question *"Can we sensibly make an LED illumination light source for the microscopy market?"*, one statement that I made was *"We should talk with prospective customers about what they want, not just with an acknowledged expert, because experts don't always see the same things as customers. Experts sometimes get things wrong"*. My advice was declined because *"We want to keep secret what we're planning"*. I then said *"OK, well that's fair enough, but I warn you now that we <u>will</u> make mistakes by not doing so. We must just hope that those mistakes are minor"*.

The case for talking with customers

At the time of those discussions, we had been discussing controlling intensity by means of pulse width modulation … a method commonly used to control the intensity of LEDs. I asked *"Do people ever take photographs through these microscopes?"* and Gerry replied *"Yes, that usual"*. I then said *"In that case we cannot do this with PWM; It won't work, there will be banding on the images. We <u>must</u> use linear control."*. That one observation meant that our first product worked, where otherwise it simply would not have, we would likely have sold zero product and we would likely have wasted six months correcting the mistake. Or worse, we may even have had to abandon the project.

In the same discussions, Nick and Gerry both stated that *"we need only three wavelengths; 565nm, 470nm and 360nm, because that will address 90% of use cases. We don't need to consider the other 10%"*. Whilst it may be true that it addresses 90% of use cases, it does not consider how people make their buying decisions. It does not consider the quandary that *"I might need it one day. That product has it and this one doesn't. Can I afford take that risk?"*. It does not consider the situation *"I can't choose … I'll make a list of pros and cons"*. More seriously in our case, it did not consider who actually buys the product, which more often than not was the lab manager, not the end user. The lab manager has to satisfy a range of consumers. If just one of a dozen of those consumers needs another wavelength, then we've just lost a sale. Very sluggish early sales were partly because nobody knew who we were, but also significantly because the buyers were very often the lab managers. A few months after launch, we re-engineered the LEDs to allow them to be interchanged.

The original three wavelengths wanted 8Amps for the 565nm, 4Amps for the 470nm and 2.8Amps for the 360nm. I proposed that I would implement that as four identical channels of 4Amps each with sufficient resolution(0.1%) that the 2.8Amp channel would still have better than 1% resolution, and that the 8Amp channel would simply comprise two 4Amp channels in parallel. My case for that was that having four identical channels increased the component count a little, but reduced the variety of components, allowing us to claw-back costs by reductions of scale. It also dispersed heat dissipation over a larger area. I also said that if we later found that I was right that three fixed wavelengths did prove to be insufficient, that we would already be more than half way to an exchangeable system. To the same end, I put the wavelength strings on the LCD display, so that they did not need printing on the 'Pod'. I did not expect further channels to come as early as they did, and I just hardwired the two 4Amp channel control wires for 565nm. That was at least fixable fixable with a simple hand-wired patch, though I did take the opportunity to insist that we changed

1 Nick, Gerry and I. There was then nobody else.

from Nick's preferred two-layer PCB to a four-layer PCB for more manageable current handling.

Nick and Gerry asserted that we did not need more than one wavelength at a time. I dislike tying my own hands on just a perception, so resolved if I could do so with no significant cost implications, I would make the hardware capable of driving all four channels concurrently at 4Amps each. My first attempt at the power supply to do that did not deliver sufficient current for that, so I asked the question again, more firmly *"Are you absolutely certain that we really do need only one wavelength on at any one time? If I don't revisit the power supply now, the product will not be capable of it. Reworking the power supply it will likely take three or fours weeks "*. Nick's answer was *"Yes; Absolutely certain. Nobody ever uses more than one wavelength at a time. In fact I'd like the operation to be such that it not impossible for them to do so"*. I did not rework the power supply. A couple of years later, Jim was adamant that we must have simultaneous operation, but neither my power supply, nor Nick's LED heads were capable of it. The latter may have been capable without also having to dissipate the power of the Peltiér device, but we were uncertain that the LED wavelengths were sufficiently stable without tight temperature. The Peltiér device controls temperature, but increases the total dissipation significantly. With it, the pE-2 could not have dissipated all the heat generated.

I proposed a module microprocessor to minimise initial time to market, rather than designing our own computer core. There are trade-offs, but they were reasonable and Nick agreed. I also proposed that we use a module that included a TCP/IP Ethernet interface as "it will be very useful for testing, allowing me to test the main unit independently from the 'Pod', rather than having to debug both simultaneously." I also suggested, despite Nick's doubts about it, that a remote control option from a PC would probably turn out to be a useful feature. It did, but if we'd talked to potential customers, we would have learned that USB was a far more acceptable interface that TCP/IP because of their perception that "The IT department always want to take control of Internet capable equipment and that's a very big nuisance".

I devised a user interface using my usual "story board" approach, then modelled it in a small PC application so that people could try it out and see if operation was really as they wanted it. It was. I also used that PC application as the basis for my test harness for the product. I also "spun off" a polished version of the PC application for use by customers. For later diagnostic purposes, that application also reported system information … software and hardware versions, serial numbers and so on.

I have devised, designed and implemented essentially every bit of electronics and software on every product made by CoolLED between when I joined CIL in 2004 until I was besmirched and forced out in 2016. Similarly virtually every bit of user-interface. Similarly all the test, configuration and related software. The only exceptions to that were one PCB re-layout done by Nick whilst I was on holiday and the arrangement of buttons on the pE-4000 Pod. Everything else was my work from switch-debounce on Pods to 1M linearity corrections per second per channel on pE-4000. Intra-unit communications, communications with PCs and serial ports, the protocols, the security procedures, the diagnostics, the telemetry, everything!

The combination of novel current sinks and tracking switched-mode power supplies have a number of features that may well have been patentable, though I generally avoid patents as rarely worth the paper. The original precisExcite current sinks were accurate to around 0.1%, but handled only 4Amps. Later iterations would operate to a 3dB point at 300kHz and

pE4000's will do that with 10Amps. The tracking power supplies keep the dissipation within the current sinks as low as is feasible, though even then it's difficult to get much below 20% of the total, which is something of which I repeatedly had to remind Nick, who otherwise only ever considered the dissipation of the LEDs.

LED light output is not linear, so within the light sources I calculate the current required such that the light output is linear. On the pE-1 and 2, I did that only for the present setting and accepted that, on systems where we had an analogue input, the light output would have a percentage of 2nd-harmonic distortion. On pE-4000, I used a quite quick ARM microprocessor for each output channel and, when driver by analogue, apply the linearity correction in real time at 1M corrections per second per channel. The processor cannot calculate that quickly, but with only a thousand possible values, it is perfectly reasonable to pre-calculate the answers and then just look them up in real time. Even that still takes around 50% of CPU time.

For all of that I was then "thanked" by being falsely accused, insulted, lied to, lied about, humiliated and forced out of my job.

I have solid evidence of false accusations against me. I invite you to take a look at the nearly forty thousand files[2] that are testament both to the amount of work I did for CoolLED and CIL, and also to the fact that at no time could I ever be fairly accused of anything less than working <u>well</u> beyond the hours expected of me. I invite you to inspect my attendance records at CoolLED and ant CIL and at Multitone. CoolLED cannot have evidence of any counter to that evidence, because there is none and has never been any.

I have only circumstantial proof of the lies about things I am alleged to have said in the HR meeting, but I can demonstrate by context, logic and history that they are not credible and must be presumed to have been orchestrated by a person of high authority within CoolLED. After Nick's departure, I can believe that only one person within CoolLED would have had in that authority.

My original "offence" was that Nick had thought I had been recruited by John Boston and Peter Barnwell to "take my job away from me". I was never ever there with that intent and I believe, though possibly wrongly, that neither did John or Peter. Because of that I was, throughout my time with both companies, deliberately disadvantaged, sabotaged and sidelined. May times I questioned why I was not being allowed to do things I ought, only to be given weak justifications for it. I now recognise that Nick was giving clues of the reason, but he was being "too clever by half" in those clues for them to be read by me when I knew nothing of the context. Clearly Nick's antipathy towards me then affected Jim, and Jim's resulting antipathy affected others. I have from the very start been quite unjustly vilified in CoolLED's name.

I remain in absolute disgust and horror of the behaviour towards me of various people within and around CoolLED.

You too should be disgusted and horrified by it.

2 That's a sustained average over 11 years of around 15 files per working day.