{ **White Paper** }

Solving the pain of Load Dumps in

DEF-STAN 61-5 Part 6 Issue 6

For many years Dstl's DEF-STAN 61-5 part 6 has concisely described the 28V DC vehicle power system architecture used in UK military vehicles. Originally issued in 1990, issue 5 of the standard ensured that UK vehicle architectures were robust enough to withstand the harsh environments and demanding requirements placed on them, whilst still remaining a practical proposition for design engineers developing the systems.

System design engineers concerned themselves with the power surges and transients associated with these types of vehicles, recognising that these were the most difficult to achieve compliance to and had the largest effect on system integration and reliability.

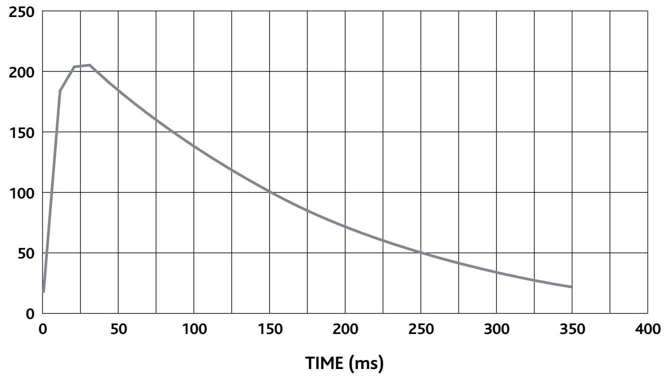
More recent threats closer to home led to a sharp increase in homeland security requirements. This meant that equipment now had to operate on commercial 12V vehicles, posing a problem for military system designers as issue 5 does not cater for 12V systems. Engineers were left with the dilemma of having to decide exactly what levels of surges and transients were present on the end vehicle, often selected on a case by case basis with their end user.

Issue 6 of the standard recognises this new requirement, and now encompasses 12V systems whilst still maintaining the need for retrofitting new systems into legacy vehicles. Engineers now have very clear parameters for both 12V and 28V vehicle platforms, enabling them to develop standard products that comply with both architectures.

Unfortunately, the introduction of 12V vehicle systems highlighted a mode of operation that presents itself in 28V vehicle systems as well. This occurs when a heavily loaded electrical system exhibits a loose battery terminal, but the requirement to consider this mode of operation was not incorporated in the issue 5 version of the specification. However, the resulting voltage transient presented onto the electrical system by the poor connection is defined in the commercial vehicle standard ISO 7637-2 and is known as *'Load Dump'*.

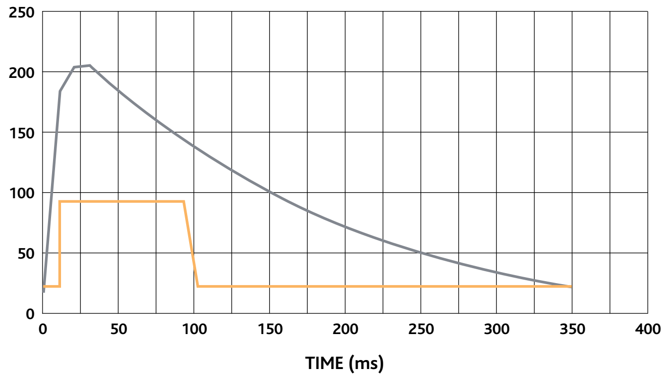
Figure 1 shows the load dump waveform for 28V vehicles and it is presented as a peak of 202V (174V DC surge + 28V DC nominal system voltage) that decays within 350mS from a very low source impedance of 1 ohm.

Figure 1 - **Load dump waveform for 28V systems.**



Previously, the largest surge requirement on the 28V system was when the system ran without a battery connected, and was fed from only the main alternator. The surge was 80V for a period of 80mS and was the result of an instantaneous change in power demand, or power feed-back from a regenerative effect on the system. *Figure 2* shows both the new load dump and the 80V Issue 5 surge.

Figure 2 – **Load Dump and 80V surge waveforms for 28V systems.**



Calculating the energy within these surges reveals that the amount of energy in the 28V DC system load dump surge is around a factor of 5 times that of the 80V surge and the peak voltage is over 2.5 times the magnitude.

In a 12V system the peak voltage is 87V superimposed onto the 12V, (total 99V DC peak) for 400ms from a 0.5 ohm source impedance. The energy and voltage levels are lower in this surge than the 28V system.

The 80V surge is seen as a common occurrence on 28V vehicles and it is necessary that the equipment continues to operate continuously throughout the duration of the surge. Electronic equipment fitted to 28V vehicles typically includes DC-DC converters to reduce the high input voltage to lower voltages required by the electronic circuitry.

In order to optimise the power conversion efficiency of the DC-DC converter stage, it is very common that the DC-DC input range is limited to 40V DC maximum, and in some cases 36V DC. This also ensures compliance with the 30V steady state operating voltages of the system for a typical battery plus alternator system, and 40V for an alternator only configuration.

With this in mind a very common method of protection for the DC-DC converter is a simple clamp circuit using a series pass element that prevents the voltage increasing above the maximum allowed input voltage of the DC-DC converter. In normal operation the device looks like a very low resistance connection from input to output, however during the surge it switches on harder and becomes more resistive. The increasing surge voltage is dropped across this series element and is dissipated as heat within the device ensuring that the output voltage is kept below the maximum allowed level.

The short term peak surge energy is only present for a period of 80mS, so relatively large power converters of several hundred watts can be made without huge premiums of space needed for the protection stage. A typical protection device may only need to be one half the size of the main high power density DC-DC conversion stage.

When choosing a series pass protection device it is common to use a FET transistor and in doing so there is a trade off between the voltage withstand of the device, and it's on resistance. A perfect device would have an infinite voltage withstand and zero on resistance, removing the normal on state resistive power losses. In reality the resistance increases with voltage, and therefore the maximum voltage rating of commonly used FET transistors in these protection devices is typically 100V DC. Choosing a 100V device allows for headroom on the 80V surge and these devices are readily available in various package sizes and current ratings within the market.

The introduction of the 202V peak surge in issue 6 immediately means that most issue 5 systems will not survive the application of the surge to their input, as the 100V protection FET will fail.

Fortunately, during the 202V load dump surge it is recognised that this is a rare event and the system is allowed to turn off, and therefore a simple solution would be to detect this large surge voltage and then safely turn the system off. This method of protection is only suitable if the downstream electronics are able to safely shut down in a mode that allows the system to re-start, once the surge has passed.

A very large hold up device such as a charged capacitor could be employed as part of the new protection circuitry, providing enough hold up time for the electronics to remain operational during the 350mS surge. This method is often impractical in higher power systems as the capacitors needed are often disproportionally large for the equipment.

In some electronic equipment it may not be allowable for the system to shut down completely, due to long re-boot times on restart. In these systems a fully clamped input may be required to ensure continued operation during the surge, as once again the size of the capacitor arrangement could prove to be prohibitively large to accommodate.

In lower power equipment the energy of the load dump surge can be dissipated using a classical clamp circuit, however once the clamp requirement reaches a few hundred watts this method becomes increasingly less practical, and instead a voltage step down power converter may prove to be more space and cost efficient.

Careful consideration is needed when defining the power architecture of the equipment. A combination of allowing some parts of the equipment to shut down whilst maintaining full power to critical elements of the equipment often results in the most cost effective smallest solution.

On Systems manufacture a comprehensive range of standard COTS protection and DC-DC converter devices, along with proven power architectures for full compliance to DEF-STAN 61-5 Part 6 Issue 6 on new design and retrofit upgrade systems.

*For more details on making your system compliant to DEF-STAN 61-5 Part 6 issue 6 or for more information please contact **Craig Benton** on:*

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