# Advanced Electronic Power Simulation

**Advanced electronic power simulation with unique specifications through basic power test building blocks, creating more efficiency, effectiveness and flexibility for a lower investment.**

## Exciting times:

The world market for cars is growing at a steady but modest CAGR of approximately 7%. More interesting is to look at the growth of all electronic components within a car. Industry annalists expect that the electronic cost content in a car will grow from 22% in 2005 to 40% in 2010. This means that the market for electronic car components show a CAGR of approximately 15%. This is twice a much as the total growth of the car industry and doubles the market in five years.

Another growth factor is the continuous need for more power within the car. What started with 6VDC batteries at a few hundred Watts has become kilo Watts at 12VDC or 24VDC. All this need for more power is causing the DC current through the DC bus to increase dramatically. Hence the discussions to increase the cal DC voltage bus to 42VDC.

The need for testing also dramatically increases. Where in the past there was just a few electronic components, there is now many hundreds of electronic devices. A car today can have up to a hundred circuits with some kind of micro-processor installed.

Two types if testing needs to be done. Each electronic device needs to be tested individually. And later, integration testing needs to be performed to ensure that all these devices do not interfere with each other and cause the total car to fail.

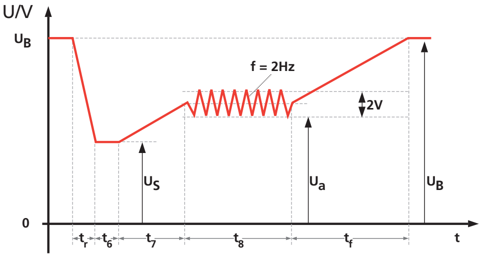
Both types of testing happen during R&D and during production. During the R&D phase, mainly margin testing and integration testing has the highest priority. During production the focus is mainly burn-in & test.

## With more power comes cheaper and better specifications.

This article focuses on power simulation of the car. For this purpose, several specialized power sub-systems exist on the market today. Their attributes are low ripple & noise, fast voltage slew-rate and low transient response time. Lets first review why these attributes are so important. For this we need to start with the ISO 7637 standard (see figure 1). Required is a 5ms fall-time over 9 Volts or a 2Hz sine wave superposed on a 5 Volts DC offset level. This kind of power simulation signal requires a fast DC output slew-rate. To do this with a switch-mode DC power supply brings the advantage of high DC output current for a reasonable price in a compact, high-power density form-factor. But at the same time the DC output topology has a high stored energy, which does not allow for fast output voltage changes. Required therefore is a down-programmer as part of the DC output topology. But still in many cases this is not always fast enough. In that case, we suggest to select a DC power supply with a higher rated DC output voltage capability than required for the application. For instance, the specific application requires a 20VDC rated power supply. The selected switch-mode supply needs 40ms to go from 90% to 10% of the rated DC output -- in this case from 18 VDC to 2 VDC. This means a DC output voltage slew-rate of 0.5 V/ms. Instead I would select a 60VDC rated switch-mode power supply. With a similar specification of 90% to 10% of the rated DC output voltage will take 40 ms, the output voltage fall-time is now 1.5V/ms. To drop 9 Volts will take 6 ms. Very close to the requirement of the ISO 7637 standard.

The disadvantage of this method is that with three times the rated output voltage at the same current requirements, three times the power is needed. At AMETEK, additional power in the same product family comes with just 50 cents per Watt. A much cheaper and more practical approach than specialized power supply sub-systems uniquely dedicated for specific automotive applications. And this last comment highlights another large benefit. A standard switch-mode DC power supply with some extra power offers a higher degree of flexibility to support other future applications, and thus a more protected investment.

**Figure. 1: ISO 7637 standard**



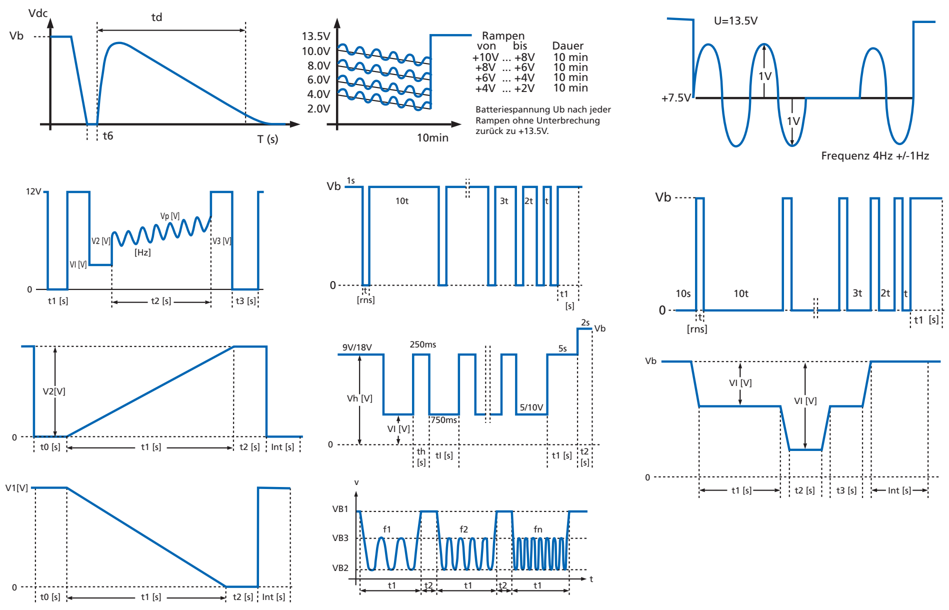

**Voltage transient at engine start-up**
**UB=12V, US=3V, Ua=4V**
**tr<5ms, t6=15ms, t7=50ms, t8=1s, tf=100ms**

Voltage rise- & fall-time specifications in V/ms.

Notice that the higher the rated DC output voltage, the faster the output voltage the unit is. This can be attributed to the fact that the space for the switch-mode power supply output filter circuitry remains the same, but the rated output voltage increases and the stored energy decreases, which makes DC output voltage changes faster.

| | SGA / SGI | |
|---|---|---|
| VDC | Rise V / ms | Fall V / ms |
| 40 | 2.2 | 0.85 |
| 60 | 3.25 | 1.55 |
| 80 | 2.67 | 0.95 |
| 100 | 4.75 | 1.85 |
| 160 | 3.66 | 1.42 |
| 200 | 4.36 | 1.69 |
| 250 | 5.10 | 1.98 |
| 330 | 5.12 | 2.00 |
| 400 | 6.70 | 2.60 |
| 600 | 15.50 | 5.97 |

Figure 2. Examples of power simulation test scenarios




### The need for fast analog control

Over the years many test scenarios have been created. For every electrical failure a new simulation had to be developed. Figure 2 shows some of the many examples of test scenarios used by the different car manufactures.

A very practical method to reproduce these typical power simulation waveforms is through an arbitrary waveform generator connected to the analog input for the DC output voltage control. Most switch-mode power supply provides an analog control input. This is normally a 25-pin connector allowing for many control functions, like: set output voltage, set current limit, voltage read-back monitoring and current read-back monitoring. Typically a zero (0) to five (5) or ten (10) volts signal will drive the DC output voltage from zero (0) to maximum rated voltage. The benefits for the use of a general arbitrary waveform generator is its extreme flexibility, combined with its memory depth and sequencing capability it can potentially simulate any power transient behavior for now or the future. Again I classify this as a very practical solution, because both the arbitrary waveform generator and switch-mode power supply are very common and relatively inexpensive pieces of equipment. Only two attributes are really important to watch for: The analog control input of the switch-mode DC power supply should have a bandwidth of at least 1kHz and the arbitrary waveform generator should be able to output at least 10Vpp in an open circuit.

Some switch-mode power supplies have an arbitrary waveform generator built in. Of course this solution is more compactly integrated. But mostly these built-in arbitrary waveform sequence generators lack the flexibility an external dedicated arbitrary waveform generator can offer. In most cases the capability of the built-in arbitrary waveform sequence generators are adequate for production purposes, but for R&D more flexibility is needed. In case of such a built-in arbitrary sequence generator, a minimum requirement will be a voltage, current or power ramp of 1ms or less and a sequence programming resolution of 1ms or less.

The next power supply attribute to discuss is transient response. Very high current demands are activated on and off in a car. Figure 3 shows the same ISO 7637 standard, but now with the typical corresponding current demands.

### These large current demand changes cause transients in the DC output voltage.

Figure 4 shows the transient effects on the DC output voltage of a switch-mode power supply due to large current changes. Important specifications are the size of the overshoot and the time it takes to recover back to the set output voltage. The internal voltage control-loop regulates this. The faster the voltage control-loop the higher the overshoot. The slower the voltage control-loop the longer it takes for the power supply to recover to the set voltage.

A large portion of automotive electronics testing relates to breakers, fuses, relays, etc. To perform these tests properly without damaging the devise under test due to the test method alone, the voltage overshoot needs to be kept to a minimum. To achieve this the current demand step for the power supply needs to be reduced. A smaller current demand step will cause smaller overshoots. A simple way to avoid these overshoots, is to put a pre-load in parallel with the devise under test (see figure 5). Imagine that 50% of the current travels through this additional pre-load and 50% through the device under test. When the device under test creates a 100% current demand step, the power supply only sees a 50% current demand change. Always a base current demand remains present. For the power supply to manage 50% in current demand changes, instead of 100%, is much easier and almost eliminates the effect of high voltage overshoots and therefore eliminates any damage on the device under test. A simple inexpensive resistive load can be used in this case to function as a pre-load. Any ratio is fine. In other words, to obtain the transient response and overshoot specifications improvements it does not really matter if this load absorbs 40%, 50% or 60% of the current demand. Again the same disadvantage arises; twice as much current is required, therefore more power is required. And also in this case, more power comes at 50 cents per Watt. In other words, increasing power is a relative simple and inexpensive method to obtain significantly better specifications.

**In conclusion:**
More power capability from a general-purpose switch-mode power supply can substitute the need for specialized linear-type unique power supplies. The benefits are much lower capital investment and much smaller form-factor. This philosophy will not completely eliminate the need for these high-end specialized power simulation subsystems, but it will provide a choice to allocate capital budget more effectively in a practical way to support automotive electronics power simulation test needs. At least in 90% of all cases this philosophy provides a more flexible alternative.

**About AMETEK**
Headquartered in San Diego, California, AMETEK Programmable Power is the new global leader in the design and manufacture of precision, programmable power supplies for R&D, test and measurement, process control, power bus simulation and power conditioning applications across diverse industrial segments. From benchtop supplies to rack-mounted industrial power subsystems, AMETEK Programmable Power produces Sorensen, Argantix and PowerTen brand DC supplies ranging from 30W to 150kW; Elgar and California Instruments brand programmable AC sources from 800VA to 480kVA, and Sorensen brand AC/DC loads in both modular and high-power models. AMETEK Programmable Power is a division of AMETEK, Inc, a leading global manufacturer of electronic instruments and electromechanical devices with annual sales of more than $2.5 billion. For more information, contact AMETEK Programmable Power, 9250 Brown Deer Road, San Diego, CA 92121. Web site: www.programmablepower.com.

Typical pin-layout of the analog-programming interface

| I/O | Function | Standard Description | Isolated Description | Pin No. | Electrical Chars. |
|---|---|---|---|---|---|
| In | ISO On/Off | Enables / Disables output with an externally supplied AC/DC voltage. Voltage may be 12 to 240 VAC or 6 to 120 VDC. A positive voltage will turn on the output of the supply. isolated up to 500v. | Enables/Disables output with an externally supplied AC/DC voltage. Voltage may be 12 to 240 VAC or 6 to 120 VDC. A positive voltage will turn on the output of the supply. I solated up to 500V. | 1 | Zin - 1.2 kohm |
| In | Ipgm | 0-5V for 0-FS current programming | 0-5V for 0-FS current programming | 10 | Zin - 10 kohm |
| Out | Iset | 0-5V for 0-FS indicates FP potentiometer setting | N/A | 11 | Zout - 100 ohm |
| In | Vsns - | Negative remote sense input | Negative remote sense input | 12 | - 100 ohm to negative output term. |
| In | Vsns + | Positive sense input (<60V) | Positive sense input (<60V) | 13 | - 100 ohm to positive output term. |
| In | ISO TTL/CMOS ON/OFF | TTL/CMOS logic level enables supply | TTL/CMOS logic level enables supply | 14 | Zin - 2.2 kohm |
| In | Vpgm | 0-10V for 0-FS for voltage programming | 0-10V for 0-FS for voltage programming | 15 | Zin - 20 kohm |
| In | Ipgm | 0-10V for 0-FS for current programming | 0-10V for 0-FS for current programming | 16 | Zin - 20 kohm |
| Out | FAULT | High for module fault -14Vdc | N/A | 17 | Zout - 100 ohm |
| In/Out | S/D FAULT | High +12V for shutdownfault; also if driven high will shutdown the supply | N/A | 18 | Zout - 100 ohm |
| Out | Vmon | 0-10V for 0-FS sample of output voltage | 0-10V for 0-FS sample of output voltage | 19 | Zout - 100 ohm |
| In | ISO RTN | Return for pins 1 and 14 | Return for pins 1 and 14 | 2 | |
| Out | Vpgm Current Source | 1mA CS | N/A | 21 | - 10.8V compliance |

| I/O | Function | Standard Description | Isolated Description | Pin No. | Electrical Chars. |
|---|---|---|---|---|---|
| Out | Ipgm Current Source | 1mA CS | N/A | 22 | - 10.8V compliance |
| — | Ipgm Return | Return for Ipgm; <2.5V to COM to enable Ipgm | Return for Ipgm; <2.5V to COM to enable Ipgm | 23, 25 | Zin - 10 kohm |
| In | REM OV SET | 0-5V for 0-FS for OVP trip point, >10V resets OVP | 0-5V for 0-FS for OVP trip point, >10V resets OVP | 3 | Zin - 20 kohm |
| — | Vpgm Return | Return for Vpgm; <2.5V to COM to enable Vpgm | Return for Vpgm; <2.5V to COM to enable Vpgm | 4, 20 | Zin - 10 kohm |
| In | ON/OFF | Tied to pin 6 to enable supply | Tied to pin 6 to enable supply | 5 | Must sink - 1 mA to turn unit on. |
| — | COM | Return for control signals; same potential as - output terminal | Return for control signals | 6, 24 | |
| Out | Imon | 0-10V wrt pin 6 for 0-FS sample of output setting | 0-10V wrt pin 6 for 0-FS sample of output current | 7 | Zout - 100 ohm |
| Out | Vset | 0-5V for 0-FS indicates FP potentiometer setting | N/A | 8 | Zout - 100 ohm |
| In | Vpgm | 0-5V for 0-FS voltage programming | 0-5V for 0-FS voltage programming | 9 | Zin - 10 kohm |