Long-Ma: The birth of a hybrid giant

Long-Ma, the dragon-scaled winged horse of Chinese mythology, came to life during the celebrations of the 50th anniversary of diplomatic relations between China and France. Dintec managed to power the dragon-horse in only 12 months.

In October 2013, Compagnie La Machine approached their partner Dintec with the request to power a giant dragon-horse. It should allegorize Long-Ma, a fabled winged horse with dragon scales in Chinese mythology. Very quickly it became obvious that this project would be like no other. As Long-Ma should come to life within only 12 months and then be the main attraction at the celebrations for the 50th anniversary of diplomatic relations between China and France, the pressure on Dintec was high. But being an experienced system integrator especially for off-highway applications, Dintec took on the challenge and the responsibility for the whole power system. Passion for mobile machines and for the entertainment created by the amazing creatures of Compagnie La Machine allowed Dintec to master the system from power generation, storage, and distribution to control and sensors. A multidisciplinary team of five engineers started by understanding the energy balance of the animal and the constraints in terms of operating mode (hybrid, fully electric for 45 minutes). After 1800 hours of engineering work, a hybrid architecture was defined in detail (shown in Figure 1) and the software for the power management written and compiled. Only seven months after kick-off, a prototype of the system could be seen working in Dintec’s workshop.

Hybrid power pack with noise insulation

In order to supply the 620 V DC electric net, Dintec designed a bespoke power pack driven by a Perkins 6-cylinder Tier 4 Interim engine to lower emissions. The diesel engine is coupled to a STW Power Mela 140 kW E-machine. Due to its integrated inverter, the Power Mela permits four-quadrant operation and works as a generator. Running at variable speeds depending on power demand, the combination offers best-in-class fuel consumption. Lots of effort was also made in terms of power pack enclosure, as the giant Long-Ma had to remain a silent machine (see Figure 2). Even when the diesel engine starts, advanced noise insulation keeps Long-Ma quiet.

The main electric consumers are the two 140 kW E-machines working as motors. They supply hydraulic...
power for all movement (head, body, legs, eyes), the hydrostatic transmission, and the steering system. A brake chopper has been implemented on the DC bus to avoid over-voltage in case of hard braking. The brake chopper is also equipped with an electric insulation measurement system that permanently controls the electric isolation of the DC bus from the machine chassis. A shortcut here would be hazardous to the operators of Long-Ma. All electric components (batteries, motors, generator, inverters) are connected to the DC bus through small cabinets integrated into the machine.

Figure 1: Visual schema of Long-Ma (Photo: Dintec)
The giant also requests a number of additional electric networks, so Dintec supplied appropriate solutions derived from the 620 V\text{DC} bus. Inverters and filters take care of the transformation to the AC world with a 400 V\text{AC} - 50 Hz (triphases + neutral) net for air compressors and water pumps and a 230 V\text{AC} - 50 Hz net to power small AC motors, lights, and music systems. A DC/DC converter converts the voltage down to 30 V\text{DC} to supply fans, controllers, and lights.

**Energy storage and electronics**

After a deep benchmarking of technologies, taking the duty cycle of the machine, its required lifetime, and the constraints in terms of use and availability into account, Dintec selected Sodium Nickel batteries for their high power and energy density and supplied five sets of 23,56 kWh each fitting to the 620 V\text{DC} net and weighing a total of 1000 kg. While each set features its own cooling system, the batteries are designed to be charged from the grid but can also be directly charged from the embedded power pack when necessary.

Animating such an animal smoothly and realistically means over 50 speed and position regulations for the movements of the head, the body, the legs, and the displacement (hydraulic propelling and steering). To handle these numerous functions and the communication between the 24 HMIs (display, joysticks, keypads) and more than 200 sensors (angles, length for cylinder heads, pressures, temperatures, etc.), a complex network of 16 embedded controllers communicating through 17 different CAN networks was defined.

An ESX-3XL control unit was selected as the center and brain of the system. It can handle up to 124 I/Os, has four independent CAN interfaces, and offers the computing power and memory to run sophisticated applications. Steering and propelling are managed through the off-the-shelf STW ESX-C, which is capable of controlling the rolling chassis. Another ESX-C control unit with two CAN interfaces was used to implement the power management algorithms. These are capable of permanently adjusting the power generation to the machine requirements and make sure all requested movements are operated at the right speed. Two ESX-IOX and eleven ESX-IOXp decentral I/O control systems were deployed for the hydraulic movement control of the head, legs, and eyes. Efficient communication between all these CAN participants was established. Lastly, an ESX-C2C with mobile communication capabilities was added so that diagnosis, software updates, and machine follow-up could be done remotely using Dintec’s web server.

**Finding its home in China**

After intensive testing in Nantes, France, Long-Ma passed all controls and certifications handled by TUV Belgium, which is specialized in unusual and therefore special applications. Long-Ma then left Nantes in September 2014 aboard an Antonov 124 to land the next day in Beijing, China. After being re-assembled and after several days of testing and rehearsals for the ceremony, Long-Ma performed three days of intensive shows, leaving the Chinese public with unforgettable memories. Finally, Long-Ma returned back to Nantes in June 2015 for a couple of presentations and performances. After those, Long-Ma will permanently stay in China as part of a larger project.

Both companies – Dintec as the System Integrator and STW as the provider of the controllers, the electric generator and motors – were proud to work on a project of this scale. This pride reached its peak when after 12 months the engineered system gave life to the animal which took part in the big show for the celebrations of the 50th anniversary of China’s and France’s diplomatic relations. This project could be realized on time only due to the long-term relationship between Dintec and STW. Only because of this relationship, the requirements of the machine manufacturer could be met as technical challenges could be solved through seamless communication.

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