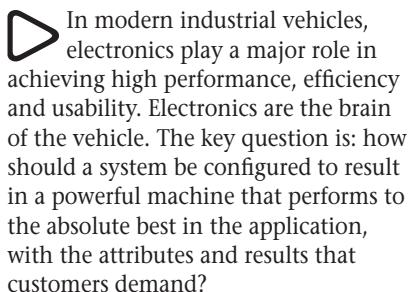


# VICTORY IS NINE

## OPTIMAL SYSTEM INTEGRATION IS A WINNING FORMULA FOR NEW FORKLIFT DEVELOPMENT – AND ALL IT TAKES IS NINE EASY STEPS TO SET UP A SUCCESSFUL APPLICATION-SPECIFIC AC DUAL-DRIVE SYSTEM

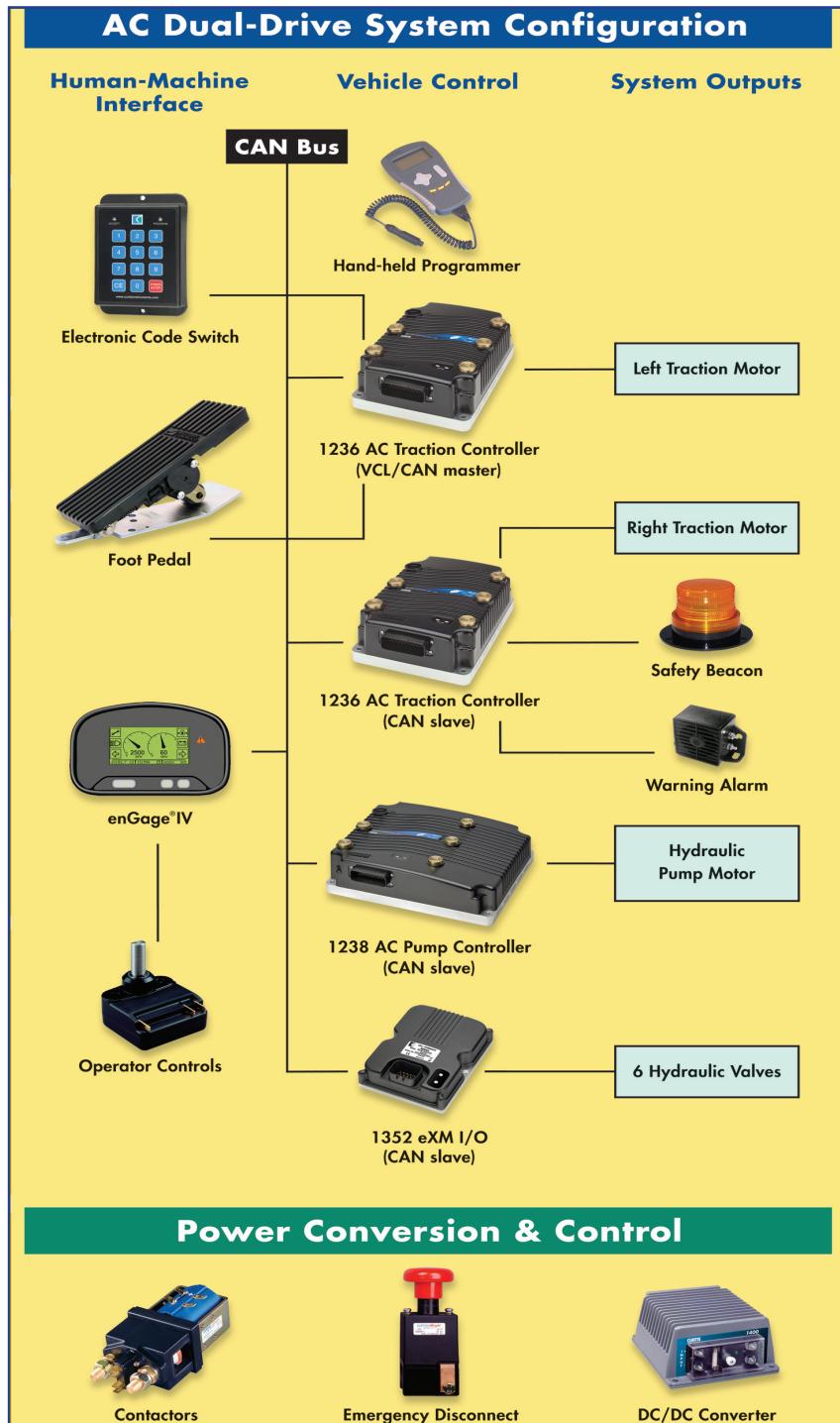


Optimal system integration is a prime consideration. This is not merely a question of selecting and matching the right components with the appropriate software; the structure of the engineering process is also a key factor and this depends to a great extent on the co-operation between manufacturer and suppliers – and on the choice of suppliers.

Let's take a hypothetical example – a medium-sized forklift manufacturer, skilled in the mechanical design of materials handling trucks but without any in-depth expertise of electrical and electronic systems, undertakes the design of a new Class 1 dual-drive AC counterbalance truck.

As with most OEMs, engineering resources are scarce. The manufacturer has already determined the vehicle's basic geometry. Parameters such as weight, battery capacity and system voltage are defined, as well as functional requirements and performance figures such as payload, speed and gradeability. The next task is determining how to achieve 'best-in-class' status ahead of its international competitors.

The relationship between the OEM and the supplier is a crucial success factor. When selecting dual traction motors, gearboxes, hoist pump, and pump motor, it is advisable to source motors and gearboxes from a supplier that works co-operatively alongside the OEM's mechanical designers and development engineers to provide the right solution.





**Landoll in Marysville, Kansas, has successfully implemented a dual-drive AC system, supplied by Curtis Instruments**

Likewise, in the selection of motor controllers to drive the dual traction and hoist pump motors, the OEM will benefit from the supplier's electrical and electronic expertise to supplement internal competencies. OEMs should source components from a motor-controller supplier that has proven platforms utilising the latest technology, providing the right balance of cost, performance and quality. The same holds true when choosing the system controller and the operator interface devices – this could include displays, pedals and joysticks. As the OEM normally has little experience of integrating electronics from different suppliers, a supplier with a comprehensive range of displays and input devices should be first choice.

### Nine steps to heaven

A comprehensive nine-step process can be used as a basic guideline for a dual traction drive system. The first step is to select the twin traction motor/gearboxes and associated motor controllers for the traction drive. This includes calculations to derive the power rating for the motors to meet vehicle speed and gradeability requirements. Parameters such as peak torque, maximum speed, peak power, gear ratios, tyre diameter and duty cycles are defined at this stage. Calculations should also be made to determine system efficiency, heat sinking requirements and energy consumption. Battery capacity needs to achieve the desired autonomy.

The second step is to select the hoist pump, pump motor and pump controller, on the basis of calculations to determine pump size and the hydraulic pressure and flow rates needed to meet

payload and lift-speed requirements. After having defined the hardware of the hoist drive, an appropriately rated motor controller has to be chosen – the OEM and its supplier will calculate parameters such as system efficiency, system losses, heat sinking requirements and energy consumption.

The next step is to choose the human-machine interface (HMI), the input devices and information the operator needs. This includes the choice and integration of components such as throttle pedals, direction selector and brake pedal.

There are also general decisions to be made. For instance, will conventional levers serve best for the lift, tilt and



**Landoll's Bendi articulated forklift**

sideshift functions, or are fingertip joysticks the better choice?

The fourth step is to determine the vehicle I/O structure based on functional requirements. This is quite a comprehensive task, as all components and functions have to be considered, including motor feedback (encoders) and motor protection (thermistors); hydraulic functions (lift, tilt, sideshift solenoid valves, lower proportional valves and steering valves); switch inputs (forward/reverse drive selector, mast height, parking brake, safety interlocks such as seat switches); steered wheel position feedback for dual-drive system; throttle and brake pedal analogue signals; hydraulic pressure switches and low oil-level switches; I/O from control lever switches or mini-joystick for hoist, tilt and sideshift; audible alarms, beacons and horns; and brake and reverse lights.

The fifth step is to create a table from the I/O list to determine I/O requirements. The list contains the quantity of each I/O type such as digital input, encoder, analogue input and output drivers. For each type, specifications such as digital threshold voltages, analogue range, resolution, zero and span and driver output current have to be defined.

The sixth step is to define the vehicle display functions. What diagnostic functions are important, and how are they supplied? What functions are needed by the operator? There is a wide range of choices, depending on the vehicle operation. Typically, speedometer, steering angle, battery-discharge indicator and hourmeter will be included, along with warnings for lift lockout, parking brake applied, motor over temperature, oil, low battery and service intervals.

The next step is to choose the display package. This includes ergonomic and physical considerations of the display's installation. Factors such as available space, daylight reflection, viewing angle and operating temperature range have to be taken into account. Does a standard display exist that provides the required functionality? Would a custom display be cost-effective, or be available within the project timescales?

The eighth step is to define the vehicle behaviour. What is needed to make it operate in a safe, predictable and efficient manner? Acceleration, braking distance and turning speed need to be set up correctly, particularly on a dual-drive system, to ensure correct differential steering. Behaviour on sharp turns, ramps, slopes and when crossing obstacles defines safety in use and how

## New expansion module for hydraulic controls

Who needs more hydraulic I/O? Many forklift engineers do when designing new systems architectures – proportional control of hydraulic functions considerably enhances the safety, productivity and comfort of the truck.

Curtis Instruments now has a compact, highly cost-efficient expansion module for its motor controllers, which can be easily added to a vehicle's CANopen network.

The new module eXM 1352 offers nine multipurpose I/O pins, allowing fully configurable control of up to six proportional hydraulic valves, together with three high-resolution analogue

inputs. These pins can also be used as basic digital I/O, providing a highly flexible mix of functionality.



the vehicle is perceived by operators.

The ideal control system will allow custom functionality to be added to the basic operating system without calling for major effort. Intuitive adjustment of vehicle behaviour, a choice of drive profiles and the ability to set up the vehicle to suit particular working areas should be provided.

The ninth, and final, step is to determine ancillary requirements and consider any other factors that will be relevant to the specific application, including the addition of management systems for the fleet and warehouse and the availability of service and diagnostic tools.

Once these nine steps are successfully completed, the hardware requirements for the vehicle's control system should

be understood. But two crucial factors have not yet been considered: cost and time schedule. It is the goal of every engineering team to implement the best possible technical solution with the best technical qualities at the lowest possible cost, within the given deadlines. This is an important factor for each of the outlined steps.

### Real-life example

One great example of a company that has implemented an optimised drive design process is Landoll in Marysville, Kansas, USA. Landoll is well-known for its articulated Bendi brand forklift, which has already been presented in the 2002 *iVT* Materials Handling Annual. In the first quarter of 2009, the company will launch an AC dual-drive Bendi,



The new Bendi forklifts offer optimum driveability and performance

designed to work in narrow aisles, bulk storage and other congested areas. These machines offer a high stacking ability and provide the low mast height necessary to work in highway trailers or travel through low doorways.

Landoll's new Bendi model, with AC dual drive, will feature the considerable performance enhancements and drivability of Curtis AC controllers. This AC dual-drive project was built as a result of the success of the rear-wheel Bendi series of trucks, which uses Curtis SepEx dual-drive systems. The control system of the new dual-drive Bendi will consist of two 1236 controllers for traction, a 1238 for lift/mast and steering operation, two Albright main contactors, an FP-6 foot pedal and a customised enGage IV display.

The standard Curtis dual-drive software allows the 1236 controllers (one master, one slave) to correctly control the dual-drive operation of the truck. This includes varying motor speed on inner and outer wheels during turns to provide true differential control. This ensures smooth control of vehicle speed, acceleration and motor current during turns. The Curtis Model 1238 controller provides variable speed control of one AC hydraulic pump motor for mast/lift operation as well as steering – eliminating the steering contactor and steering motor in the process. The FP-6 foot pedal provides the throttle signal while the enGage IV display provides onboard diagnostics and operator interface.

In effect, the new trucks will take advantage of the improved performance, efficiency and flexibility of Curtis AC controllers, along with the dual-drive electronic differential benefits of increased traction and reduced tyre wear. Optimum drivability of the truck is thereby provided. In keeping with the Curtis integrated system concept, Landoll is able to use Curtis VCL control to effectively communicate between vehicle components and fully utilise system I/O embedded in the AC motor controllers and the enGage LCD – which importantly, eliminates the need for a separate system controller or customised firmware. This all translates to enhanced functionality, performance, cost-effectiveness and a rapid development time. **iVT**

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