Crane drive and control systems: Part 1

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The container transportation industry has witnessed a remarkable growth over the last decade. More cranes are being purchased annually then ever before and crane sizes have increased dramatically. The myriad of crane types required in terms of form and function have always been evident. Thus, more efficient AC converter solutions were developed to cater the demand for 'power hungry' cranes yet with the availability of different power configurations, ease of maintenance and reliability in mind to meet the demands of the ever challenging container transportation industry. Siemens as the leading supplier for container crane drive systems now introduces an innovative drive and control system solution that offers crane builders, system integrators and end-users for the first time standardized yet flexible hardware and software solutions.

Crane drive systems

The different types of cranes available in the market have one thing in common: a need for power. Since on cranes, energy is stored during hoisting and released during lowering, the AC drive systems were designed to deliver power with the capability to regenerate. Over the last 10 years AC drive technology has been further improved by gradually introducing self-commutated line-side converters that offer the end-user an almost perfect power factor, low harmonic injection and a high tolerance with respect to line voltage fluctuations. Also, the line commutated converters have become more robust and efficient compared to their predecessors. Line side converters with common DC bus configurations deliver the torque required for all motions on the crane apart from being efficient and reliable to the end-user. Nevertheless, safety should not be compromised for performance hence the relevant standards and norms have to be fulfilled.

The principle of infeeds

The AC converter system converts the AC line supply of 50 Hz or 60 Hz to variable voltage/frequency required for all motions on a

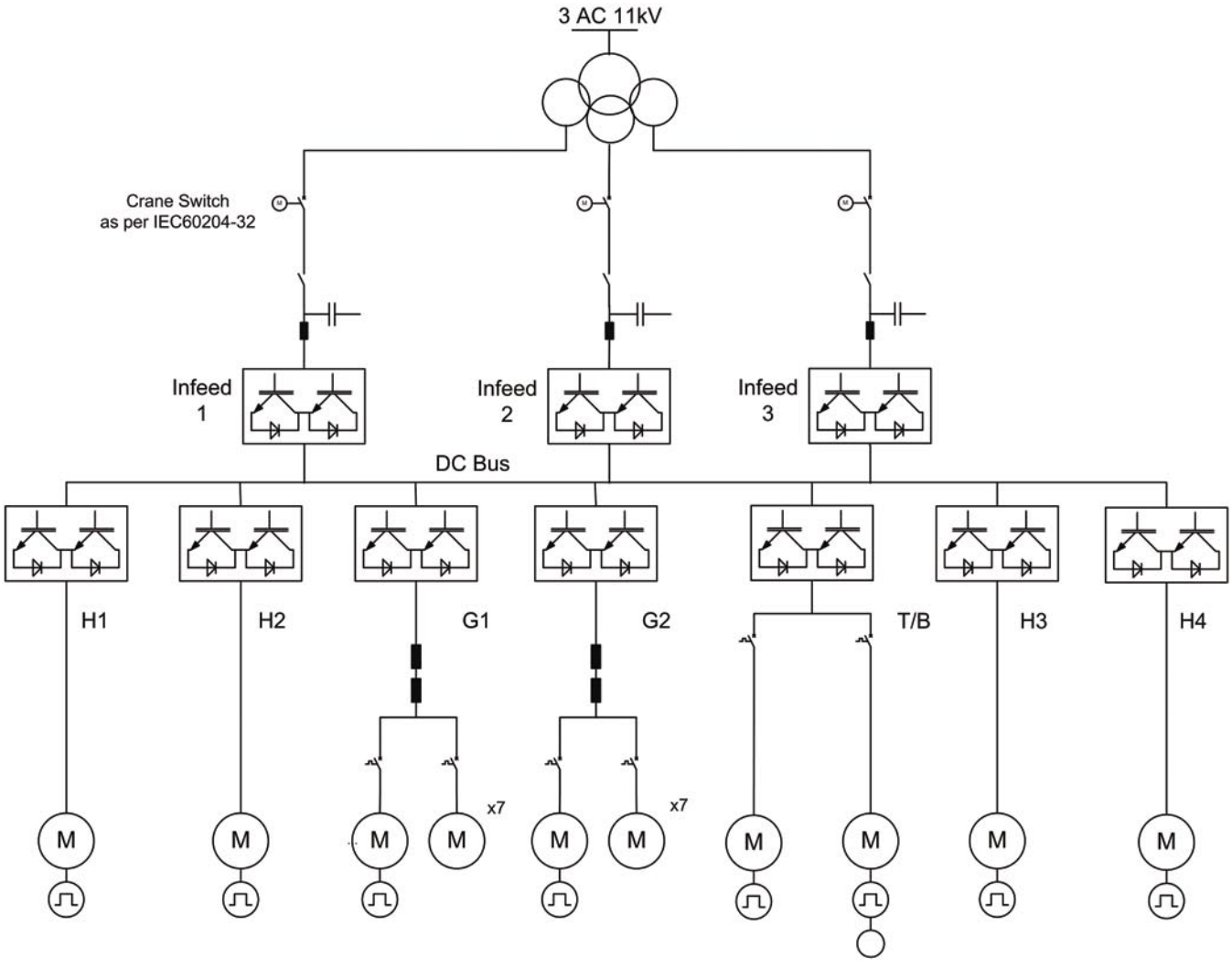

Figure 1. Typical overview of a tandem lift STS drive system.

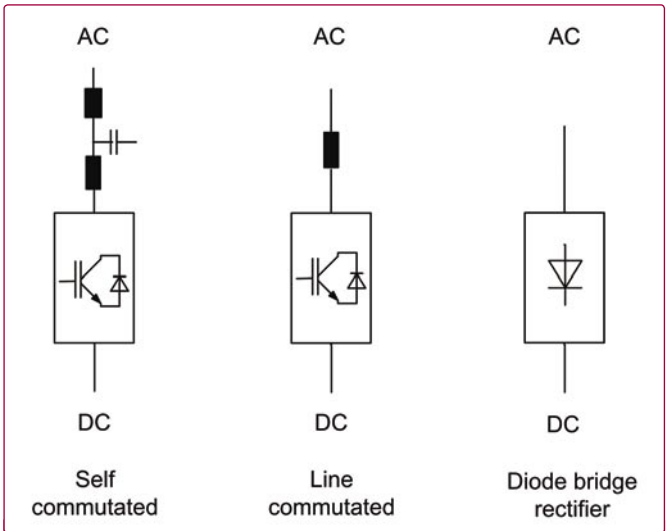

Figure 2. Overview of general infeed types.

Figure 3. SINAMICS S120 Cabinet Module.

crane. The diode bridge rectifier or IGBT types are the two most commonly found infeed configurations in the market today. The former is used for 2 Quadrant non-regenerative operations, for example on a RTG and straddle carrier. This type of unregulated infeed is usually robust and compact yet in principle, fairly priced. However, braking modules and resistors have to be implemented to dissipate the regenerative energy which is mostly generated by the hoisting system, leading to high energy cost. Modern RTG's nowadays are equipped with hybrid solutions, such as Siemens ECO RTG's, which are more fuel efficient then conventional RTG's. These hybrid solutions utilize 4 Quadrant infeed systems.

Self commutated IGBT infeed is the preferred solution for regenerative operation in STS and RMG's. The IGBT's are actively pulsed using a pulse width modulation method and are not susceptible to short time line voltage fluctuations (within limits), thus maintaining a constant DC bus voltage at all times. Also, the power factor of near unity (during loaded operation) is attainable, making it the preferred solution for end-users with ever increasing electricity bills from power utilities. Furthermore, the latest development in state-of-the-art IGBT's, have a higher power density, hence they are more compact in size with lower conduction losses. Due to lower thermal losses, the heat sinks are also smaller. An optimised modulation scheme allows lower PWM carrier switching frequency which results in reduced losses within the drive system.

Line modules

The Siemens drive system SINAMICS S120 has recently been introduced to the crane market. There are three basic types of line side converters available for different types of cranes as shown in Figure 2:

a) Basic line module (BLM) is a thyristor or diode bridge rectifier, which is extremely compact.

b) Smart line module (SLM) is a line commutated infeed that is enhanced by the use of IGBT's that avoid commutation faults/ failures as known for thyristor based rectifiers.

c) Active line module (ALM) is a self-commutated infeed with a high dynamic performance and a 'line friendly' solution.

SINAMICS adds to features well known from the SIMOVERT MASTERDRIVES series such as wide power range, modularity and global support with additional benefits:

- Increased power density
- Improved efficiency
- Minimal cooling fan noise
- Draw-out type phase modules

Based on Siemens vast experience in the building of crane control panels, a modularized range of standard crane drive cabinets comprising the necessary line connection, switch-over, motor modules (MoMo) and-multi motor modules have been developed.

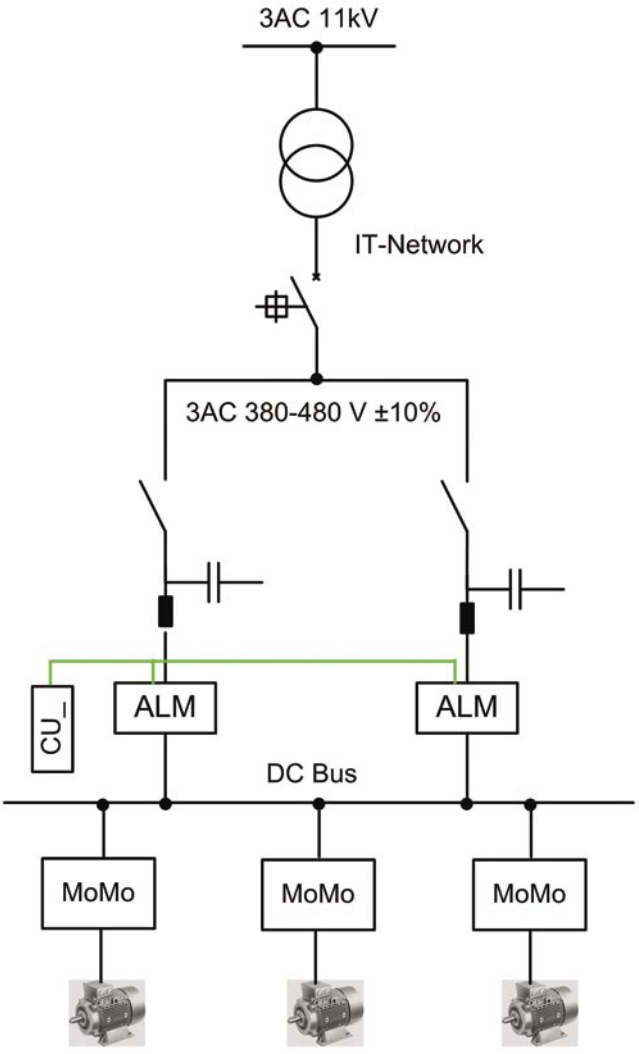

Figure 4. Direct parallel connection.

Drive configurations

With the availability of a grid network as power source for the crane, the self commutated converter is the best option for regenerative operation in 4 Quadrant applications. Redundancy of the infeeds can be achieved with a single control unit as shown in Figure 4 above and can be described as 'direct parallel connection' redundancy. In cases where one infeed fails, the operator or service personnel can switch into emergency mode and the remaining infeeds can be operated again but with lower crane capacity i.e reduced motion speeds. This is a cost effective solution as a two winding transformer, a single crane switch as per IEC60204-32, a single control unit for the infeeds, reduced low voltage devices such as auxiliary contacts and terminals are sufficient. The line contactors are used as crane On/Off switches while the ACB's upstream are utilised as an E-Stop.

For a more stringent requirement on availability of infeeds, the crane drive and control configuration differs. The 'galvanic separation' operation, as shown in Figure 1, is where a failure of one or more infeeds will not disrupt the operation other than the availability of reduced power on the crane in line with the remaining healthy infeeds. Such an availability however, has a price to be paid compared with the previous solution, with the need of individual galvanic isolated secondary windings, individual crane switch and individual control units, and additional low voltage devices for each line side converter. Also, with additional equipment comes the need for more space required to place the control cubicles.

The line side commutated converters or SLM's used in 4 Quadrant operations with the capability to regenerate are foreseen in a 'galvanic separation' configuration as mentioned above with the exception that a 12 pulse parallel connection is implemented via a symmetrical three winding transformer which are recommended to be vector group Dy5d0 or Dy11d0. Also, a line reactor with a relative short circuit voltage of 4 per cent should be installed. 'Direct parallel connection' is not advisable with SLM type infeeds due to the high harmonic injection into the system. The advantage of SLM's as an IGBT inverter in comparison to their thyristor based predecessors is that it can now be switched off at any time hence commutating short circuits do not occur during regenerative operation in the event of supply voltage failures.

SINAMICS converters and the corresponding line side system components such as line reactors are designed to be connected to supplies with a permanent level of voltage harmonics in accordance with EN 61000-2-4, Class 3. For the active line module, Total Harmonic Distortion factor of the line voltage, THD(V) is typically three per cent.

The overall drive system should be an insulated earth (IT) supply. TN systems suffer from substantially higher voltage stress levels on motor windings due to common mode oscillation. For IT supply, an insulation monitoring device is installed to comply with IEC60204-32 (refer to application note "Crane Drive System Configurations – SINAMICS S120 Active Line Module Sizing and Configuration").

From past experience, failure of infeeds are more critical then the motor side in terms of two aspects; time required to service/replace components quickly to avoid long downtimes and the cost of such failures. Unpredictable behaviour of the grid which affects the supply of the crane in terms of voltage, frequency and current could put a higher demand on the sizing and configuration of the system.

Conclusion

The rapid growth in the production of container cranes poses new requirements to crane builders, system integrators and also end-users. Drive and control configuration determine the performance, reliability and safety of the crane. Siemens' new crane drive and control solutions based on SINAMICS with SIMOTION D can offer flexibility yet dynamic performance and enhanced reliability. The latest development in crane control system will be discussed further in the next edition of Port Technology International.

ABOUT THE COMPANY

Siemens is one of the world's largest electrical engineering companies. Siemens is committed to delivering state of the art solutions which minimize the impact on the environment. With over a century of experience in supplying electrical traction equipment a revolutionary new drive system has evolved in the crane market.

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