Architecture for a High-to-Medium-Voltage Power Converter

High input voltage would be divided evenly among many converter blocks.

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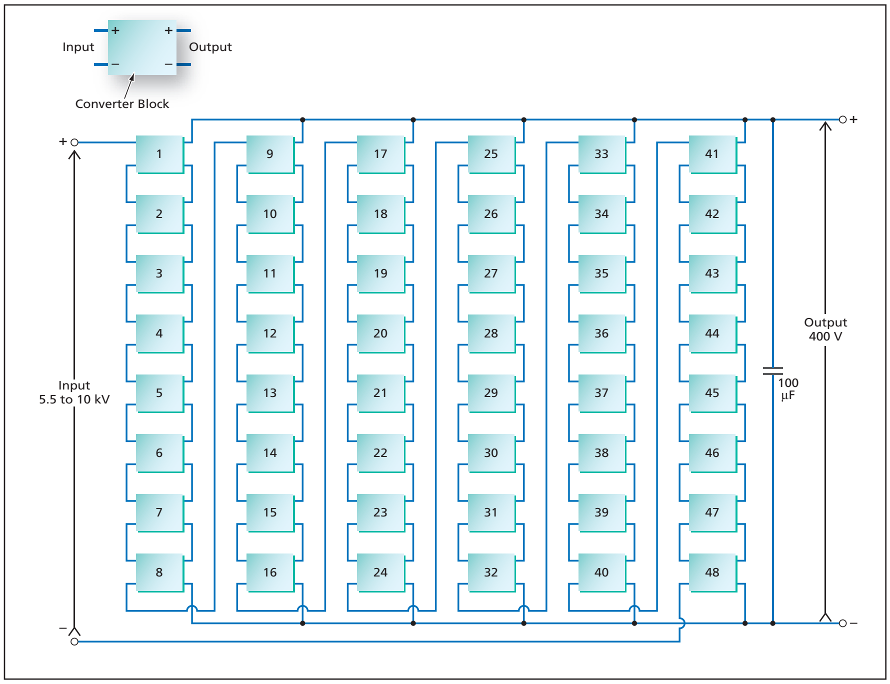
A power converter now undergoing development is required to operate at a DC input potential ranging between 5.5 and 10 kV and a DC output potential of 400 V at a current up to 25 A. This power converter is also required to be sufficiently compact and reliable to fit and operate within the confines of a high-pressure case to be lowered to several miles (≈5 km) below the surface of the ocean. The architecture chosen to satisfy these requirements calls for a series/parallel arrangement of 48 high-frequency, pulse-width-modulation (PWM), transformer-isolation DC-to-DC power converter blocks.

The input sides of the converter blocks would be connected in series so that the input potential would be divided among them, each of them being exposed to an input potential of no more than 10 kV/48 ≈ 210 V. The series connection of inputs would also enforce a requirement that all the converter blocks operate at the same input current. The outputs of the converter blocks would be connected in a matrix comprising 6 parallel legs, each leg being a cascade of eight outputs wired in series (see figure).



Converter Blocks would be connected in a series/parallel arrangement, which, together with control circuitry, would result in equal sharing of current and voltage.

All the converter blocks would be identical within the tolerances of the values of their components. A single voltage feedback loop would regulate the output potential. All the converter blocks would be driven by the same PWM waveform generated by this feedback loop. The power transformer of each converter block would have a unity turns ratio and would be capable of withstanding as much as 10 kVDC between its primary and secondary windings. (Although, in general, the turns ratio could be different from unity, the simplest construction for minimizing leakage and maximizing breakdown voltage is attained at a turns ratio of unity.)

Each converter block would contain an output filter that would serve two purposes, one being the conventional purpose of smoothing out the pulsations in the output potential. The other purpose is to interact with the power transformer in such a manner as to result in equal sharing of voltage among all the converter blocks.

The secondary-side circuits in the converter blocks would include synchronous rectifiers instead of diode rectifiers, in order to prevent inductor-current discontinuities at no load or light load. Such discontinuities could upset the desired sharing of voltage because they would cause the output potential to depend on the output current in addition to the PWM duty cycle.

The following two additional features would not be crucial to sharing of current and voltage but would be needed for good performance:

- Each converter block would include a two-stage input filter that would smooth out input-current pulsations caused by switching of the input voltage applied to the primary winding of the power transformer. The input filter would include damping resistors to prevent oscillations that could otherwise occur in the presence of negative-input resistance of the converter.
- The peak current in the switch on the primary side of one of the converters blocks would be sensed and compared with an error signal after the addition of an external ramp signal. This current feedback loop will improve the dynamic response and provide natural peak current limiting of the converter.

This work was done by Vatché Vorpérian of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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