Analysis and Design of SQR-Based High-Voltage LLC Resonant DC–DC Converter

Introduction:

One of the main requirements of such converters is to provide high voltage gain with reduced weight and high power conversion efficiency. An important application of the high-voltage dc–dc converter is to power travelling wave tubes (TWTs) in high power-density radio frequency (RF) transmitters, also known as microwave power modules (MPMs). MPMs are the hybridization of solid-state and vacuum tube technology and used as an RF amplifier for medium-power application. They have been widely used in unmanned aerial vehicles and satellites owing to their reduced weight and superior RF performance compared to the conventional vacuum tube based transmitter.

Existing system:

The performance of an MPM-based transmitter is very sensitive to the applied high voltage dc. There are strict dc output voltage ripple requirements that must be met to drive a TWT. The output voltage ripple can be reduced by increasing the output filter capacitor. However, the maximum value of the output capacitor is restricted by maximum allowed stored energy in the output side (typically less than 2 J).

Moreover, for application such as MPM, the estimation of accurate output voltage ripple is necessary as the phase of amplified RF output depends on the output voltage and any error in the estimation of the output voltage ripple results in a significant amount
of power loss when multiple MPMs are combined for increased RF output power. In an MPM, the high voltage output is connected to the cathode of the TWT. The phase of the RF output can change almost 100° for 1% change in the cathode voltage.

**Dis-advantages:**

- The increased insulation in the windings further exacerbates the parasitic effects leading to poorer performance of the transformer at high switching frequency.

**Proposed system:**

An isolated high-voltage *LLC* resonant dc–dc full-bridge converter based on symmetrical quadrupler rectifier (SQR). Unlike conventional Cockcroft–Walton and full-bridge diode rectifiers, the SQR circuit provides significant improvement in power density by reducing the transformer turns-ratio without much increase in the output Impedance. Moreover, the *LLC* converter can provide additional voltage boost, if operated, below the series resonant frequency of the *LLC* tank. The operating region of the converter is chosen in such a way that the converter always operates in ZVS for all line and load conditions with additional voltage boost.

The *LLC* converter is operated at lower than the series resonant frequency of the *LLC* tank to have additional voltage boost. During this mode, the primary current in the tank becomes discontinuous, and therefore, the usual design based on the FHA does not hold true. Therefore, a new method of solving the *LLC* resonant tank without any approximation is proposed.
Advantages:
- Reduces the required turns ratio of the transformer contributing to high-frequency operation
- And reduced transformer size.

Applications:
- DC-dc Power conversion applications.

Block Diagram: