

DESIGN AND IMPLEMENTATION A RESONANT DC POWER BUS

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Abstract

We design and implement a power convert to supply dc power bus for the MCOR30 correction supply. The dc power supply's characteristics were variable frequency at heavy and medium/light load. These characteristics matched with the correction supply working requirement. The dc power bus has a relaxation oscillator generating a symmetrical triangular waveform, which MOSFET's switching is locked to. The frequency of this waveform is related to a current that will be modulated by feedback circuitry. As a result, the tank circuit driven by half-bridge will be stimulated at a frequency dictated by the feedback loop to keep the output voltage regulated, thus exploiting its frequency-dependent transfer characteristics. The high performance characteristics of the resonant dc power bus are illustrated in this paper.

INTRODUCTION

The L69599 controller was designed in the resonant dc power bus. It is an advanced double-ended controller specific for resonant half-bridge topology. In this dc power supply, the switches device of the half-bridge leg are alternated switch ON and OFF (180° out-of phase) for exactly the same time. This is commonly referred as operation at "50% duty cycle". Although the real duty cycle, which is the ratio of the ON-time of either switch to the switching period, is actually less than 50%. The reason is that there is an internally fixed dead time T_D , inserted between the turn-OFF of either MOSFET and turn-ON of the other one, where both MOSFET are OFF. This dead time is essential in order for dc power bus to work correctly: it will ensure soft switching and enable high frequency operation with high efficiency and low EMI emissions. The block diagram of the L69599 controller is showed as figure 1.

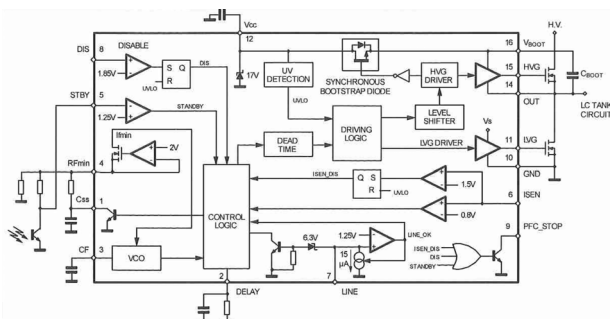


Figure 1: The L69599 controller block diagram.

MUTI-MODE OPERATION

Bust-mode control with no or very light load. When the load falls below a value, the power bus will enter a controlled inter mitten operation, where a series of a few switching cycles at nearly fixed frequency are spaced out

by long idle periods where both MOSFETs are in off state. A further load decrease will be translated into longer idle periods and then in reduction of the average switching frequency. When the power bus is completely unload, the average switching frequency can go down even to few hundred Hz, thus minimizing magnetizing current losses as well as frequency-related loss and making it easier to comply with energy saving recommendations. The multi-mode operation is showed as figure 2.

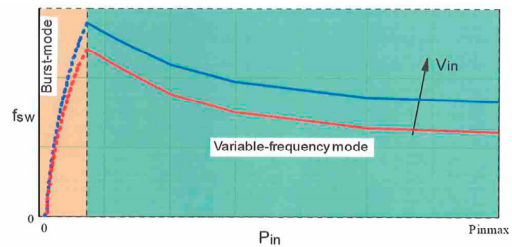


Figure 2: The multi-mode operation.

During this frequency sweep phase, the operating frequency will decay following the exponential charge of C_{SS} , that is, initially, it will change relatively quickly but the rate of change will get slower. This counteracts the non-linear frequency dependence of the tank circuit that makes dc power supply's power capability change little as frequency is away from resonance and change very quickly as frequency approaches resonance frequency. The power via frequency curve in a resonant half-bridge is showed as figure 3.

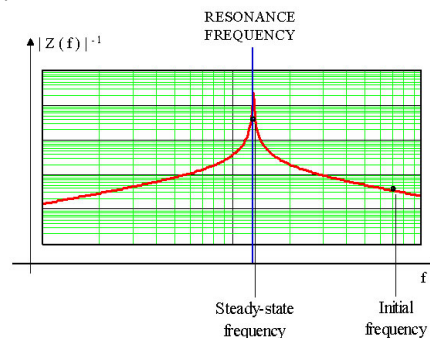


Figure 3: The power via frequency curve in a resonant half-bridge.

As a result, the average input current will smoothly increase, without the peaking that occurs with linear frequency sweep, and the output voltage will reach the regulated value with almost no overshoot.

CURRENT SENSING DESIGN

The resonant half-bridge is essentially voltage-mode controlled; hence a current sense input will only serve as an over current protection (OCP).

We design the current sensing technique with sense shunt. The figure 4 is showed the current sensing technique with sense shunt.

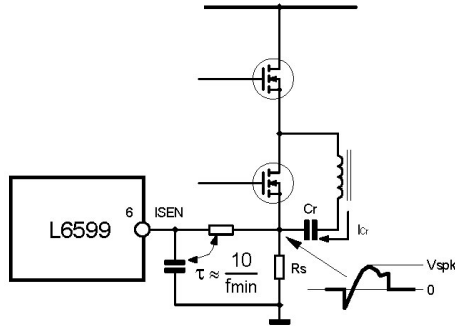


Figure 4: The current sensing technique with sense shunt.

In figure 4, a couple of current sensing methods are illustrated describing in the following. The circuit of figure 4 is simpler and the dissipation on the sense shunt R_s . We design the power bus by circuit of figure 4, thus the shunt loss is smaller compare with the output power. Table 1 is showed all parameter data as figure 4.

Table 1: All the parameters data value were showed as figure 4

Name	Cr	R_s	ISEN-R
Value	0.027uf/1KV	0.39 ohm/2W	10 ohm

TRNASFORMER DESIGN AND MEASUREMENT

We use Agilent 4294A impedance analyzer to get the transformer parameters of the equivalent circuit model. At first, we short the secondary characteristic, and then sketch the diagram of scan frequency versus impedance response of the primary characteristic for the transformer. We can find out the maximum value for $Y = 1 / Z$, which is the resonant curve, as figure 5 shows.

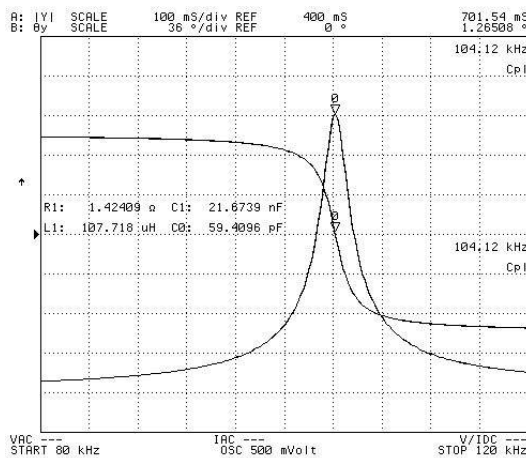


Figure 5: Impedence response diagram of the primary characteristic for the resonant transformer.

We check the resonant curve of the transformer form figure 5. The main resonant frequency curve is designed from the 100kHz to 120kHz. The equivalent resonant circuit model is the most appropriate selection, which accords with Type E of the Agilent 4294A LCR simulation model, as figure 6 shows.

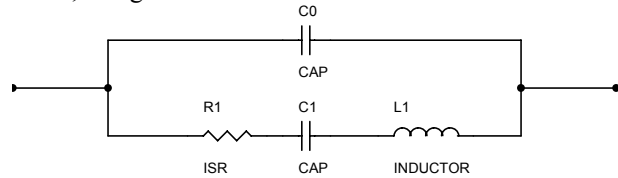


Figure 6: Type E of the Agilent 4294A LCR simulation model.

We calculate the parameter of the model via Agilent 4294A. At the same resonant frequency curve, calculate out Y curve and draw their simulation frequency response, the results show as figure 6 and in the table 2.

Table 2: The measured parameters result of the model E and resonant frequency is from 100kHz to 120kHz

Name	R_{IP}	C_{IP}	L_{IP}	C_{OP}
Value	1.4241ohm	21.6739nF	107.16uH	59.4096pF

Among them, the resistance R_{IP} in series is the internal resistance of the primary behavior for the resonant transformer. We can get 150W output of the supply bus, if we use the current about 0.75 amperes to pass the primary connection, it will produce the thermal energy above 0.19983W.

We short the primary connection to observe, calculate and simulate parameters of the secondary connection for the transformer, as figure 7 shows, using the Agilent 4294A impedance analyzer. Namely, it is the relation diagram of the resonant curve versus frequency of the secondary connection. We can get the coefficient from these measurement and calculation as table 3.

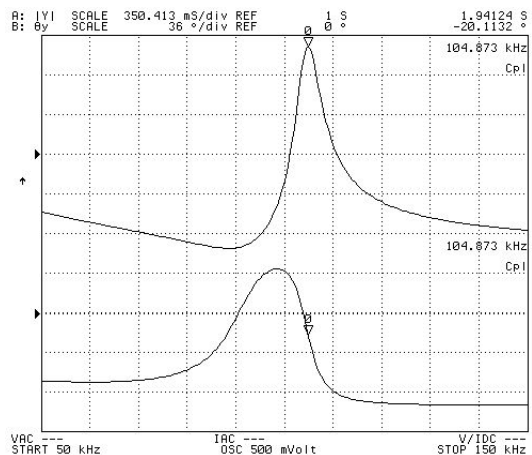


Figure 7: Impedence response diagram of the secondary characteristic for the resonant transformer.

Table 3: The measured parameters result of the secondary parameters

Name	R_{1S}	C_{1S}	L_{1S}	C_{0S}
Value	556.7mohm	150.198nF	15.561uH	198.578pF

We can get 150W and 50V output of the supply bus. If we use the current about 3 amperes to pass the secondary connection, it will produce the thermal energy above 5.0103W. So the total loss we can get of the transformer is 5.21W and equal to 3.473%. The transformer's loss is very small. It's close to the resonant frequency from the experiment tested at the beginning using the power amplifier. It proves that the power bus of the above experimental methods.

TESTING AND RESULT

We can get power bus voltage ripple without filter and with filter form the DSA. The results were showed in figure 8 and 9.

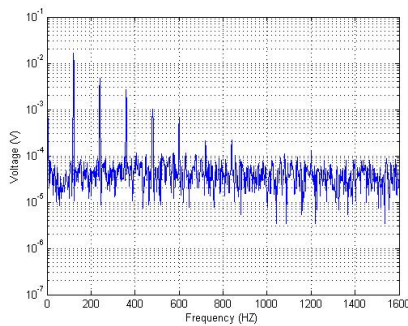


Figure 8: The power bus without filter and output voltage ripple is large then 0.1%.

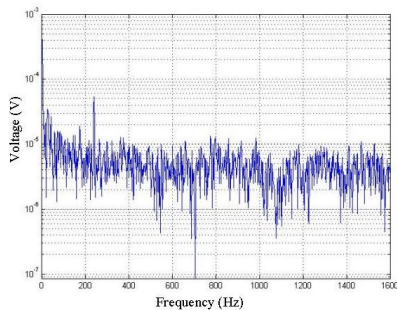


Figure 9: The power bus with filter and output voltage ripple under 1.5ppm.

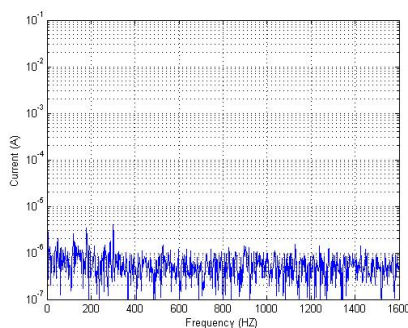


Figure 10: The correction power supply output current ripple.

We can get the correction power supply output current ripple again form the DSA. The result is showed in figure 10.

The last measure is long-term stability of the correction power supply with the power bus. The output current drifted as figure 11. The excellent result of the 12 hours current drift is 10ppm.

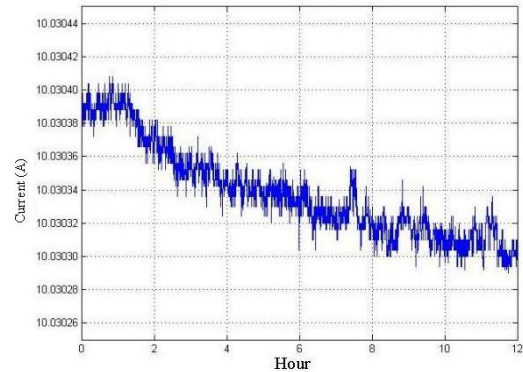


Figure 11: Long-term stability of the correction power supply output current (12Hours; 10ppm).

ANALYSIS AND CONCLUSION

The essential methods in this research are resonant curve scanned and equivalent circuit model construction of the resonant transformer. By the measurement quantities through the Agilent 4294A and calculating its equivalent circuit model, we can choose resonant frequency while designing the resonant switching PWM dc power bus.

Our study purpose is the development of resonant power supply and their control circuits producing the power bus. It provides the 50V dc power bus to MCOR30 correction power supply to solve the problems such as volume miniaturization, low weight, 90 to 240V universal ac input voltage with power factor control, independent power bus and efficient enhancement. The high quality and low voltage ripple are desperately required to the correction power supply in the NSRRC. In this way, we should be prudent to develop this technology.

REFERENCES

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