Power Bipolar Transistors Division
Discretes & Standard ICs Group

Design with ST Bipolar Complementary Pairs In Philips 20W-220Vac CFL

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Design Description

Aim of this work was done to obtain a self-oscillating topology using the ST power bipolar complementary pair in SOT32 (ST83003 is the NPN and ST93003 is the PNP), driving the device bases through additional windings on the inductor in series to the lamp, in a Philips 20W-220V CFL board.
The chosen topology with voltage base driver avoids the current transformer with saturable core and it uses only additional turns like secondaries on the choke inductance to assure the feedback to the transistors.
The resonant drive circuit adopts a common emitter half bridge topology with a unique driving source.
The LC_1 network and the two capacitors C_2, C_3 in series to the bases of the transistors with a resonant effect achieve the working frequency. Moreover, this resonant configuration allows obtaining the I_{bon} and I_{boff} to assure good performance during the turn off.
At first, an analysis was done on the original board (20W) which was using the ST13003 by ST devices in traditional topology driven through saturable core transformer.
In order to obtain the above-mentioned topology for this application, the original board was modified: the new driver circuit was inserted (see the schematic on page 4).
As can be observed in the modified circuit, a consistant components cost reduction is obtained, avoiding the Diac, the start-up network and the emitter resistors too.
The tables below and the I_b, V_{ce}, I_c vs time waveforms graphs on the following pages show that the performance of the ST bipolar complementary pair is comparable with the original board considering also the case temperature of the devices (they were cold at any time).
At last, in figure 5 the waveforms related to both NPN and PNP transistors on the 20W board have been reproduced showing a more than satisfactory symmetry in normal operative conditions.
The following tables resume the devices behaviour about working frequency, max collector current I_{cmax}, power input P_{in} with the bipolar mounted in appropriate sockets during steady state operation and start up in full load. All measurements were made in free air. The chosen package for both the transistors was the SOT-32 one, in order to assure a good thermal behavior when the board is closed in the box and assembled with lamp.

20W

Original Board

Full Load at T_{amb}= 25ºC @ 220Vac

Device	Frequency [kHz]	I_{cmax} [mA]	P_{in} [W]
ST13003	40.80	323	19

Modified Board

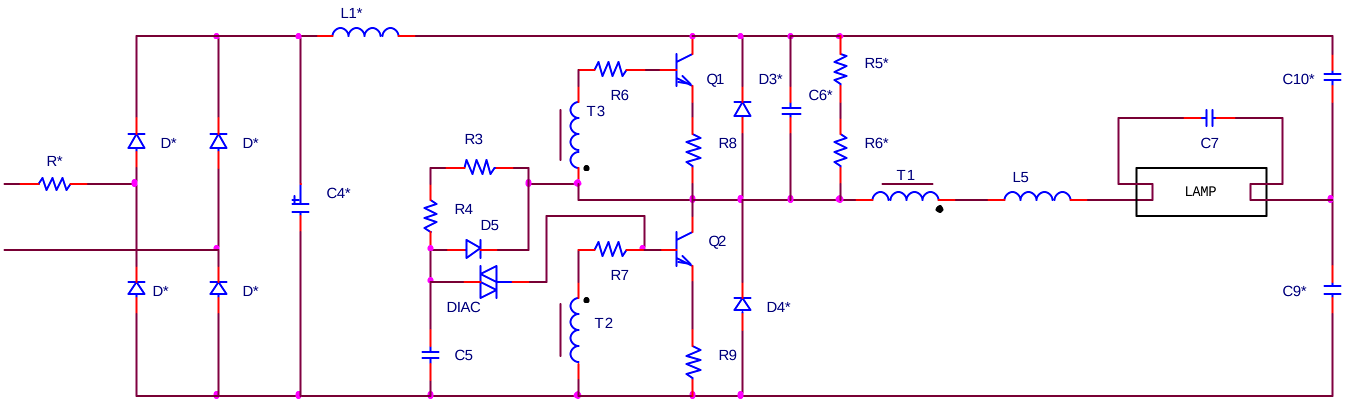
Full Load at T_{amb}= 25ºC @ 220Vac

Device	Frequency [kHz]	P_{in} [W]	I_{cmax} [mA]
ST83003 (npn) (SOT32)	43.90	19	334
ST93003 (pnp) (SOT32)	43.90	19	330

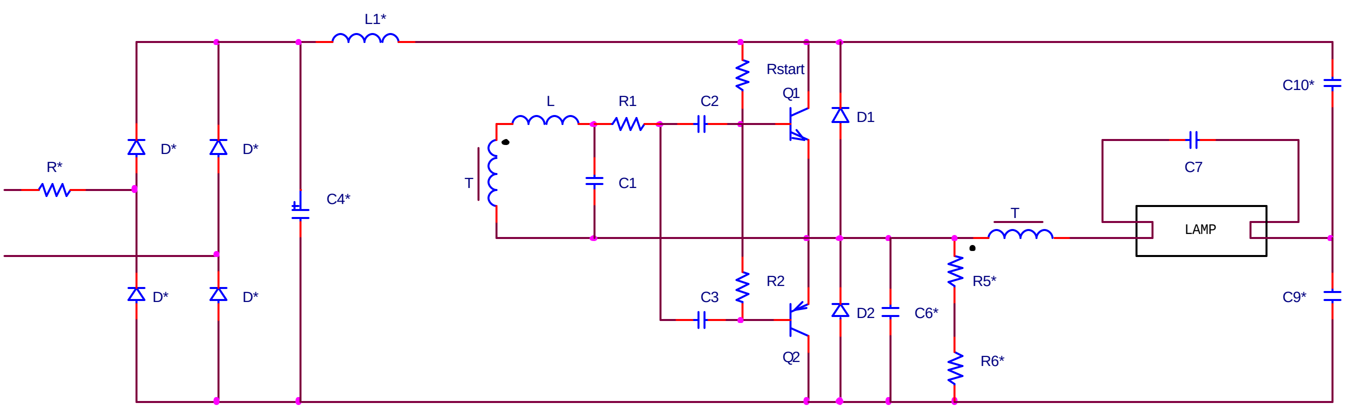
Start up at T_{amb}= 25ºC @ 220Vac **full load**

Device	Frequency [kHz]	V_{cepeak}[V]	I_{cpeak}[A]
ST83003 (npn) (SOT32)	49.90	408	2.09
ST93003 (pnp) (SOT32)	49.90	401	2.21

PHILIPS CFL with original circuit



PHILIPS CFL with Voltage Resonant Driver and Complementary BJT Pair Schematic



Following the components used for the 20W CFL:

L = 100µH	C_2, C_3 = 220nF	n_s = 2	C_7 = 4.7 nF
C_1 = 56nF	R_{start} = 330kΩ	Q_1: ST83003 (npn)	C_{9*}, C_{10*} = 100nF
R_1 = 8.2Ω	R_2 = 560Ω	Q_2 : ST93003 (pnp)	R_{5*},R_{6*} = 240 kΩ
C_{6*} = 2.2 nF	L_{1*} = 2.2mH	C_{4*} = 5.6µF	D_1, D_2: BA157 or 159

The components marked with star are the same components mounted on the original board. In particular C6*, R5*, R6* must be connected between emitter and collector of Q2 rather than Q1.

The capacitor C_7 was changed from the value of 3.3 nF up to 4.7 nF.

The primary is the old inductor used in the original board (its value is 2.4 mH).

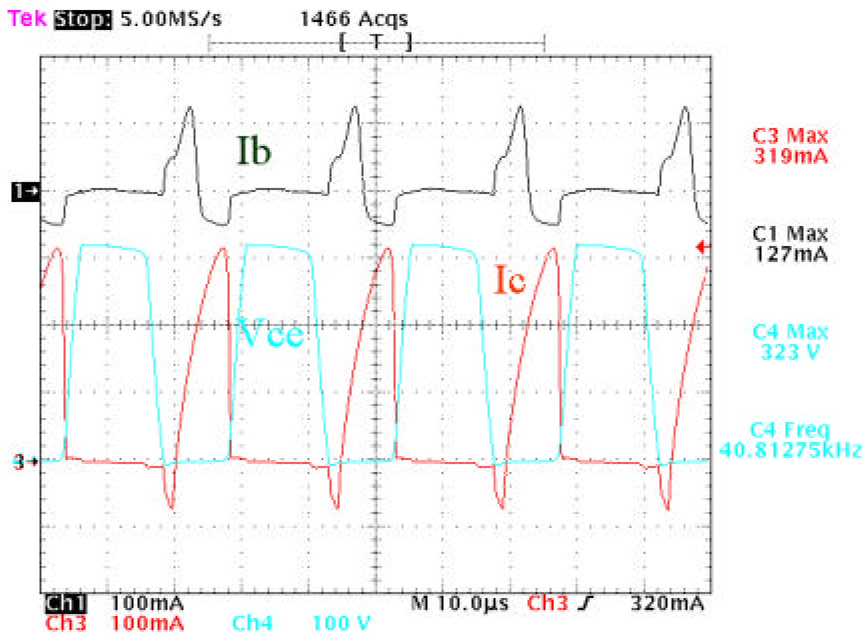


Fig.1. ST13003: full load steady-state waveforms at V_{main}=220V on the 20W original board.

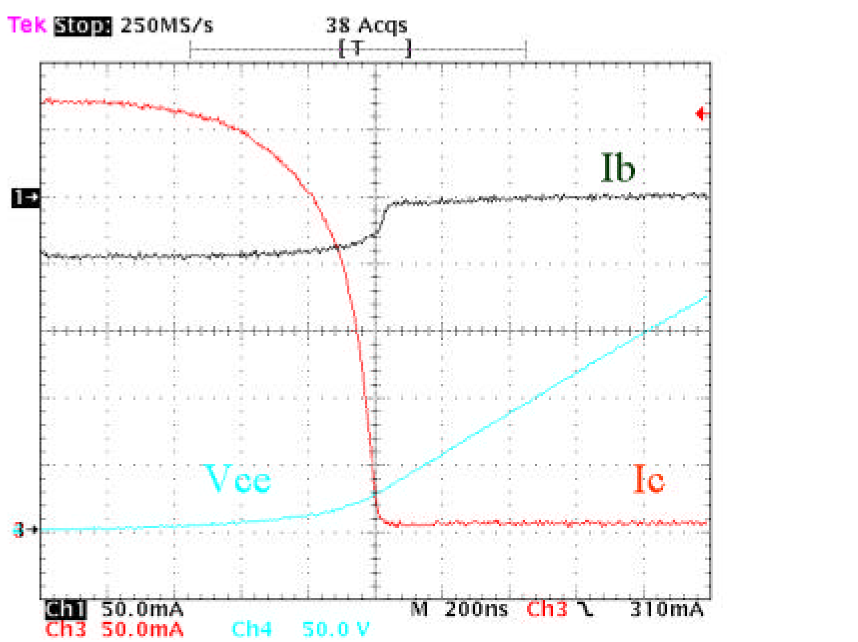


Fig.2. ST13003: turn-off at V_{main}=220V on the 20W original board.

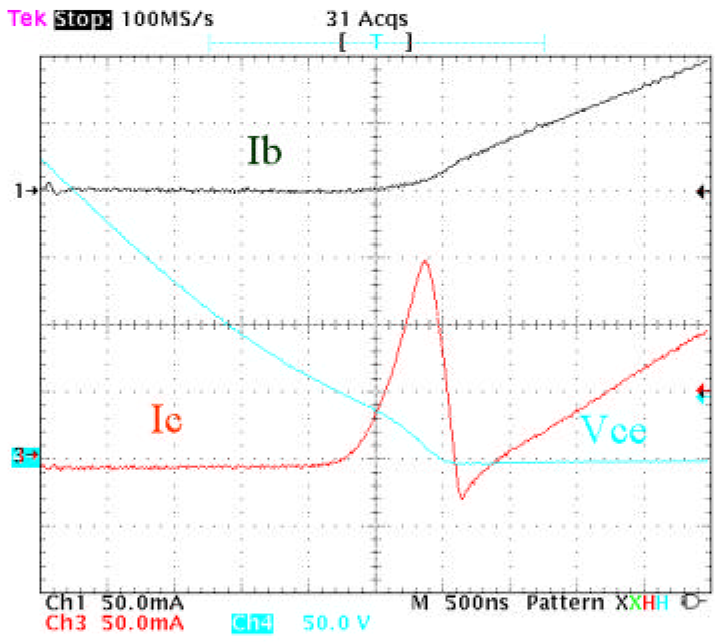


Fig.3. ST13003: turn-on at V_{main}=220V on the 20W original board.

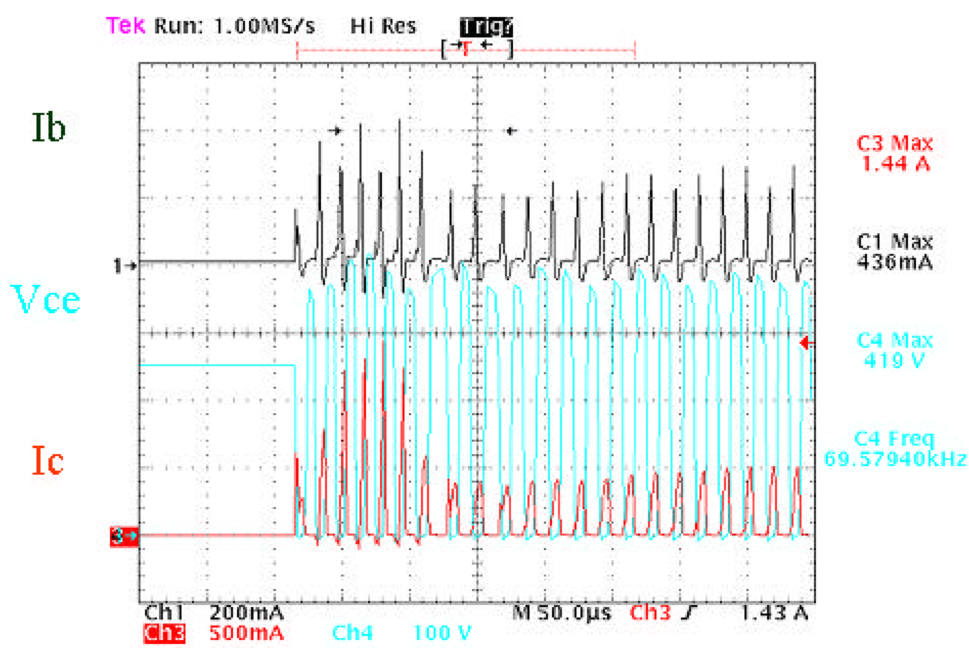


Fig.4. ST13003: start-up at V_{main}=220V on the 20W modified board.

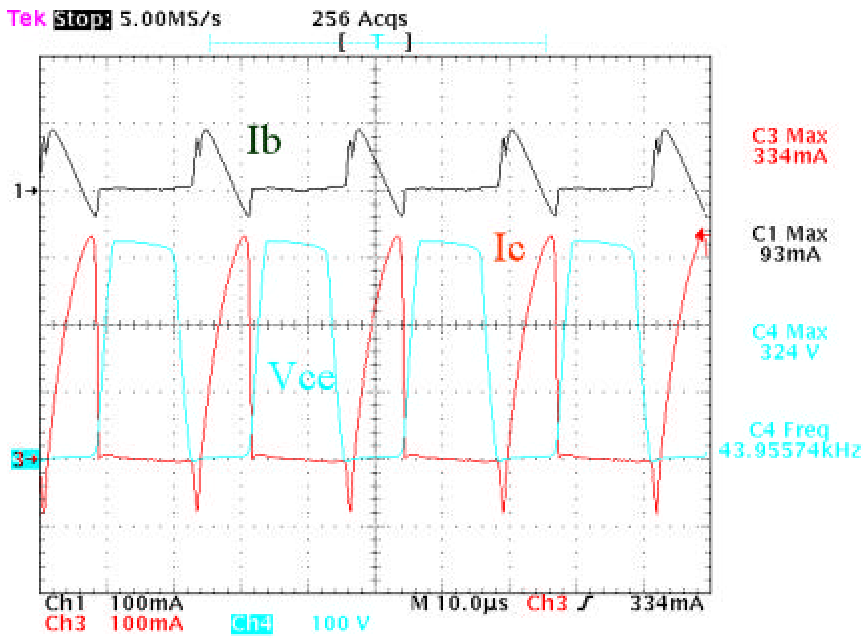


Fig.5. ST83003: full load steady-state waveforms at V_{main}=220V on the 20W modified board.

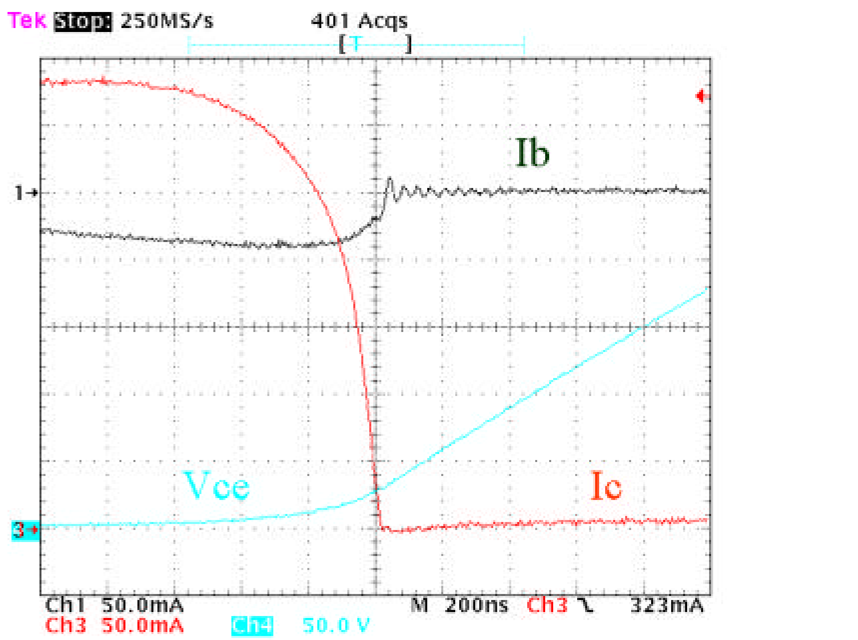


Fig.6. ST83003: turn-off at V_{main}=220V on the 20W modified board.

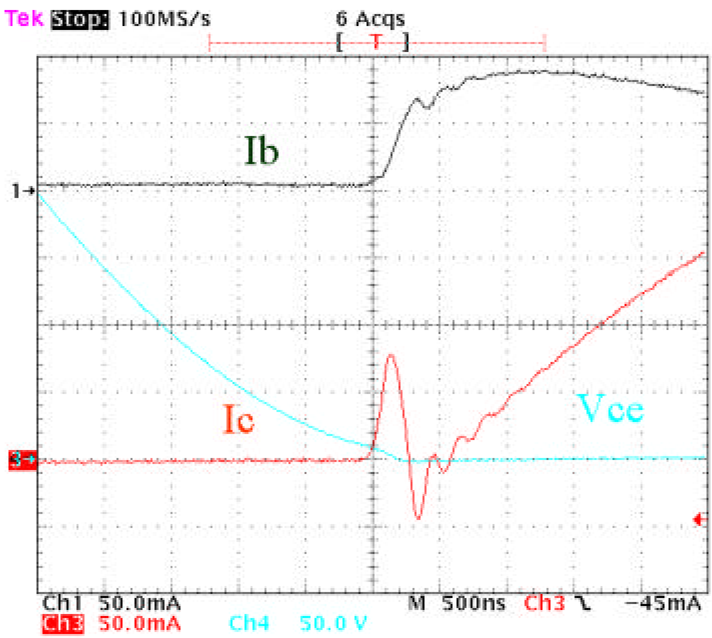


Fig.7. ST83003: turn-on at V_{main}=220V on the 20W modified board.

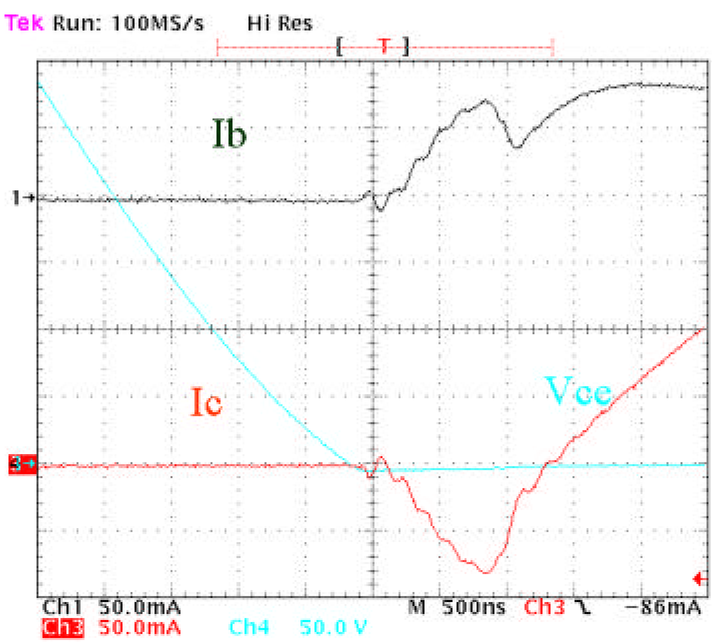


Fig.7bis. ST83003: turn-on at V_{main}=220V on the 20W modified board.

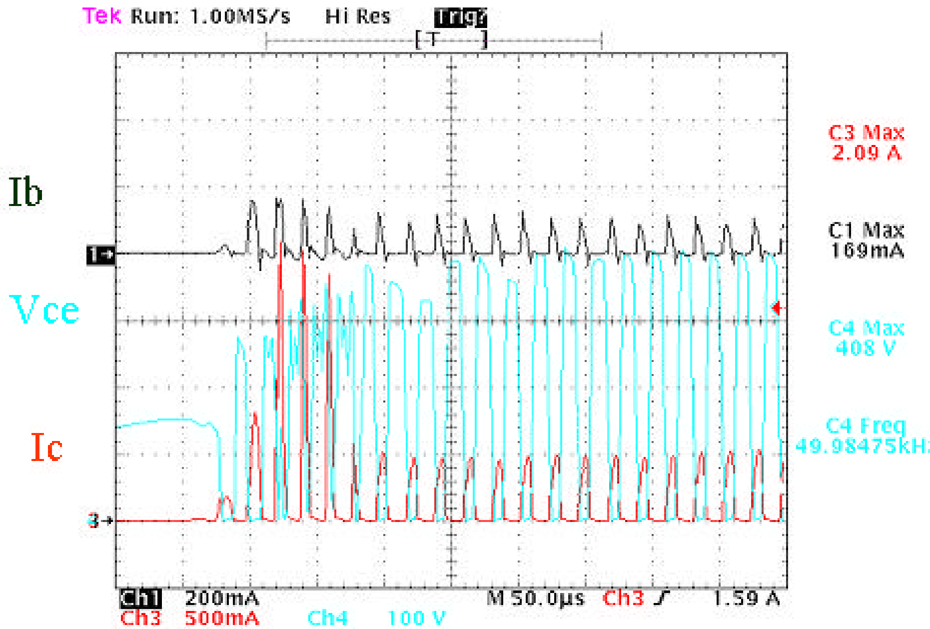


Fig.8. ST83003: start-up at V_{main}=220V on the 20W modified board.

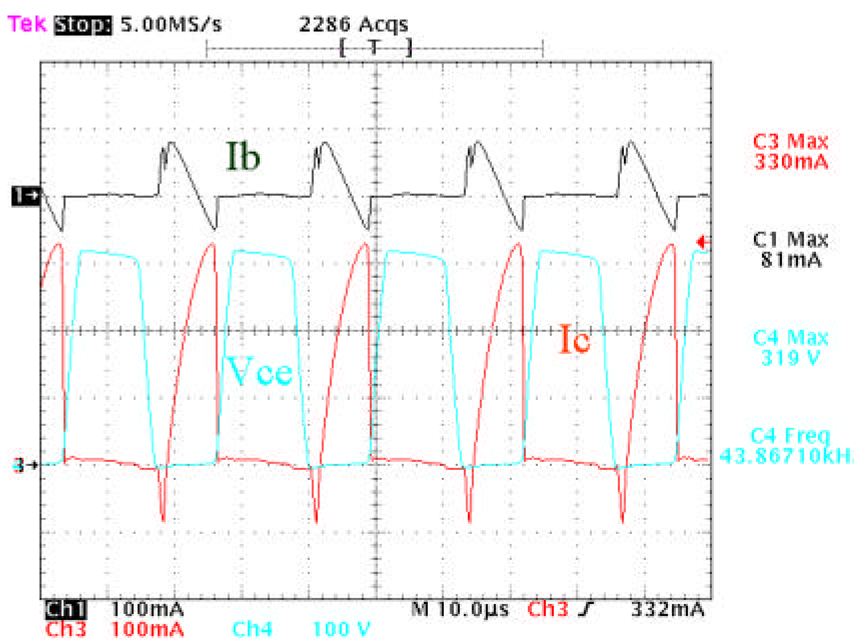


Fig.9. ST93003: full load steady-state waveforms at V_{main}=220V on the 20W modified board.

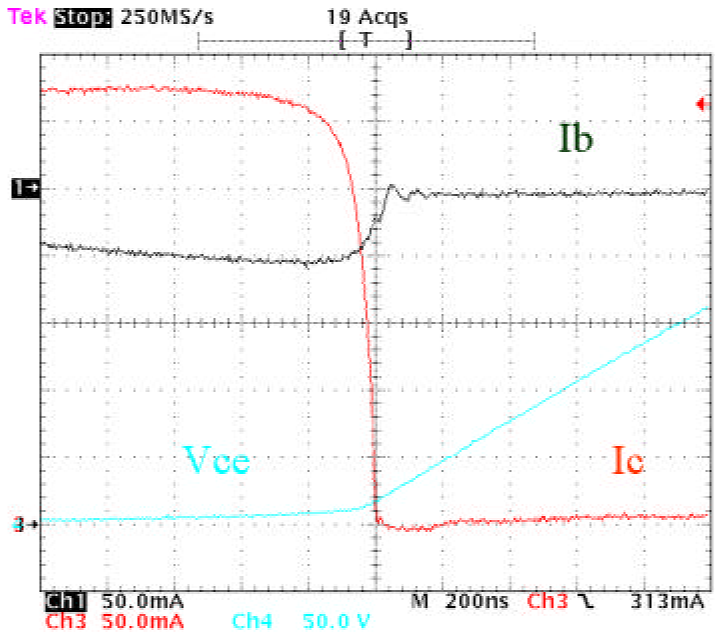


Fig.10. ST93003: turn-off at V_{main}=220V on the 20W modfied board.

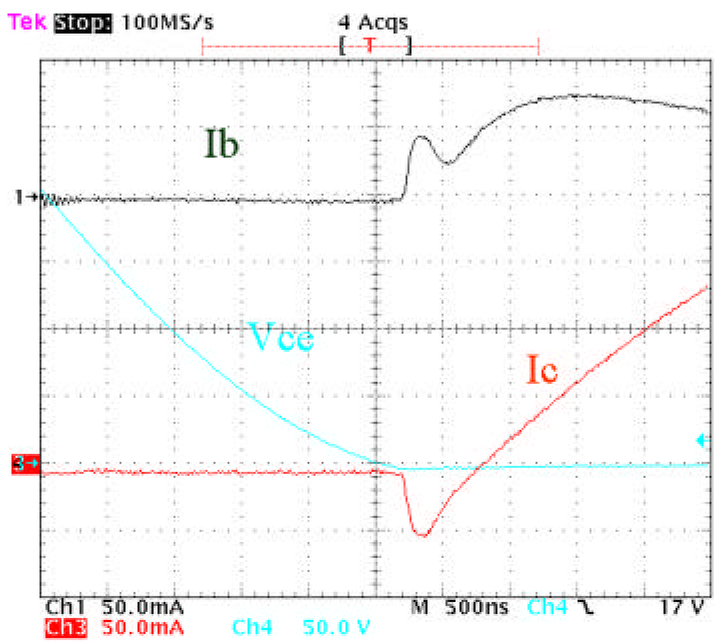


Fig.11. ST93003: turn-on at V_{main}=220V on the 20W modfied board.

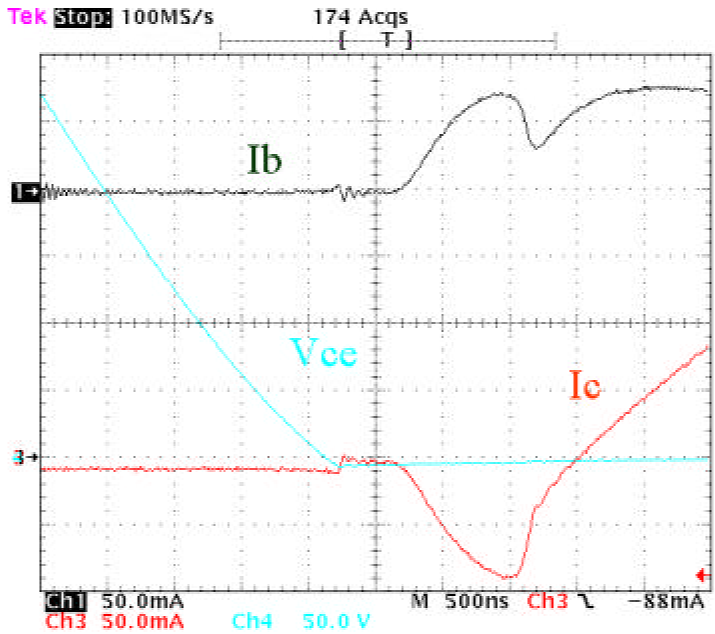


Fig.11bis. ST93003: turn-on at V_{main}=220V on the 20W modfied board.

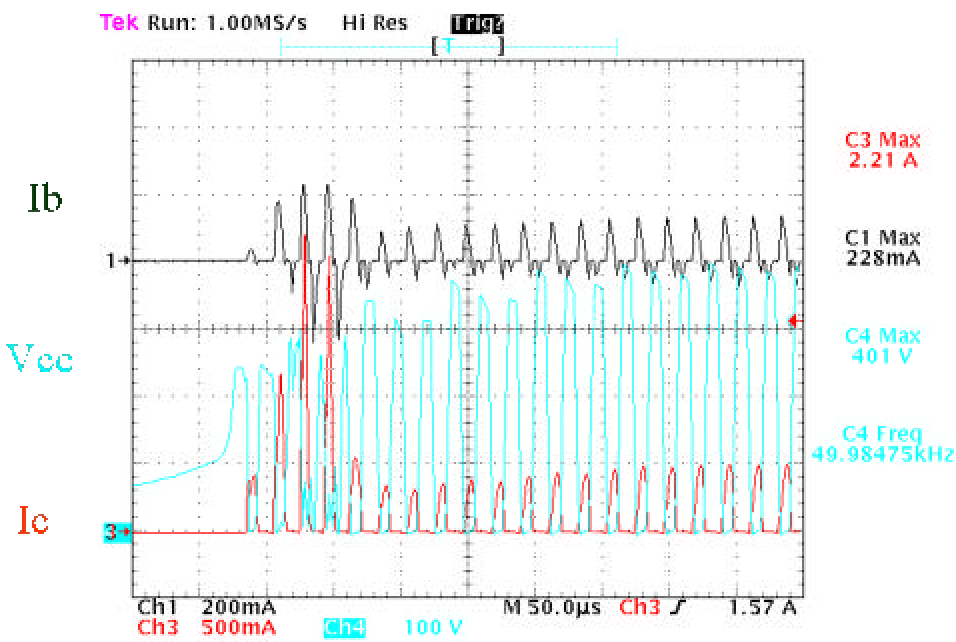


Fig.12. ST93003: start-up at V_{main}=220V on the 20W modfied board.

Conclusions

As can be observed from the tables and graphs above, the new topology with the ST complementary pair fit very well this application, with the advantage of a consistant reduction of the components cost respect to the original board.
The realization of the circuits has been made possible thanks to the development of a new high gain and high voltage PNP power bipolar transistor (ST93003).
The proposed solution allows designers not only to simplify and consequently cut the cost of the application, but to also reduce the design window since one of the most important variables to be taken into consideration, the variability of the storage time of the transistors, can be neglected during the tune up of the project.