APPLICATION NOTE

B+ Converter Topologies for Horizontal Deflection and EHT with TDA4855/58.

AN96052

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B+ Converter Topologies for Horizontal Deflection and EHT Generators.

Application Note AN96052

Abstract

Several circuits are discussed for use in multi/autosync deflection and EHT generator stages. All examples use the B+ control part of the ASDC TDA4855 or TDA4858.

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Summary

The B+ control section of the ASDC TDA4855/58 can be used with boost, buck and flyback converters in feedback or feedforward mode with current sense or RC sawtooth generator for power supplies of deflection and EHT generators. All circuits have their own specific advantages and application areas. If cost is important, a combination of horizontal deflection and EHT generator is possible with a so called "constant T-on circuit". The performance of this constant T-on can be improved with several options like feed forward, quasi-stabilised EHT and deflection compensation. For higher performance monitors, separate horizontal deflection and EHT generators will become more and more popular. For this part of the market several solutions are presented for both deflection and EHT generators.

When EHT and deflection are separated, both circuits need a controller like the B+ part in the TDA4855/58. In this report the controller part itself is not subject of review. Therefor the presented circuits are designed around the TDA4855/58. Where necessary additional circuits are mentioned but not discussed in detail.

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1. ABBREVIATIONS AND KEY-WORDS

ASDC	Auto Sync Deflection Controller
B+	Output voltage of B+ modulator
BDRV	TDA4855/58 pin 6: Open collector driver output of B+ control part
BIN	TDA4855/58 pin 5: Inverting input of B+ OTA
BOP	TDA4855/58 pin 3: Output of B+ OTA
BSNS	TDA4855/58 pin 4: Sawtooth/Current sense input of B+ comparator
EWDRV	TDA4855/58 pin 11: EW parabola output
EWWID	TDA4855/58 pin 32: Input for width control
HDRV	TDA4855/58 pin 7: Horizontal driver output
HFLB	TDA4855/58 pin 1: Horizontal flyback input
CRT	Cathode Ray Tube
C_b	Boost-converter supply storage capacitor
C_g	Flyback capacitor of deflection/EHT generator
C_s	S-correction capacitor
DAF	Dynamic Astigmatism and Focus
D_b	Freewheel or supply rectifier diode
D_g	Flyback diode of deflection/EHT generator
EHT	Extreme High Tension
F_s	Scan frequency
L_b	Supply coil
L_c	Deflection/EHT generator coil
L_{defl}	Deflection coil
LOT	Line Output Transformer
PWM	Pulse width modulator
SMPS	Switched Mode Power Supply
T_b	B+ switching transistor like BUK455-200B
T_g	Generator transistor like BU2527
T_{off}	Non-conducting period of device
T_{on}	Conducting period of device
TCO	The Swedish Confederation of Professional Employees
V_{++}	SMPS output voltage, input for B+ modulator

2. INTRODUCTION

The ever increasing demand for higher performance in monitors calls for improved control of horizontal deflection amplitude and EHT. The ASDC TDA4855/58 gives the monitor designer easy access to higher order geometry controls for horizontal deflection while the B+ control part allows a variety of supply converters and controls to be used. The report starts with the building blocks for deflection and EHT generators mentioning their specific pro's and con's. An endless variety of combinations is possible to create different solutions for EHT/deflection/combined generators, all controlled by the B+ section of the TDA4855/58. In the following part five application examples are given. These application examples are not detailed descriptions but should used as a guideline for an orientation on how to design a deflection or EHT generator. By substitution of the building blocks of the first part in the given examples one can alter the design to specific wishes.

3. BUILDING BLOCKS

The deflection and/or EHT generator(s) can be designed by combining different blocks from the following sections.

3.1 B+ Converter types

The B+ converter is an output stage supplying power to the following deflection or EHT generator stage. Input voltage is V_{++} while the output depends upon the type being used (see table).
The converter is basically one of three types:

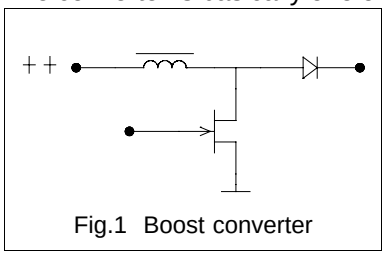

Fig.1 Boost converter

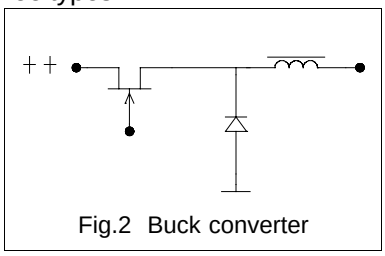

Fig.2 Buck converter

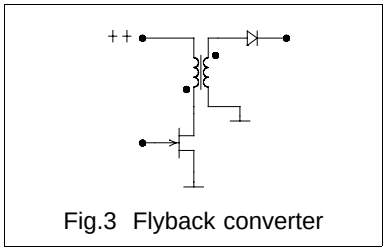

Fig.3 Flyback converter

TABLE 1: Comparison of converters

Property	Boost	Buck	Flyback
Input V_{++}	ca. 40 to 70 V	> 160 V	any (40 to 200 V)
Control	feedback necessary difficult to optimise no linear transfer	no feedback necessary feedforward possible linear transfer	no feedback necessary feedforward possible linear transfer
Output	Always > V_{++}	0 to V_{++}	0 to 'any voltage'
Slow start	Not possible (starts at V_{++})	start at 0 V possible	start at 0 V possible
Transistor Failure	deflection/EHT ok	deflection/EHT damage	deflection/EHT ok

3.2 Operating mode

All shown converter types can be operated in the continuous or discontinuous mode:

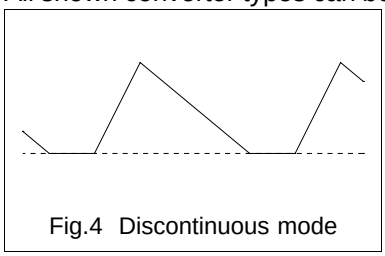
Fig.4 Discontinuous mode

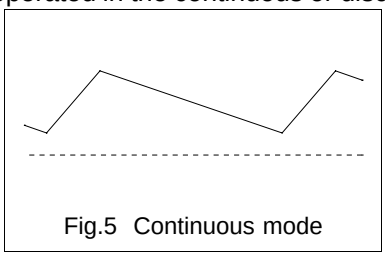
Fig.5 Continuous mode

TABLE 2: Comparison of operating modes

	Discontinuous	Continuous
Transfer	No extra pole; feedback possible.	One extra pole: feedback difficult; feedforward possible
Semiconductors	High peak current	Lower peak current
Wire wound components	Smaller core	Increased core size

3.3 Output filter

The output of the converter can be followed by an LC filter to isolate the converter output from the deflection or EHT generator:

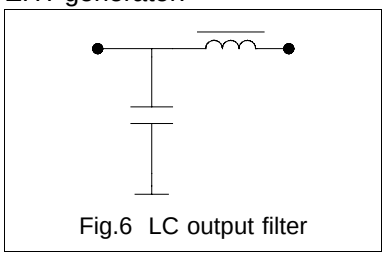

Fig.6 LC output filter

Advantage: In an EHT generator (separate or combined with deflection) the filter isolates the converter switching voltage from the LOT reducing the LOT operating temperature and ringing.
The DC voltage across the capacitor is tracking with the scan frequency and may be used for auxiliary purposes.

Disadvantage: Extra pole in the transfer complicating the loop design for fast response.

3.4 Feedforward versus feedback

TABLE 3: Preferred combinations

	Feedforward	Feedback
Design	Simple	Difficult to optimise for fast response
Combination with Boost	-	Discontinuous mode without LC filter
Combination with Buck	Continuous mode without LC filter Continuous mode with LC filter and (1-p) correction*.	Discontinuous mode without LC filter
Combination with Flyback	Continuous mode without LC filter but with (1-p) correction*.	Discontinuous mode without LC filter

* Note: The so-called (1-p) correction can be obtained by using a correction circuit as shown in Ref. 4 page 43.

3.5 Deflection and EHT generator

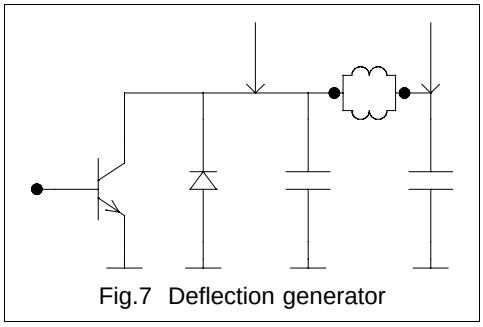

Fig.7 Deflection generator

The basic deflection and EHT generators show a great deal of similarity. Even the two possible power supply injection points (indicated with arrows in the figures) are the same.
When the EHT generator is supplied on top of the LOT primary winding the capacitor to ground may be deleted.

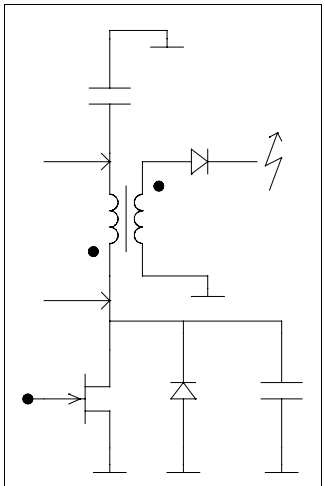

Fig.8 EHT generator

3.6 Combined deflection/EHT generator

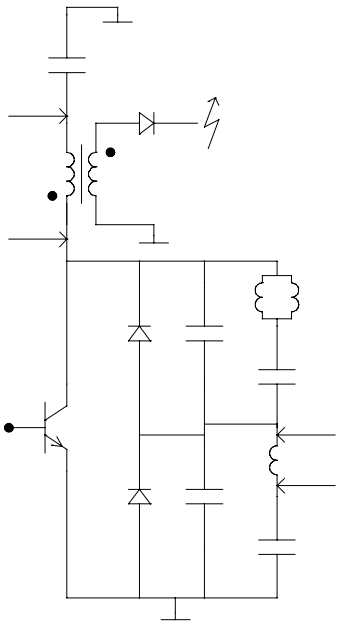

Fig.9 Combined deflection and EHT

When deflection and EHT generator are combined the diode modulator circuit is necessary in order to keep the EHT free from EW modulation.
The two upper arrows (left hand side) indicate the power supply points. When the supply is connected to the top of the LOT primary winding the capacitor to ground may be deleted. The two lower arrows (right hand side) indicate the points where an EW modulator can be connected. This EW modulator can be a switching source (i.e. buck-converter) or a dissipative stage.

3.7 Upside-down topology

Sometimes an upside-down topology may be interesting to simplify power switch drive:

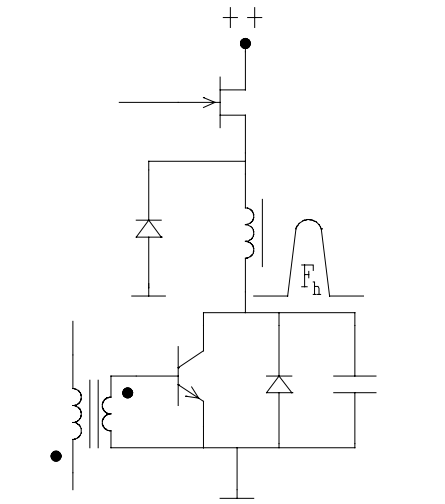

Fig.10 Normal configuration

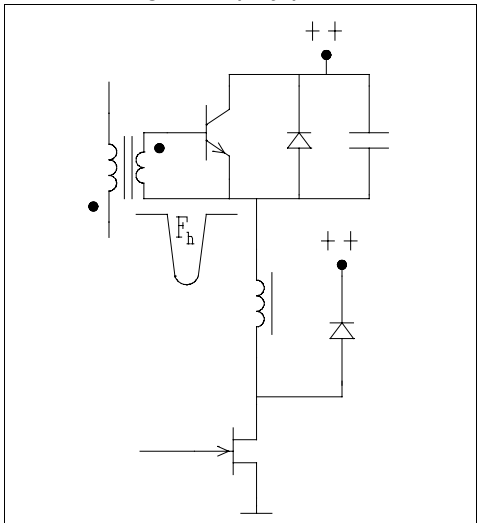

Fig.11 Upside-down configuration

3.8 Conclusion

To build a deflection or EHT generator a number of blocks must be combined. It will be clear that this leads to an enormous variety of designs. The converter has to be combined with a control part as described in the next section.

4. TDA4855/58 B+ CONTROL TOPOLOGIES

The B+ control part of the TDA4855/58 can be applied in a number of different designs. Again building blocks will be presented that can be combined to form a control section to drive a deflection or EHT generator.

4.1 TDA4855/58 B+ control section

A block diagram of the internal part of the TDA4855/58 B+ control section is presented in the following figure.

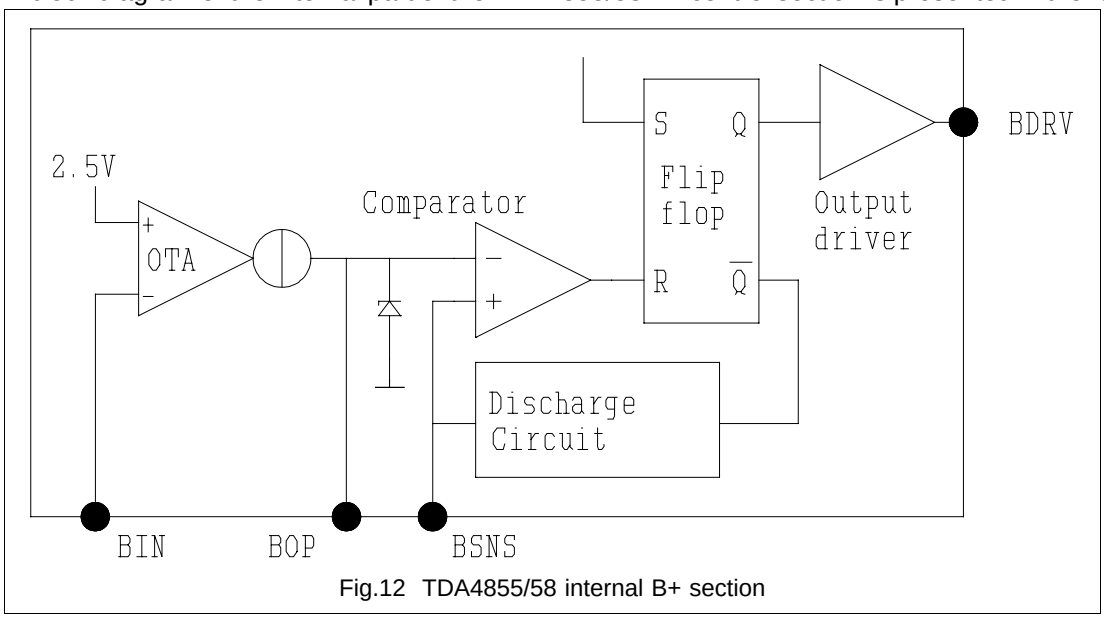

Fig.12 TDA4855/58 internal B+ section

The Set input of the Flipflop is triggered by the rising edge of the horizontal drive pulse.

4.2 Feedback versus Feedforward

The Operational Transconductance Amplifier of the TDA4855/58 can be operated in feedback or in feedforward mode.

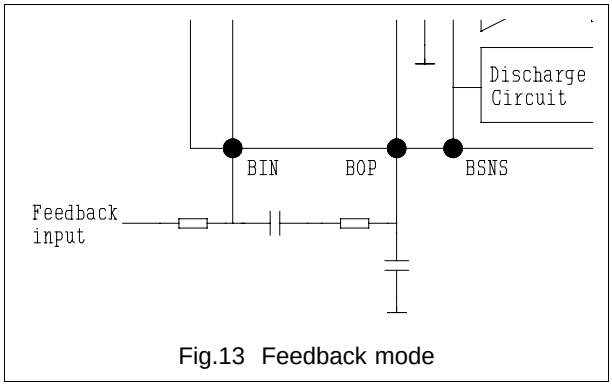

Fig.13 Feedback mode

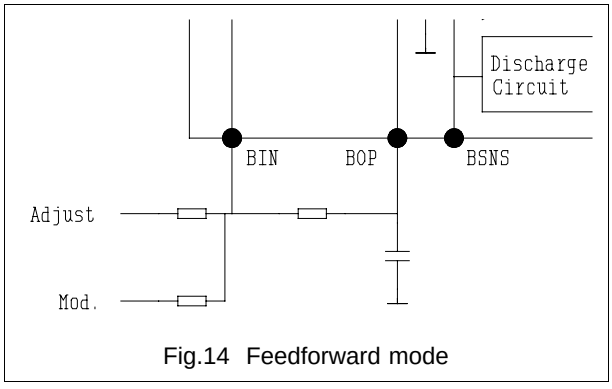

Fig.14 Feedforward mode

Feedback mode: The input pin BIN is used as feedback input but can also be used to insert signals for adjustment and/or correction.

Feedforward mode: The input pin BIN is used as input for adjustment and/or correction signals and local feedback of the OTA. The adjusting signals can be DC voltages to control the T-on of the B+.

4.3 T-on adjust

To control the T-on time in constant T-on applications the following configurations are possible:

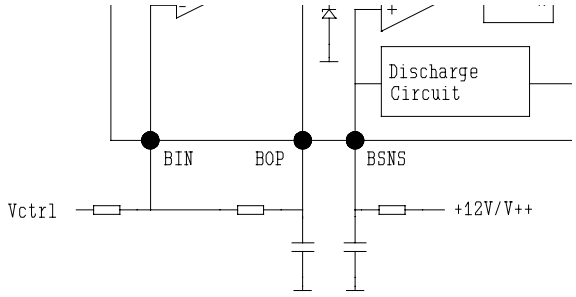

Fig.15 DC control

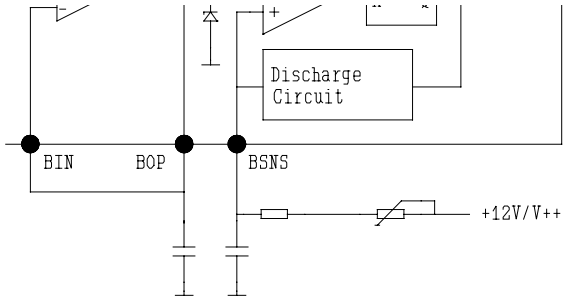

Fig.16 Control with potentiometer

Input 'V_{ctrl}' is a DC voltage input from a potentiometer, DAC or PWM of a µP.

4.4 Slow-start

In applications were no modulation is present on pin BOP slow-start can be performed by increasing the capacitor at pin BOP to ground to a value of 22.....100 µF ($C_{min} \geq 4.7$ nF). In applications were a modulation signal is present on pin BOP another circuit must be used to perform slow-start:

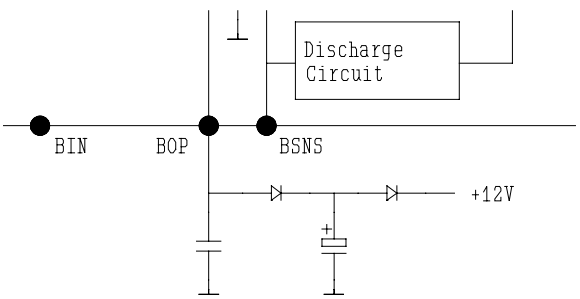

Fig.17 Slow-start

In this configuration the voltage on pin BOP is prevented from large voltage steps. This protects the deflection from dangerous peak currents or EHT generator from dangerous output voltages. With a pull-up resistor from the electrolytic capacitor to + 12 V the voltage across the electrolytic capacitor will rise to + 12 V further reducing its influence on pin BOP after slow-start.
The diode to +12 V allows quick discharge at switch-off.

4.5 PWM ramp generator

A sawtooth voltage to control the width of the output pulse must be present on pin BSNS of the TDA4855/58. This sawtooth voltage can be taken from a current sensing resistor or from an RC combination:
The RC sawtooth generator can be supplied from a clean small signal supply voltage (i.e. +12 V) or from the V_{++} supply voltage. Connection to V_{++} has the advantage that ripple present on V_{++} is fed forward into the loop and thus cancelled before disturbing the deflection or EHT generator.

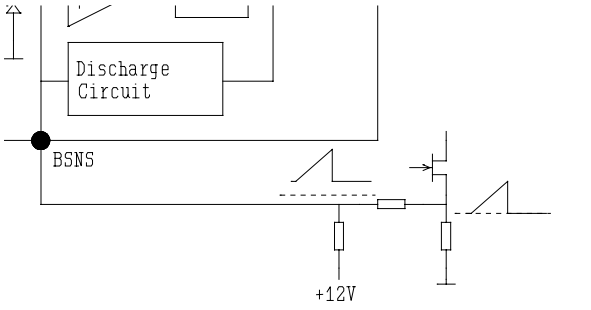

Fig.18 Current sense mode

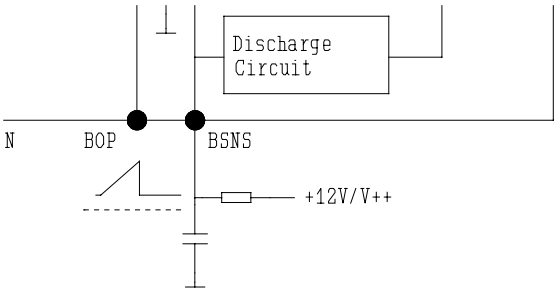

Fig.19 RC Sawtooth generator

4.6 Duty-cycle limiting

A duty-cycle limiter can be simply made because of the current-output of pin BOP:

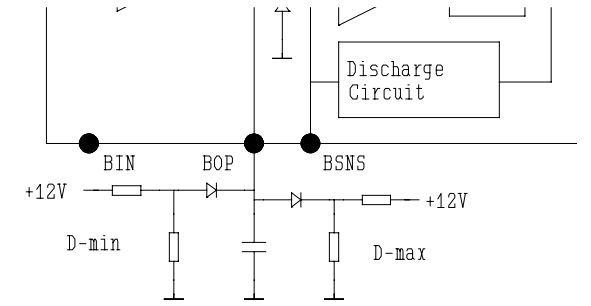

Fig.20 Duty-cycle limiting

4.7 Output driver

The most common interfaces between pin BDRV and the power switching devices are as follows:

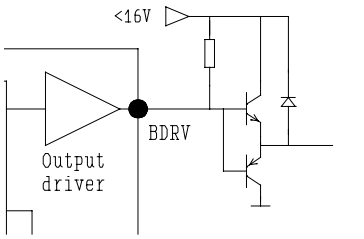

Fig.21 Non-inverting buffer

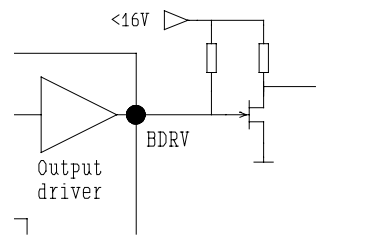

Fig.22 Inverting buffer

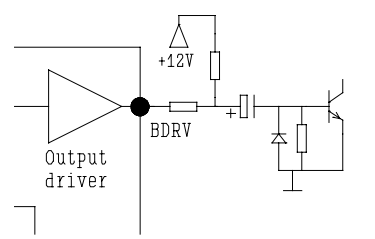

Fig.23 AC coupled driver

4.8 Conclusion

It may be clear that the B+ section of the ASDC TDA4855/58 is a versatile building block and can be combined in many ways with a power converter to establish a deflection or EHT generator. In the next paragraph just a few of many possible applications combining the B+ section of the TDA4855/58 with a power converter are given. It is however possible to make much more combinations all with their own specific pro's and contra's.

5. APPLICATIONS

Many of the above shown circuit parts can be combined to obtain a deflection or EHT generator or even a combined system. It may be clear that not all possible combinations can be described in this report. Only the most common applications will be discussed here.

TABLE 4: Properties per application

Property	Application 1	Application 2	Application 3	Application 4	Application 5
Output	Deflection + EHT	Deflection	Deflection	EHT	EHT
Frequency range	24 - 70 kHz	24 - 105 kHz	24 - 105 kHz	24 - 105 kHz	24 - 105 kHz
Converter type	Down	Up	Down	Up	Down
Operating mode	Continuous	Dis-/Continuous	Continuous	Continuous	Continuous
Duty control	Sawtooth osc.	Current mode/ Sawtooth osc.	Sawtooth osc.	Current mode/ Sawtooth osc.	Sawtooth osc.
Feedback	note 1	yes	yes/no	yes	yes/no
Feed forward	V_{++} to sawt. osc.	V_{++} to sawt. osc.	V_{++} to sawt. osc.	V_{++} to sawt. osc.	V_{++} to sawt. osc.
Performance	■	+	++	++	+
Cost	++	■	+	■	+
Application area	14" / 15"	17" / 21"	17" / 21"	17" / 21"	17" / 21"
Application Note	AN95086	-	-	-	-

note 1: In case a full bleeder and smoothing capacitor (both connected to the EHT output voltage) are present they can be used to extract EHT information to cancel picture geometry distortion due to EHT variation.

5.1 Design optimisation

An optimum design of a horizontal deflection circuit handles geometry correction waveforms without distortion and without ringing. An EHT generator must be capable of handling the specified load current without excess output ripple voltage.
Best performance of both circuits is achieved by increasing the bandwidth of the power part (converter, LC filter etc.) as much as possible, and defining the closed-loop bandwidth in the small-signal control part (resistor-capacitor combination between BIN and BOP and capacitor from BOP to ground: see Fig.13). The closed-loop bandwidth must be smaller than one third of the switching frequency of the power converter.

The best way to optimise a deflection or EHT control loop is by analyzing it with a network analyzer. Analysis must be done at different switching/scan frequencies and different loads/deflection-width settings.
Final check is always on screen.
In case no network analyzer is available the design can also be optimised by looking at the performance on screen.
In the following part some hints are given which may be useful during the design optimisation.

To judge the performance of the deflection circuit display a cross-hatch pattern on the screen of the monitor under test. Increasing the East-West trapezium correction will result in distortion becoming first visible in the upper part of the picture (it might be necessary to increase the control range by decreasing the resistor at pin 20

of the TDA4855/58). Ringing or poor bandwidth will be clearly visible as horizontal deflection amplitude variations. See Fig.24 .
If ringing is observed increase the capacitor from pin BOP to ground.

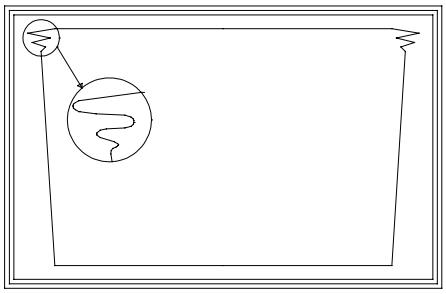

Fig.24 Deflection distortion

A pattern to test the EHT performance displays a cross-hatch pattern with a white horizontal bar in the middle of the screen. Poor regulation of the EHT will result in horizontal deflection distortion at the start, during and at the end of the white bar. See Fig.25 .
If ringing is observed at the start and end of the white bar, then the phase margin is too small (increase the capacitor from pin BOP of the TDA4855/58 to ground).
If the deflection amplitude is smaller during the white bar compared to above and beyond the white bar then the mid-band gain of the circuit is not high enough (increase the resistor between pins BOP and BIN of the TDA4855/58).
If the complete picture increases in size with increased contrast setting, then the DC gain of the circuit is not high enough (decrease the capacitor between pins BOP and BIN of the TDA4855/58).
If the resistor or capacitor between pins BOP and BIN is/are changed then the performance should also be checked at the other item again.

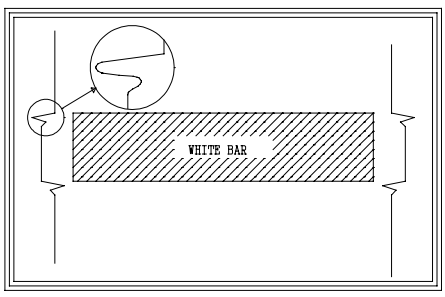

Fig.25 Picture breathing

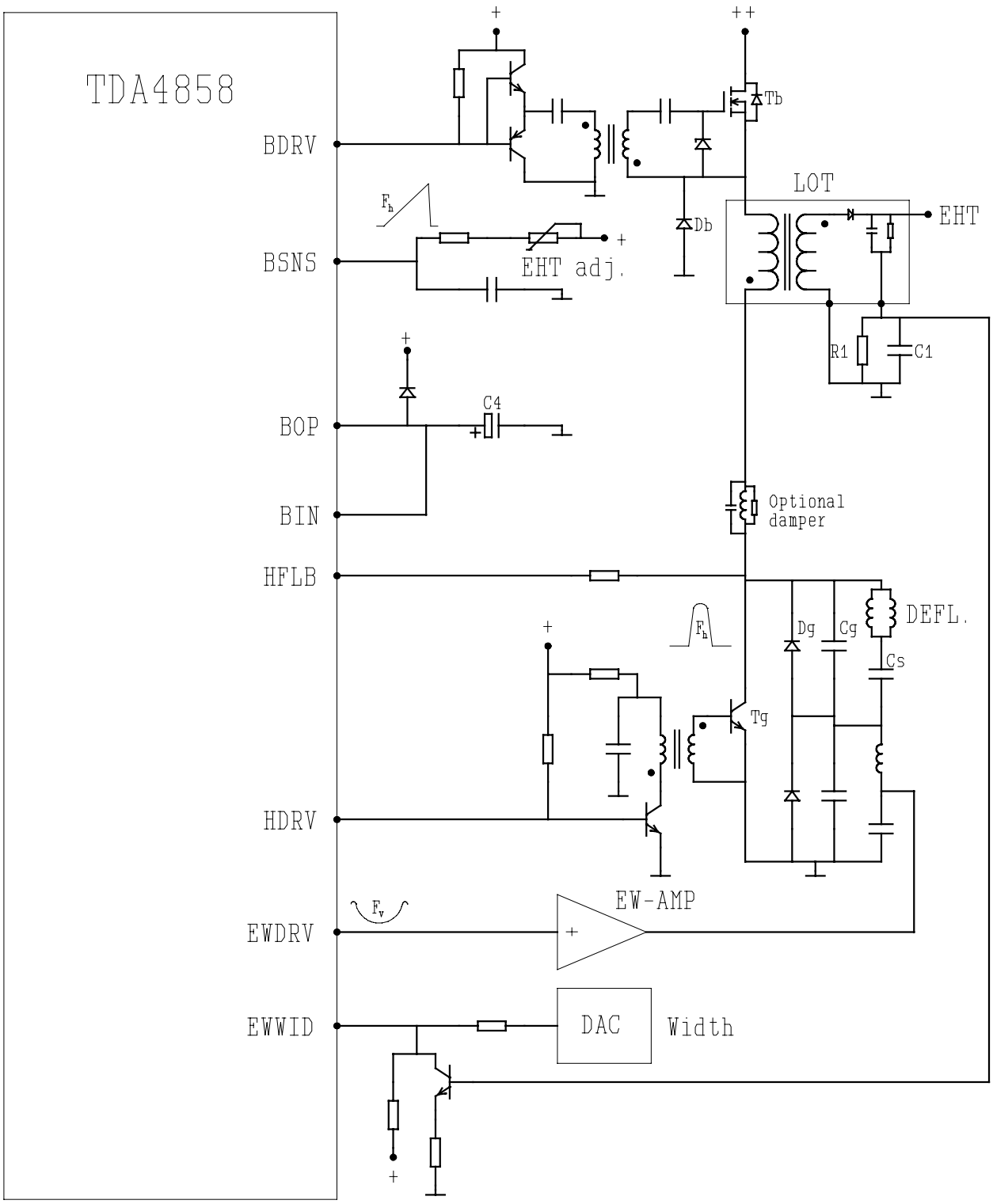

Fig.26 Combined deflection/EHT circuit for 14/15"

5.2 Combined deflection and eht generator

This is the most cost effective application to achieve a constant horizontal deflection amplitude and EHT over a wide scan frequency range and still maintain a good level of performance. The circuit basically is a diode modulator generating deflection current and EHT but with a variable supply voltage depending upon scan frequency.

Slow start is realised with C_4 (increased to 22.....100 µF).

Options are:
- **LCR damper** between converter and deflection generator reducing LOT core temperature and ringing.
- **Feed forward** of V_{++} to the sawtooth generator compensating for ripple on this supply voltage (V_{++}).
- Use of a **compensated EHT bleeder** reducing picture breathing.
- A **negative impedance converter** is a cost effective solution to reduce ripple on the EHT to fulfil TCO requirements and enhance performance at the cost of an extra EHT smoothing capacitor and a high voltage output amplifier (Patent of Nokia; see ref. 1).

See also reference 1 for an upside-down topology of this application for 15".

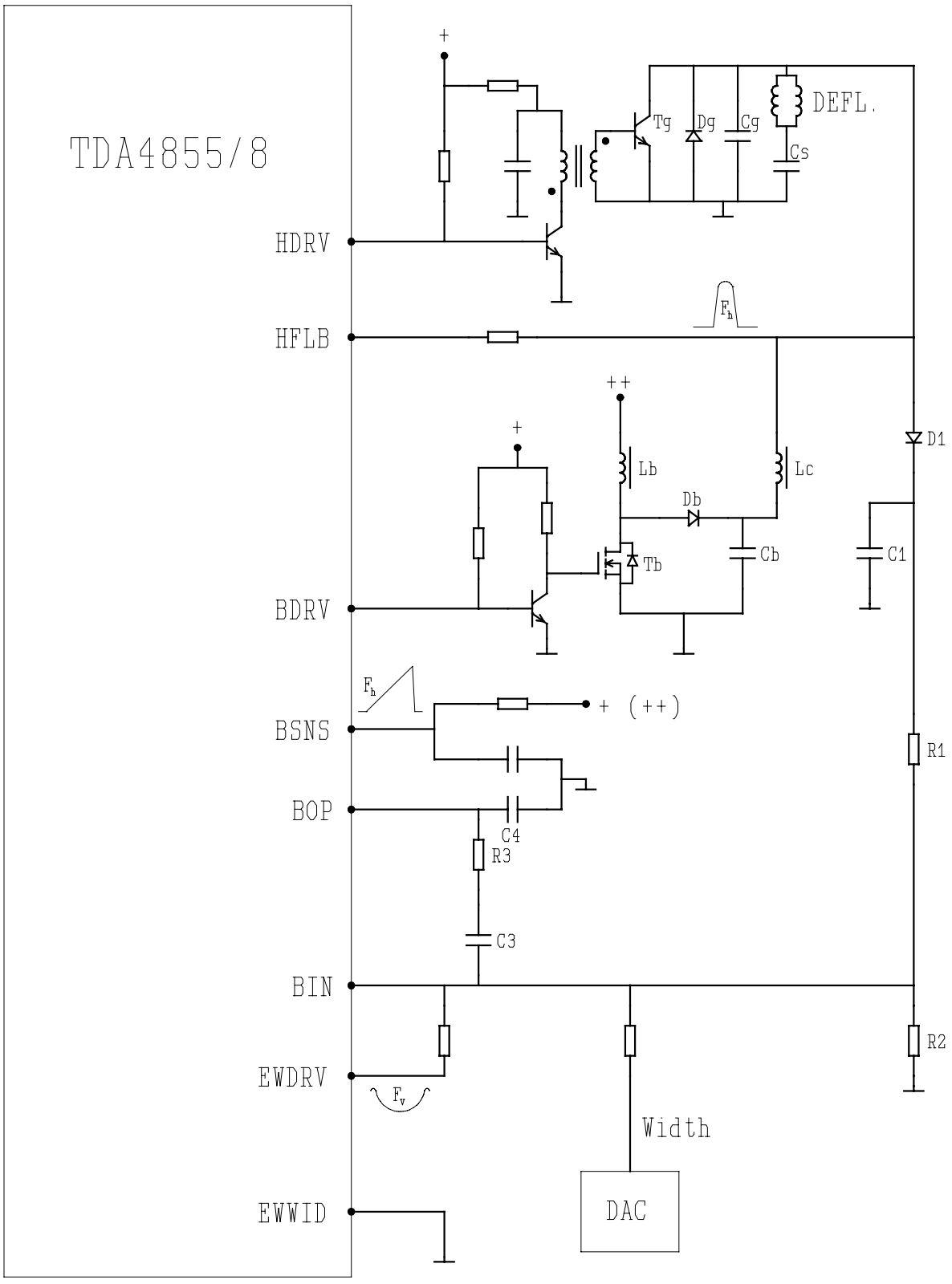

Fig.27 Deflection generator with boost-converter

5.3 Deflection generator with boost-converter

The application shown in Fig.27 is a maximum component solution. It has several extra poles in the control path which make it difficult to realise a stable operation. But with the **alternative** given here it is an interesting solution with simple drive of all power transistors. The only difficult item being slow-start.

Alternative 1:

Without degrading performance but greatly improving ease of design (optimum feedback) while saving components but at the expense of part of the horizontal position control range.

Delete: C_b, L_c, D_1 and C_1;
Connect: Cathode of D_b and R_1 to C_s.
Advantage: Less components;
Less poles in feedback path.
Disadvantage: DC current through deflection coil causing shift.

Alternative 2:

If the horizontal position control range is not allowed to be decreased then the following alternative might be considered.

Delete: C_b, L_c, D_1 and C_1;
Connect: Cathode of D_b to cathode of D_g and R_1 to C_s.
Advantage: Less components;
Less poles in feedback path.
Disadvantage: Maximum voltage Drain-to-source of T_b equals peak flyback voltage across Collector-emitter of T_g (No DC current through deflection coil).

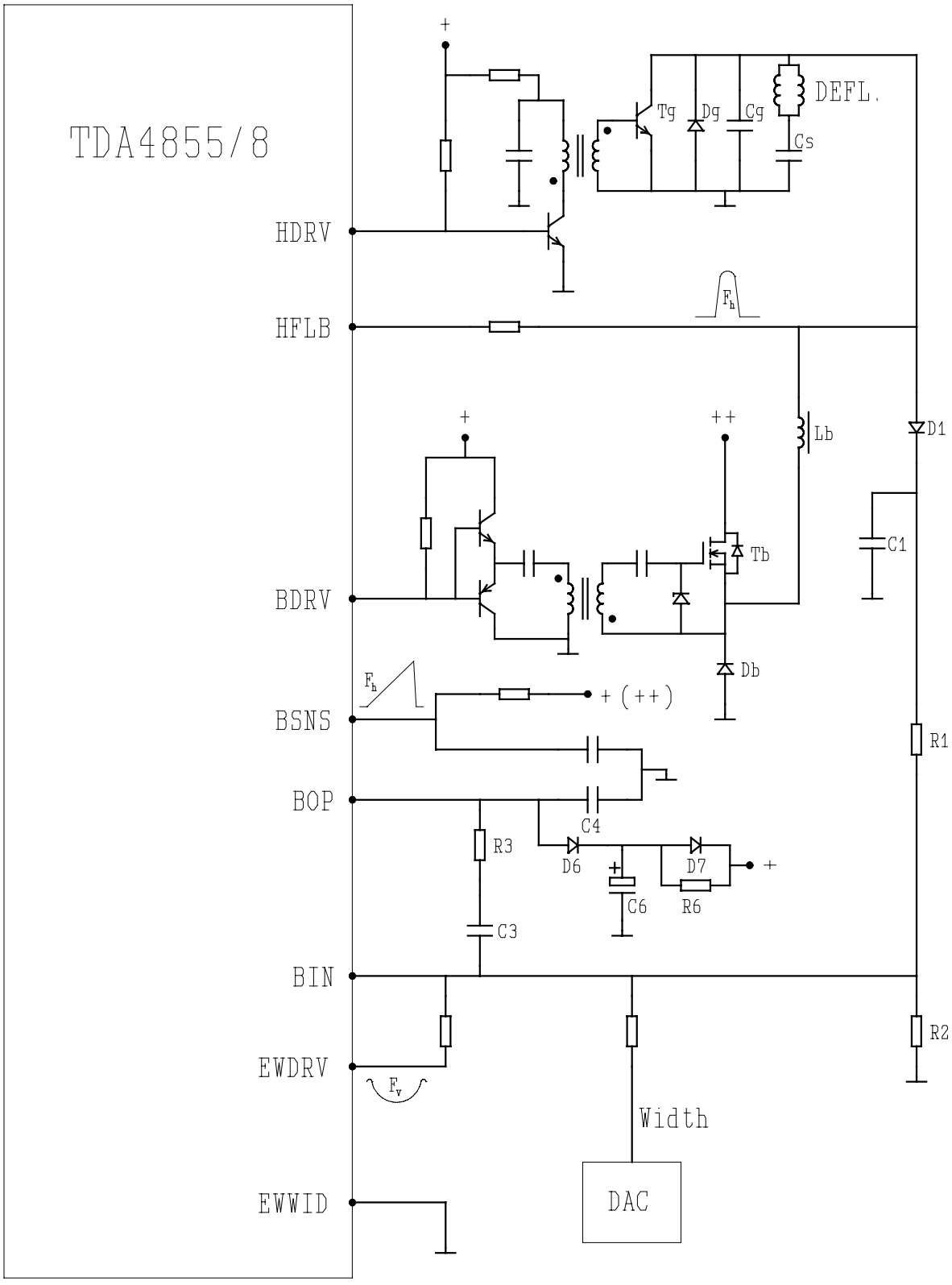

Fig.28 Deflection generator with buck-converter

5.4 Deflection generator with buck-converter

Compared to the boost-converter the buck-converter needs a higher supply voltage and the supply switch is connected to V_{++} but it provides an easy slow-start solution.

Advantage: Less components;
Less poles in feedback path: ease of design.
Disadvantage: DC current through deflection coil causing shift.

Alternative 1:
Instead of using the peak rectified flyback pulse as feedback signal the voltage across the S-correction capacitor C_s can also be used.
Delete: D_1 and C_1;
Connect: R_1 to C_s.
Advantage: Less components;
Less poles in feedback path: ease of design.
Disadvantage: DC current through deflection coil causing shift.

Alternative 2:
Instead of using feedback the design can also run in feedforward mode. In that case it is advantageous to use the supply voltage V_{++} also for the sawtooth generator connected to BSNS.
Delete: D_1 ,C_1, R_1 and C_3 (short circuit C_3);
Connect: R_3 directly between pins BIN and BOP.
Advantage: Less components;
Only feedforward: ease of design.
Disadvantage: Circuit performance depending upon power component parameters.

5.5 EHT generator with boost-converter

The topology presented here is intended for high output power (peak > 30 W) and high frequencies (maximum over 100 kHz) minimizing transformer stress while keeping cost within reasonable limits. This is possible by separating functions to dedicated components resulting in lower operating temperatures and/or higher maximum load.

In case the generator is synchronised with the horizontal deflection it might be considered to increase the flyback time for lower frequencies in order to decrease peak charge currents in the EHT windings to maintain output power capability.

Advantage: High output power
Separated functions per component: optimum device specification
Horizontal flyback pulse and EHT flyback pulse coincide eliminating visual side effects

Disadvantage: Many large components
Difficult slow start
Two different drive signals necessary

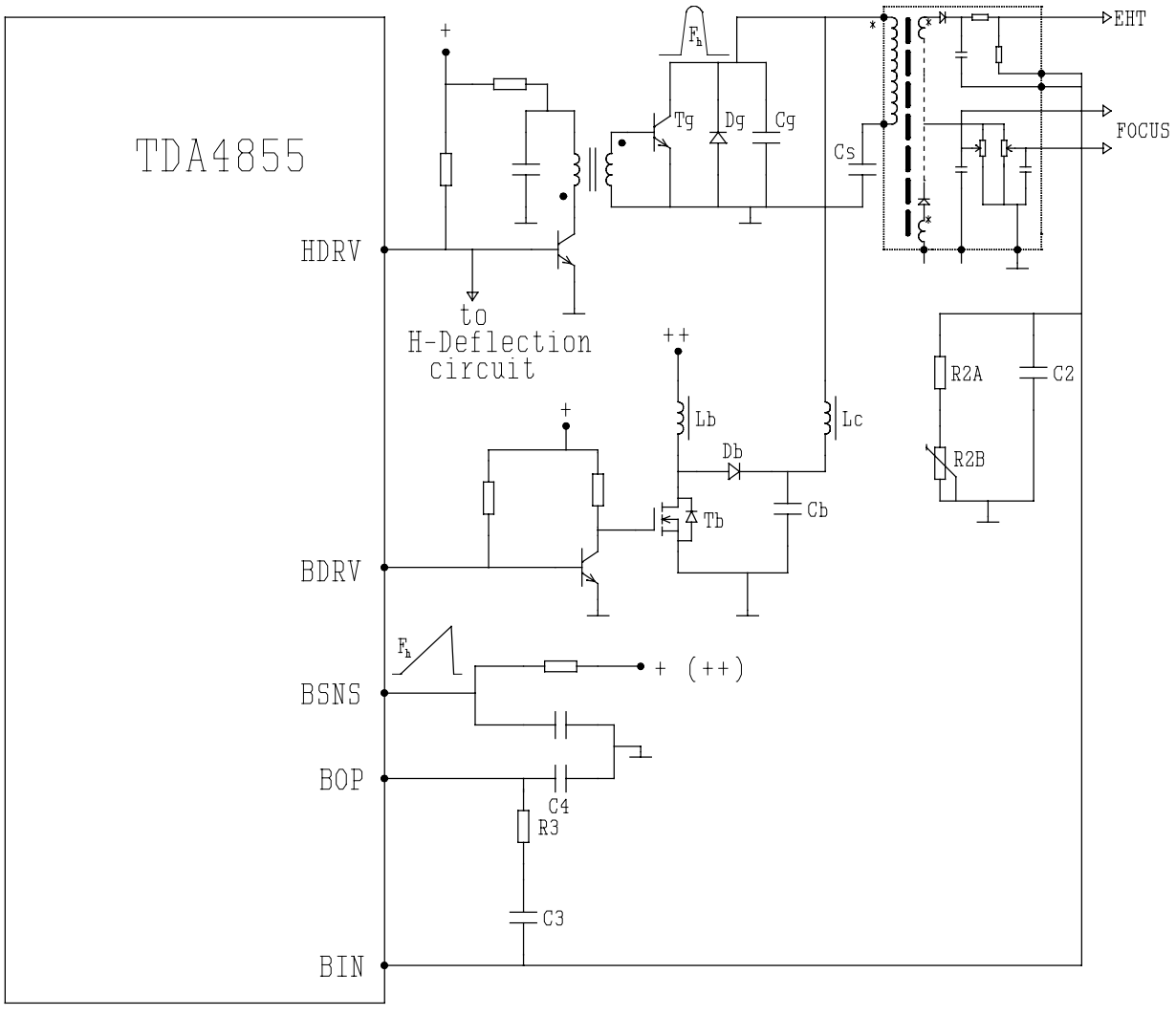

Fig.29 Boost-converter for EHT generator with high output power

Alternative:
With even less components the generator can be further optimised at the penalty of DC current flowing through the LOT primary.

Delete: C_b and L_c
Connect: cathode of D_b to C_s.
Advantages: Less components;
Less poles in feedback path: easier to design.
Disadvantage: DC supply current runs through the primary winding of the EHT transformer causing an extra temperature rise.

5.5.1 Upside-down alternative

This is an interesting solution with minimal component count and maximum performance. The boost-converter supply part of the previous application is replaced by a buck-converter part and the generator part is on top connected to V_{++} while the supply switch T_b is connected to ground (see next figure).

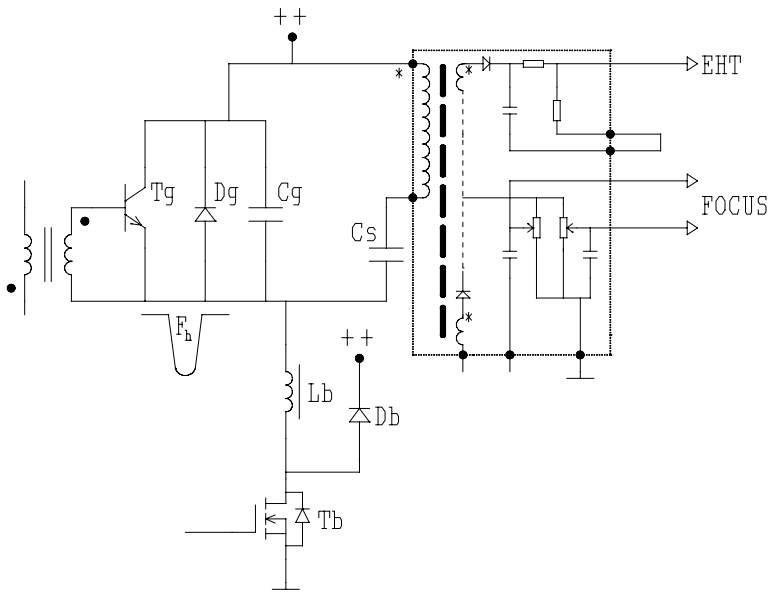

Fig.30 Alternative topology with buck-converter

Important specification point here is that the secondary winding of the driver transformer of T_g must be capable to withstand the generator flyback pulse at the maximum operating frequency. Especially when the flyback pulse amplitude exceeds 1000 Volt insulation may become a problem.

Advantage: Simple drive of both power switching transistors
Simple slow start

Disadvantage: Switching different C_g and C_s.

5.6 EHT generator with buck-converter

This design operates with a short circuit switch T_b.
For this design a transformer with two primary windings is used: T_b can be driven against ground. If a transformer with only one primary winding is available connect D_b - T_b across this primary winding: T_b must now be driven against the supply voltage.

Advantage:
Simple circuit
Easy slow-start
Few components
Simple drive of power transistors

Disadvantage:
LOT with two primary windings
Extra inverter necessary
No delay allowed between T_b and T_g
The flyback pulse of the horizontal deflection and the flyback pulse of the EHT generator do **not** coincide! This may cause a visible disturbance during the horizontal scan.

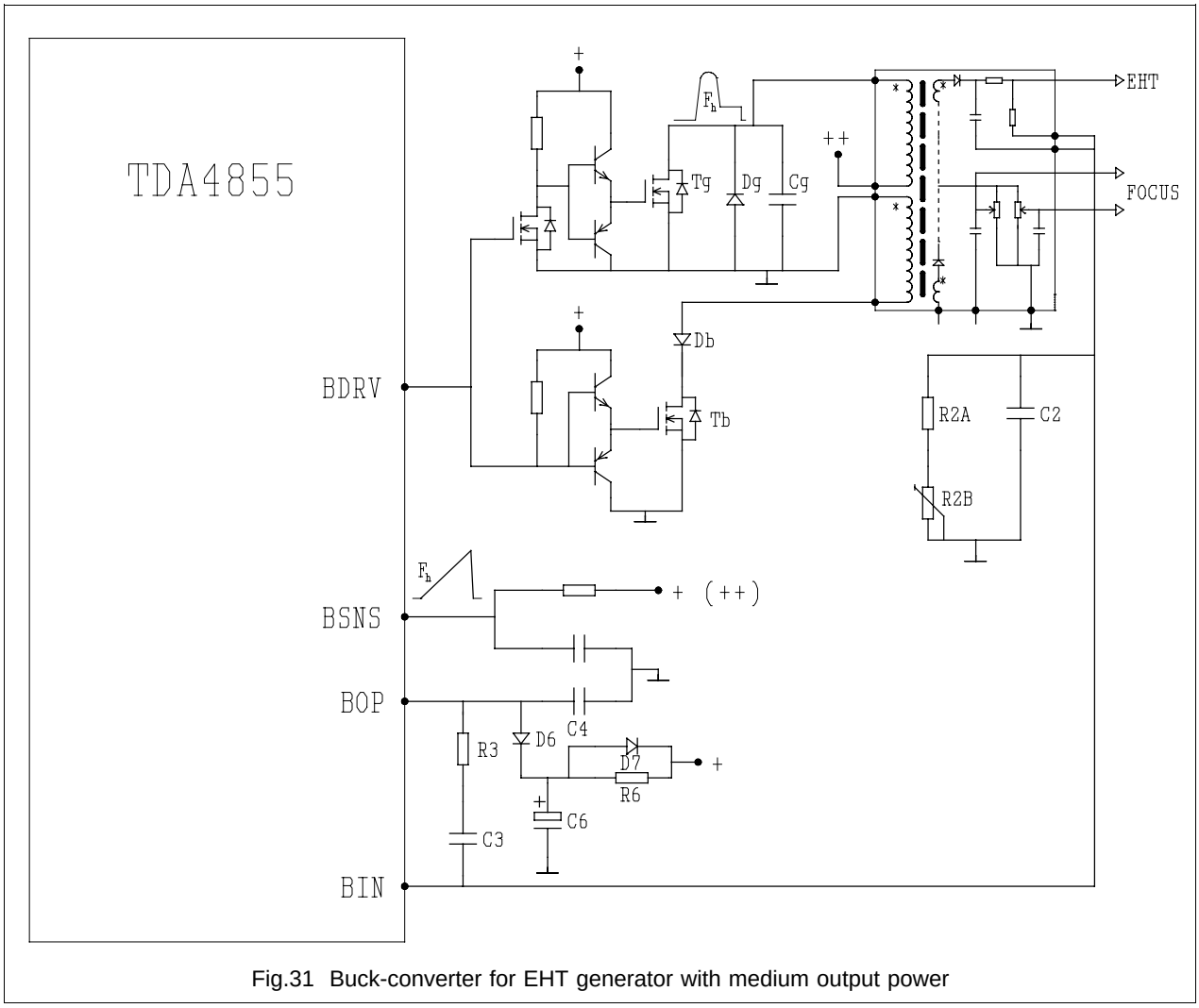

Fig.31 Buck-converter for EHT generator with medium output power

6. REFERENCES

1. AN95086 PCALE 15" Autosync Monitor MkII circuit description
H. Misdom

2. ETV/AN91003 A universal FET driver transformer
D. Büthker

3. TDA4855 Autosync Deflection Controller ASDC
Data Sheet july 1996

4. AN95087 Autosync Deflection Controllers TDA4855 and TDA4858
G. Habraken

APPENDIX :TDA4855/58 B+ SECTION VERSUS UC3842

Here is a survey of the differences between the TDA4855/58 B+ section and the 3842. These differences are designed to make the B+ section better suitable for use in autosync monitors.

1. The B+ section does not have its own oscillator. It uses trigger pulses from the horizontal oscillator.
2. The output of the error amplifier and the input of the PWM comparator are not separated but combined in one pin BOP.
3. The frequency roll-off capacitor is not integrated but can be optimised externally on pin BOP.
4. The output of the error amplifier is not voltage driven but current driven. This allows external limiting of the maximum pulse width and also soft-start applications.
5. The control levels of the PWM comparator inputs (BOP, BSENS) are not 0 V...1 V, but are 1 V...5.6 V.
   Note: In case of current sense at the source of the switching Power Mosfet, we advise to
   (a) double the value of the sense resistor,
   (b) apply a DC shift of +1 V at the BSENS input, using a pull-up resistor divider
   (c) apply external clipping at +3 V.
6. The PWM comparator can also be used as a one shot timer (like the NE555) or as an artificial current sense. Only one R+C is needed.
7. All monitor protection functions of the TDA4855/58 also apply to the B+ section (XRAY, low supply, etc.)

In the next figure (Fig.32) an example is given of a deflection boost supply converter with the UC3842. In the same figure the application with TDA4855/58 is drawn to show the equivalence between the two applications. The following table lists the differences in short form.

TABLE 5: UC3842 replaced by TDA4855/58 B+ section

UC3842	#	TDA4855/58	#	Remarks
OUTPUT	6	BDRV	6	UC3842 output has high power drive capability. TDA4855/58 output pulse is active low and open collector type.
Isense	3	BSNS	4	UC3842 has 0 to 1.0 V input range. TDA4855/58 has 1.0 to 5.6 V input range.
COMP	1	BOP	3	TDA4855/58: Easy to set bandwidth, define slow-start and duty-cycle limiting.
Vfb	2	BIN	5	Both operating at 2.5 V (internal reference)
Rt/Ct	4	Internal	-	UC3842 needs external interface to synchronise. TDA4855/58 always synchronised with horizontal oscillator.
Vref	8	-	-	UC3842 has reference voltage externally available (needs 100 nF capacitor).

The TDA4855/58 B+ section has internal triggering but lacks the high output drive capability. Slow-start can be implemented in the same way with both applications. With the TDA4855/58 the slow-start is better defined because the maximum output current of pin BOP is specified. Duty-cycle limiting (minimum and maximum) can be easily defined with a few external components.

With TDA4855/58 definition of the bandwidth is external (capacitor pin BOP to ground) and independent from the gain setting (impedance between pins BIN and BOP w.r.t. the input resistors of feedback, width and EW parabola). With UC3842 gain and bandwidth setting components influence each other.

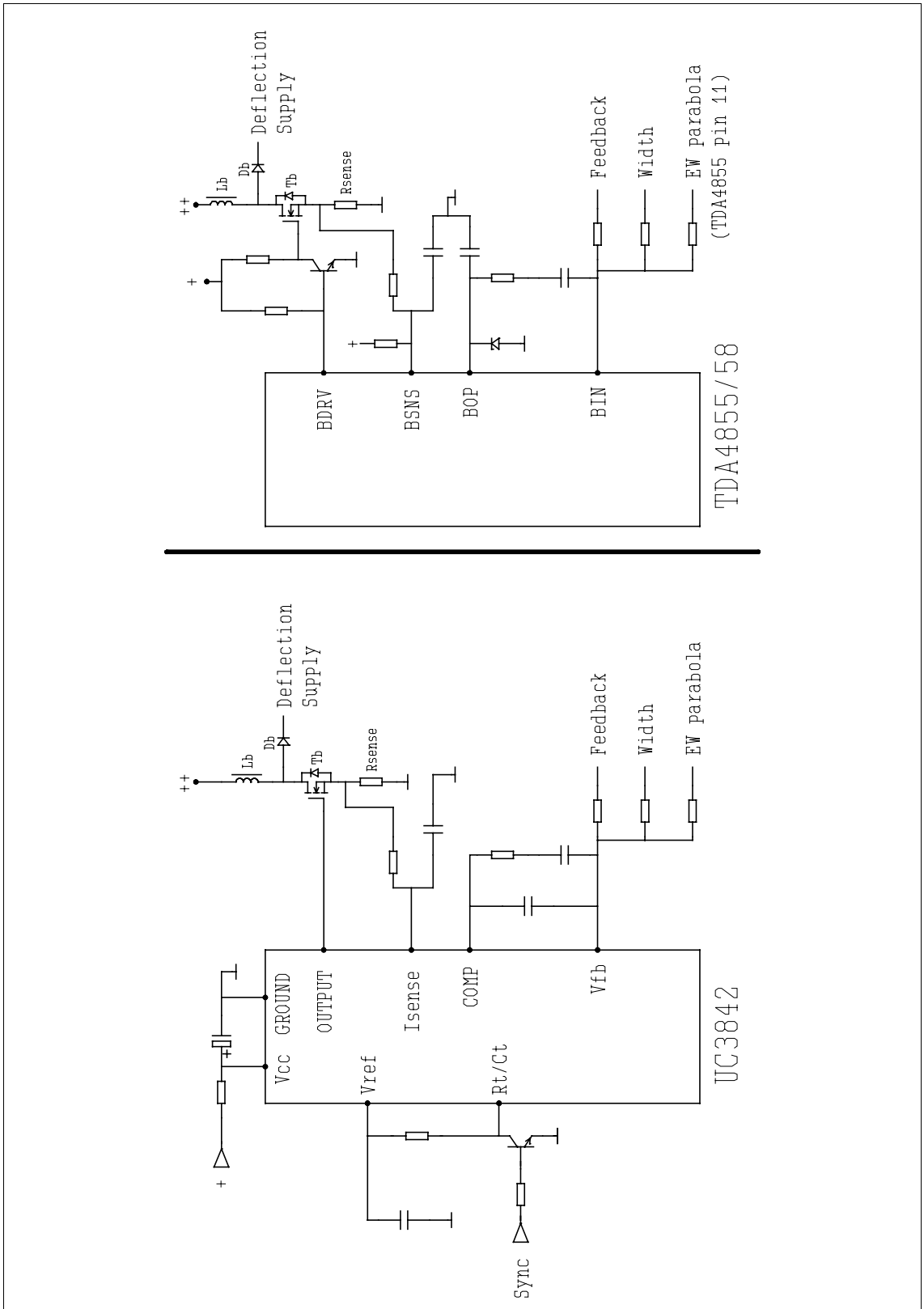

Fig.32 UC3842 replaced by B+ section of TDA4855/58