

A 3 Watt LDMOS Driver for the 432MHz band

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Introduction

The popularity of my 2.5-Watt driver kit for the 1296MHz band (1) and the recent publication of G4DDK's Iceni 4322MHz transverter (2) inspired me to create a version of the driver board for 432MHz. This article describes that driver amplifier covering the band 430-440MHz band requiring around 10-20mW of drive for full output. As well as its use for SSB, CW and digital modes with the Iceni, it should prove useful to add to the BATV "Portsdown" DATV transmitter (3).

Specification

The design is very simple and based around a single SOT-89 plastic PD85004 40V LDMOS device from ST (3). The device is rated to give 17dB gain and 4 watts out at 870MHz at a V_{dd} of 13.5V but it performs even better with good linearity at 2.5-3 Watts at 432MHz.

The linear power output, P_{1dB} is around 2.5Watts at a quiescent drain current of 150mA and the saturated power output is around 4Watts subject to component and device tolerances. Power gain at P_{1dB} is around 26dB.

It can be added after low power transverters such as that by G4DDK (2) to boost the power output to a couple of Watts, sufficient to drive a larger PA device if necessary. The PCB is designed to fit in to a readily available 37 x 74 x 30mm Schubert tinplate box (4) (5) and if the PCB design is copied carefully, needs just a small stick-on heatsink at 2.5 Watts output.

Circuit description

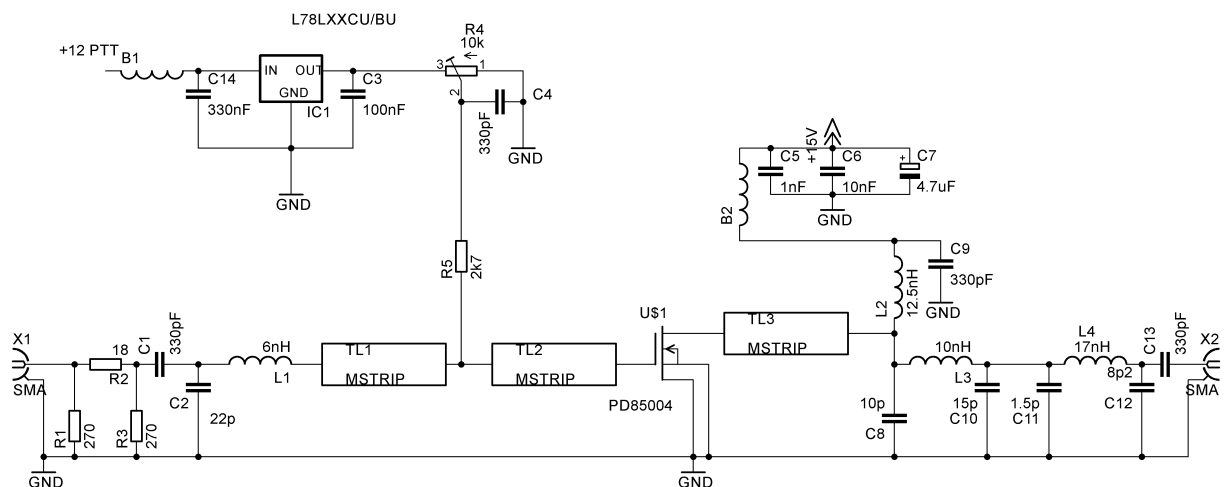


Figure 1 Circuit Diagram

The amplifier uses a combination of 50-ohm microstrips, lumped and LC matching and requires no tuning. The device input is matched to 50 ohms using low pass networks consisting of C1 (a DC block), shunt C2, L1, and series lines, TL1, and TL2 split to allow the gate bias to be connected. It has an input attenuator, to reduce the

gain and improve input match. Values shown are for a 3dB attenuator, but other attenuators can be fitted by choosing suitable values for R1,2 and 3. The attenuation can be set to zero by not fitting R1 and R3 and fitting a zero-ohm resistor in the place of R2.

The 13.5-volt supply is connected to the drain via a network of two chokes, B2 and L2 plus a short 50-ohm line TL3. It is decoupled over a wide range of frequencies by C9, C5, C6 and C7.

The output is matched to 50 ohms with a low pass pi network consisting of C8, L3, C10, C11, L4, C12, plus a DC block C13. This ensures that all harmonics are less than -50dBc.

To allow the amplifier to be switched in to standby mode on receive, or to switch it off under fault conditions, a low current +8 to 20V supply is applied on transmit, via B1. This feeds a 5V regulator IC1 decoupled with C3 and C14. The 5V is fed via R4, and R5 to provide adjustment of the quiescent drain current of the FET. This gate supply is decoupled by C4. Without gate bias, the amplifier takes very little current so switching the gate supply from the press to talk (PTT) line is a convenient way to switch the amplifier out of standby. Some Power Amplifiers produce a VSWR and/or over temperature alarm at logic level of +5V, so with some extra circuitry you have a way to switch off the drive to it under VSWR fail conditions or overheating by disabling the driver's bias regulator.

Construction

The PA is built on 0.8mm thick, standard FR4 PCB material. Layout is shown in Figure 2 PCB layout. The PD85004 used in the design is in a SOT-89 solder-down plastic package which eliminates the need for hazardous beryllium oxide. Under the device tab there are six plated through holes to connect the tab both thermally and electrically to the ground plane underneath. This acts as a heatsink for the device along with a small stick-on copper heatsink placed directly under the device on the ground plane side.

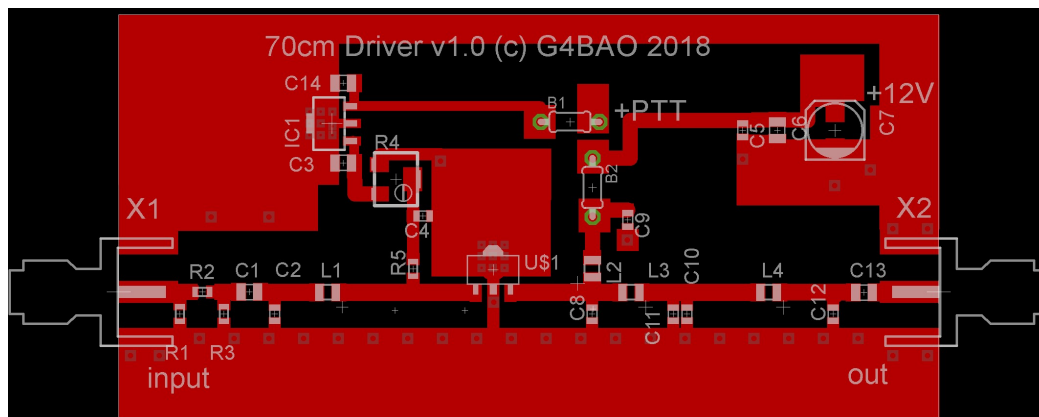


Figure 2 PCB layout

Checking the completed PCB

Connect the output from your low power 432MHz transverter to the amplifier input after first ensuring that the input power does not exceed 10mW (+10dBm). Depending on the attenuator fitted (in this example 3dB) this can be higher by the attenuator loss.

Connect the amplifier output to a power meter/dummy load capable of dissipating at least 3 Watts.

Connect the drain to 13.5 volts via an ammeter on the 1A amp range. Disconnect the RF drive and connect the gate bias supply, starting with minimum voltage on the gate and VERY carefully increase the gate voltage until the device begins to take current. This onset is very sharp, so be very careful, as the drain current can easily swing up to many Amperes if you are not careful. Set the drain current to 150mA. Switch off and then switch the ammeter to the 1 Amp range. Switch back on. Apply drive and check that the output power is in the order of 2.5- 3 Watts depending on drive level. Typical test results for my prototype amplifier are shown in Figure 4 and Figure 5.

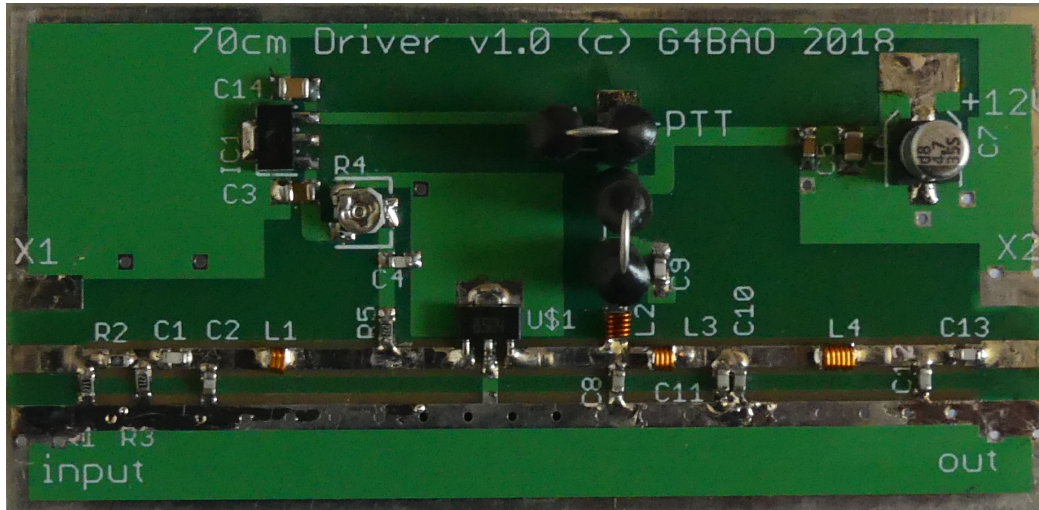


Figure 3 Completed prototype amplifier

Test Results

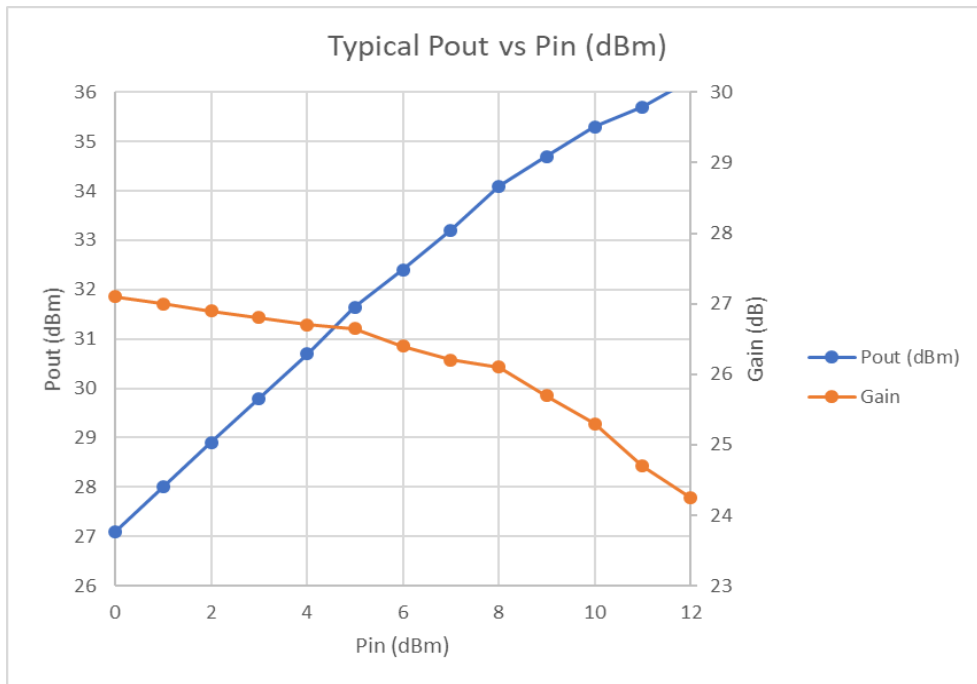


Figure 4 Prototype Amplifier Gain and Power out vs Power in

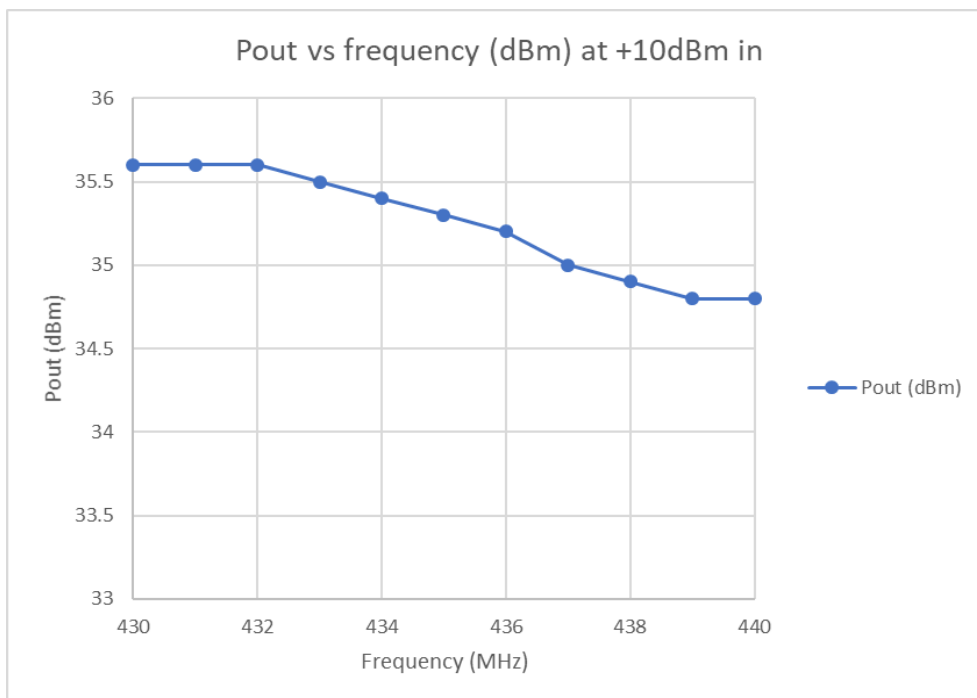


Figure 5 - Prototype Amplifier Power out vs frequency at +13dBm in

Results for DATV operation

Measurements were made with a Class A style bias to see how the Amplifier performed in ultra-linear operation for DATV. Generally, DATV operators on 70cms measure spectral regrowth beyond the main signal and aim for a level of -35dB relative to the signal for the first spectral re-growth with no visible secondary growth below that.

The measurements were done with a DATV signal at 1Ms/s (~1MHz wide) on 437MHz. By experimentation it has been discovered that for ATV operation, the bias level has a “sweet spot” around 550ma for best spectrum and good power out. Operation at this level MUST use the supplied stick-on heatsink or better.

The signal source used, was a DATVExpress transmitter (6) set at +4dBm output which had a -50dB spectral regrowth, See Photo 1.

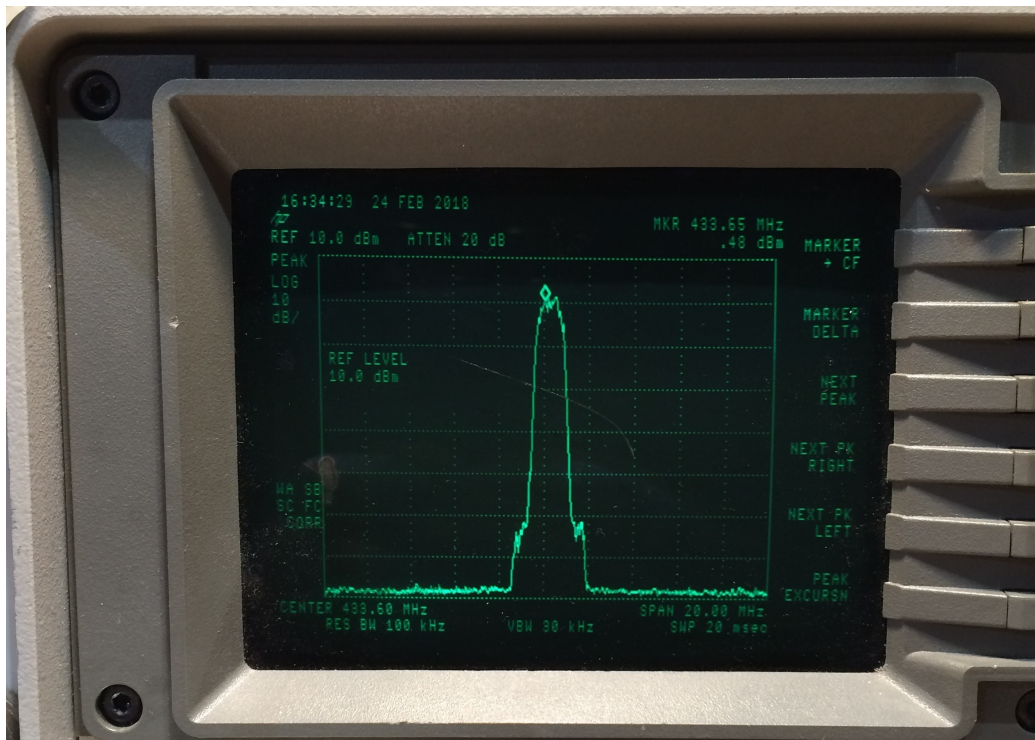


Photo 1 DATV express drive signal +4dBm

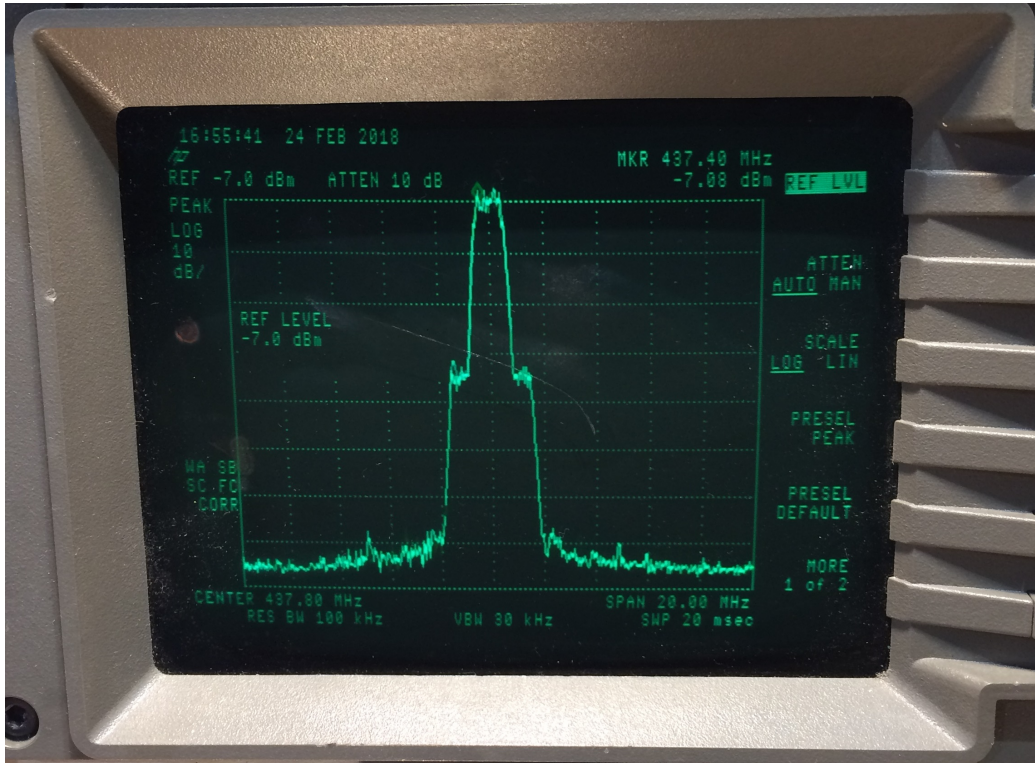


Photo 2 Amplifier spectrum at $I_{dq} = 550\text{mA}$ $P_{out} = +27\text{dBm}$

I_{dq} (ma)	P_{out} (dBm)	Spectral regrowth	Secondary regrowth
550	+27dBm	-35dB	No

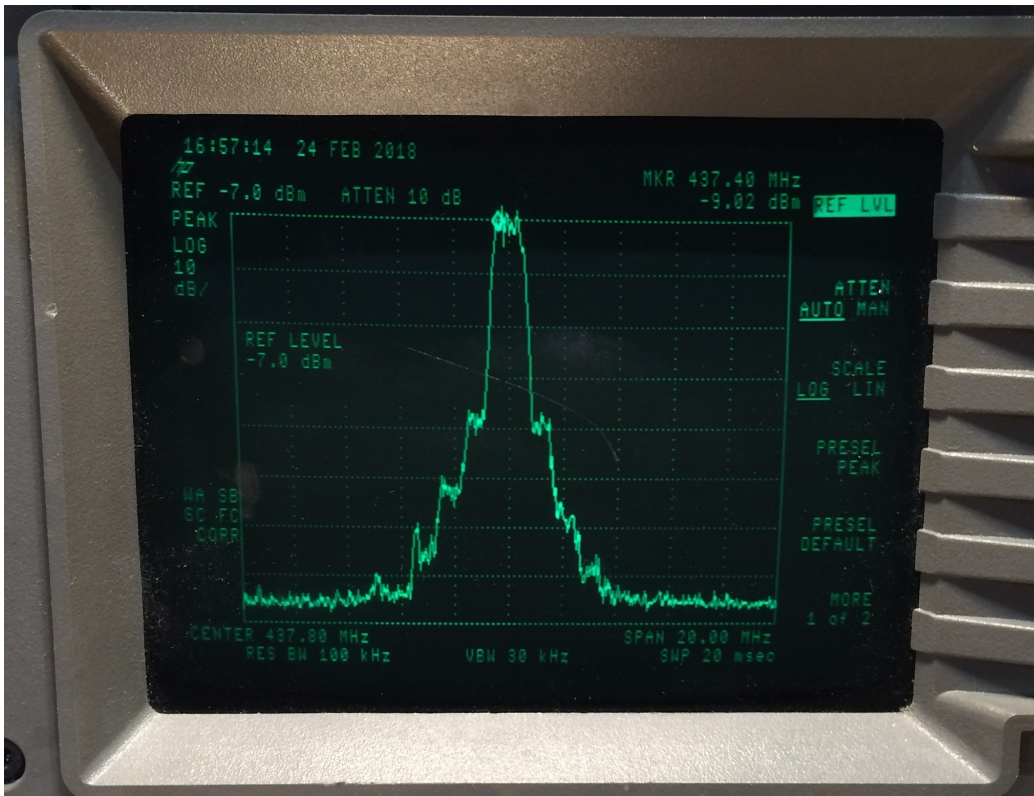


Photo 3 Amplifier spectrum at IDq = 350mA Pout = +27dBm

Idq (ma)	Pout (dBm)	Spectral regrowth	Secondary regrowth
350	+27	-40dB	Yes

Conclusions

This inexpensive driver is easy to build, with readily available components and produces a useful increase in output power for low power transverters such as those using modamps as PA devices. It covers the whole of the 430-440MHz band and for DATV use the design can be regarded as a +27dBm (500mW) ultra linear amplifier if run at 550ma quiescent current with a heatsink.

Component kits for the PCB are available from G4BAO. Kits can be ordered by email to oscarmax42@ntlworld.com which is also the address for PayPal payments See www.g4bao.com for prices and ordering details before sending an email!G4BAO

Component list

Component	Value	Type
R1	270R	SMD 0603
R2	18R	SMD 0603
R3	270R	SMD 0603
R4	10k	SMD preset
R5	2k7	SMD 0603
C1, C13	330pF	ceramic 0805
C2	22pF	ceramic 00603
C4,C9	330pF	ceramic 0603
C5	1nF	ceramic 0603
C6	10nF	ceramic 0805
C7	4.7 uF 35V	SMD electrolytic
C8	10pF	ceramic 0603
C10	15pF	ceramic 0603
C11	1p5	ceramic 0603
C12	8p2	ceramic 0603
U\$1	LDMOS FET	PD85004
L1	6nH	Coilcraft air core 0806SQ-6N0G
L2	12nH	Coilcraft 0805HQ-12NX E
L3	10nH	Coilcraft air core 0807SQ-10NG
L4	17nH	Coilcraft air core 0807SQ-17NG
IC1	5V regulator	L7805CU/BU
B1, B2	Dual ferrite bead	Panasonic EXCELDRC35 or 25

References

1. Original 1.3GHz driver article: - http://www.g4bao.com/Files/23cm_D.zip
2. G4DDK Iceni Transverter: - <http://g4ddk.com/IceniTechdesc.pdf>
3. PD85004 Datasheet:- <http://bit.ly/2F4prKi>
4. Tinplate boxes (UK) from alan.melia@btinternet.com
5. Tinplate boxes (Germany) from Eisch-Kafka: - <http://bit.ly/2F35K5u>
6. DATV express project: - <https://datv-express.com/>

Acknowledgements

Thanks to Sam, G4DDK for his comments on the prototype and Noel, G8GTZ for the DATV measurements.

All figures and photos are supplied as separate JPEG but are included in the text to indicate where they should appear