Low-Noise Charge-Pump Negative Bias Supply with Power-OK for GaN/GaAs Power Amplifier

1 Features

- 3.5V to 5.5V Input
- -0.5V to -(VIN - 0.6V) Output at up to 15mA
- Power-OK Signal to Control GaN/GaAs Drain Supply Switch
- 160μA Logic-Controlled Shutdown
- Operates with One 100μF One 10μF and Two 1μF Capacitors (no inductors needed)
- Compact and low-cost 3mm x 3mm QFN package(MSL3, 260 per JEDEC J-STD-020)
- ESD Level: 2kV to POWER/GND; IO to IO 500V
- ROHS compatible

2 Applications

- GaN/GaAs Power Amplifier
- Wireless Basestation
- RF Front-End Module
- LED Back-Light
- Optical Data Transfer Unit

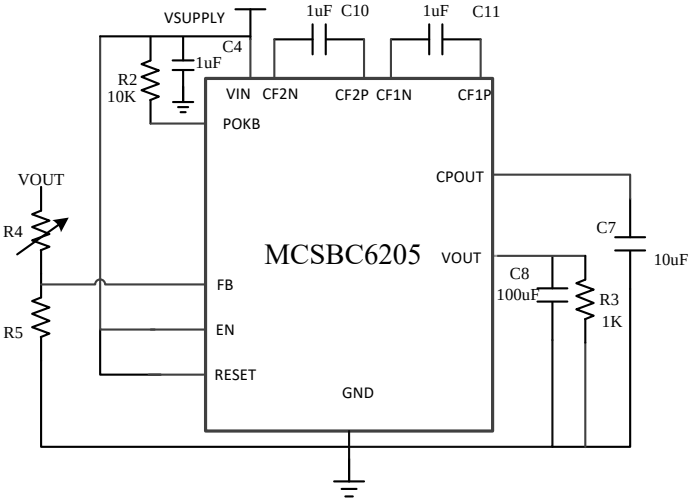


Figure 2. MCSBC6205 Application Circuit

3 Description

The MCSBC6205 low-noise, inverting power supply is designed for biasing GaN/GaAs FET power amplifiers in wireless applications. This device is a charge pump inverter followed by a negative linear regulator. The input voltage range i s 3.5V to 5.5V. The output is preset at -2.0V or can be set, using two resistors, to any voltage from -0.5V to -(VIN - 0.6V). It can deliver up to 50mA (source current). Other features include a power-OK (POKB) output that signals when the negative voltage is within 7.5% of its set point. It protects the GaN/GaAs FET by not allowing power to be applied to the GaN/GaAs FET's drain/collector until it is properly biased. The signal can be routed either to a microcontroller or directly to a switch at the GaN/GaAs FET drain/collector The MCSBC6205 is available in a QFN 3*3mm 16 package.

Figure 1. 16 Pin 3 x 3 mm QFN Package

Ordering Information

Part No.	Description
MCSBC6205	Low-Noise Charge-Pump Negative Bias Supply with Power-OK, 7' Reel with 1500pcs

4 Pin Configuration and Functions

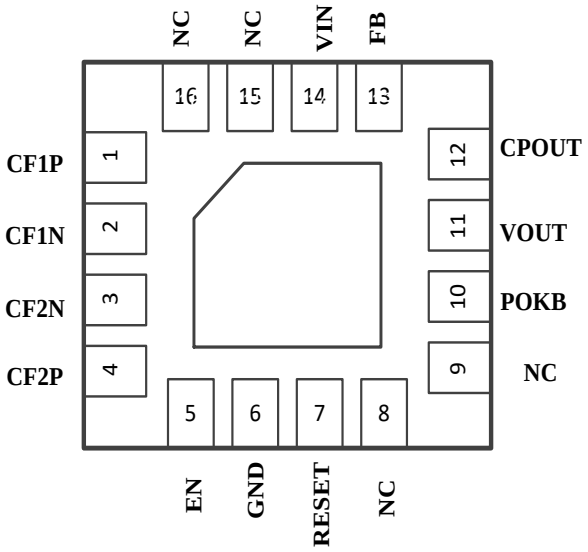


Figure 3. MCSBC6205 Pinout (Top View)

Signal Descriptions

Pin			Description
Name	QFN-16	TYPE	
CF1P	1	I/O	Positive Terminal for C11
CF1N	2	I/O	Negative Terminal for C11
CF2N	3	I/O	Negative Terminal for C10
CF2P	4	I/O	Positive Terminal for C10
EN	5	I	Active-Low, Logic-Level Shutdown Input. Connect to IN for normal operation. Do not leave this pin unconnected
GND	6	GND	Ground
RESET	7	I	Connect to IN for normal operation. Do not leave this pin unconnected
NC	8	NA	No Connection. Not internally connected.
NC	9	NA	No Connection. Not internally connected.
POKB	10	O	Active-Low, Open-Drain Power-OK Output. Goes low when VOUT reaches 92.5% of its set value. pulled up resistor to VIN.
VOUT	11	O	Regulated Negative Output Voltage， biasing for PA Gate
CPOUT	12	O	Negative Output Voltage (unregulated)
FB	13	I/O	Dual-Mode™ Feedback Input. When FB is connected to GND, the output is preset to -2V. To select other voltages, connect FB to an external resistor-divider. Do not leave this pin unconnected.
VIN	14	I	Positive Power-Supply Input
NC	15	NA	No Connection. Not internally connected.
NC	16	NA	No Connection. Not internally connected.

5 Specification & Description

5.1 Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Storage Temperature	TSTG	-55 to 125	˚C
Operating Temperature	TC	-40 to 85	˚C
Operating Junction Temperature	TJ	150	˚C
Thermal Resistance	Rθjc		˚C/W
VIN to GND	VIN	-0.3 to +6	V
EN to GND	VEN	-0.3 to +6	V
RESET to GND	VRESET	-0.3 to +6	V
POKB to GND	VPOKB	-0.3 to +6	V
CF2N/CF1N/CPOUT/VOUT/FB to GND	/	-5.5V to (VIN + 0.3V)	V
CF1P/CF2P to GND	/	-0.3V to (VIN + 0.3V)	V

5.2 Electrical Specifications

TA=25°C, VIN=5V, GND=0V, CVIN=2uF, CVOUT=10/100uF, C7=10uF, C10/11=1uF , R2=10K, R5=5.1K, R3=1K, R4=50K(3296W) related to fig2 unless otherwise specified。

Parameters	Min	Typ	Max	Units	Note
Supply Voltage-VSUPPLY	3.5		5.5	V	Supply voltage for analog circuits
Adjustable Output Voltage Range-VOUT	-(VIN-0.6)		-0.5	V	VIN ≥3.5V, IOUT = 0 to 15mA
Adjustable Output Voltage Range-VOUT	-4		-0.5	V	VIN ≥3.5V, IOUT = 0 to 50mA
Preset Output Voltage-VOUT（Vgate for PA）		-2		V	VIN ≥3.5V, IOUT = 0 to 50mA
Output Load Regulation		2	6	mV/mA	VIN=5V, IOUT = 0 to 50mA
FB Voltage-FB		-0.5		V	
Output Ripple		3		mVp-p	IOUT = 4mA
Oscillator Frequency-fOSC	160	200	240	kHz	
POK Threshold	90	92.5	95	% of VOUT	FB = OUT
POK Output Level		50	100	mV	VIN ≥ 3.5V, sinking 1mA
EN Input High Voltage	1.2			V	VIN = 5.5V
EN Input Low Voltage			0.35	V	VIN = 2.5V
RESET Input High Voltage	1.2			V	VIN = 5.5V
RESET Input Low Voltage			0.35	V	VIN = 2.5V
Shutdown Supply Current		160		uA	VIN=5V, EN/RESET=0

5.3 Functional Diagram

Fig4 shows functional diagram of MCSBC6205.The applied input voltage (VIN) is inverted to a negative voltage at CPOUT by a switching charge pump. This voltage is regulated by an internal linear regulator at VOUT (Figure 2). With FB connected to GND, VOUT is regulated at -2V. Alternatively, use a voltage-divider at FB to adjust the output voltage between -0.5V and -(VIN - 0.6V) (see the section Setting the Output Voltage). The internal linear regulator reduces the ripple noise induced by the charge-pump inverter to 3mVp-p at VOUT. In addition, the excellent AC rejection of the linear regulator attenuates noise from the in coming supply.

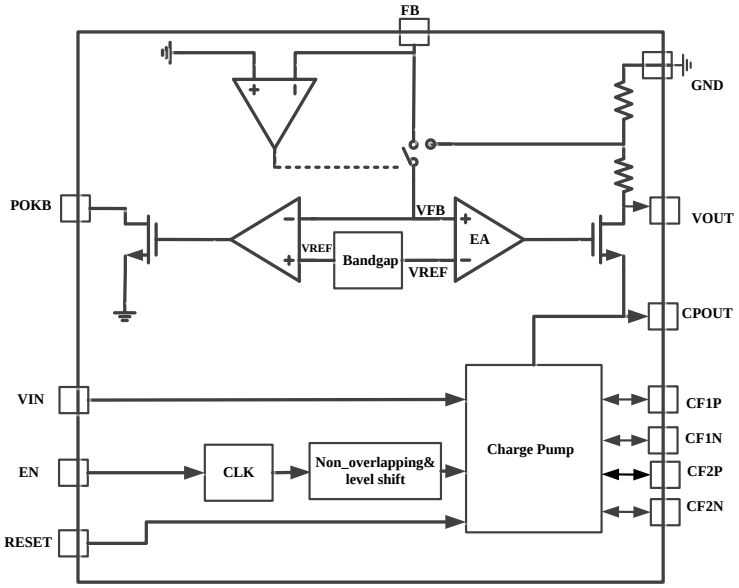


Figure 4. MCSBC6205 Functional Diagram

5.4 Power-OK Signal

The MCSBC6205 has an active-low, open-drain, power-OK (POKB) output. This output goes low when VOUT reaches 92.5% of the regulated output voltage. POKB can be used to drive the gate of a P-MOSFET that switches power to the GaN FET power amplifier (Figure 5), thereby ensuring that the power amplifier is not powered before the required negative bias voltage is present. Use a 10kΩ or larger pull-up resistor to signal a logic high when POK goes high impedance.

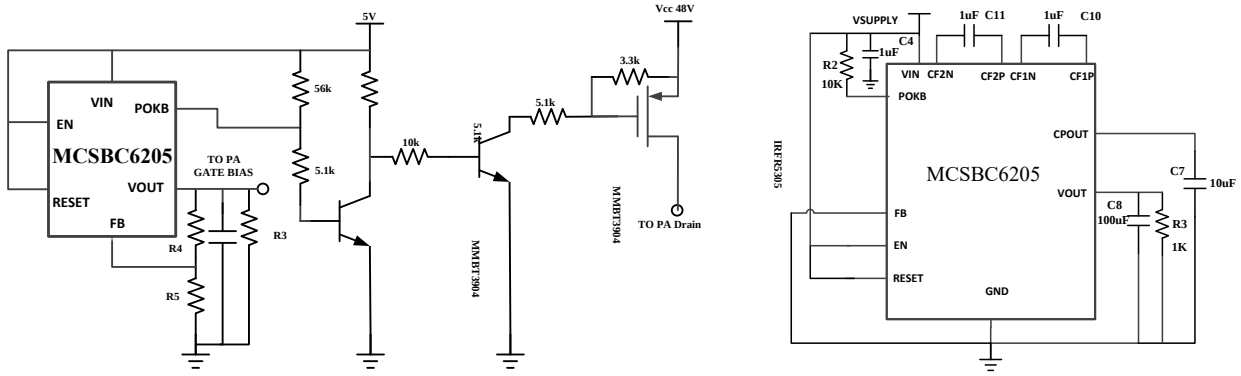


Figure 5. MCSBC6205 Standard Application Circuit

5.5 Setting the Output Voltage

Select either a fixed or adjustable output for the MCSBC6205. Connect FB to GND for a fixed -2V output (Figure 3). Select an alternative output voltage by connecting FB to the midpoint of a resistor-divider from VOUT to GND (PAGE 1). When operating under full load (50mA), the voltage at VIN should be at least 0.6V higher than the absolute voltage required at VOUT. Note that the minimum input voltage required for operation is 3.5V, regardless of the desired output voltage. Choose R5 to be between 1kΩ and 10kΩ and calculate variable resistor R4 for a target value. For greater accuracy, use resistors with 1% or better tolerance.

While VREF=-0.5V

If FB=0,

VOUT=-2V

If FB≠0,

VOUT =VREF*(1+R4/R5)

By using variable resistor R4，we can get any required VOUT value.

5.6 Typical Operating Characteristics

MCSBC 6205 load regulation & line regulation are showed in fig6 and fig7 when VOUT set at -3V, we can see from fig6, when load change from 0 to 50mA, VOUT change about 70mV, we also can see when VIN ch ange from 3.5V to 5.5V, VOUT change about 127mV with fixed load in fig7. Power on/off sequence are showed in fig8-10, we can see POKB pulled down when EN/RESET pulled up in fig9-10, also we can see VOUT arrive at target value in fig8, we can see POKB pulled up and VOUT turn to be 0 when power off.

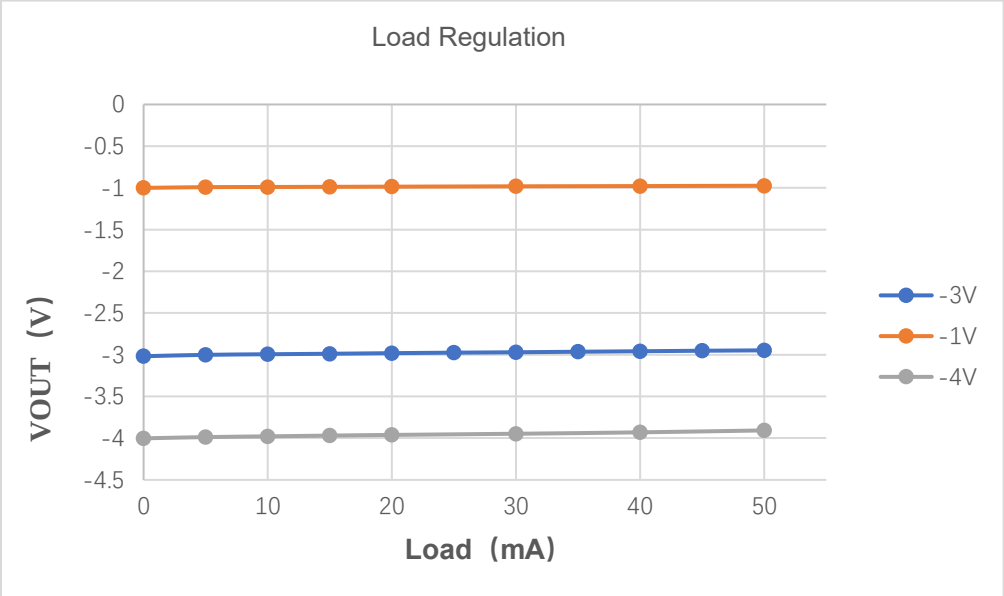


Figure 6. Load Regulation

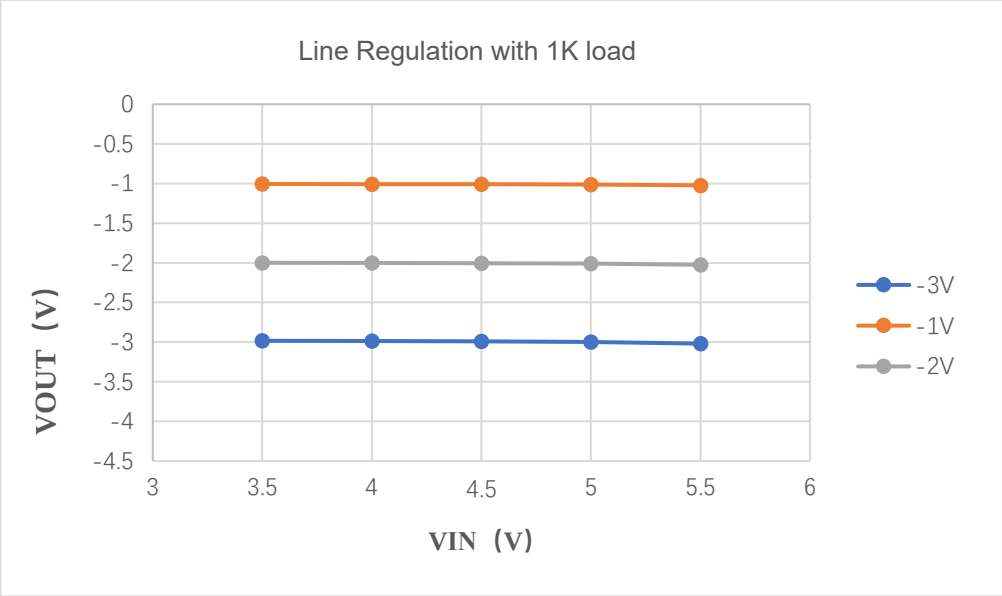


Figure 7. Line Regulation

Figure 8. Power ON/OFF Sequence

Figure 9. RESET ON Sequence

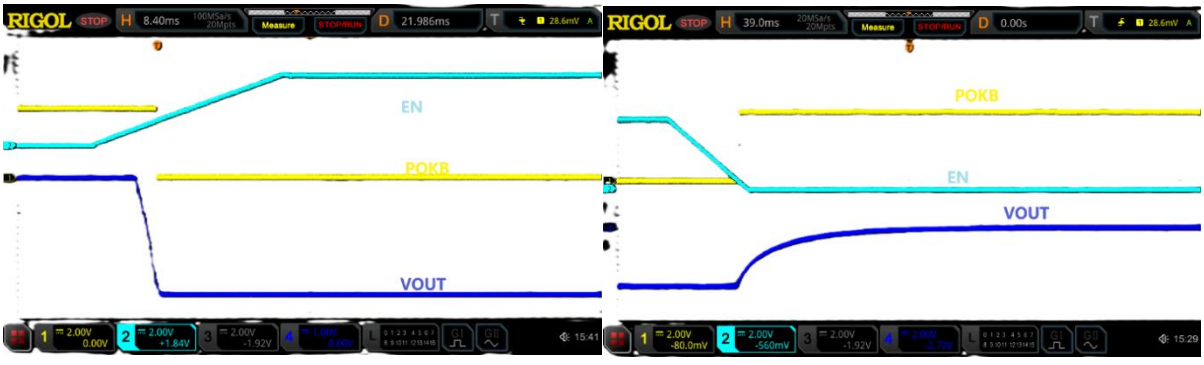


Figure 10. EN ON/OFF Sequence

5.7 Evaluation Board

The MCSBC6205 schematic and measurement setup can be seen in the following circuit diagram (Fig11-12). The detailed parts are listed in the Table4 as references.

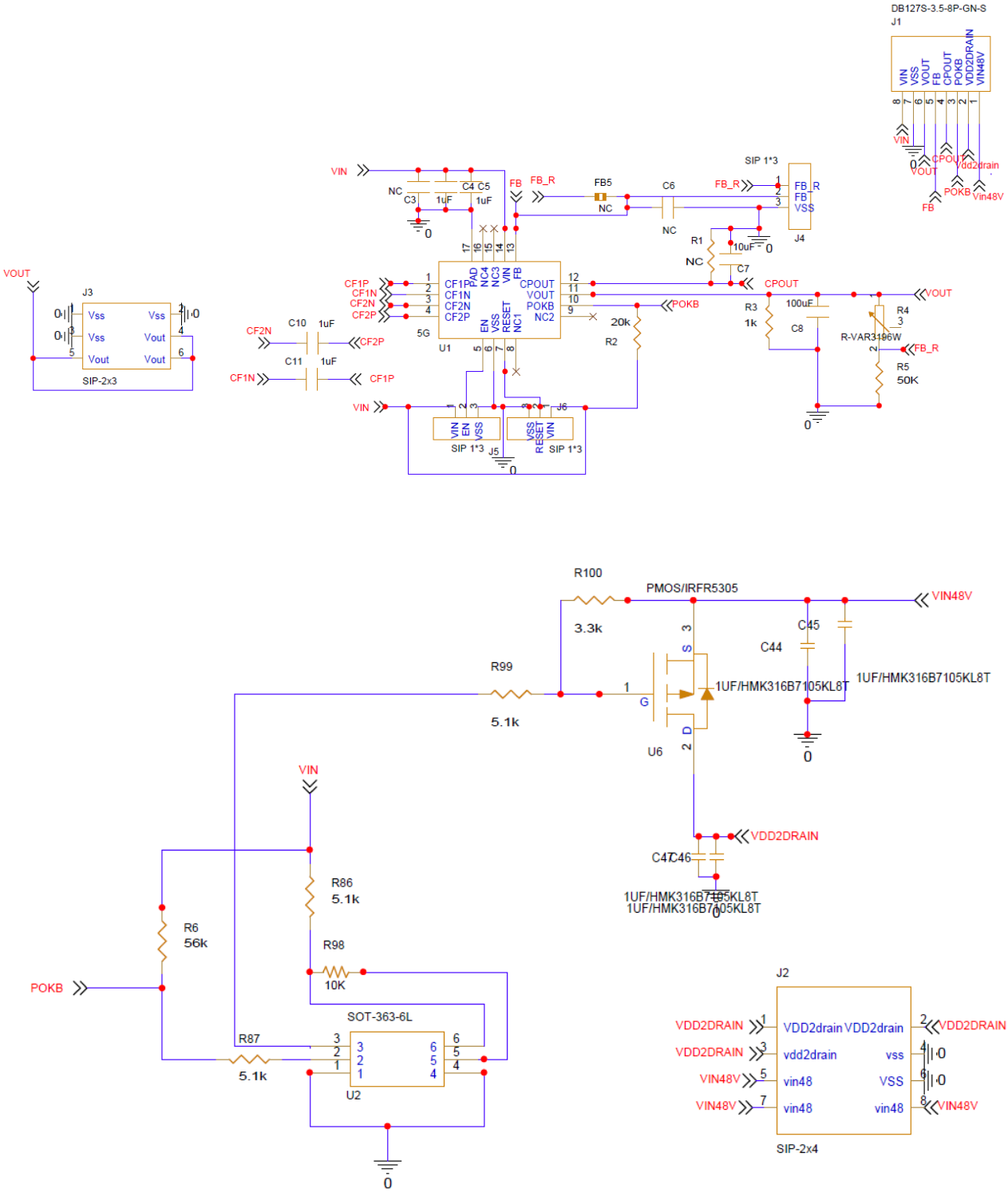
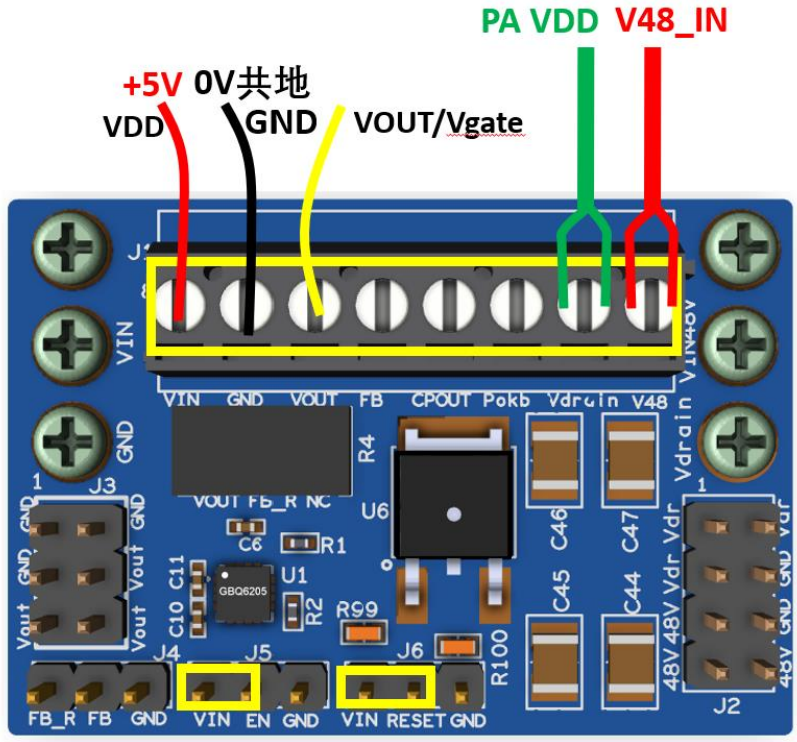
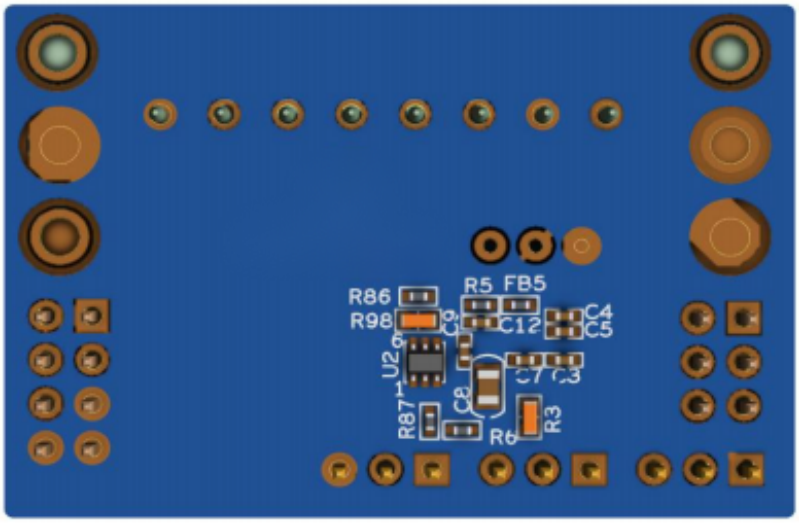


Figure 11. MCSBC6205 Evaluation Board Schematic



Top Layer



Bottom Layer

Figure 12. Evaluation board PCB information

Evaluation Board Bill of Materials (BOM)

Component	Description	Size
C10, C11, C4, C5	1uF cap	C0402
C8	10uF cap	C0805/C0603
C7	10uF	C0402
R4	50k	3296W
R3	1k	R0402
R5	5.1k	R0402
FB5	0ohm	R0402
J4, J5, J6	SIP 1*3	SIP3-2_54-S
U2	NPN(MMBT3904DW)	SOT-363-6L
U6	PMOS/ IRFR5305	TO-252
R86/87	5.1K	R0402
C44/45/45/47	1uF	HMK316B7105KL8T
R98	10k	R0402
R99	5.1k	R0603
R100	3.3k	R0603
R6	50K	R0402
J1	DB127S-3.5-8P-GN-S	SIP8-3_5
U1	C202DD	QFN3*3_16

Rest of the components on the schematic are not used in this part.

5.8 Evaluation board test procedure

5.8.1 Turn-on sequence

1. Connect power supply to the input (VIN) of Evaluation board and then connect DC ground, then use jumper to pull up EN/RESET to VIN. If we want to get a fixed VOUT=-2V，we can use jumper to connect FB to GND, if we want to get adjustable VOUT , we need to use jumper to connect FB to FB_R.
2. Turn on power supply to check input current and if POKB be pulled down, then measure VOUT, we can also rotate slide rheostat to get any voltage we require.
3. Apply VOUT to gate of PA device etc.
4. Attention: MCSBC6205 can't be powered on with high load current, while we can add load current after power on.

5.8.2 Turn-off sequence

1．Turn off power supply
2．Remove VOUT from gate of PA device

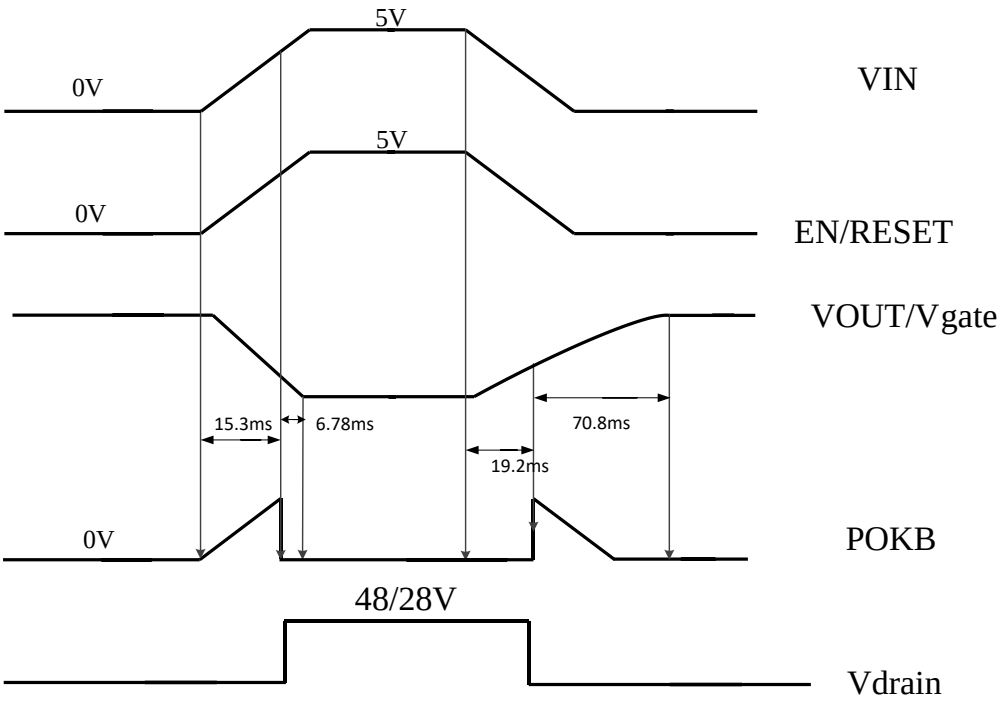
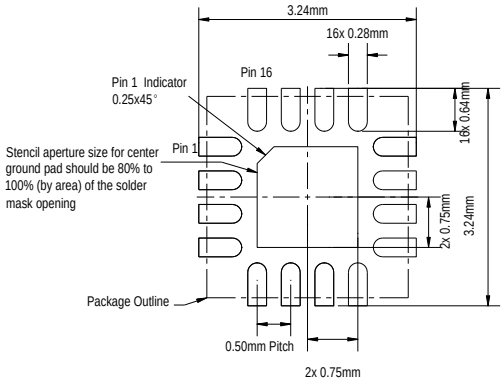
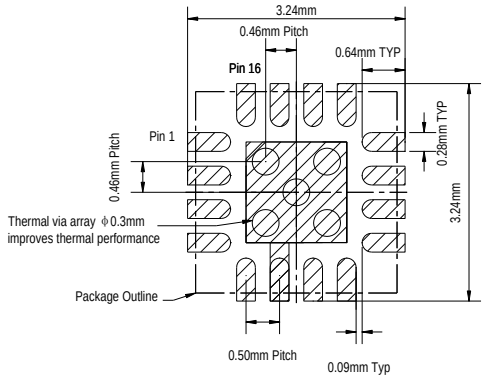


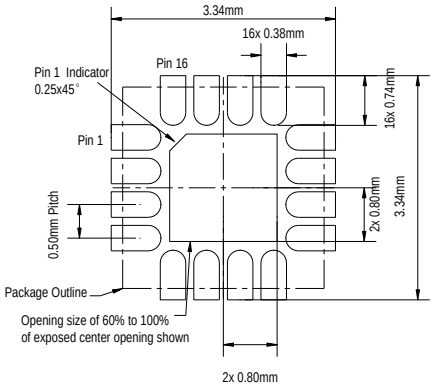
Figure 13. MCSBC6205 power on sequence



Stencil Aperture Top View



Metallization Top View



Solder Mask Opening Top View

Figure 14. MCSBC6205 PCB Layout Footprint

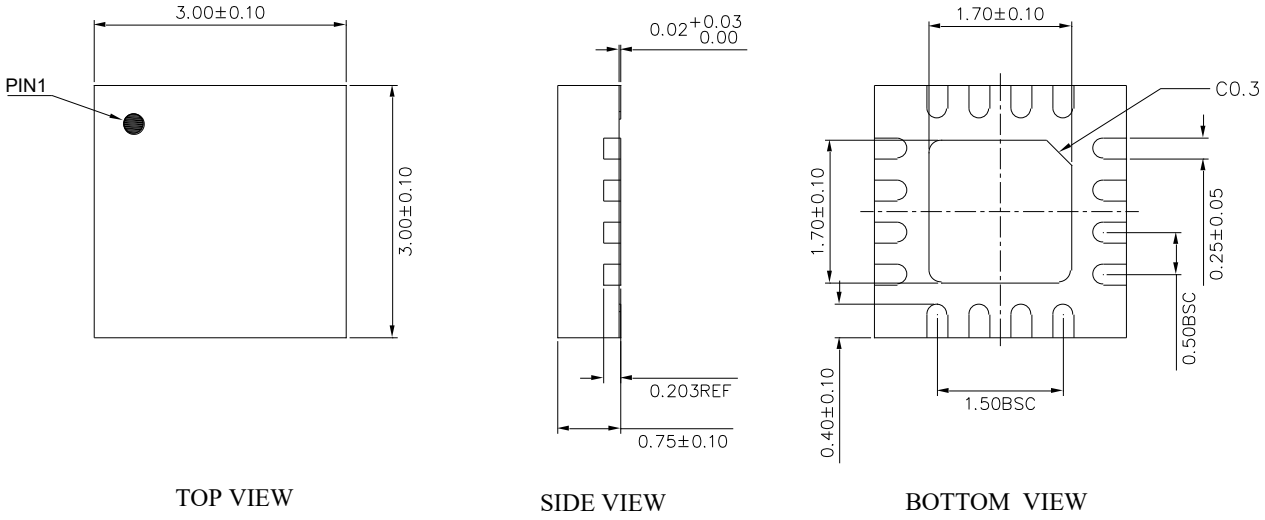


Figure 15. MCSBC6205 Package Dimensions

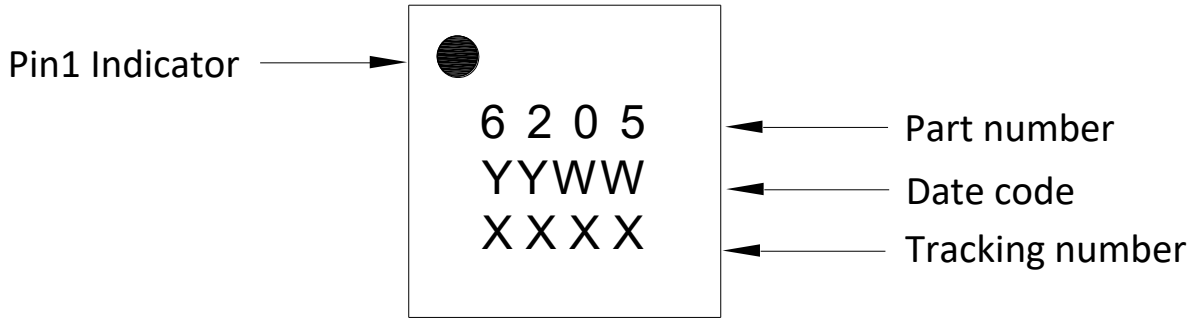


Figure 16. Typical Part Marking for the MCSBC6205

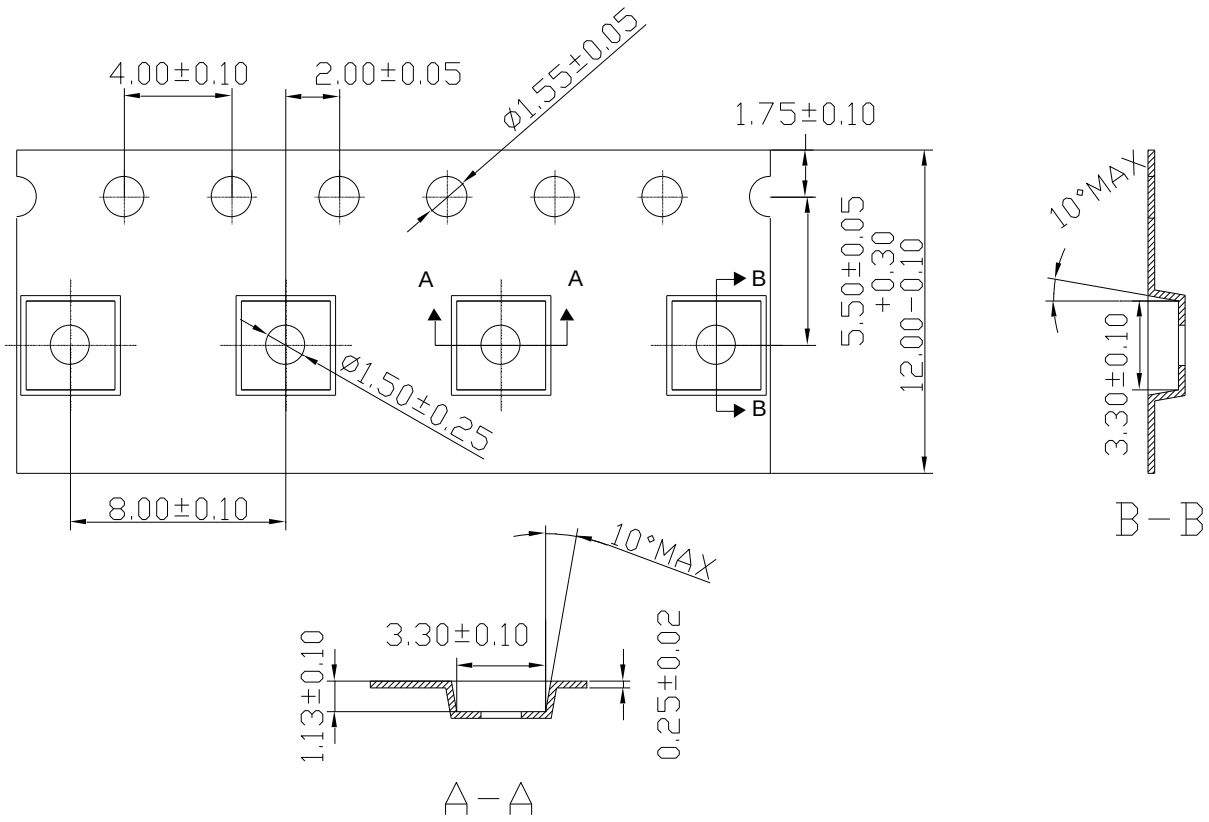


Figure 17. Tape and Reel Dimensions

Technical requirements：

1.The accumulative error of the distance between any 10 transmitting holes is ± 0.1 mm;

2.The lateral bending of the belt along the length direction is ≤1mm/100mm;

3.Roughness：Ra＜0.8um;

4.Carrier tape color:Black.