Application Guide for FBS-GAM01P-C-PSE and FSMD-B Demo Board (FBS 29-024)

EPC Space

August 17, 2020

ESD Precaution

Proper ESD precautions should be employed when handling the FBS-GAM01P-C-PSE and FSMD-B Demo Board to prevent damage to the components installed on the board.

Introduction

This document describes the recommended connection of the FBS-GAM01P-C-PSE and FSMD-B Demo Board (FBS 29-024) to power supplies and monitoring instruments for proper operation for the evaluation of the switching performance of the EPC Space single, low-side gate driver driving an associated power output HEMT.

This document also provides typical switching performance, the schematic of the evaluation board and the layout of the board in the form of layer-by-layer Gerber rendering of the evaluation printed circuit board.

Evaluation PCB Photograph

Figure 1a shows the top view and Figure 1b shows the bottom view of the FBS 29-024 Demo Board. These pictures illustrate the component placements, power and input signal connections and the numerous test points available for monitoring by the end-user:

Figure 1a. *FBS-GAM01P-C-PSE and FSMD-B Demo Board (Top View).*

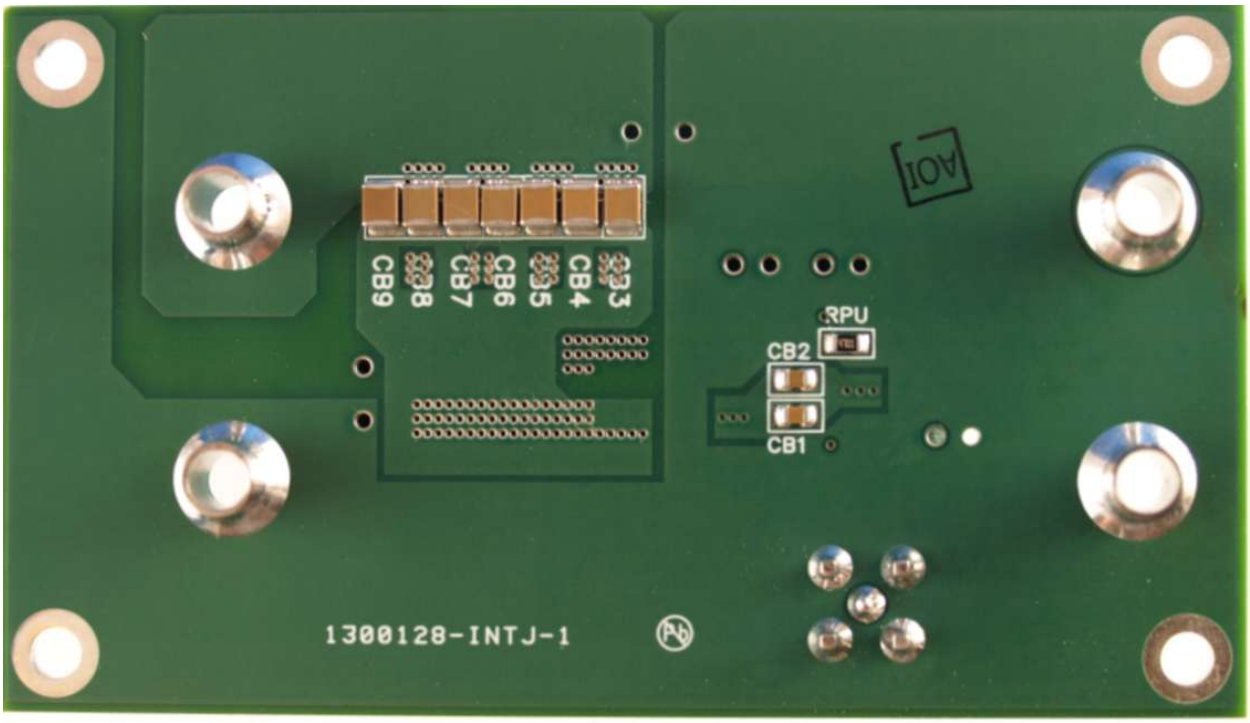

Figure 1b. *FBS-GAM01P-C-PSE and FSMD-B Demo Board (Bottom View).*

Description of Test Points

The description of each test point on the FBS 29-024 Demo Board is found in Table I.

TABLE I. FBS 29-024 Demo Board Test Point Identification.

Test Point	+/- Spacing (in.)	Parametric Measurement Location
TP1	0.100	PWM Input Signal Monitor.
TP2	0.100	Q1 Gate Signal Monitor.
TP3	0.150	Q1 Drain Signal Monitor.
TP4	0.150	VDD Signal. Monitor.
TP5	0.100	PG (Power Good) Monitor.

Each set of test points (signal to be measured as indicated by "+", and ground as indicated by "-") have the physical spacings shown in Table I so as to facilitate easy oscilloscope probing by the end-user.

IMPORTANT NOTE: The "-" side of each test point is connected to the ground potential (i.e. 0Vdc) of the Demo Board. ALWAYS make sure that the ground connection to the oscilloscope is connected to this point when power is applied to the board as damage may occur to the oscilloscope, the Demo Board or BOTH.

Recommended Test Equipment Connections

Figure 2 shows the recommended connection to/from the FBS 29-024 Demo Board.

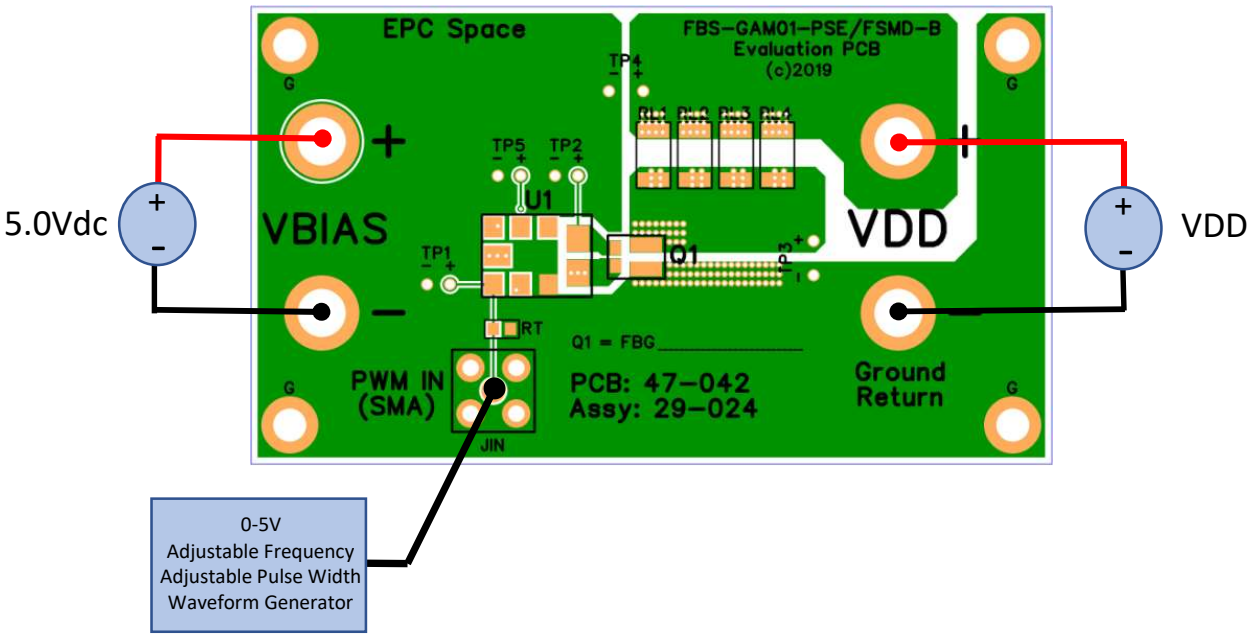

Figure 2. *FBS-GAM01P-C-PSE and FSMD-B Demo Board Test Equipment Connections.*

It is recommended that the connections to the Demo Board from the VBIAS (5.00V) and VDD power supplies be made with banana plug-to-banana plug cables. The connection from the pulse/frequency generator should be made via an SMA (board)-to-BNC (generator) cable.

Recommended Test Equipment

The following test equipment is recommended to properly evaluate the FBS-GAM01P-C-PSE and FSMD-B Demo Board:

0-100V, 1A adjustable DC power supply
0-10V, 100mA adjustable lab power supply set to 5.00Vdc
0-1MHz, 0-5V, adjustable duty cycle signal generator
500MHz two channel oscilloscope
Two 10:1 passive oscilloscope probes configured with 0.100” spacing between probe tip and ground.

VDD Settings and Load Resistor Values

There are three versions of the FBS 29-024 Demo Board: the first is a 40V version that utilizes an EPC7001B power HEMT for Q1; the second is a 100V version that utilizes the EPC7004B HEMT; and the third is a 200V version that utilizes the EPC7007B HEMT.

The Demo Board is configured to observe the switching performed at one-half the maximum rated BV_{DSS} of the HEMT used for Q1. The load resistors (RL1 through RL4 in Figure 2) are selected to provide approximately one-half the maximum rated load current draw at this one-half de-rated VDD supply voltage. The operating VDD levels versus HEMT used for Q1 versus the resultant load current are shown in Table II.

TABLE II. FBS 29-024 Demo Board EPC Space P/N vs Q1 Identity vs Load resistance vs Drain Current.

EPC Space P/N	Q1 HEMT	VDD (V)	Load Resistance (Ω)	ID (A)
FBS-S-203-20-008	EPC7001B	20	1.48	13.6
FBS-S-203-20-007	EPC7004B	50	3.25	15.4
FBS-S-203-20-009	EPC7007B	100	11	9

IMPORTANT NOTE: Due to the physical size and power rating limitations of the load resistors, it is required that the duty cycle of the ON-state test pulse provided to the FBS-GAM01P-PSE driver be limited to 2%, maximum, of the PWM switching frequency, for any frequency supplied to the Demo Board.

Typical Switching Performance

The following switching performance was obtained for each HEMT version of the Demo Board at 200kHz and 1% duty cycle. The parameters ON delay time ($t_{d(ON)}$), rise time (t_r), OFF delay time ($t_{d(OFF)}$) and fall time (t_f) are shown for each HEMT voltage version. All the following oscilloscope captures were obtained via TP1 (PWM In, yellow) and TP3 (Q1 Drain, blue). It should be noted that due to power supply availability circumstances that the 100V measurements were obtained with VDD = 90V.

EPC7001B, VDD = 20Vdc

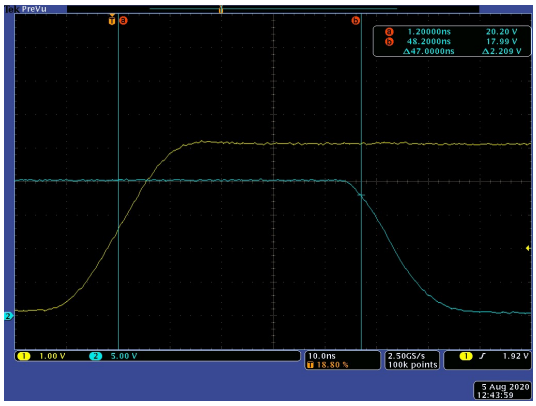

Figure 3. *EPC7001B* $t_{d(ON)}$

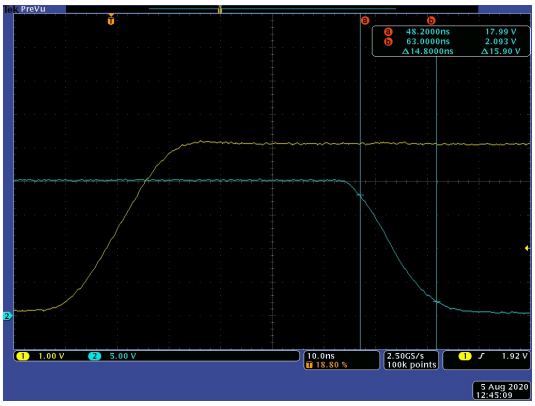

Figure 4. *EPC7001B* t_r

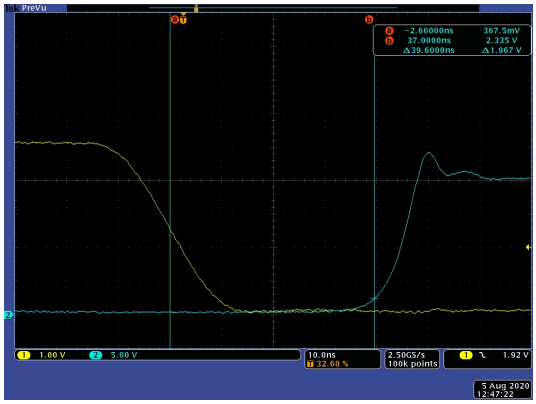

Figure 5. *EPC7001B* $t_{d(OFF)}$

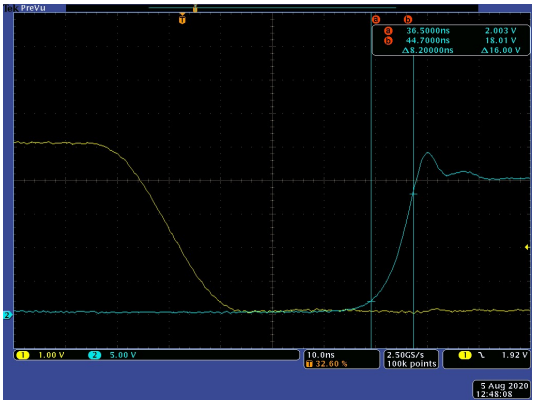

Figure 6. *EPC7001B* t_f

EPC7004B, VDD = 50Vdc

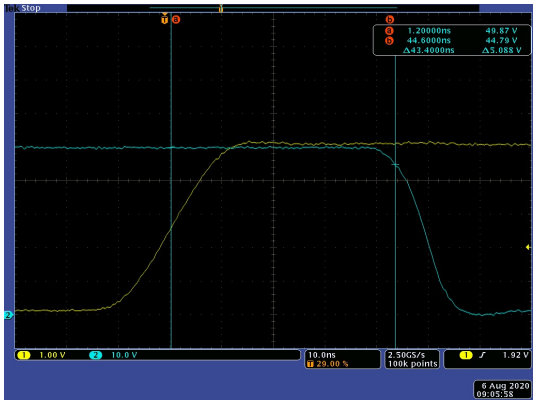

Figure 7. *EPC7004B* $t_{d(ON)}$

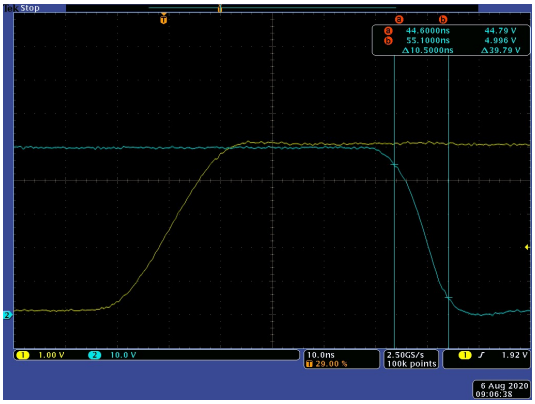

Figure 8. *EPC7004B* t_r

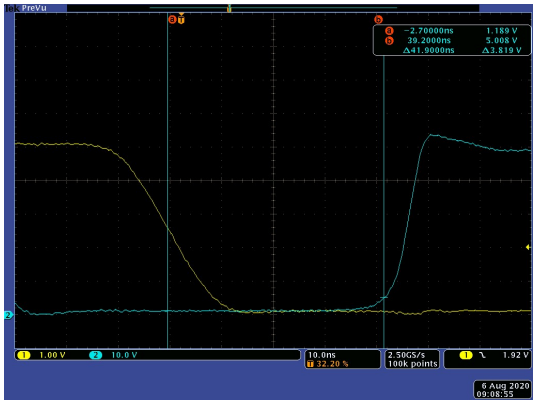

Figure 9. *EPC7004B* $t_{d(OFF)}$

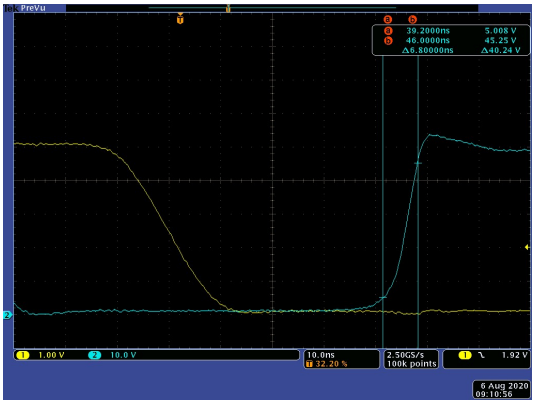

Figure 10. *EPC7004B* t_f

EPC7007B, VDD = 90Vdc

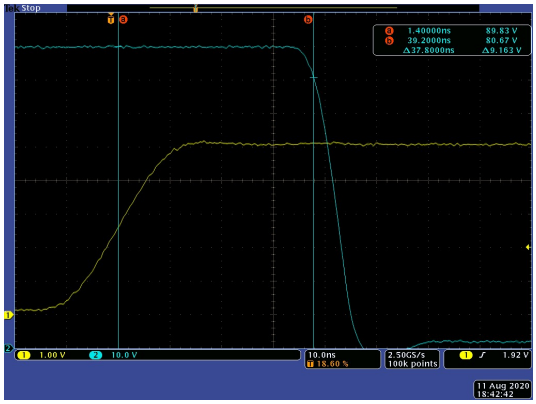

Figure 11. *EPC7007B* $t_{d(ON)}$

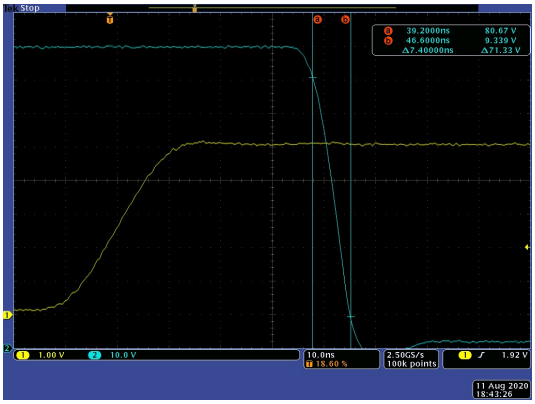

Figure 12. *EPC7007B* t_r

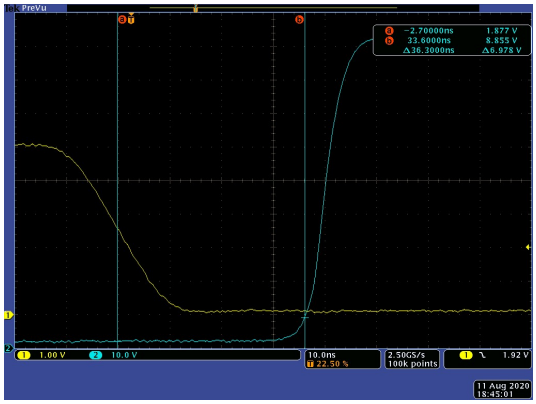

Figure 13. *EPC7007B* $t_{d(OFF)}$

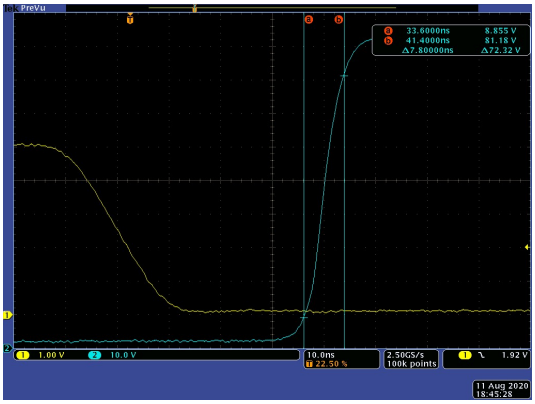

Figure 14. *EPC7007B* t_f

The switching performance obtained for each voltage variant is summarized in Table III:

Table III. Switching Performance Summary

EPC Space P/N	Q1 HEMT	$t_{d(ON)}$ (ns)	t_r (ns)	$t_{d(OFF)}$ (ns)	t_f (ns)
FBS-S-203-20-008	EPC7001B	47	14.8	39.6	8.2
FBS-S-203-20-007	EPC7004B	43.4	10.5	41.9	6.8
FBS-S-203-20-009	EPC7007B	37.8	7.4	36.3	7.8

In all of the previous oscilloscope captures, the ON-delay time is defined as the time difference between the PWM input rising to the 50% point and the time it takes for the Q1 drain voltage to fall to 90% of its peak value. The rise time is defined as the time difference between the time it takes the Q1 drain voltage to fall from 90% of the peak value to 10% of the peak value. The OFF-delay time is defined as the time difference between the PWM input falling to the 50% point and the time it takes for the Q1 drain voltage to rise to 10% of its peak value. Finally, the fall time is defined as the time difference between the time it takes the Q1 drain voltage to rise from 10% of the peak value to 90% of the peak value.

FBS-GAM01P-C-PSE and FSMD-B Demo Board Schematic

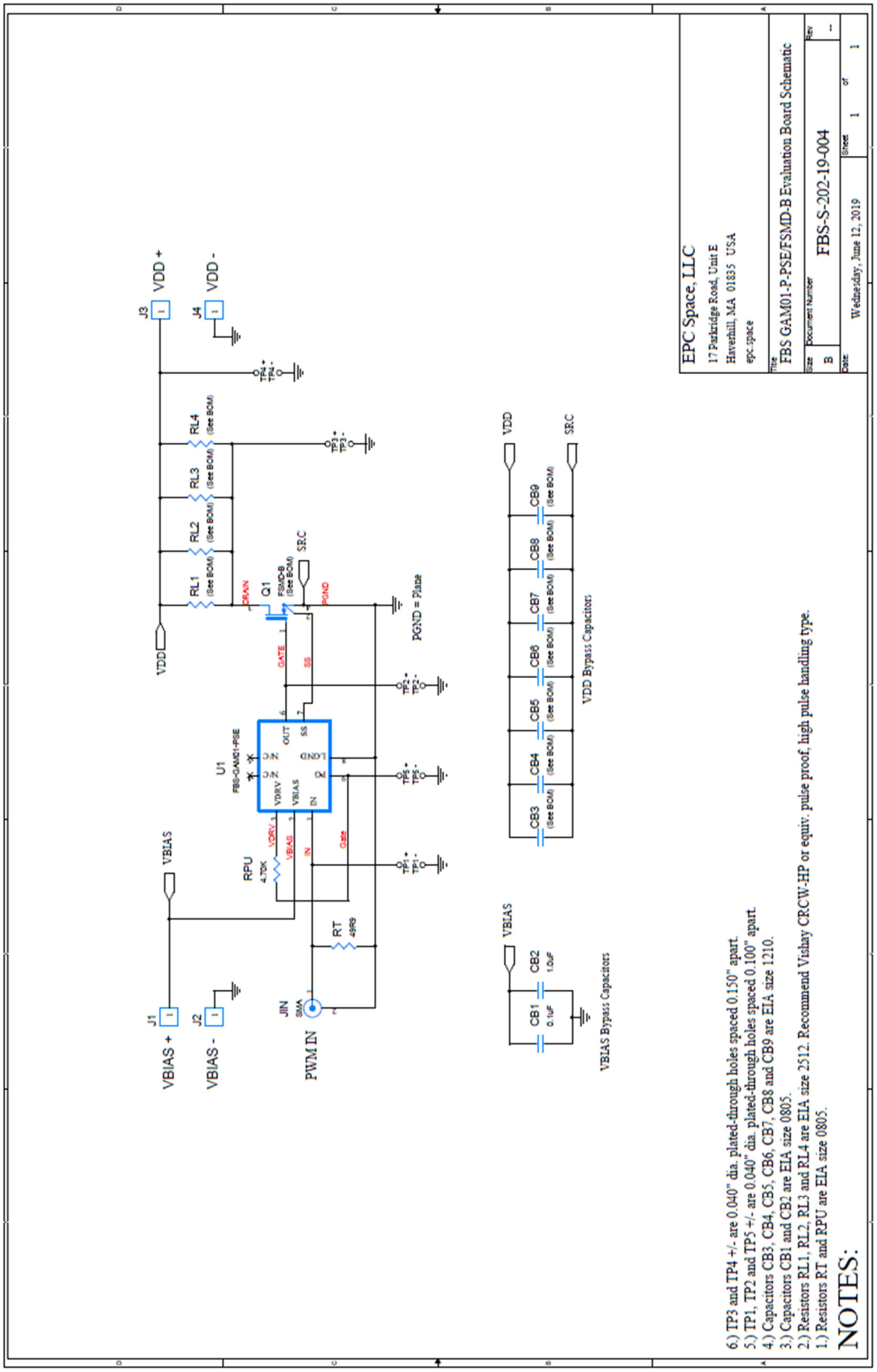

Figure 15. *FBS-GAM01P-C-PSE and FSMD-B Demo Board Schematic Diagram.*

FBS-GAM01P-C-PSE and FSMD-B Demo Board BOMS

The BOMs for the three voltage variants of the FBS-GAM01P-C-PSE and FSMD-B Demo Board are shown in Tables IV though VI. All passive components used are qualified to AEC-QXXX standards.

Table IV. FBS-S-203-013 (40V) BOM.

Item	Quantity	FBS P/N:	Description/Value	Ref. Des.	Number of components needed	Manufacturer	Manufacturer P/N
1	1	N/A	0.1uF/25V/X7R/10%/0805 Ceramic Capacitor	CB1	10	Kemet	C0805C104K3RACAUTO
2	1	N/A	1.0uF/25V/X7R/10%/0805 Ceramic Capacitor	CB2	10	Kemet	C0805C105K3RACAUTO
3	6	N/A	2.2uF/100V/X7R/10%/1210 Ceramic Capacitor	CB3,CB4,CB5, CB7,CB8,CB9	60	AVX	12101C225K4T4A
4	1	N/A	0.1uF/100V/X7R/10%/1210 Ceramic Capacitor	CB6	10	Kemet	C1210C104K1RACAUTO
5	1	N/A	SMA/Vertical/50 Ohms/Brass-Gold/SMT	JIN	10	Johnson/Cinch	142-0701-201
6	4	N/A	Through Hole Banana Jacks	J1,J2,J3,J4	10	Keystone	575-8
7	1	EPC7001B	40V/50A HEMT FSMD-B Package	Q1	10	EPCS	EPC7001B
8	1	N/A	0R0/1%/0603 Thick Film Chip Resistor (Zero Ohm Jumper)	RG	10	Vishay	CRCW06030000Z0EA
9	2	N/A	0L300/1%/2512 Low Value Metal Strip SMT Resistor	RH1,RH1	20	Vishay	WSLF2512L3000FEA
10	1	N/A	49R9/1%/0805 Thick Film Chip Resistor	RT	10	Panasonic	ERJ-P06F49R9V
11	1	N/A	4.70K/1%/0805 Thick Film Chip Resistor	RPU	10	Vishay	CRCW08054K70FKEAC
12	4	N/A	5R90 Ohm/1%/2512 High Power Thick Film Chip Resistor	RL1,RL2,RL3,RL4	40	Vishay	CRCW25125R90FKEGHP
13	1	FBS GAM01P-C-PSE	GAM01 Gate Driver	U1	10	EPCS	FBS GAM01P-C-50
14	4	N/A	0.5" Length/0.25" Width/#6-32 Threaded Standoff/Nylon 6-6	N/A	40	Keystone	1903C
15	4	N/A	0.25" Length/#6-32 Philips Head Screw/Nylon	N/A	40	Essentra	010632PW025
16	1	47-042	FBS GAM01-PSE/FSMD-B Evaluation PCB	N/A	10	Fab9	47-042

Table V. FBS-S-203-014 (100V) BOM.

Item	Quantity	FBS P/N:	Description/Value	Ref. Des.	Number of components needed	Manufacturer	Manufacturer P/N
1	1	N/A	0.1uF/25V/X7R/10%/0805 Ceramic Capacitor	CB1	10	Kemet	C0805C104K3RACAUTO
2	1	N/A	1.0uF/25V/X7R/10%/0805 Ceramic Capacitor	CB2	10	Kemet	C0805C105K3RACAUTO
3	6	N/A	0.22uF/200V/X7R/10%/1210 Ceramic Capacitor	CB3,CB4,CB5, CB7,CB8,CB9	60	TDK	CGJ6M3X7R2D224K200AA
4	1	N/A	0.1uF/200V/X7R/10%/1210 Ceramic Capacitor	CB6	10	TDK	CGJ6M3X7R2D104K200AA
5	1	N/A	SMA/Vertical/50 Ohms/Brass-Gold/SMT	JIN	10	Johnson/Cinch	142-0701-201
6	4	N/A	Through Hole Banana Jacks	J1,J2,J3,J4	10	Keystone	575-8
7	1	EPC7004B	100V/46A HEMT FSMD-B Package	Q1	10	EPCS	EPC7004B
8	1	N/A	0R0/1%/0603 Thick Film Chip Resistor (Zero Ohm Jumper)	RG	10	Vishay	CRCW06030000Z0EA
9	2	N/A	0L300/1%/2512 Low Value Metal Strip SMT Resistor	RH1,RH1	20	Vishay	WSLF2512L3000FEA
10	1	N/A	49R9/1%/0805 Thick Film Chip Resistor	RT	10	Panasonic	ERJ-P06F49R9V
11	1	N/A	4.70K/1%/0805 Thick Film Chip Resistor	RPU	10	Vishay	CRCW08054K70FKEAC
12	4	N/A	13R0 Ohm/1%/2512 High Power Thick Filk Chip Resistor	RL1,RL2,RL3,RL4	40	Vishay	CRCW251213R0FKEGHP
13	1	FBS GAM01P-C-PSE	GAM01 Gate Driver	U1	10	EPCS	FBS GAM01P-C-50
14	4	N/A	0.5" Length/0.25" Width/#6-32 Threaded Standoff/Nylon 6-6	N/A	40	Keystone	1903C
15	4	N/A	0.25" Length/#6-32 Philips Head Screw/Nylon	N/A	40	Essentra	010632PW025
16	1	47-042	FBS GAM01-PSE/FSMD-B Evaluation PCB	N/A	10	Sierra Ckts.	47-042

Table VI. FBS-S-203-015 (200V) BOM.

Item	Quantity	FBS P/N:	Description/Value	Ref. Des.	Number of components needed	Manufacturer	Manufacturer P/N
1	1	N/A	0.1uF/25V/X7R/10%/0805 Ceramic Capacitor	CB1	10	Kemet	C0805C104K3RACAUTO
2	1	N/A	1.0uF/25V/X7R/10%/0805 Ceramic Capacitor	CB2	10	Kemet	C0805C105K3RACAUTO
3	7	N/A	0.15uF/500V/X7R/10%/1210 Ceramic Capacitor	CB3,CB4,CB5, CB7,CB8,CB9	70	KEMET	C1210V154KCRACTU
4	1	N/a	0.047uF/500V/X7R/10%/1210 Ceramic Capacitor	CB6	10	KEMET	C1210C473KCRACAUTO
5	1	N/A	SMA/Vertical/50 Ohms/Brass-Gold/SMT	JIN	10	Johnson/Cinch	5-1814832-1
6	4	N/A	Through Hole Banana Jacks	J1,J2,J3,J4	10	Keystone	575-8
7	1	EPC7007B	200V/18A HEMT FSMD-B Package	Q1	10	EPCS	EPC7007B
8	1	N/A	0R0/1%/0603 Thick Film Chip Resistor (Zero Ohm Jumper)	RG	10	Vishay	CRCW06030000Z0EA
9	2	N/A	0L300/1%/2512 Low Value Metal Strip SMT Resistor	RH1,RH1	20	Vishay	WSLF2512L3000FEA
10	1	N/A	49R9/1%/0805 Thick Film Chip Resistor	RT	10	Panasonic	ERJ-P06F49R9V
11	1	N/A	4.70K/1%/0805 Thick Film Chip Resistor	RPU	10	Vishay	CRCW08054K70FKEAC
12	4	N/A	44R2 Ohms/1%/2512 Thick Filk Chip Resistor	RL1,RL2,RL3,RL4	40	Vishay	CRCW251244R2FKEG
13	1	FBS GAM01P-C-PSE	GAM01 Gate Driver	U1	10	EPCS	FBS GAM01P-C-50
14	4	N/A	0.5" Length/0.25" Width/#6-32 Threaded Standoff/Nylon 6-6	N/A	40	Keystone	1903C
15	4	N/A	0.25" Length/#6-32 Philips Head Screw/Nylon	N/A	40	Essentra	010632PW025
16	1	47-042	FBS GAM01-PSE/FSMD-B Evaluation PCB	N/A	10	Sierra Ckts.	47-042

Demo Board Modifications and "Cut In's"

It is encouraged that end-users modify the load resistors and bypass capacitors to suit their application operating parameters. Other loads, such as inductors and transformers may be "cut into" the PCB in order to allow the GaN-driving-GaN GAM01P-C-PSE and FSMD-B gate driver and power HEMT tandem be used to obtain operating performance in the end-user's actual application.