

SPOC™+2 12V

SPI Power Controller

EMC Test Report V1.2

Index

General	3
General Test Condition	3
External Components used for Measurement Methods	4
1. Conducted Immunity - Direct Power Injection	5
Hardware Test Setup	6
DPI test results global IC pin Vs, driven by SPI	7
DPI test results global IC pin Vs, driven by SPI	8
DPI test results global IC pin OUT0, driven by SPI	9
DPI test results global IC pin OUT1, driven by SPI	10
DPI test results global IC pin OUT2, driven by SPI	11
DPI test results global IC pin OUT3, driven by SPI	12
DPI test results global IC pin Vs, driven by input pins	13
DPI test results global IC pin OUT0, driven by input pins	14
DPI test results global IC pin OUT1, driven by input pins	15
DPI test results global IC pin OUT2, driven by input pins	16
DPI test results global IC pin OUT3, driven by input pins	17
2. Conducted Emission - 150Ω Direct Coupling Method	18
Hardware Test Setup	18
Test results 150Ω method for global IC pin Vs, driven by SPI, normal & slow SR	19
Test results 150Ω method, global IC pin OUT0, driven by SPI, norm. & slow SR	20
Test results 150Ω method, global IC pin OUT2, driven by SPI, norm. & slow SR	21
Test results 150Ω method for global IC pin Vs, driven by inputs, normal SR	22
Test results 150Ω method, global IC pin OUT0, driven by inputs, normal SR	23
Test results 150Ω method, global IC pin OUT1, driven by inputs, normal SR	24
Test results 150Ω method, global IC pin OUT2, driven by inputs, normal SR	25
Test results 150Ω method, global IC pin OUT3, driven by inputs, normal SR	26
3. Conducted Emission - Voltage Method (LISN)	27
Hardware Test Setup	27
Test result – LISN method, normal slew rate	28
Test result – LISN method, slow slew rate	29
4. Time Domain Measurement.....	30
Hardware Test Setup	30
Measurement Result - Time Domain OUT0, normal slew rate	31
Measurement Result - Time Domain OUT0, slow slew rate	32
Measurement Result - Time Domain OUT1, normal slew rate	33
Measurement Result - Time Domain OUT1, slow slew rate	34
Measurement Result - Time Domain OUT2, normal slew rate	35
Measurement Result - Time Domain OUT2, slow slew rate	36
Measurement Result - Time Domain OUT3, normal slew rate	37
Measurement Result - Time Domain OUT3, slow slew rate	38
5. Conducted Immunity - Transient Disturbances.....	39
Hardware Test Setup	39
Measurement Result - Test pulses applied to VS	40
Classification of the Transient Test Levels	41
Test Pulse Definition for the 12V System.....	42

General

Device under Test: BTS71220-4ESx (L8431)
Date code: GE805 / GE808
Design step: J21 / J61
Lot number: ZF802193.04
Description: High Side Switch w. Diagnosis and Embedded Protection, 2x 9.5 mΩ, 2x 22.5 mΩ

General Test Condition

Temperature:	23°±5C
Supply voltage:	V _{Bat} =+13.5V; V _{In} = +5V; V _{DD} = +5V or +3.3V
Kind of load:	3.3Ω / 55W Bulb each Bulb mode Out0, Out3 6.8Ω / 27W Bulb Bulb mode Out1, OUT2
Operation mode:	OFF; ON, PWM Operation Frequency: 100Hz Duty Cycle: 50%/80% <u>V_S test:</u> OFF, ON, PWM; switching signal provided by SPI commands or input pins; <u>OUT test:</u> OFF, ON, PWM; switching signal provided by SPI commands or input pins; <u>V_{DD} test:</u> OFF, PWM; switching signal provided by SPI commands or input pins; LHi to GND or to +5V
DUT Specific:	GND connection = resistor 47Ω (0805) from GND-Pin to module GND LHi with 4.7 kΩ (0805) to GND or +5V, VDD Pin with 470nF (X7R 0805) to chip GND and serial resistor of 470Ω (0805) to +5V or +3.3V R1 _{In1} -R1 _{In4} =4.7kΩ (0805) R1_SO, R1_SI, R1_SCLK and R1_CS=1.2kΩ (0805) C1 _{In1} -C1 _{In4} not placed All elements with <xx> value not placed if not otherwise specified below. As external decoupling capacitors a ceramic 100nF 0805 X7R between V _S and module ground and a ceramic 10nF 0805 X7R between the outputs and module ground were used.

EMC Test Schematic:

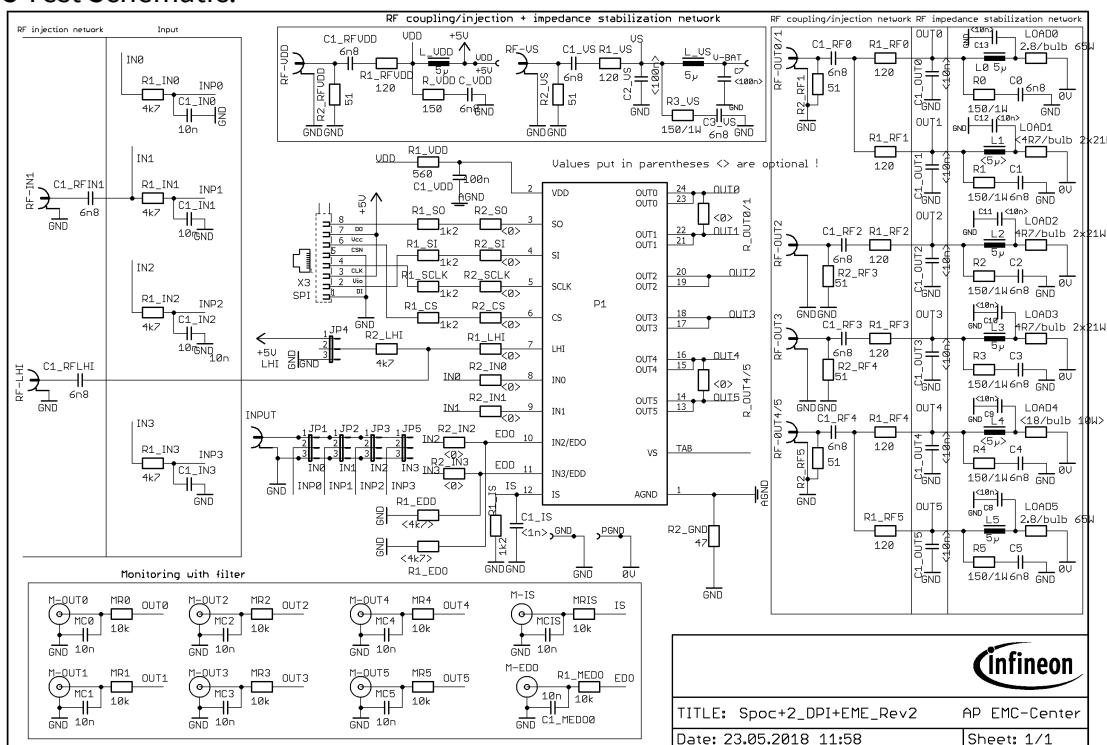


Figure 1 Schematic for DPI and Emission tests

External Components used for Measurement Methods

DPI measurement

VS	R2_VS	open	R1_VS	0Ω	C1_VS	6.8nF	R3_VS	150Ω	C3_VS	6.8nF	L_VS	5uH
OUT0	R2_RF0	open	R1_RF0	0Ω	C1_RF0	6.8nF	R0	150Ω	C0	6.8nF	L0	5uH
OUT0	R_OUT0/1	0Ω	R1_RF1	open			R1	open	C1	open	L1	open
OUT1	R2_RF3	open	R1_RF2	0Ω	C1_RF2	6.8nF	R2	150Ω	C2	6.8nF	L2	5uH
OUT2	R2_RF4	open	R1_RF3	0Ω	C1_RF3	6.8nF	R3	150Ω	C3	6.8nF	L3	5uH
OUT3	R2_RF5	open	R1_RF4	0Ω	C1_RF4	6.8nF	R4	150Ω	C4	6.8nF	L4	5uH
OUT3	R_OUT4/5	0Ω	R1_RF5	open			R5	open	C5	open	L5	open

150Ω measurement

VS	R2_VS	51Ω	R1_VS	120Ω	C1_VS	6.8nF	R3_VS	open	C3_VS	open	L_VS	5uH
OUT0	R2_RF0	51Ω	R1_RF0	120Ω	C1_RF0	6.8nF	R0	open	C0	open	L0	5uH
OUT0	R_OUT0/1	0Ω	R1_RF1	open			R1	open	C1	open	L1	open
OUT1	R2_RF3	51Ω	R1_RF2	120Ω	C1_RF2	6.8nF	R2	open	C2	open	L2	5uH
OUT2	R2_RF4	51Ω	R1_RF3	120Ω	C1_RF3	6.8nF	R3	open	C3	open	L3	5uH
OUT3	R2_RF5	51Ω	R1_RF4	120Ω	C1_RF4	6.8nF	R4	open	C4	open	L4	5uH
OUT3	R_OUT4/5	0Ω	R1_RF5	open			R5	open	C5	open	L5	open

LISN measurement

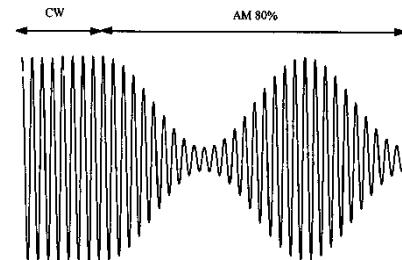
VS	R2_VS	open	R1_VS	open	C1_VS	open	R3_VS	open	C3_VS	open	L_VS	bridged
OUT0	R2_RF0	open	R1_RF0	open	C1_RF0	open	R0	150Ω	C0	6.8nF	L0	5uH
OUT0	R_OUT0/1	0Ω	R1_RF1	open			R1	open	C1	open	L1	open
OUT1	R2_RF3	open	R1_RF2	open	C1_RF2	open	R2	150Ω	C2	6.8nF	L2	5uH
OUT2	R2_RF4	open	R1_RF3	open	C1_RF3	open	R3	150Ω	C3	6.8nF	L3	5uH
OUT3	R2_RF5	open	R1_RF4	open	C1_RF4	open	R4	open	C4	open	L4	open
OUT3	R_OUT4/5	0Ω	R1_RF5	open			R5	150Ω	C5	6.8nF	L5	5uH

1. Conducted Immunity - Direct Power Injection

References: ISO 11452-7 12-95; IEC 62132-3 01-00

Disturbance signal

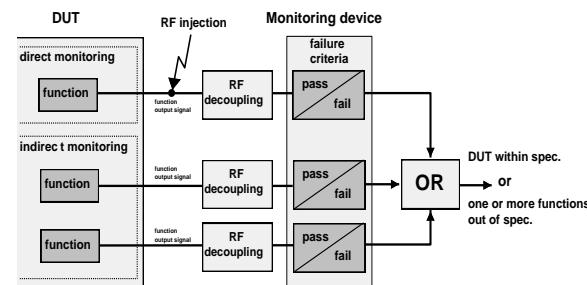
Forward Power	17 / 37dBm
Modulation:	CW
	AM (80%, 1kHz sine wave, $P_{\text{peak AM}} = P_{\text{peak CW}}$)
Frequency range:	1MHz - 1GHz
Frequency step size:	0.5MHz (1-10MHz) 1MHz (10-100MHz) 2MHz (100-200MHz) 4MHz (200-400MHz) 10MHz (400-1000MHz)
Power step size:	0.2dB
Step Time:	ts=1s



DUT monitoring

The monitored signals are combined to a logical sum "within specification or out of specification" as shown in the figure.

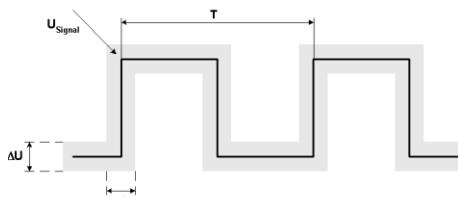
As monitoring device an oscilloscope with a programmable signal tolerance mask is used. To prevent the monitoring device from the disturbance a RF decoupling filter is necessary.



Failure criteria

The signal tolerance mask is defined by the nominal value and the period of the signal plus the allowed tolerances specified in %.

$$\Delta U > U_{\text{Signal}} \pm 10\% \text{ or} \\ \Delta t > T \pm 5\%$$

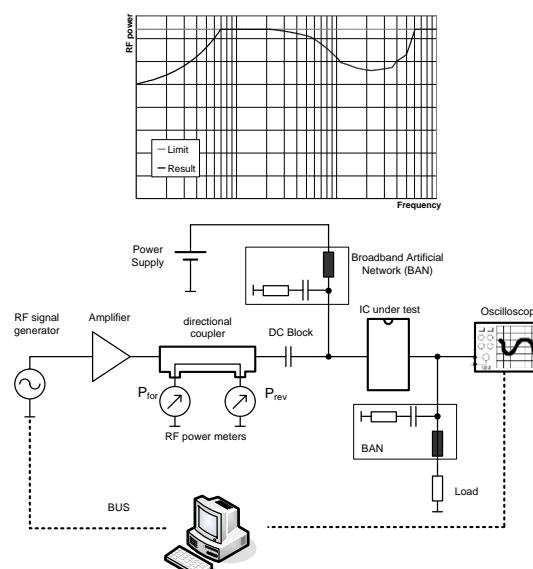


Typical diagram

The graph in the immunity diagram shows the value of the maximum injected RF power to a pin up to that the DUT operates without any failure. The maximum RF power to apply is defined by the limit line.

Test setup

A signal generator is used to provide the disturbance signal that is further amplified. A directional coupler and a power meter are used to measure the actual forward power that is coupled to the IC under test. The DC supply and the load are connected to broadband artificial networks. To monitor the behaviour of the IC measurement devices (e.g. oscilloscopes) are used.



Hardware Test Setup

Operation modes

1 OFF

2 ON

3 PWM 100Hz 50% driven by SPI commands or input pins, ISx activated (LHI=GND) or LHI=+5V

Load

Load 0 and 3	3.3Ω	Bulb mode
Load 1 and 2	6.8Ω	Bulb mode

Monitoring

OUT0, OUT1, OUT2, OUT3, ISense

Table 1 DPI test table

Injection point		Operation mode	Monitoring	Forward power [dBm] w/o modulation (CW)	Comment/ Condition
Pin					
Name	Function				
RF-V _s	Supply	1,2,3	OUT0-3, ISense	37 dBm, CW	with 100nF@Vs, 10nF@Outputs
RF- OUT0	HS	1,2,3	OUT0-3, ISense	37 dBm, CW	with 100nF@Vs, 10nF@Outputs
RF-OUT1	HS	3	OUT0-3, ISense	37 dBm, CW	with 100nF@Vs, 10nF@Outputs
RF_OUT2	HS	1,2,3	OUT0-3, ISense	37 dBm, CW	with 100nF@Vs, 10nF@Outputs
RF_OUT3	HS	3	OUT0-3, ISense	37 dBm, CW	with 100nF@Vs, 10nF@Outputs

DPI test results global IC pin V_s , driven by SPI

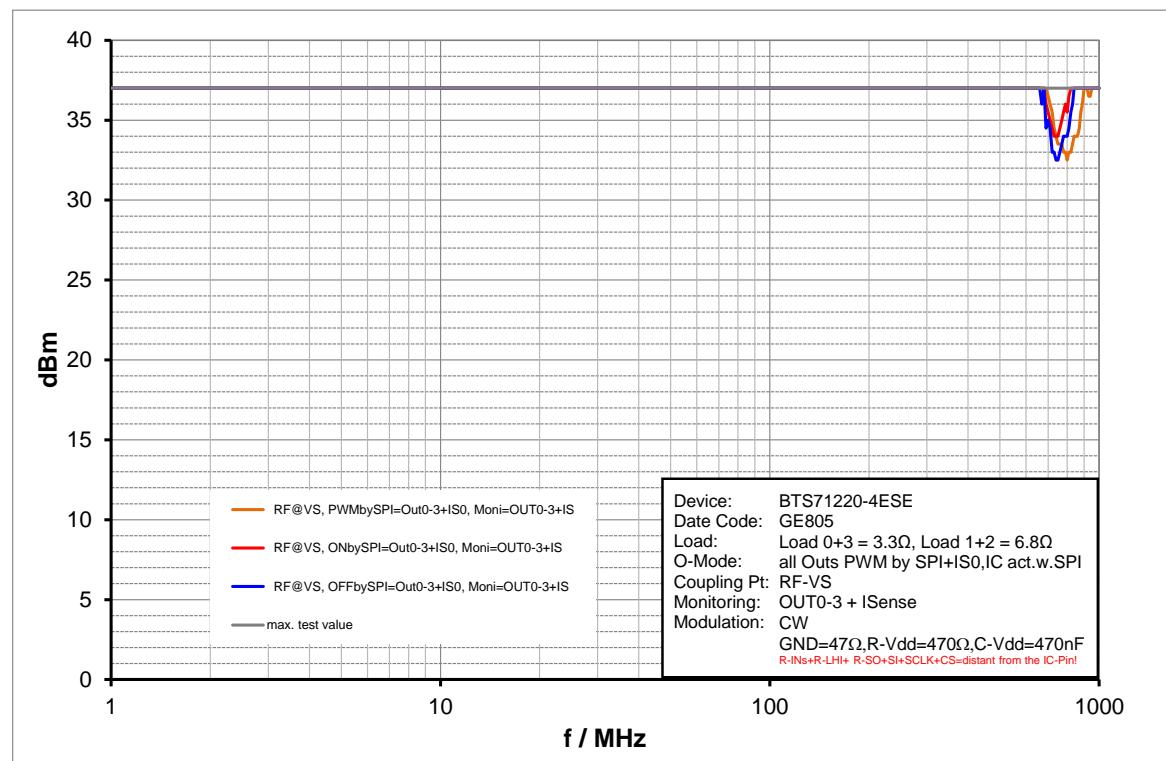


Figure 2 RF injection into connector RF- V_s , PWM -state OUT0-3,
DUT driven by SPI, ISense0 activated, monitoring outputs and ISense,
with external capacitors 100nF @ V_s to module GND, 10nF @ Outputs to module GND

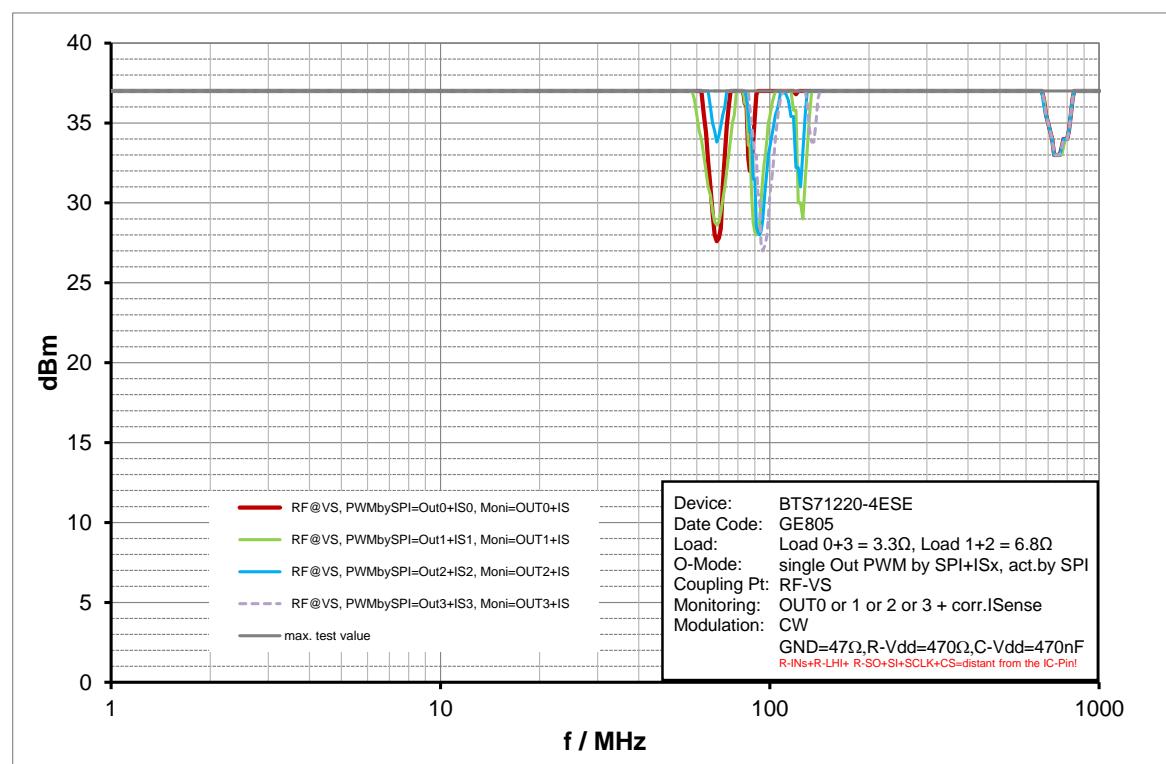


Figure 3 RF injection into connector RF- V_s , single PWM-state of one channel by SPI, others off,
ISenseX activated, monitoring outputs and ISense,
with external capacitors 100nF @ V_s to module GND, 10nF @ Outputs to module GND

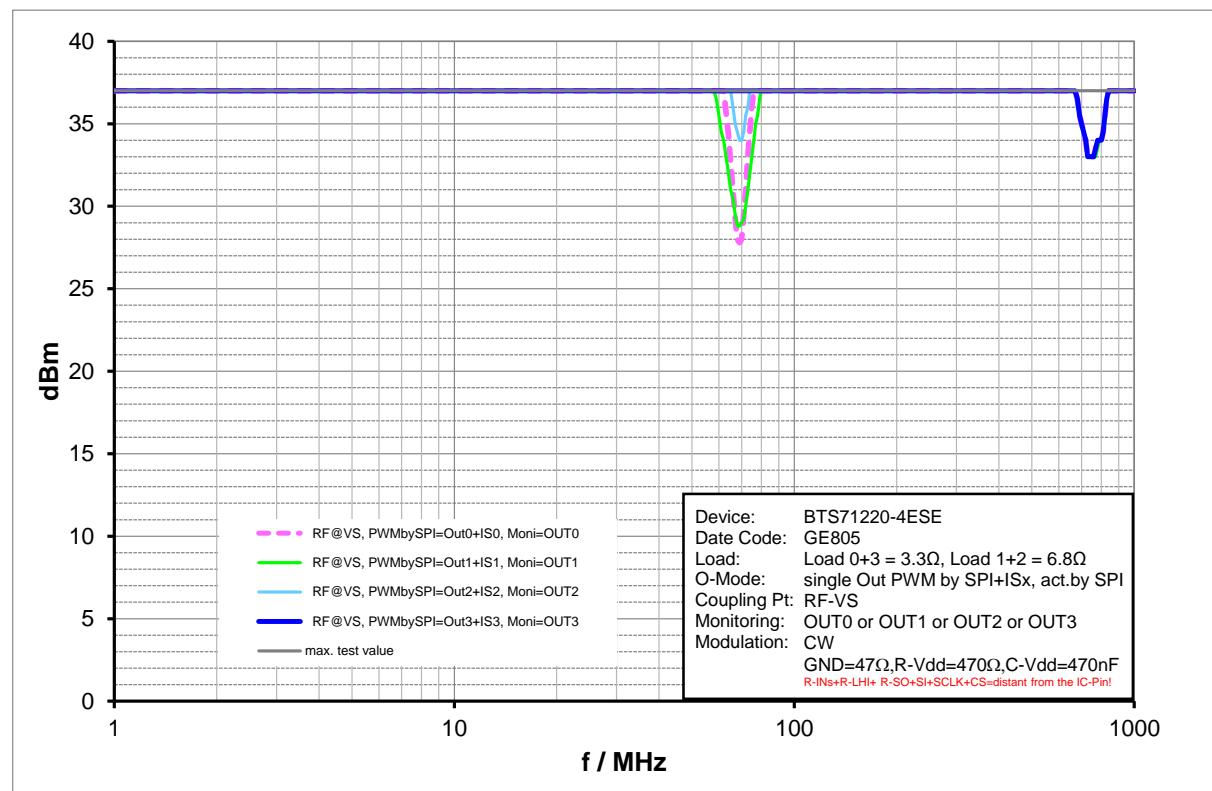
DPI test results global IC pin Vs, driven by SPI


Figure 4 RF injection into connector RF-Vs, single PWM-state of one channel by SPI, others off, ISenseX activated, monitoring outputs only, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

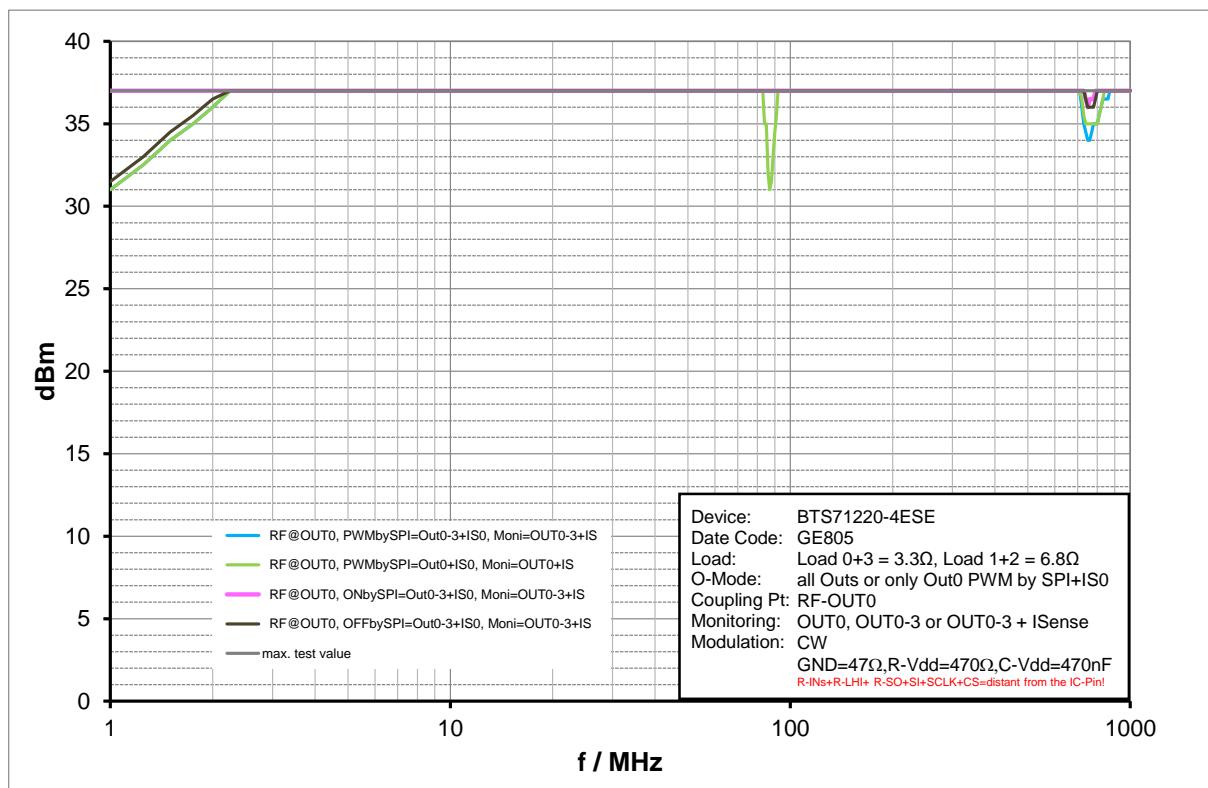
DPI test results global IC pin OUT0, driven by SPI


Figure 5 RF injection into connector RF-OUT0, PWM -state OUT0 only or OUT0-3,
 DUT driven by SPI, ISense0 activated, monitoring outputs and ISense,
 with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

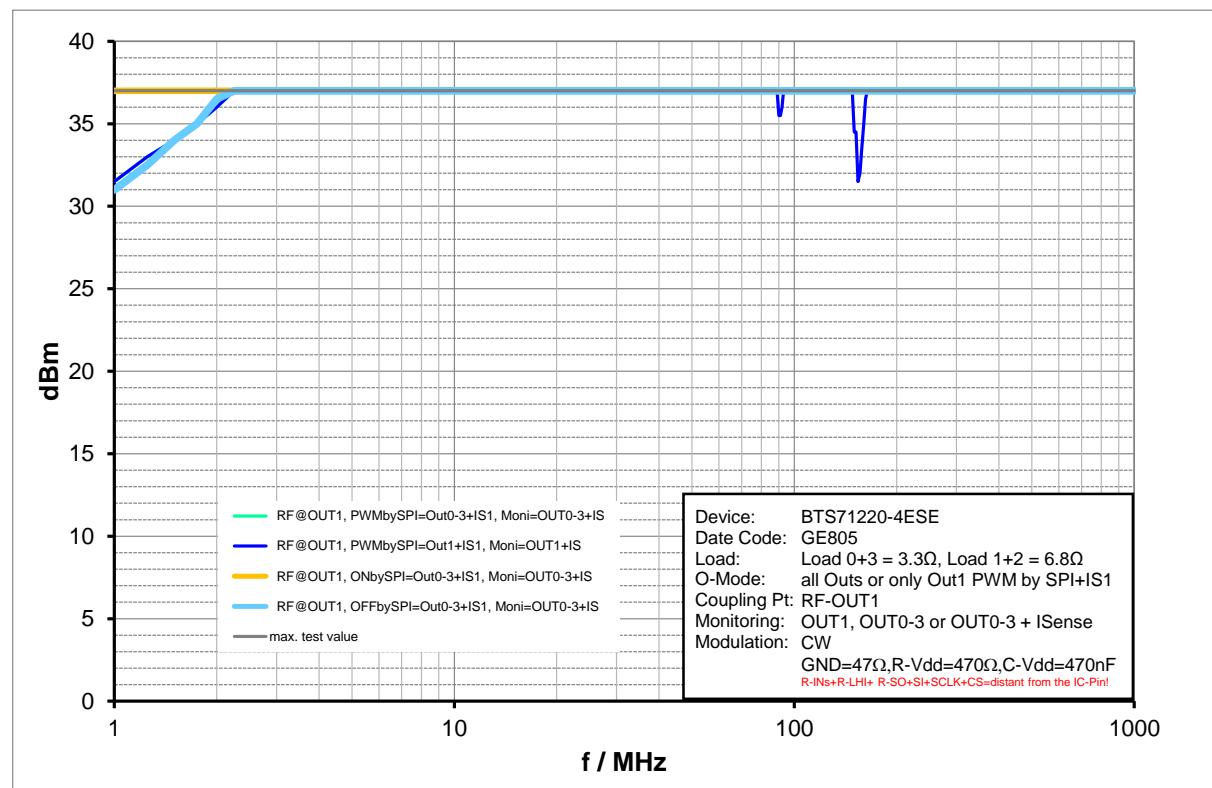
DPI test results global IC pin OUT1, driven by SPI


Figure 6 RF injection into connector RF-OUT1, PWM -state OUT1 or OUT0-3,
 DUT driven by SPI, ISense1 activated, monitoring outputs and ISense,
 with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

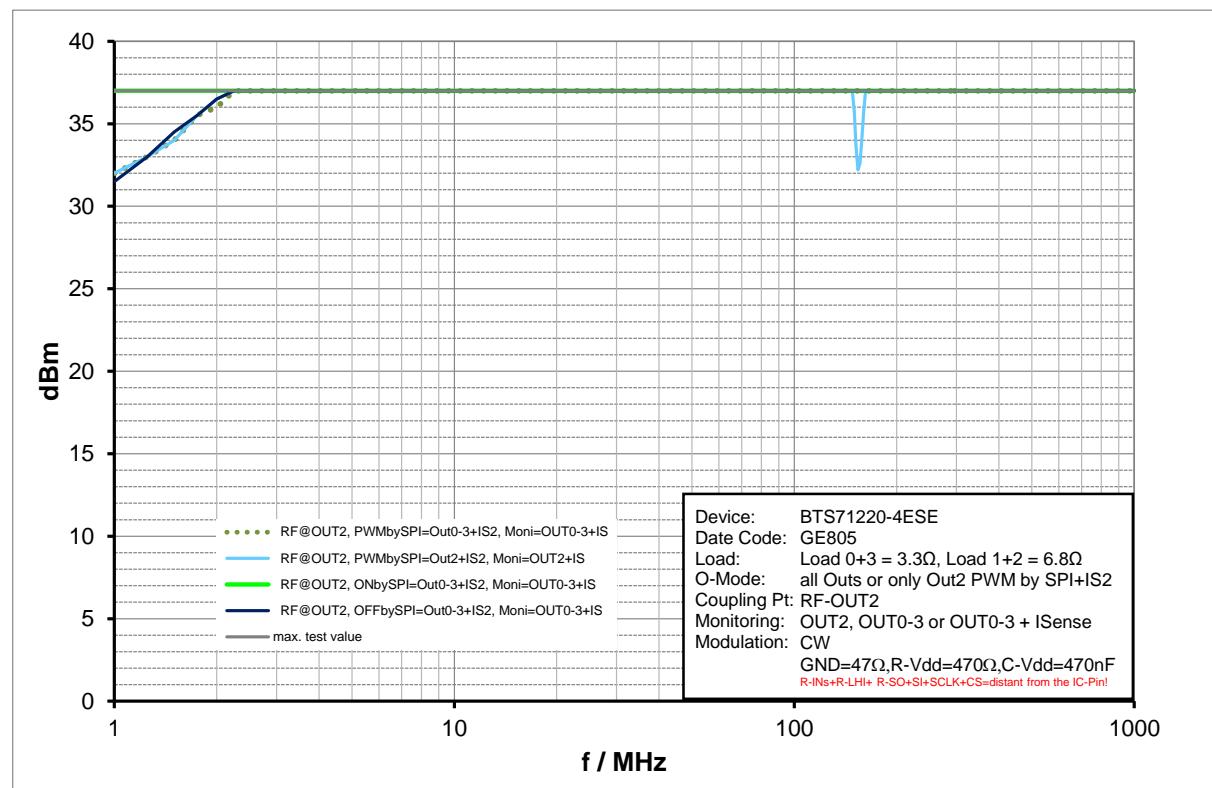
DPI test results global IC pin OUT2, driven by SPI


Figure 7 RF injection into connector RF-OUT2, PWM -state OUT2 or OUT0-3, DUT driven by SPI, ISense2 activated, monitoring outputs and ISense, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

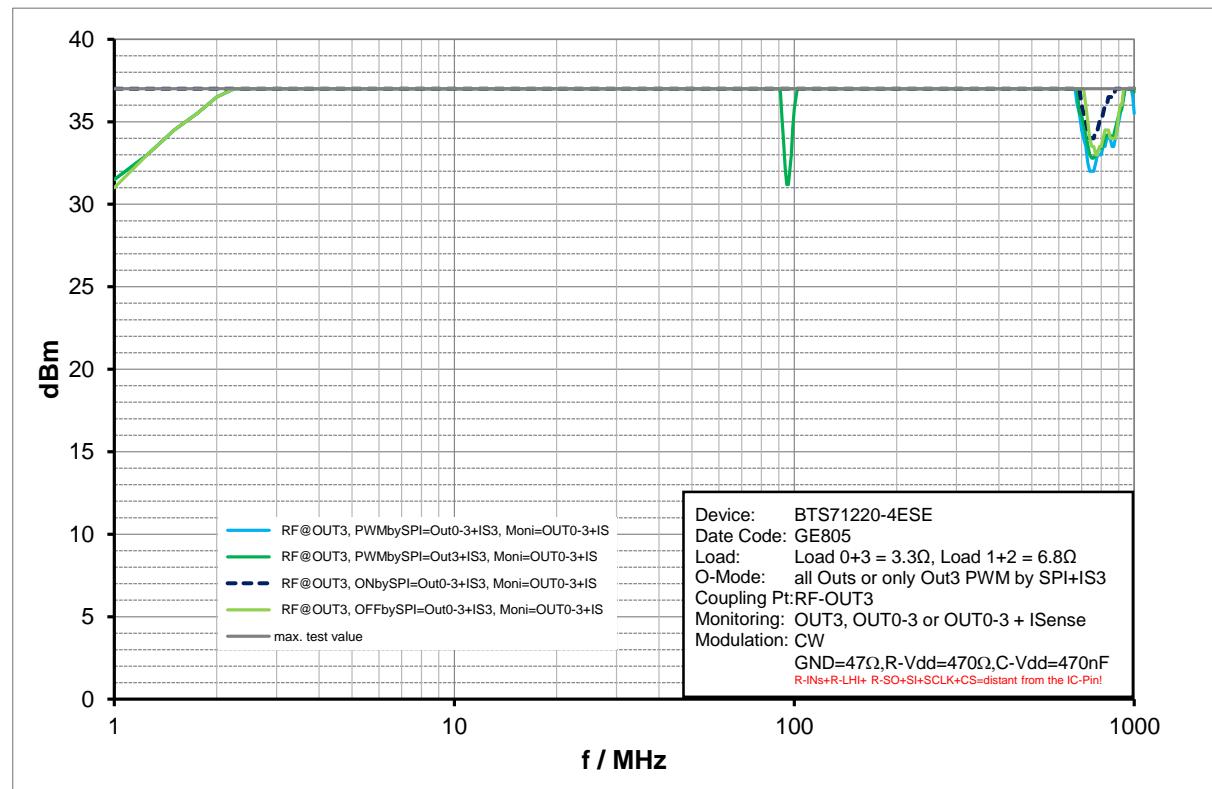
DPI test results global IC pin OUT3, driven by SPI


Figure 8 RF injection into connector RF-OUT3, PWM -state OUT3 or OUT0-3,
 DUT driven by SPI, ISense3 activated, monitoring outputs and ISense,
 with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

DPI test results global IC pin Vs, driven by input pins

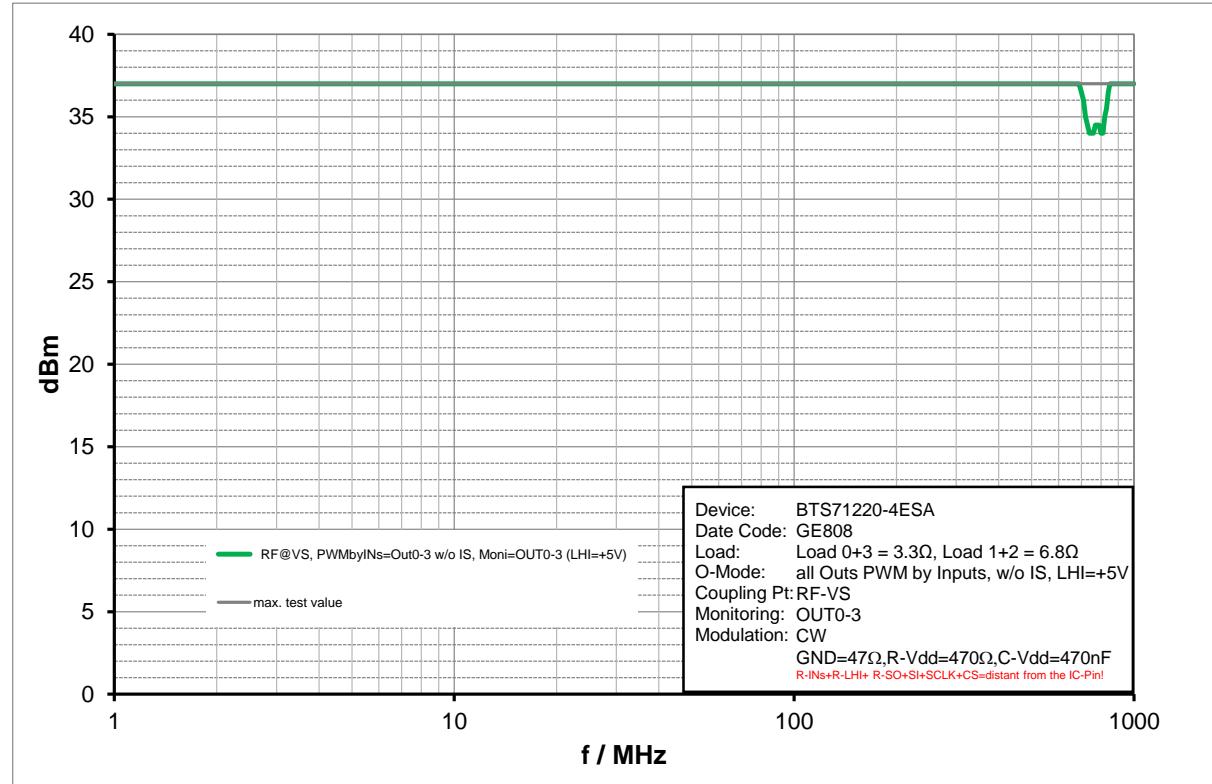


Figure 9 RF injection into connector RF-Vs, PWM-state OUT0-3, DUT driven by inputs, no ISense activated, LHI=+5V, monitoring outputs only, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

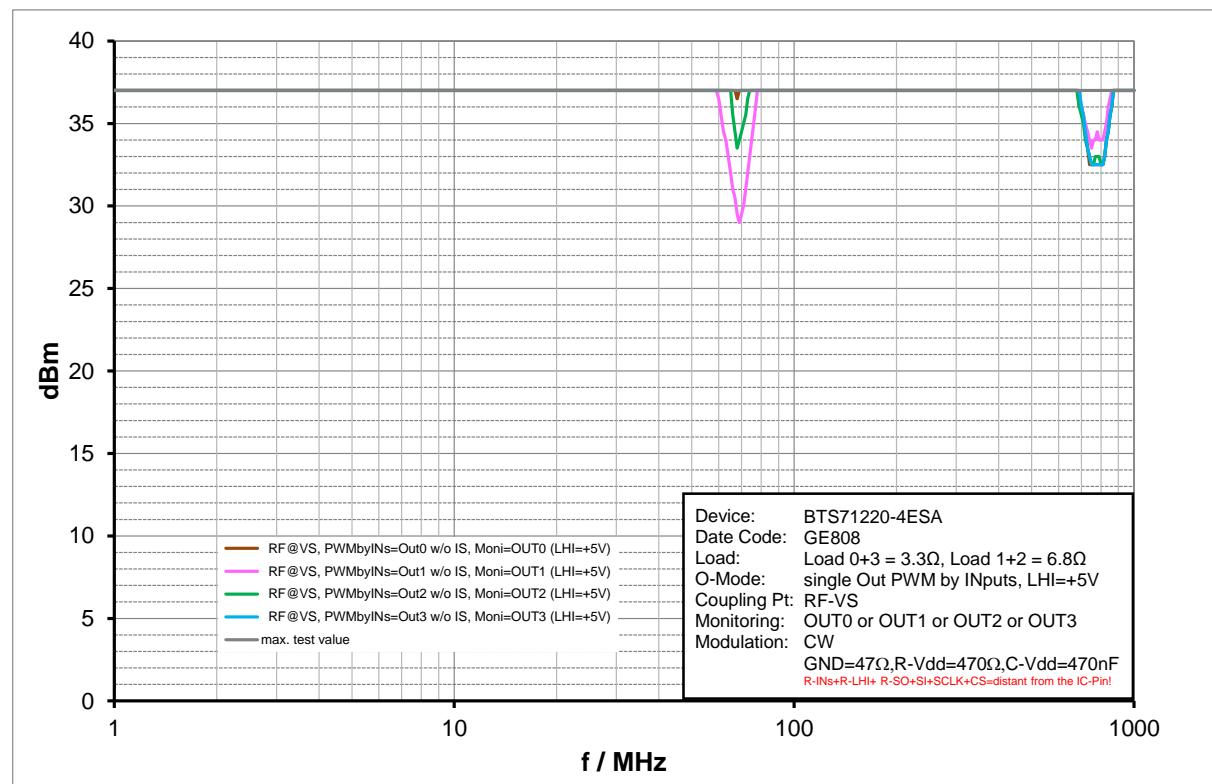
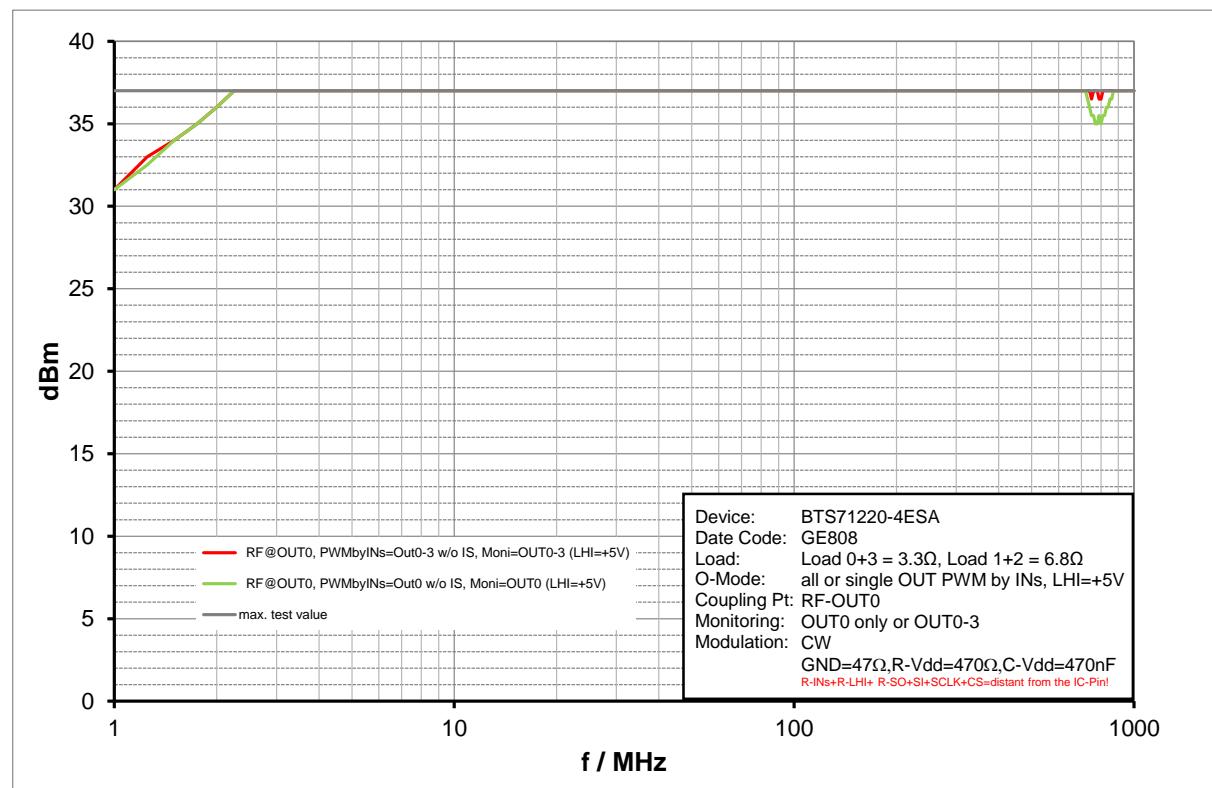


Figure 10 RF injection into connector RF-Vs, single PWM-state of only one channel, DUT driven by inputs, no ISense activated, LHI=+5V, monitoring outputs only, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

DPI test results global IC pin OUT0, driven by input pins


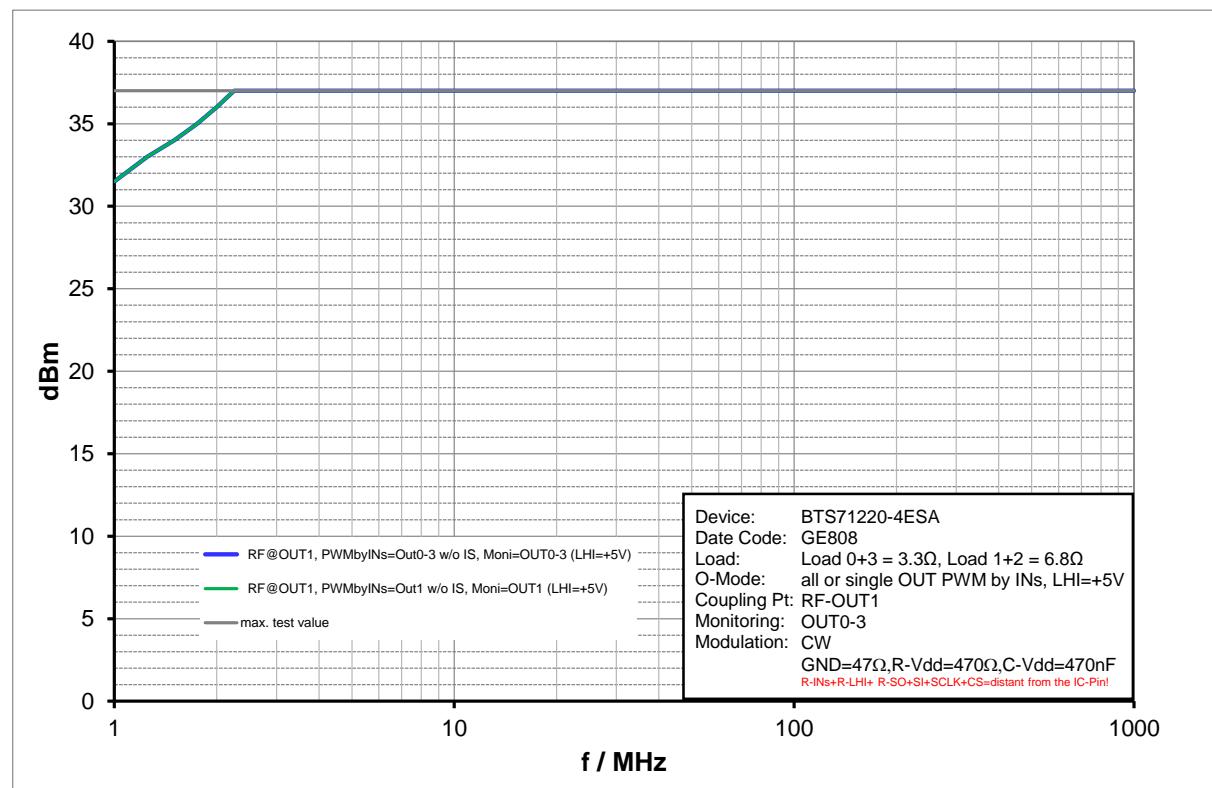
DPI test results global IC pin OUT1, driven by input pins


Figure 12 RF injection into connector RF-OUT1, PWM-state OUT1 or OUT0-3,
DUT driven by inputs, no ISense activated, LHI=+5V, monitoring outputs only,
with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

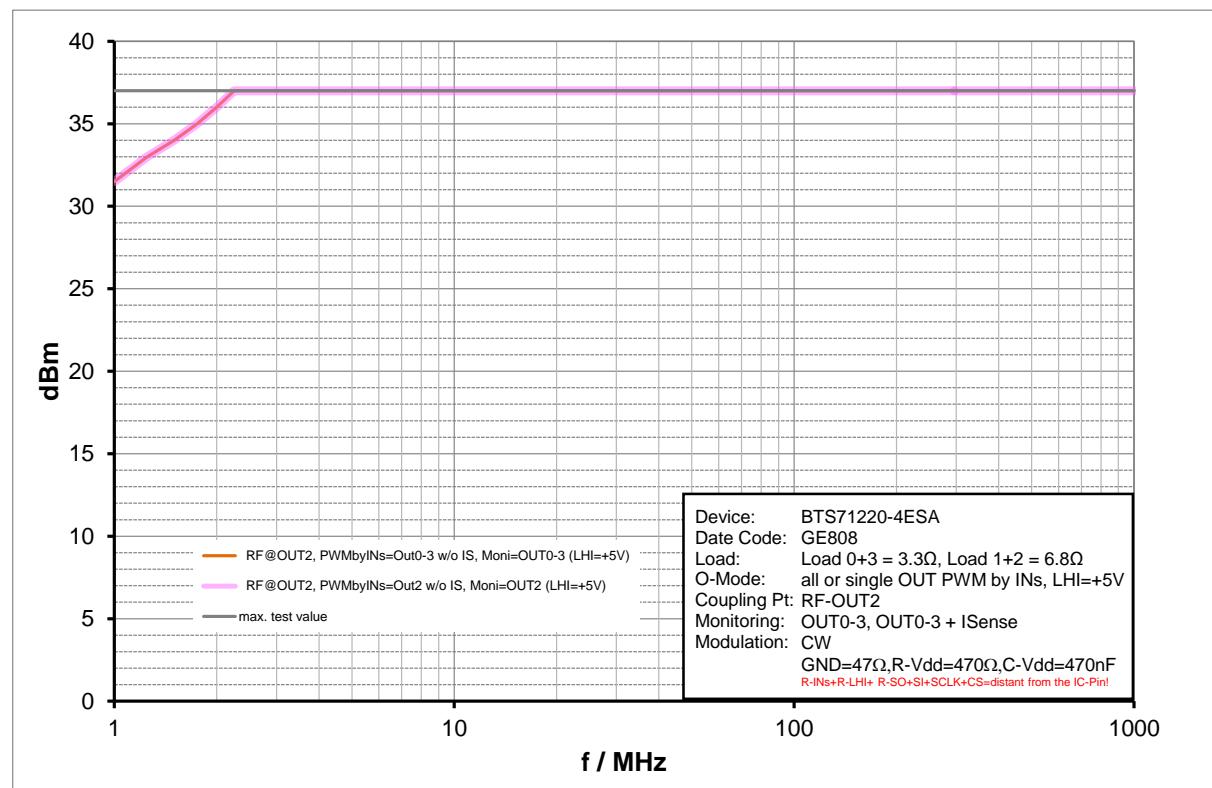
DPI test results global IC pin OUT2, driven by input pins


Figure 13 RF injection into connector RF-OUT2, PWM-state OUT2 or OUT0-3,
DUT driven by inputs, no ISense activated, LHI=+5V, monitoring outputs only,
with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

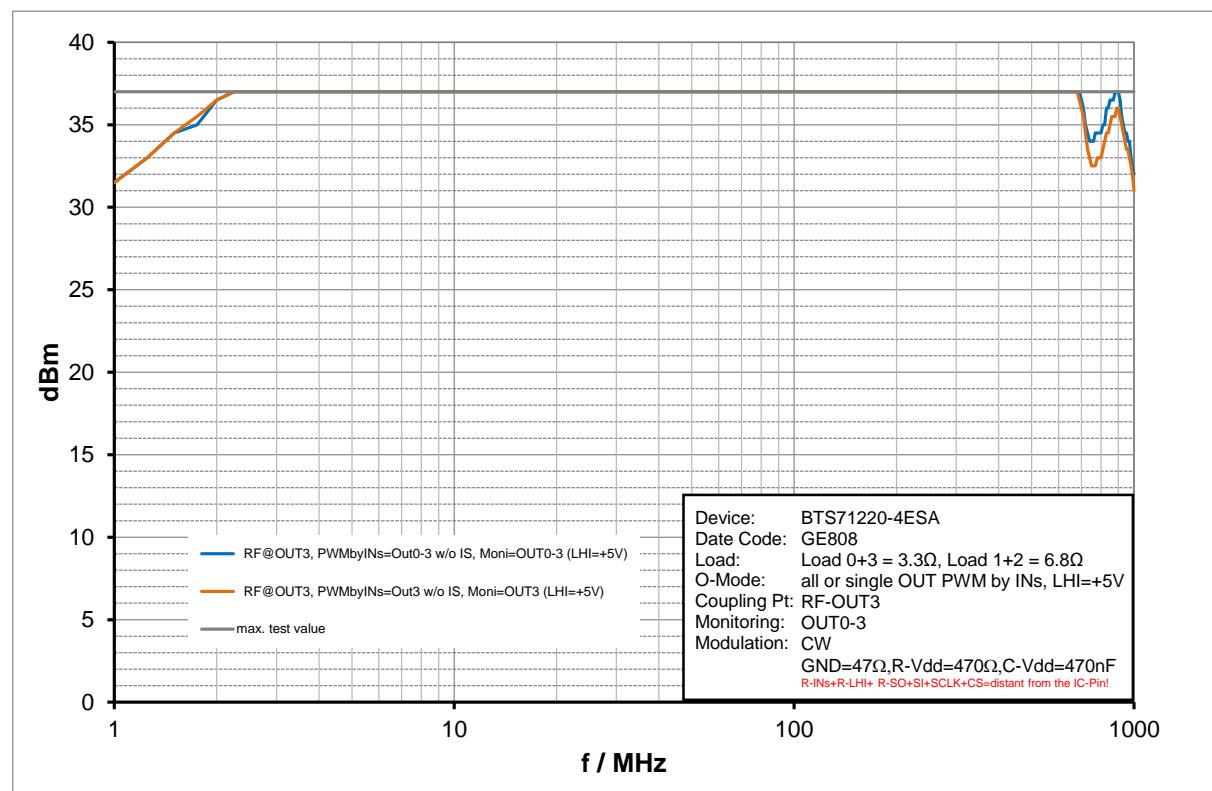
DPI test results global IC pin OUT3, driven by input pins


Figure 14 RF injection into connector RF-OUT3, PWM-state OUT3 or OUT0-3, DUT driven by input pins, no ISense activated, LHI=+5V, monitoring outputs only, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

2. Conducted Emission - 150Ω Direct Coupling Method

References: IEC 61967-1, IEC 61967-4

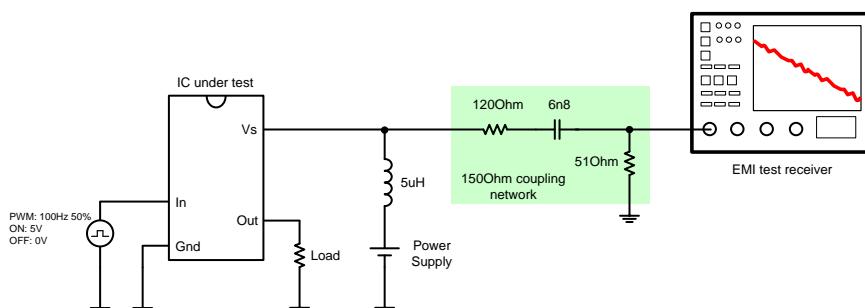
Settings for the EMI test receiver

Detector type: max. peak detector

Measurement time: at least 2 times the cycle/period time but not less than 5ms

Method	Frequency range	Receiver	
		RBW	Step size
150 Ω	150 kHz to 30 MHz	9 kHz	9 kHz
	30 MHz to 1000 MHz	120 kHz	120 kHz

Hardware Test Setup



Basic setup for the conducted emission measurement

Load

Load 0 and 3	55W Bulb	Bulb mode
Load 1 and 2	27W Bulb	Bulb mode

Table 2 Emission 150Ω test table

Measuring point		Operation mode	Load	Limit	Comment / Condition				
Pin									
Name	Function								
RF-V _S	Supply	PWM, ON, OFF	L0-3	Global	with C, w&w/o SPI, with or without ISense				
RF-OUT0	Output	PWM, ON, OFF	L0-3	Global	with C, w&w/o SPI, with or without ISense				
RF-OUT1	Output	PWM, ON, OFF	L0-3	Global	with C, w&w/o SPI, with or without ISense				
RF-OUT2	Output	PWM, ON, OFF	L0-3	Global	with C, w&w/o SPI, with or without ISense				
RF-OUT3	Output	PWM, ON, OFF	L0-3	Global	with C, w&w/o SPI, with or without ISense				

Test results 150Ω method for global IC pin V_s , driven by SPI, normal & slow SR

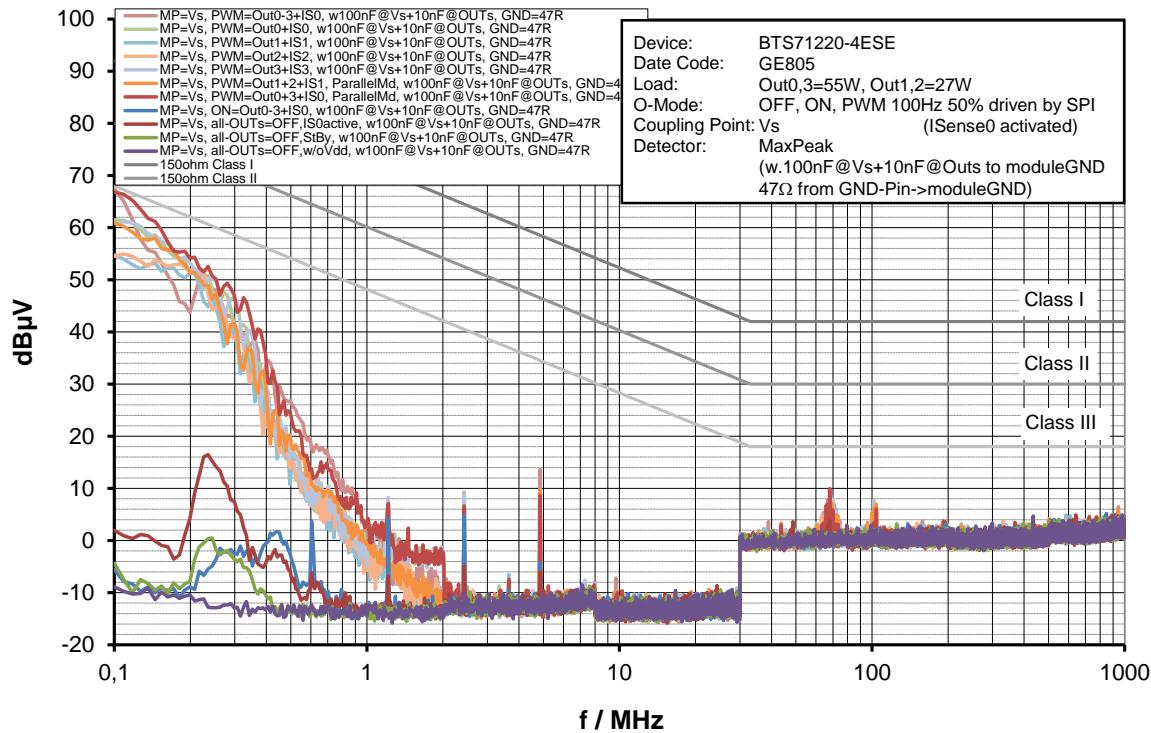


Figure 15 Emission results at measurement point RF-Vs, in PWM-, ON- and OFF-state, DUT driven by SPI, ISense activated, normal slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

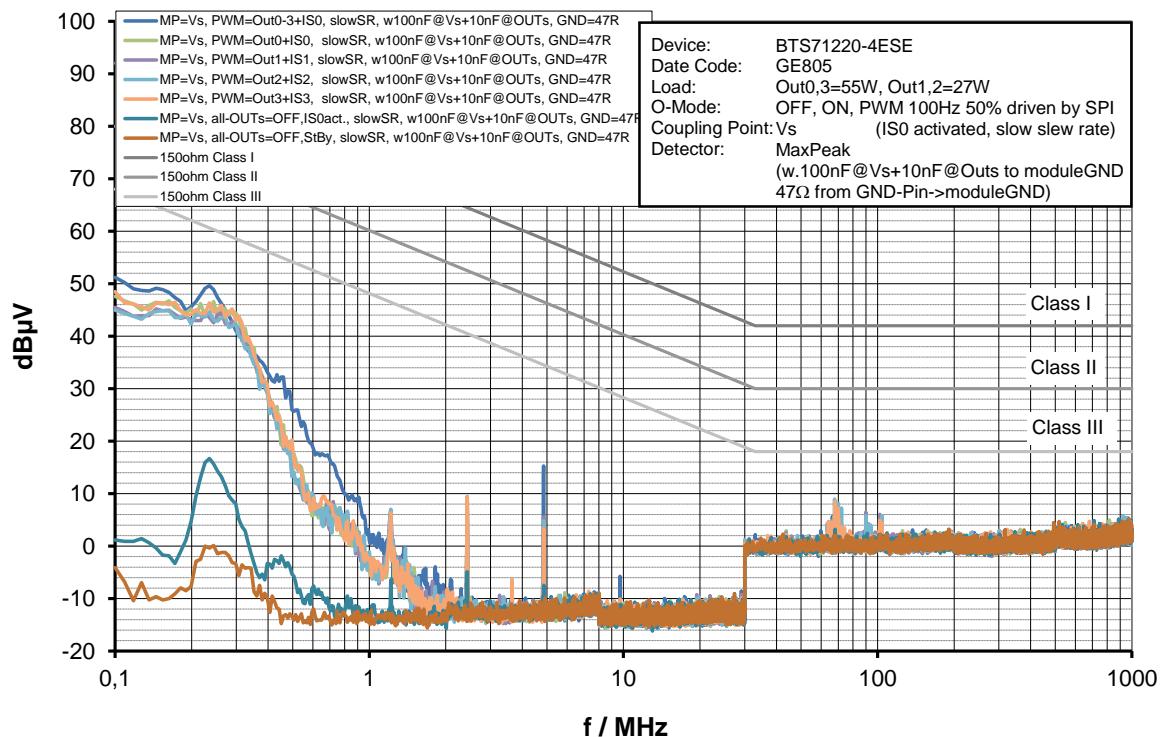


Figure 16 Emission results at measurement point RF-Vs, in PWM- and OFF-state, DUT driven by SPI, ISense activated, slow slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

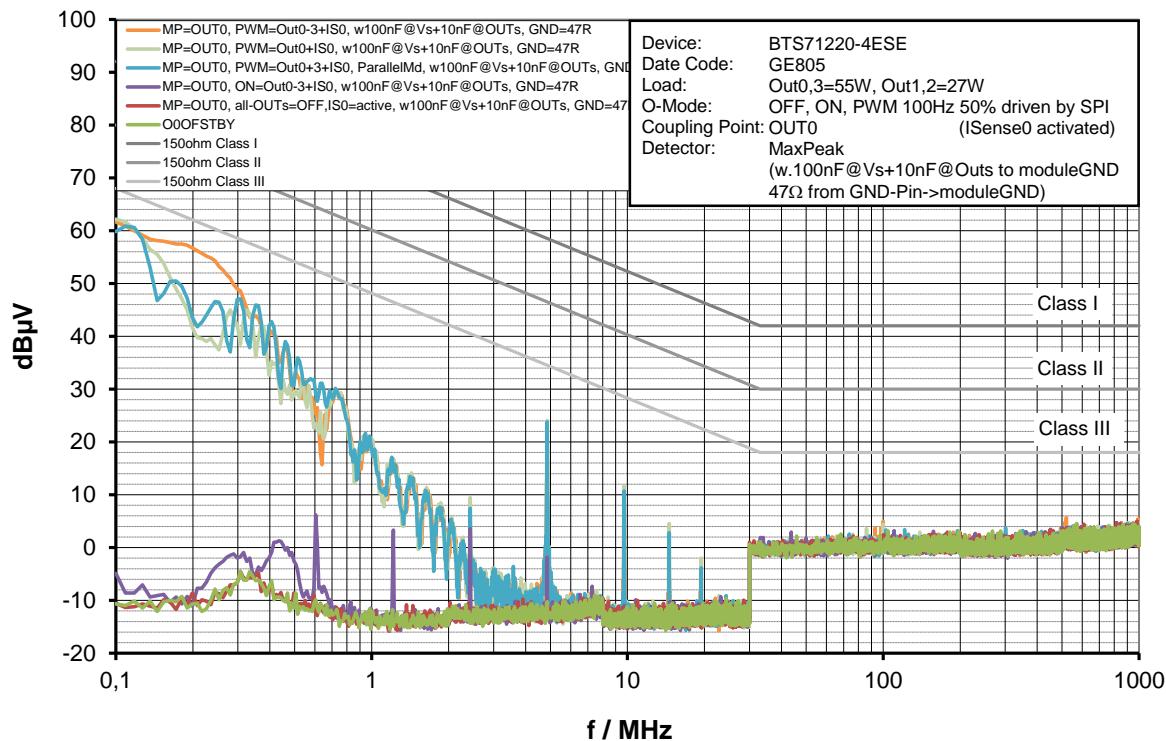
Test results 150Ω method, global IC pin OUT0, driven by SPI, norm. & slow SR


Figure 17 Emission results at measurement point RF-OUT0, in PWM-, ON- and OFF-state, DUT driven by SPI, ISense0 activated, normal slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

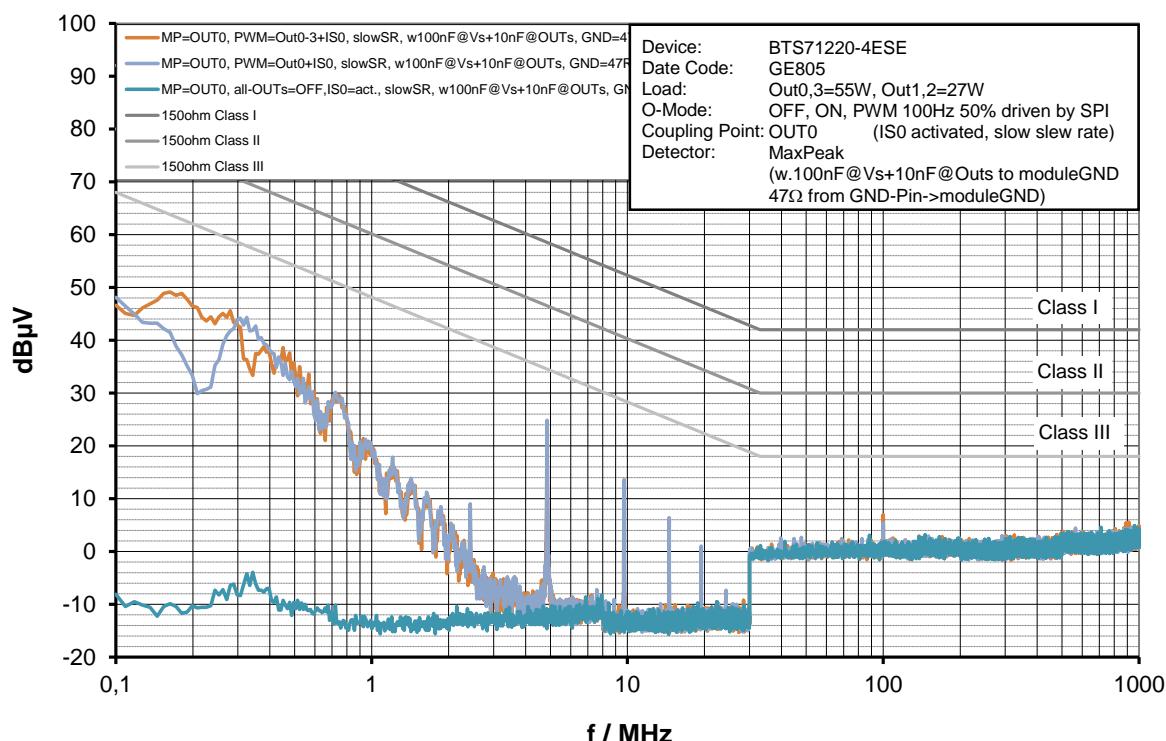
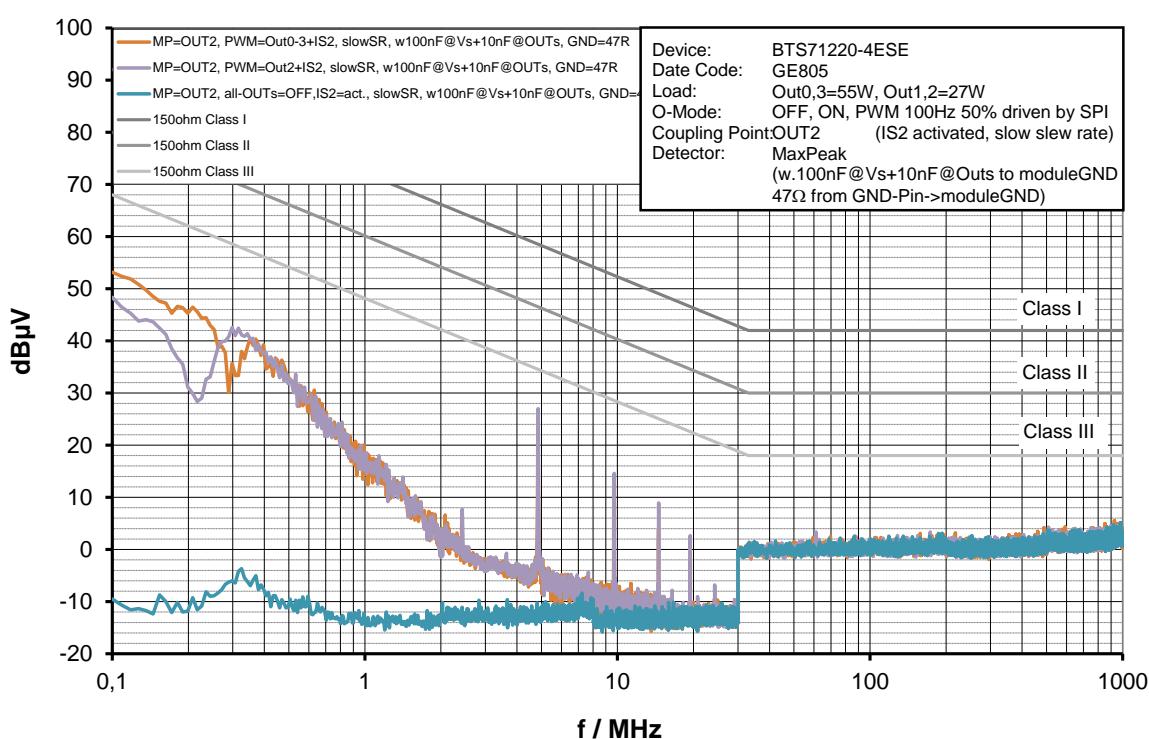
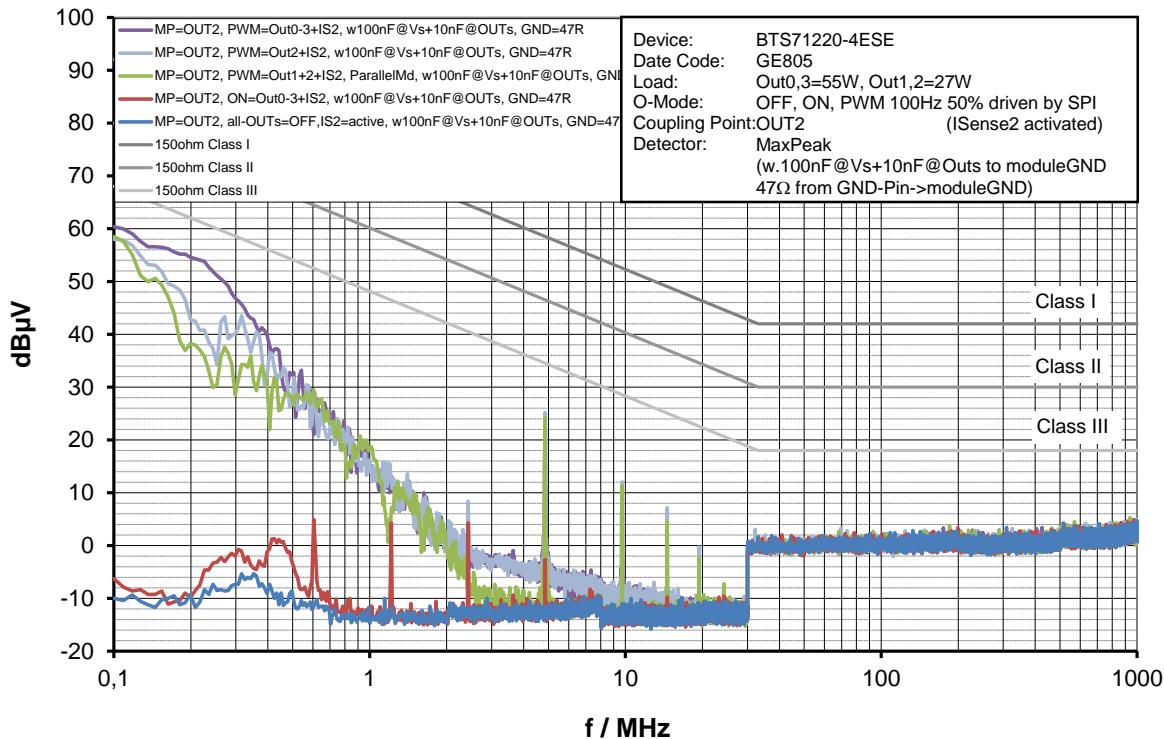


Figure 18 Emission results at measurement point RF-OUT0, in PWM- and OFF-state, DUT driven by SPI, ISense0 activated, slow slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

Test results 150Ω method, global IC pin OUT2, driven by SPI, norm. & slow SR


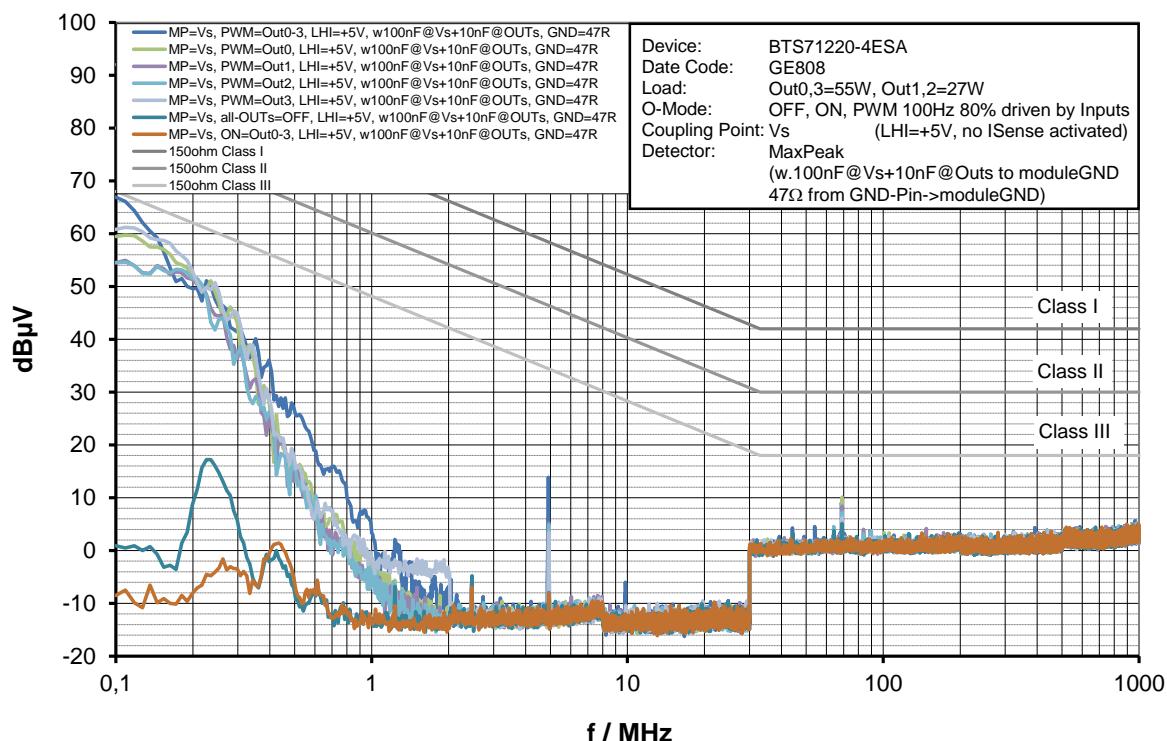
Test results 150Ω method for global IC pin Vs, driven by inputs, normal SR


Figure 21 Emission results at measurement point RF-V_s, in PWM-, ON- and OFF-state, DUT driven by input pins, no ISense activated, LHI=+5V, normal slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

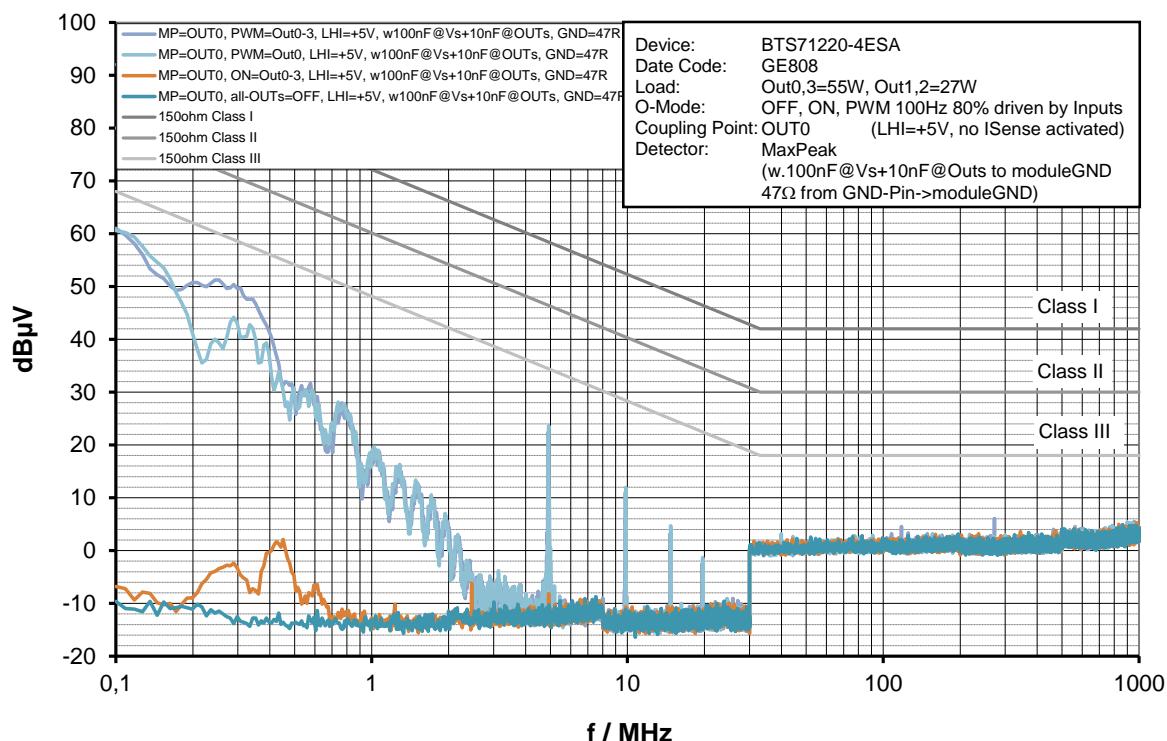
Test results 150Ω method, global IC pin OUT0, driven by inputs, normal SR


Figure 22 Emission results at measurement point RF-OUT0, in PWM-, ON- and OFF-state,
DUT driven by input pins, no ISense activated, LHI=+5V, normal slew rate,
with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

Test results 150Ω method, global IC pin OUT1, driven by inputs, normal SR

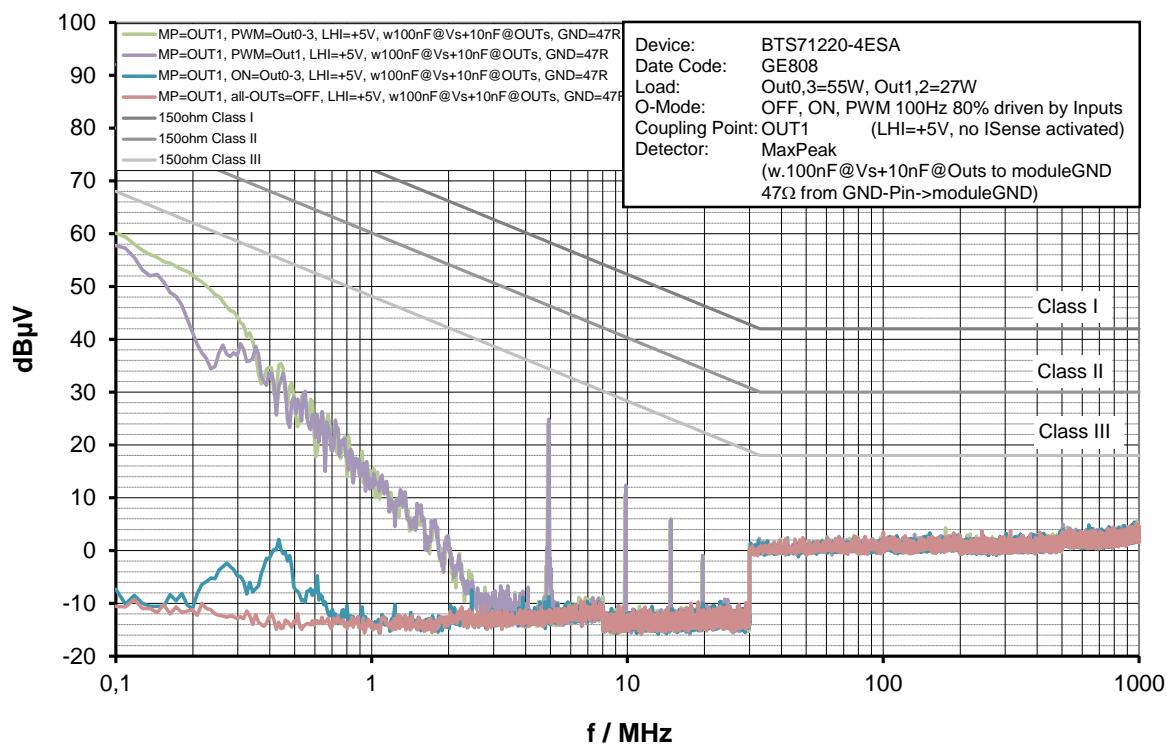


Figure 23 Emission results at measurement point RF-OUT1, in PWM- and OFF-state, DUT driven by input pins, no ISense activated, LHI=+5V, normal slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

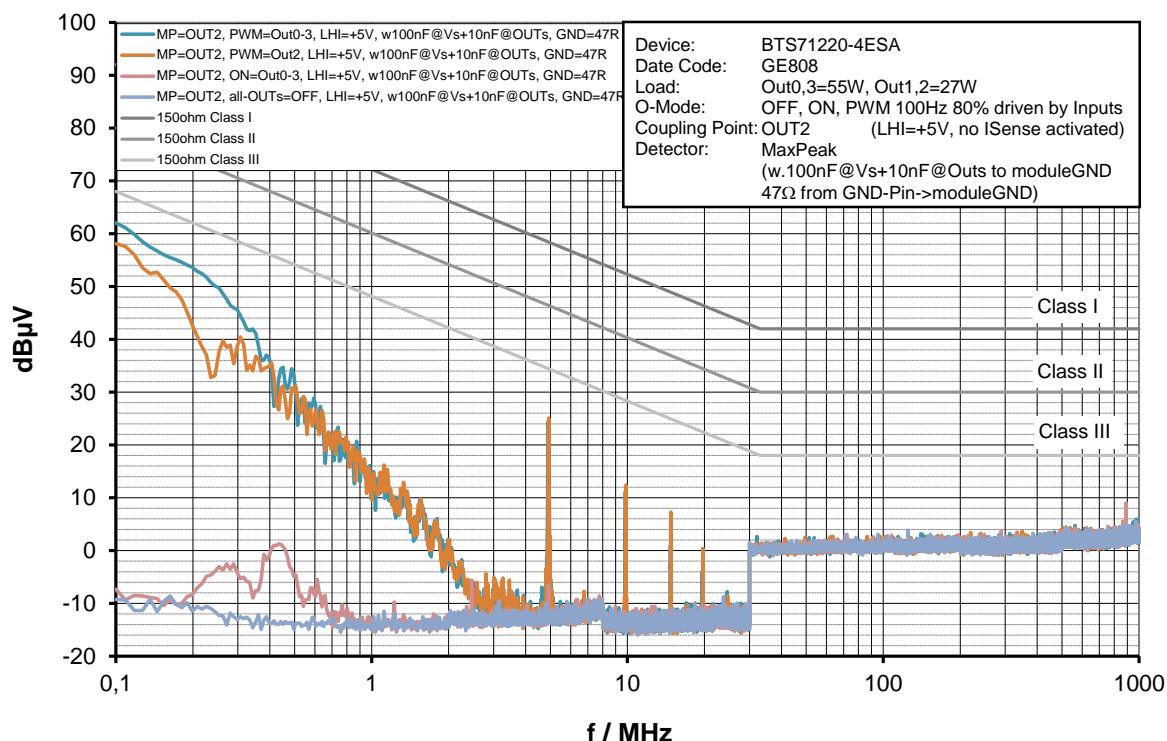
Test results 150Ω method, global IC pin OUT2, driven by inputs, normal SR


Figure 24 Emission results at measurement point RF-OUT2, PWM-mode, DUT driven by input pins, no ISense activated, LHI=+5V, normal slew rate, with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

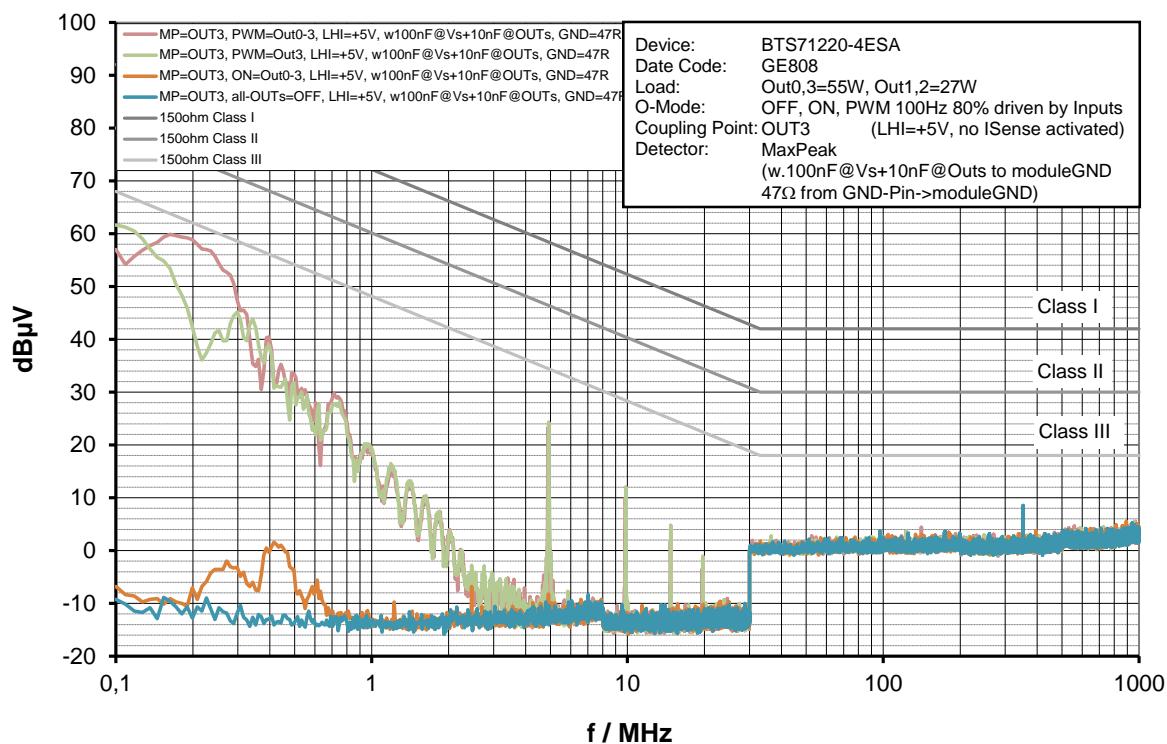
Test results 150Ω method, global IC pin OUT3, driven by inputs, normal SR


Figure 25 Emission results at measurement point RF-OUT3, PWM-mode,
DUT driven by input pins, no ISense activated, LHI=+5V, normal slew rate,
with external capacitors 100nF @ Vs to module GND, 10nF @ Outputs to module GND

3. Conducted Emission - Voltage Method (LISN)

References: IEC CISPR 25 Edition 3.0 (2008-03)

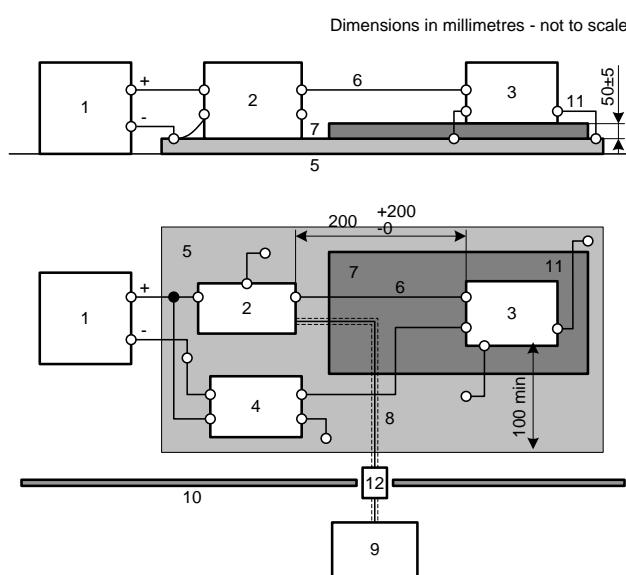
Test parameter LISN

Detector type: Max peak detector

Measurement time: at least 2 times the cycle/period time but not less than 5ms

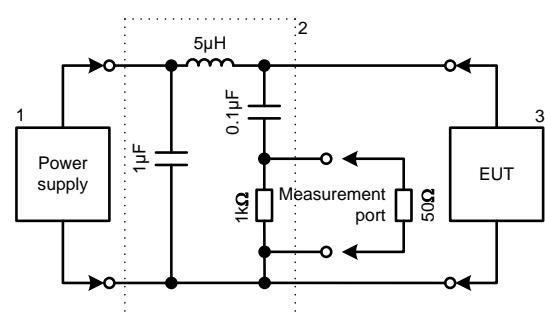
Method	Frequency range	Receiver	
		BW	Step size
LISN	150 kHz to 30 MHz	9 kHz	9kHz
	30 MHz to 108 MHz	120 kHz	120 kHz

Hardware Test Setup

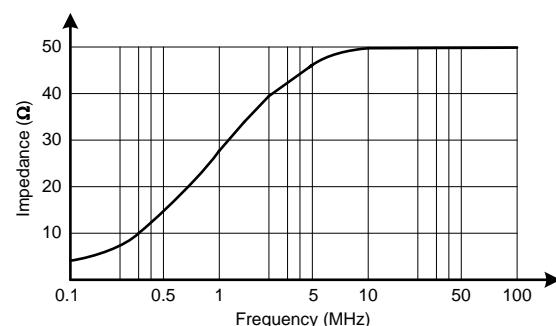


- 1 Power supply (may be placed on the ground plane)
- 2 Artificial network
- 3 EUT (housing ground if required in test plan)
- 4 Load simulator (metallic casing grounded if required in test plan)
- 5 Ground plane
- 6 Power supply line
- 7 Low relative permittivity support ($\epsilon_r \leq 1.4$)
- 8 High-quality coaxial cable e.g. double-shielded (50Ω)
- 9 Measuring instrument
- 10 Shielded enclosure
- 11 EUT housing ground lead should not be longer than 150mm
- 12 Bulkhead connector

Artificial network: test setup



Artificial network: equivalent circuit



Artificial network: impedance behaviour

Load

Load 0 and 3	55W Bulb	Bulb mode
Load 1 and 2	27W Bulb	Bulb mode

Test result – LISN method, normal slew rate

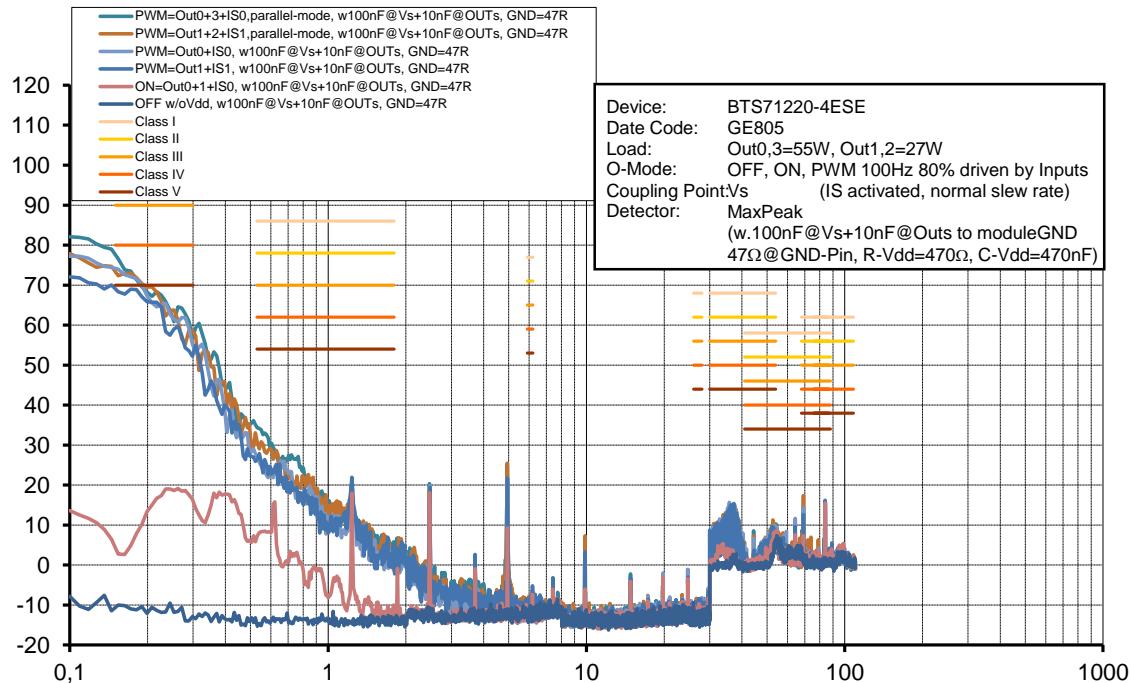


Figure 26 Emission results LISN at V_s , in PWM mode of OUT0-3, OUT0, OUT1, OUT2, OUT3 and on- and off-state, DUT driven by input pins, with SPI - ISense activated, with external capacitors 100nF @ V_s to module GND, 10nF @ Outputs to module GND

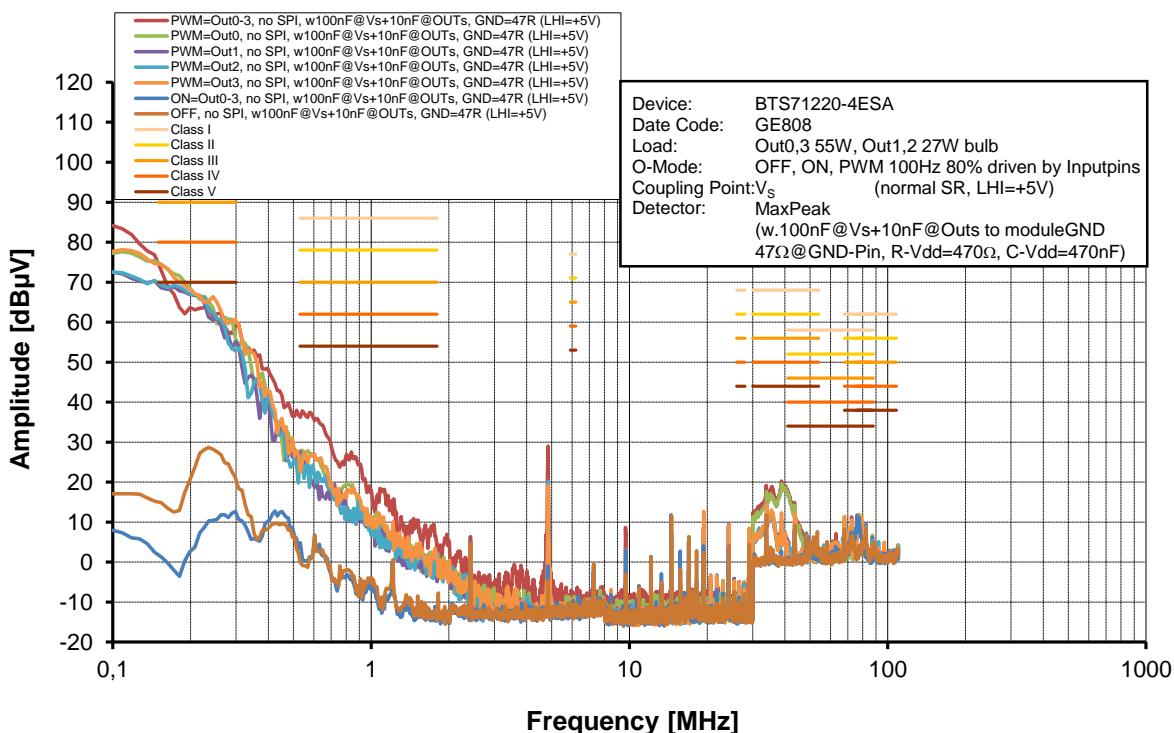


Figure 27 Emission results LISN at V_s , in PWM mode of OUT0-3, OUT0, OUT1, OUT2, OUT3 and on- and off-state, DUT driven by input pins, without SPI, LHI=+5V, with external capacitors 100nF @ V_s to module GND, 10nF @ Outputs to module GND

Test result - LISN method, slow slew rate

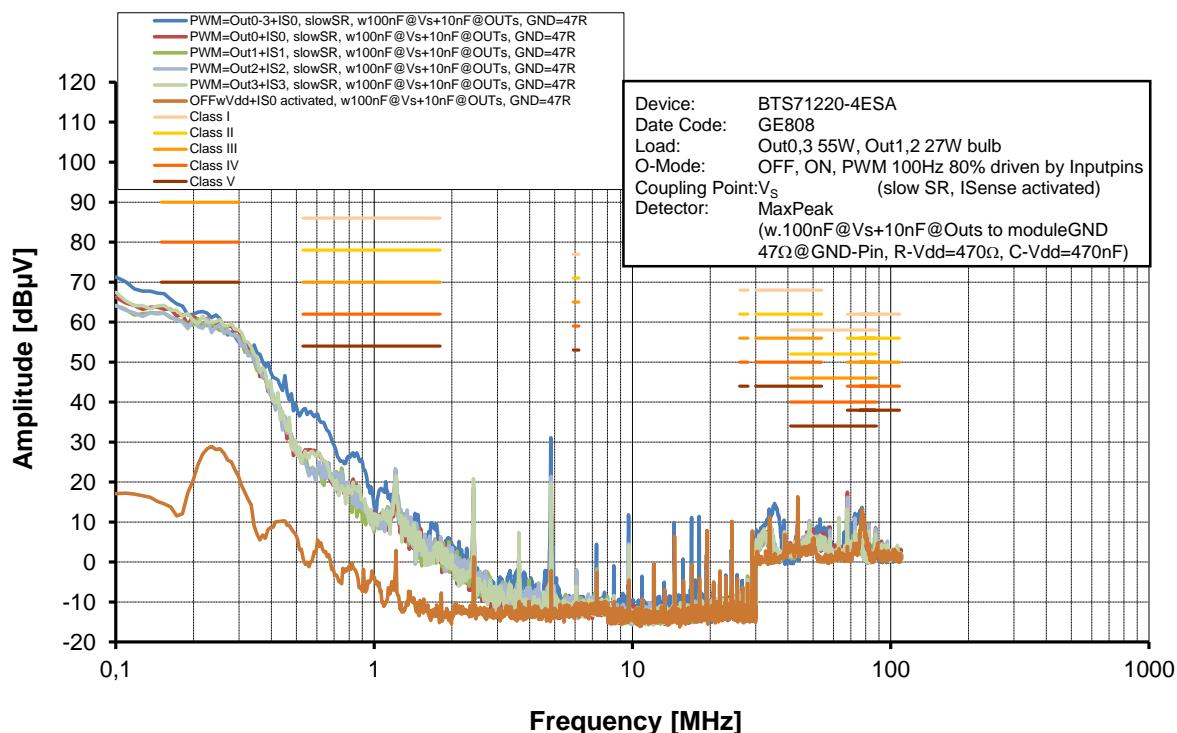
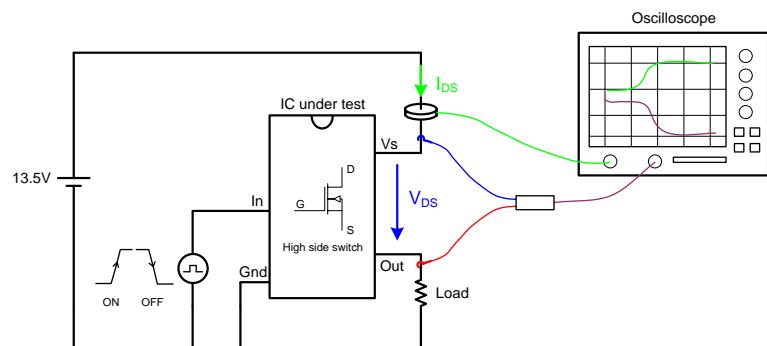


Figure 28 Emission results LISN at V_s , in PWM mode of OUT0-3, OUT0, OUT1, OUT2, OUT3 and on- and off-state, DUT driven by input pins, with SPI – ISense + slow SR activated, with external capacitors 100nF @ V_s to module GND, 10nF @ Outputs to module GND

4. Time Domain Measurement

Hardware Test Setup



Test setup time domain measurement (V_{DS} , I_{DS})

Measurement Result - Time Domain OUT0, normal slew rate

Load: 55W Bulb

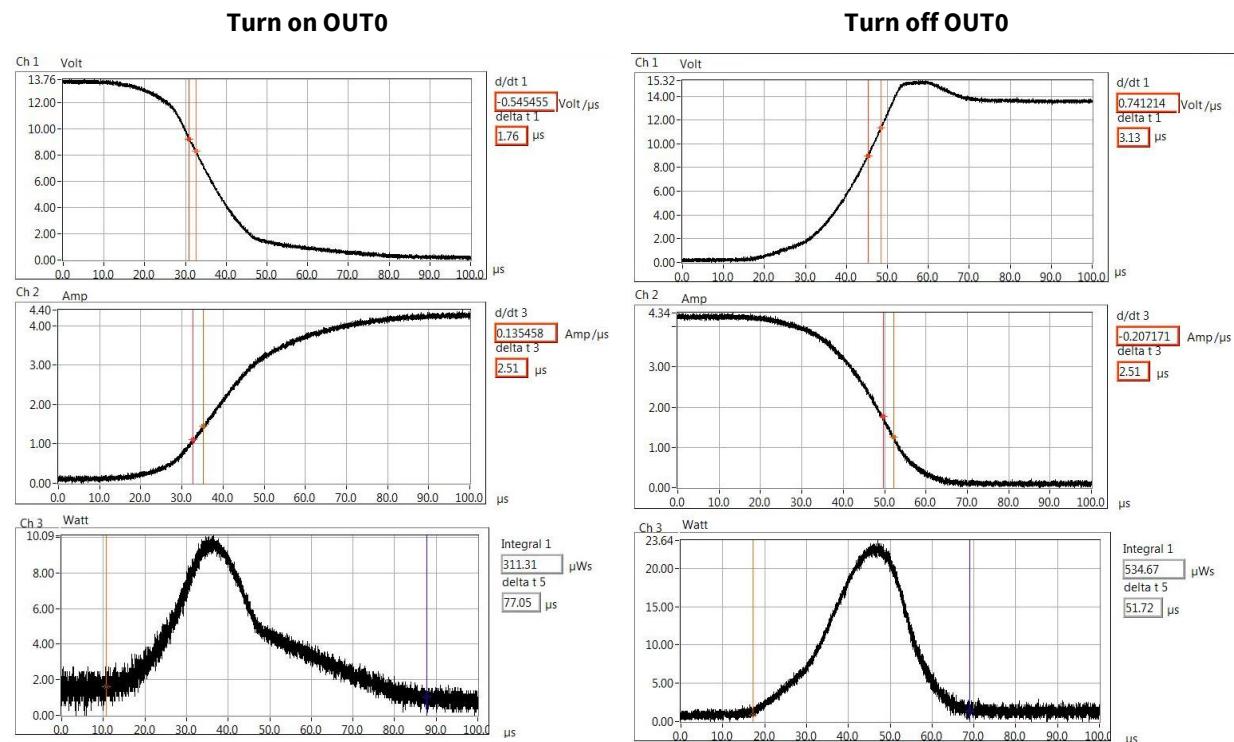


Figure 29 BTST1220-4ESA - Time Domain Measurement, normal slew rate

Table 3 Time domain measurement results

Turn on		Turn off	
max du/dt	-545mV/μs	max du/dt	741mV/μs
max di/dt	135mA/μs	max di/dt	-207mA/μs
switching loss energy (Ws)	311μWs	switching loss energy (Ws)	535μWs
switching power loss (W)			0,085W (=311μWs+535μWs) * 100Hz

Measurement Result - Time Domain OUT0, slow slew rate

Load: 55W Bulb

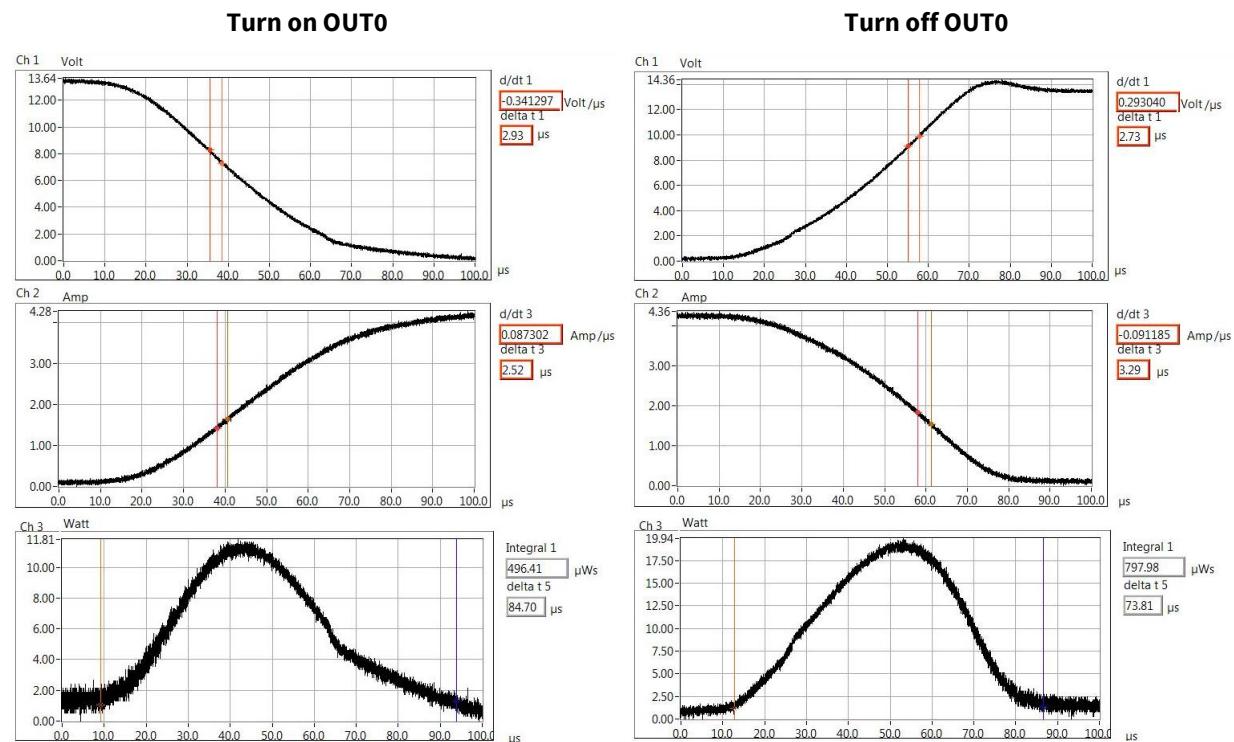


Figure 30 BTS71220-4ESA - Time Domain Measurement, slow slew rate activated

Table 4 Time domain measurement results

Turn on		Turn off	
max du/dt	-341mV/μs	max du/dt	293mV/μs
max di/dt	87mA/μs	max di/dt	-91mA/μs
switching loss energy (Ws)	496μWs	switching loss energy (Ws)	798μWs
switching power loss (W)	$0,141\text{W} (= (496\mu\text{Ws} + 798\mu\text{Ws}) * 100\text{Hz})$		

Measurement Result - Time Domain OUT1, normal slew rate

Load: 27W Bulb

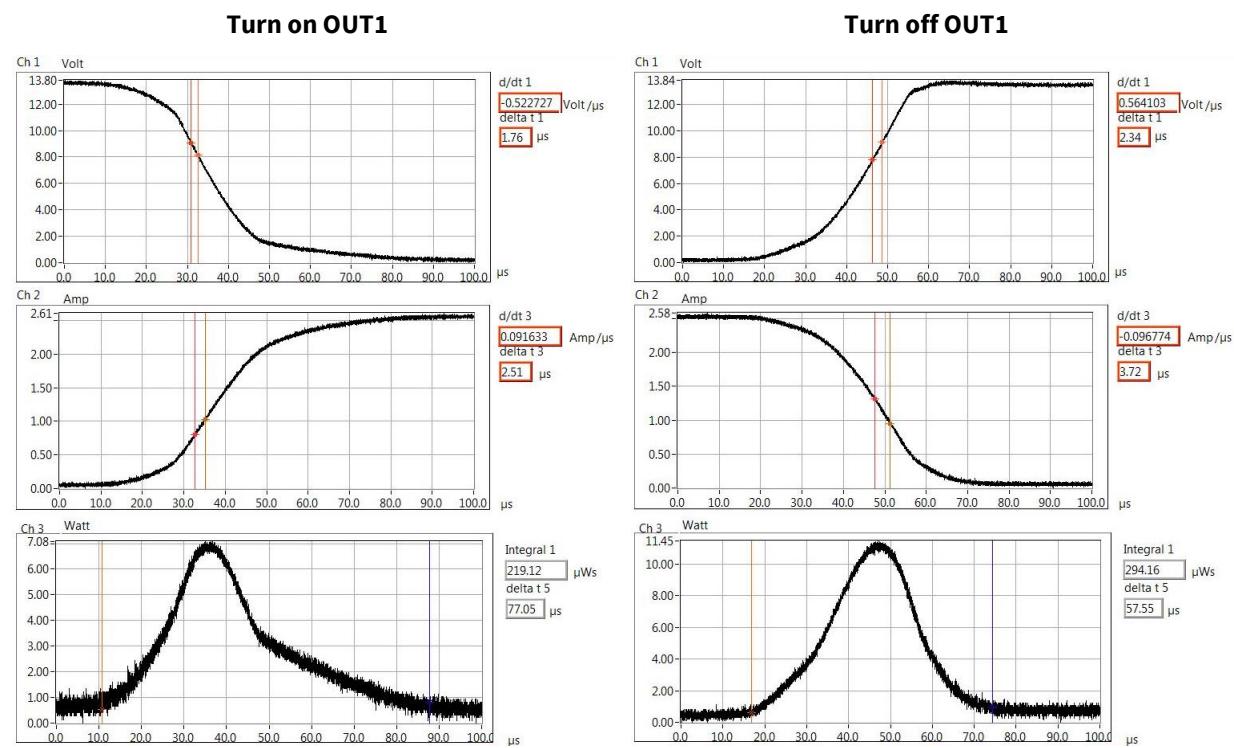


Figure 31 BTST1220-4ESA - Time Domain Measurement, normal slew rate

Table 5 Time domain measurement results

Turn on		Turn off	
max du/dt	-523mV/μs	max du/dt	564mV/μs
max di/dt	92mA/μs	max di/dt	-97mA/μs
switching loss energy (Ws)	219μWs	switching loss energy (Ws)	294μWs
switching power loss (W)	0,051W (= (219μWs + 294μWs) * 100Hz)		

Measurement Result - Time Domain OUT1, slow slew rate

Load: 27W Bulb

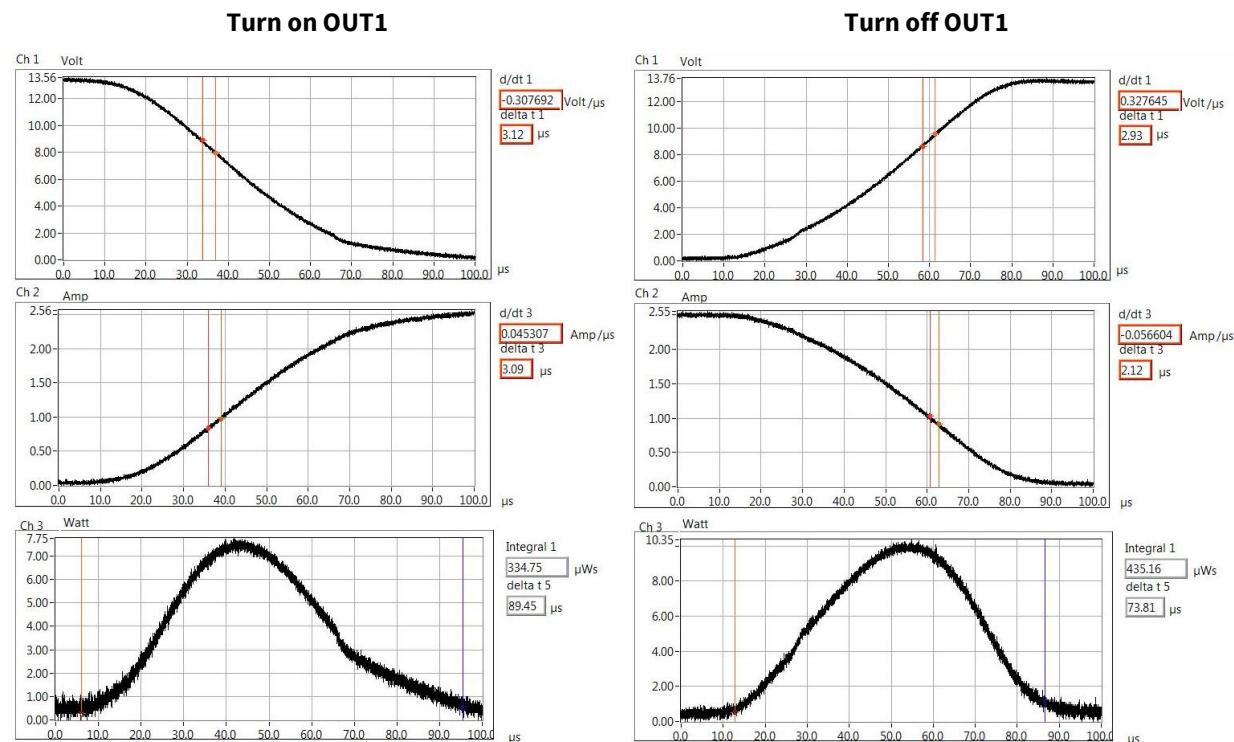


Figure 32 BTST1220-4ESA - Time Domain Measurement, slow slew rate activated

Table 6 Time domain measurement results

Turn on		Turn off	
max du/dt	-308mV/μs	max du/dt	328mV/μs
max di/dt	45mA/μs	max di/dt	-57mA/μs
switching loss energy (Ws)	335μWs	switching loss energy (Ws)	435μWs
switching power loss (W)	0,077W (= (335μWs + 435μWs) * 100Hz)		

Measurement Result - Time Domain OUT2, normal slew rate

Load: 27W Bulb

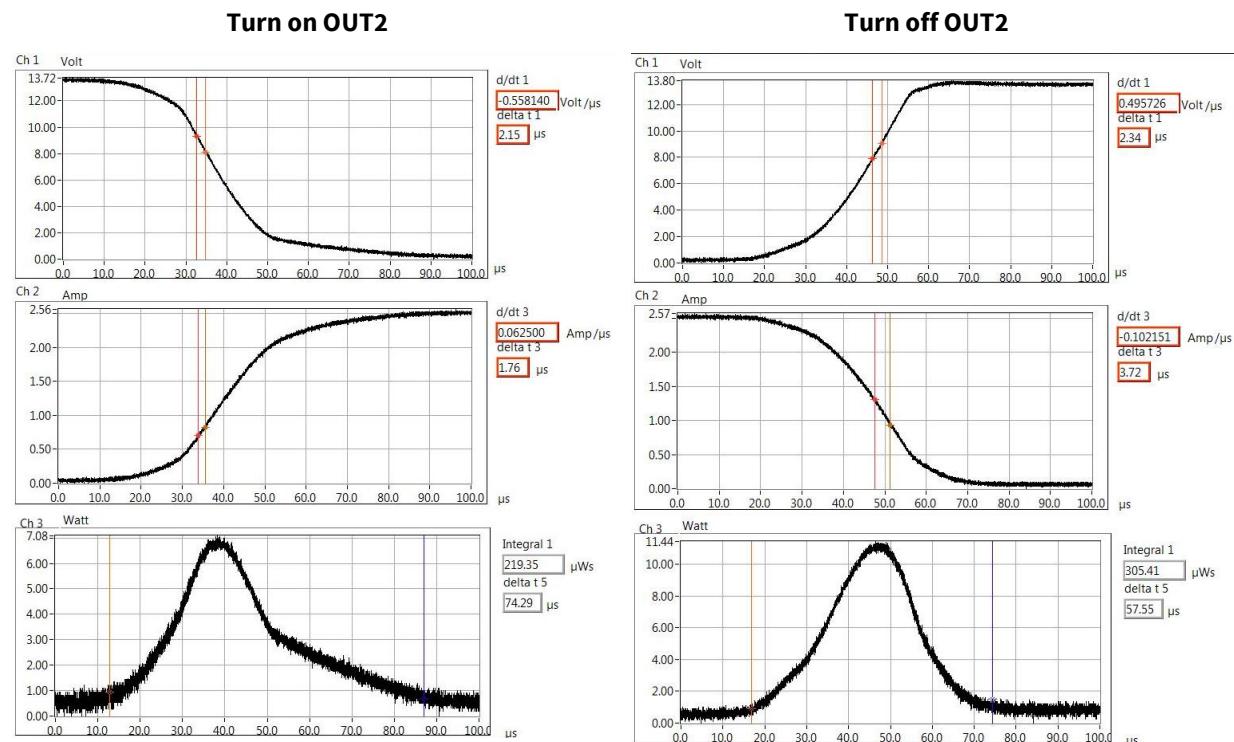


Figure 33 BTST1220-4ESA - Time Domain Measurement, normal slew rate

Table 7 Time domain measurement results

Turn on		Turn off	
max du/dt	-558mV/μs	max du/dt	496mV/μs
max di/dt	62mA/μs	max di/dt	-102mA/μs
switching loss energy (Ws)	219μWs	switching loss energy (Ws)	305μWs
switching power loss (W)	0,052W (= (219μWs + 305μWs) * 100Hz)		

Measurement Result - Time Domain OUT2, slow slew rate

Load: 27W Bulb

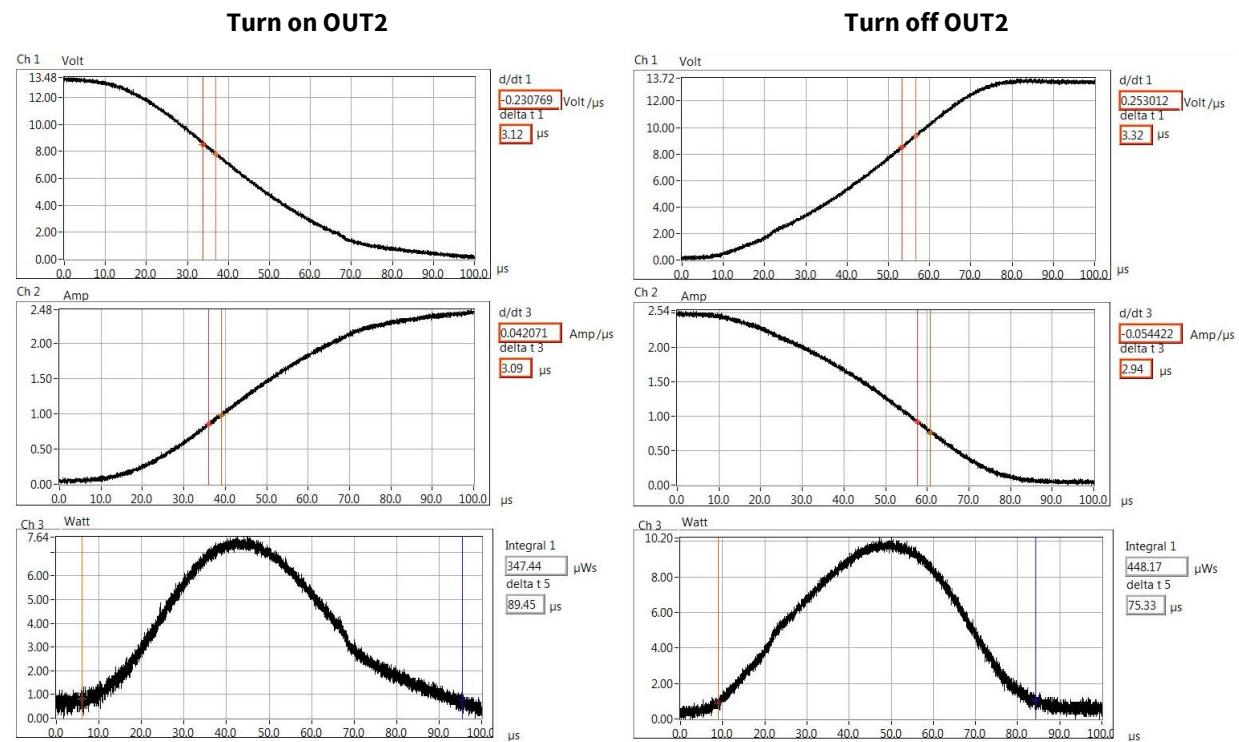


Figure 34 BTST1220-4ESA - Time Domain Measurement, slow slew rate activated

Table 8 Time domain measurement results

Turn on		Turn off	
max du/dt	-231mV/μs	max du/dt	253mV/μs
max di/dt	42mA/μs	max di/dt	-54mA/μs
switching loss energy (Ws)	347μWs	switching loss energy (Ws)	448μWs
switching power loss (W)	0,079W (=347μWs+448μWs) * 100Hz		

Measurement Result - Time Domain OUT3, normal slew rate

Load: 55W Bulb

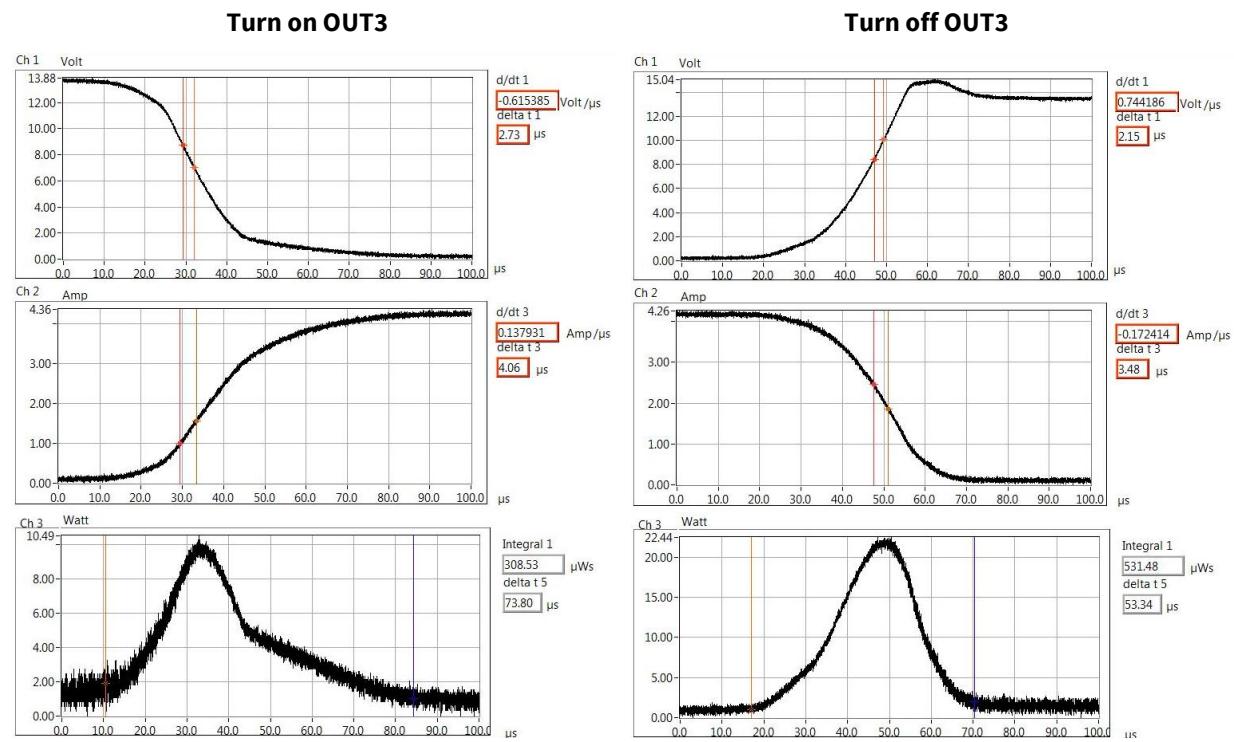


Figure 35 BTST1220-4ESA - Time Domain Measurement, normal slew rate

Table 9 Time domain measurement results

Turn on		Turn off	
max du/dt	-615mV/µs	max du/dt	744mV/µs
max di/dt	138mA/µs	max di/dt	-172mA/µs
switching loss energy (Ws)	308µWs	switching loss energy (Ws)	531µWs
switching power loss (W)	$0,084\text{W} (= (308\mu\text{Ws} + 531\mu\text{Ws}) * 100\text{Hz})$		

Measurement Result - Time Domain OUT3, slow slew rate

Load: 55W Bulb

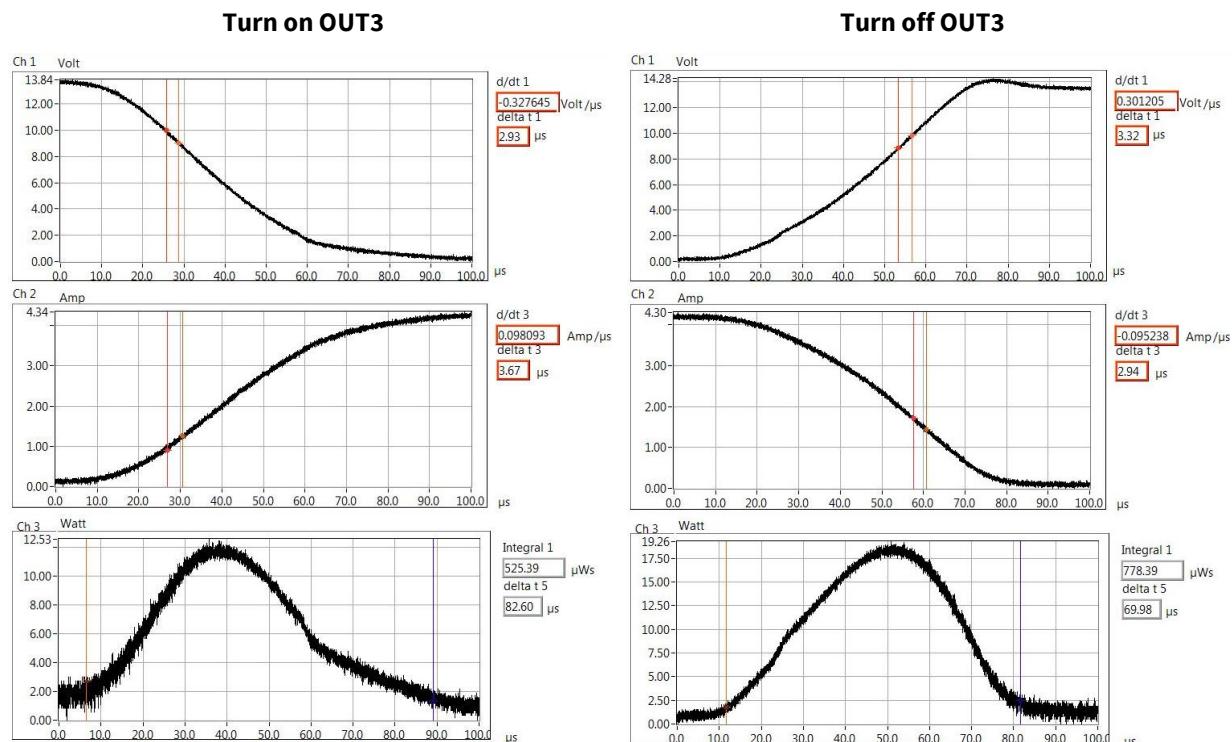


Figure 36 BTST1220-4ESA - Time Domain Measurement, slow slew rate activated

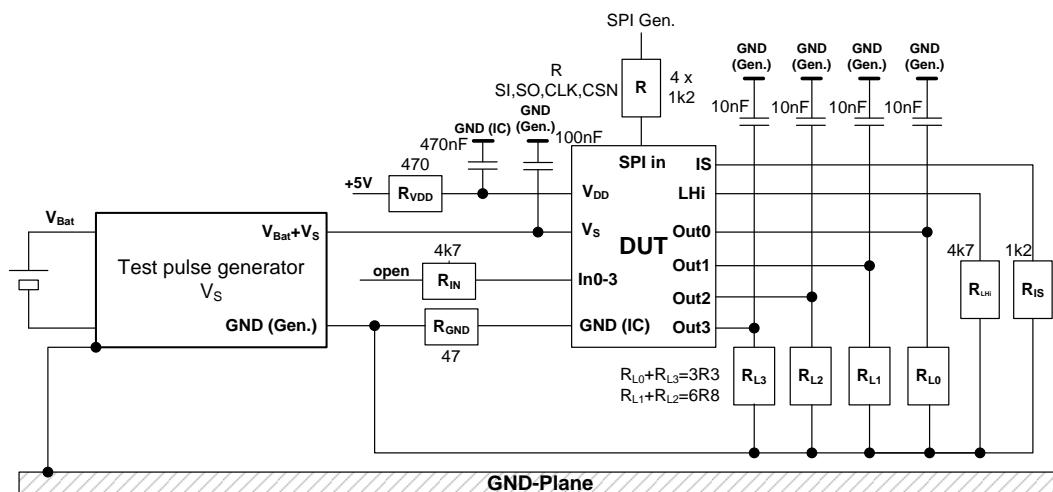
Table 10 Time domain measurement results

Turn on		Turn off	
max du/dt	-328mV/µs	max du/dt	301mV/µs
max di/dt	98mA/µs	max di/dt	-95mA/µs
switching loss energy (Ws)	525µWs	switching loss energy (Ws)	778µWs
switching power loss (W)		0,130W (= (525µWs + 778µWs) * 100Hz)	

5. Conducted Immunity - Transient Disturbances

References: ISO 7637-1:2010(E); ISO 7637-2:2010(E); ISO 16750-2:2010(E)

Hardware Test Setup



Test setup for the transient disturbances applied to VS

Operation modes

All outputs switched on and Isense0 activated by SPI command
All outputs switched off (device is awake)

Load	Load 0 and 3	3.3Ω	Bulb mode
	Load 1 and 2	6.8Ω	Bulb mode

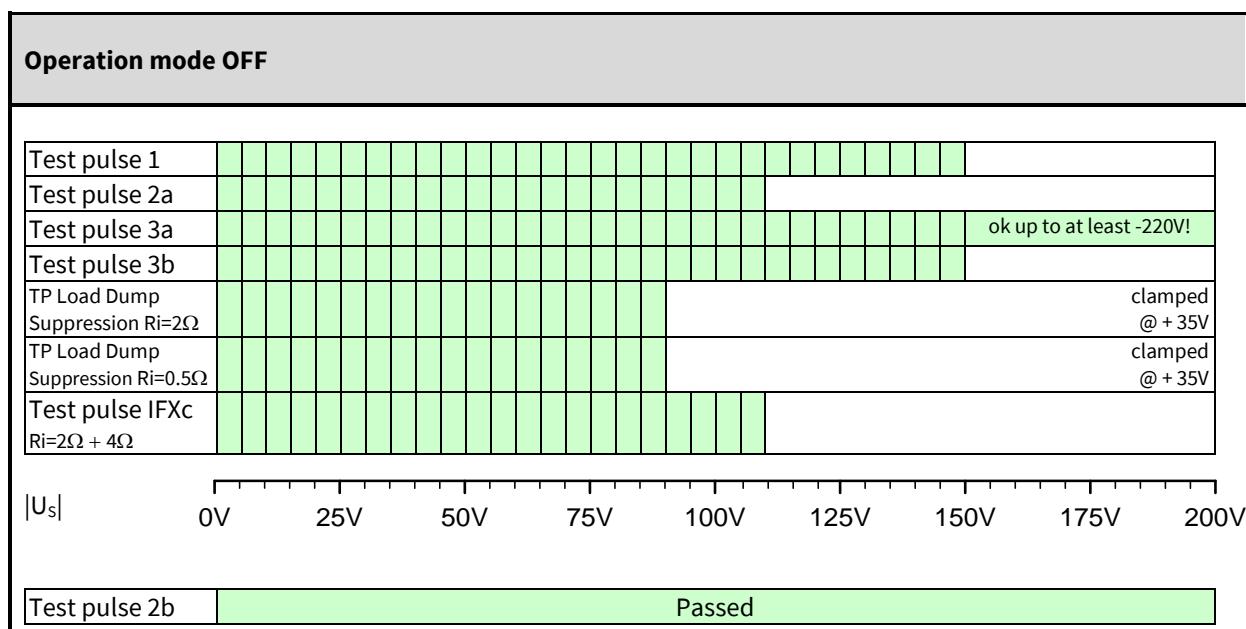
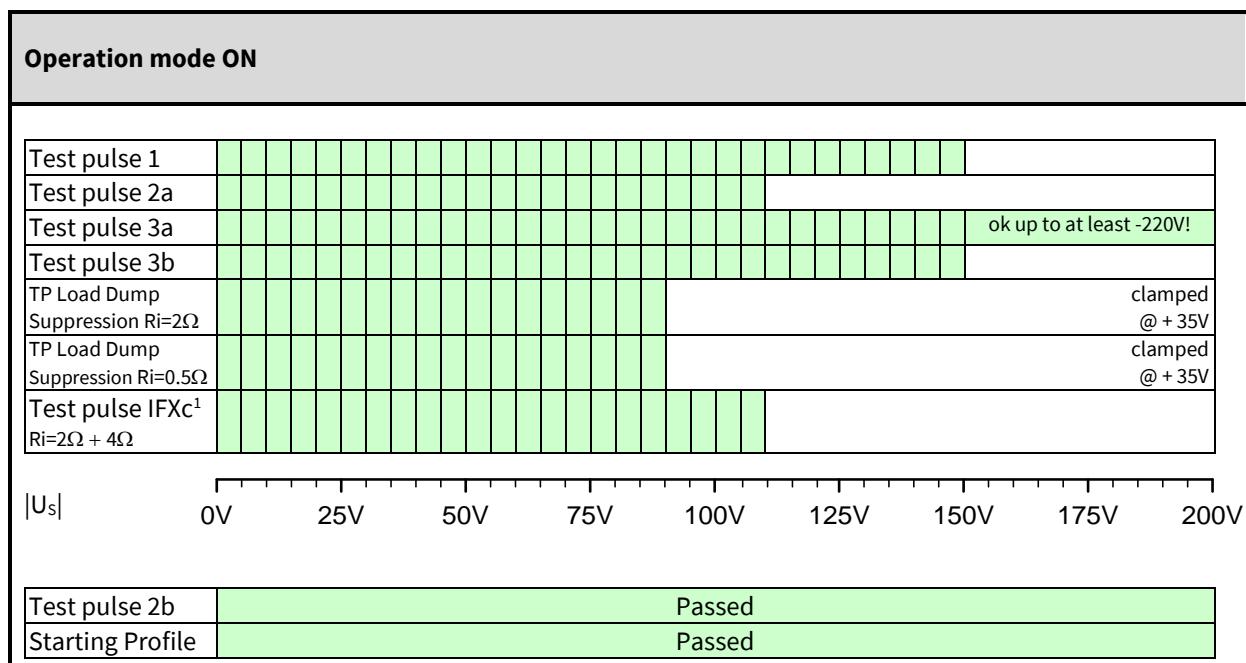
Monitoring

V-Generator/ Supply
Output2
ISense0
Current of whole application

Measurement equipment (workbench: ISO 3)

Device	Manufacturer	Model
Supply	EM-Test	VDS200 / Pulse 2b + "start.profile"
Pulse Generator	EM-Test	UCS200 / Pulse 1, 2a, 3a, 3b
Pulse Generator	EM-Test	LD200 / Pulse load dump
Digital Oscilloscope	Tektronix	TDS5054

Measurement Result - Test pulses applied to VS



¹ For $R_i=2\Omega$ and $V_{dd}=+5V$ min. immunity = -110V (max.tested voltage), for $R_i=2\Omega$ and $V_{dd}=+3.3V$ min. immunity = -100V (fail but no damage). For $R_i=4\Omega$ the min. immunity is -110V (max.tested voltage) no matter if V_{dd} is +5V or +3.3V.

Classification of the Transient Test Levels

The immunity of an IC can be classified by IC performance classes which slightly differ from ECU performance classes e.g. as specified in the ISO 7637 standard. For the transient immunity test on IC level only functional class C, D, E is tested.

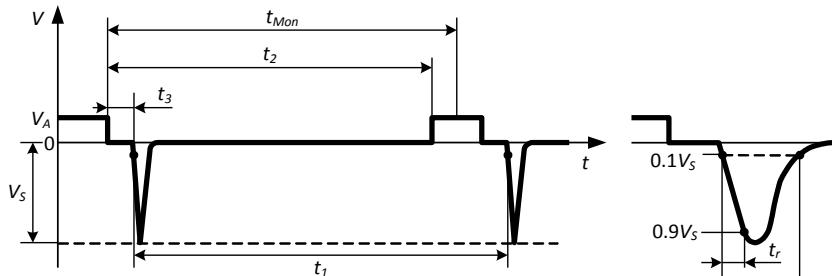
Table 11 Definition of functional status

Class	Content
Class A:	All monitored functions of the IC perform within the defined tolerances during and after exposure to disturbance.
Class B:	This classification is not applicable for ICs.
Class C:	One or more monitored functions of the IC do not perform within the defined tolerances during exposure but return automatically to the defined tolerances after the disturbance.
Class D:	One or more monitored functions of the IC do not perform within the defined tolerances during exposure and do not return to the defined tolerances automatically after the exposure. The IC returns to normal operation by simple action (e.g. reset).
Class E:	One or more monitored functions of the IC do not perform within the defined tolerances after exposure and the IC can not be returned to proper operation.

Test Pulse Definition for the 12V System¹

Table 1 Test Pulse 1

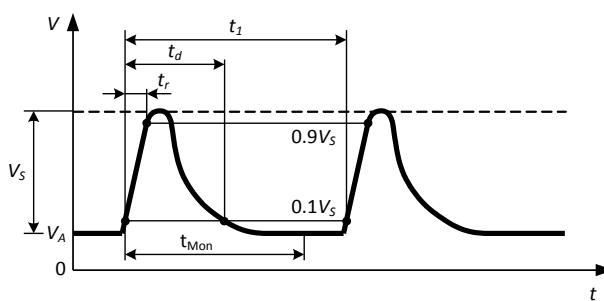
V_A	13.5V
V_{Smax}	-75V to -150V
R_i	10Ω
t_d	2ms
t_r	1μs (+0μs, -0.5μs)
t_1	≥0.5s
t_2	200ms
t_3	<100μs
# of pulses	5000
t_{Mon}	Time between 2 pulses
Standard	ISO7637-2: 2010



Test Pulse1 simulates the turn-off for inductive loads in parallel to the DUT Therefore also the battery voltage is turned-off for 200ms.

Table 2 Test Pulse 2a

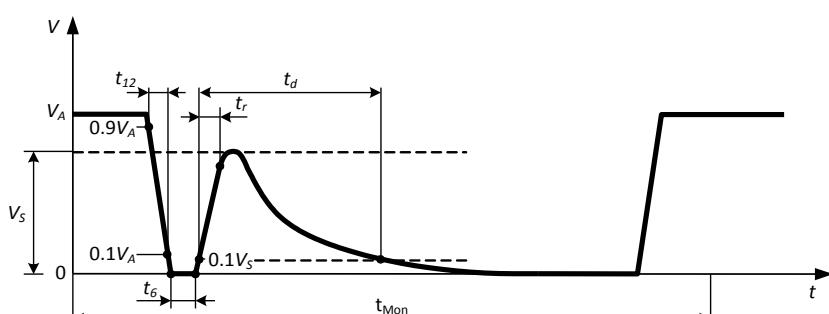
V_A	13.5V
V_{Smax}	+37V to +112V
R_i	2Ω
t_d	50μs
t_r	1μs (+0μs, -0.5μs)
t_1	0.2s to 5s
test time	10 minutes
# of pulses	5000
t_{Mon}	Time between 2 pulses
Standard	ISO7637-2: 2010



Test Pulse2a simulates transients due to sudden interruption of currents in a device connected in parallel with the DUT due to t. due to the inductance of the wiring harness.

Table 3 Test Pulse 2b

V_A	13.5V
V_{Smax}	+10V
R_i	0Ω to 0,05Ω
t_d	0.2s to 2s
t_r	1ms (±0.5ms)
t_{12}	1ms (±0.5ms)
t_6	1ms (±0.5ms)
# of pulses	10
t_{Mon}	after next power on
Standard	ISO7637-2: 2010

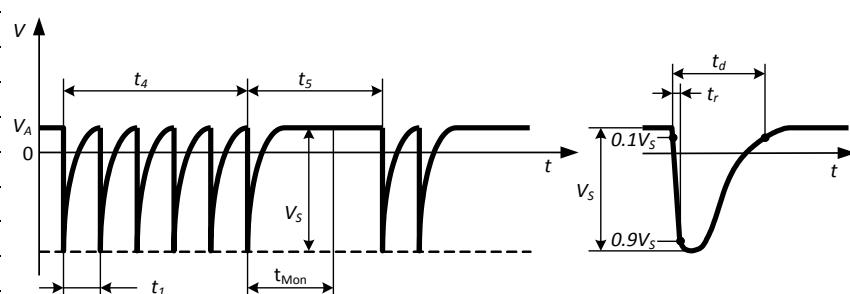


Test Pulse2b simulates transients from dc motors acting as generators after the ignition is switched off.

¹ The peak voltage V_S shall be adjusted to the test levels with a tolerance of +10%, -0%. The timing tolerances and internal resistance R_i tolerance shall be ±20%, unless otherwise specified.

Table 4 Test Pulse 3a

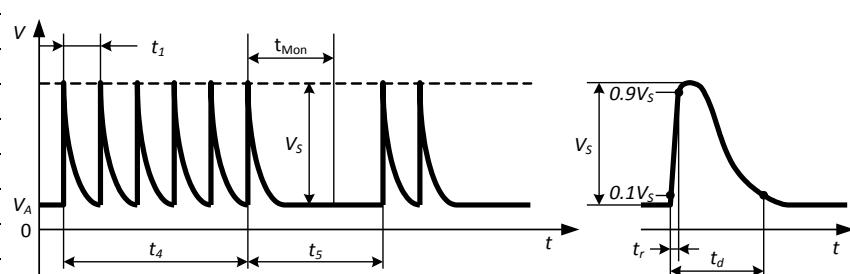
V_A	13.5V
V_{Smax}	-112V to -220V
R_i	50Ω
t_d	150ns ± 45ns
t_r	5ns ± 1.5ns
t_1	100μs
t_4	10ms
t_5	90ms
test time	1h
t_{Mon}	between burst package
Standard	ISO7637-2: 2010



Test Pulse 3a simulates a switching process.

Table 5 Test Pulse 3b

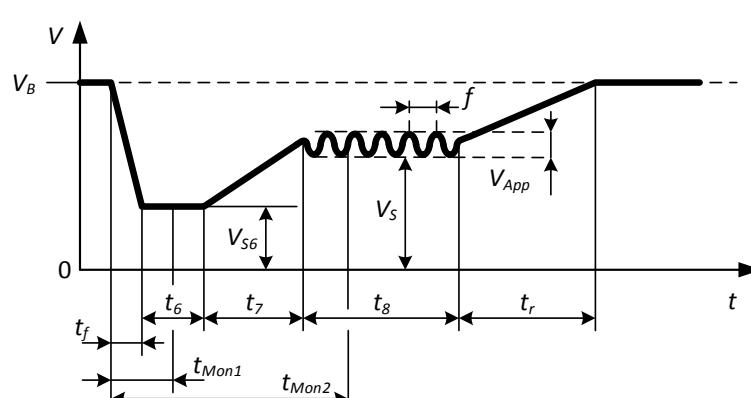
V_A	13.5V
V_{Smax}	+75V to +150V
R_i	50Ω
t_d	150ns ± 45ns
t_r	5ns ± 1.5ns
t_1	100μs
t_4	10ms
t_5	90ms
test time	1h
t_{Mon}	between burst package
Standard	ISO7637-2: 2010



Test Pulse 3b simulates a switching process.

Table 6 Pulse Starting profile

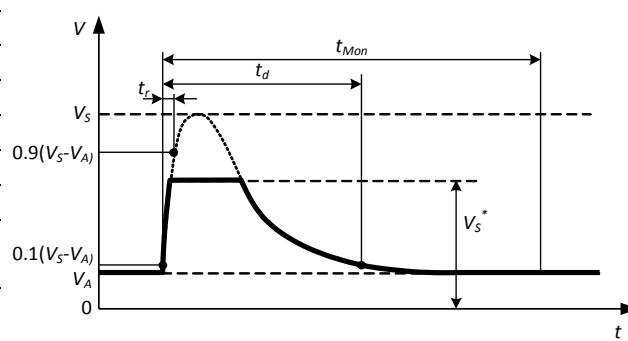
Level	I
V_B	+12V
V_{S6}	8V
V_A	9.5V
V_{APP}	2.0V
R_i	0.01Ω
t_f	5ms
t_6	15ms
t_7	50ms
t_8	1s
t_r	40ms
f	2Hz
# of pulses	1
t_{Mon1}	during t_6
t_{Mon2}	during t_8
Standard	ISO 16750-2: 2010



The starting Profile simulates the battery voltage during the ignition process

Table 7 Pulse Load Dump Suppression

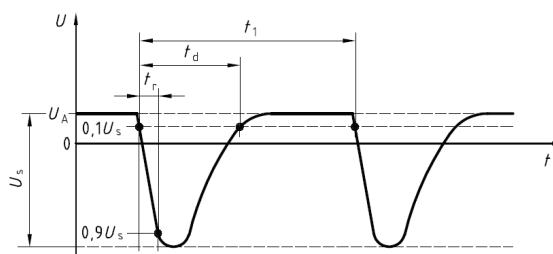
V_A	+13.5V
V_{Smax}	+79V to +101V
V_S^*	+35V
R_i	0.5Ω to 4Ω 2Ω
t_d	40ms to 400ms
t_r	10ms(+0ms, -5ms)
# of pulses	10 pulses at intervals of 1 min
t_{Mon}	between burst package
Standard	ISO16750-2: 2010



This pulse simulates the load dump pulse in case of suppressor diodes integrated into the generator.

Table 8 Test Pulse IFX-C

V_A	+13.5V
V_{Smax}	-50V to -100V
R_i	2Ω for $V_s \leq 50V$ 4Ω for $V_s > 50V$
t_d	50μs
t_r	1μs (+0μs, -0.5μs)
T_1	0.2s to 5s
# of pulses	500
t_{Mon}	Time between 2 pulses
Standard	Infineon internal



Test Pulse IFX-C is the negative Test pulse2a connected to the battery line.

Trademarks of Infineon Technologies AG

μHVIC™, μIPM™, μPFC™, AU-ConvertIR™, AURIX™, C166™, CanPAK™, CIPOS™, CIPURSE™, CoolDP™, CoolGaN™, COOLiR™, CoolIMOS™, CoolSET™, CoolSiC™, DAVE™, DI-POL™, DirectFET™, DrBlade™, EasyPIM™, EconoBRIDGE™, EconoDUAL™, EconoPACK™, EconoPIM™, EiceDRIVER™, eupec™, FCOS™, GaNpowlR™, HEXFET™, HITFET™, HybridPACK™, iMOTION™, IRAM™, ISOFACE™, IsoPACK™, LEDrivIR™, LITIX™, MIPAQ™, ModSTACK™, my-d™, NovalithIC™, OPTIGA™, OptiMOS™, ORIGA™, PowIRaudio™, PowIRStage™, PrimePACK™, PrimeSTACK™, PROFET™, PRO-SIL™, RASIC™, REAL3™, SmartLEWIS™, SOLIDFLASH™, SPOCT™, StrongIRFET™, SupIRBuck™, TEMPFET™, TRENCHSTOP™, TriCore™, UHVIC™, XHP™, XMC™

Trademarks updated November 2015

Other Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (www.infineon.com).

WARNINGS

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.

Published by

Infineon Technologies AG
81726 Munich, Germany

© 2018 Infineon Technologies AG.
All Rights Reserved.

Do you have a question about this document?

Email: erratum@infineon.com

Document reference
EMC Test Report