



BRF6300 Class 1 Implementation

Application Note

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Overview

This document describes the interface between BRF6300 and an external Class1 power amplifier.

1. Introduction

The TI BRF6300 device is targeted to be a Class 2 Bluetooth device. Class 2 device maximum output power is defined in BT specifications as +4dbm. When an output power higher than 4dbm is required, the BRF6300 is also designed to support an external Class 1 power amplifier (PA). Class 1 device maximum output power is defined in BT specifications as +20dbm.

Supporting Class1 can be achieved by adding an external PA and RF switches.

The BRF6300 interface supports both a digitally-controlled PA and an analog-controlled PA

This document defines the connectivity between BRF6300 and external class1 power amplifiers.

This document is complementary to the BRF6300 data sheet, and is not intended to replace it. It is strongly recommended that the designer will use the full spectrum of data sheets and application notes for a system design.

2. Description

Two types of PA connectivity are available; digital control and analog control. The BRF6300 supports both types of amplifiers using a dedicated interface.

One digital and two analog control modes can be selected by VS command:

2.1. Digitally-Controlled External PA

Digital control of an external PA is achieved using the following output lines:

- EXT_PA_CMD1 and EXT_PA_CMD2 are input into the voltage control lines of the digital PA. These two lines together comprise the 2-bit control command of the digital PA.
- EXT_PA_EN and nEXT_PA_EN lines serve for two purposes- The first is to enable the PA (only one of these two lines is used, which are complementary, depending on the PA and polarity of the PA's enable input). The second purpose is to control the RF switch (refer to 2.3)

Figure 1 depicts these four output lines and their functionality.

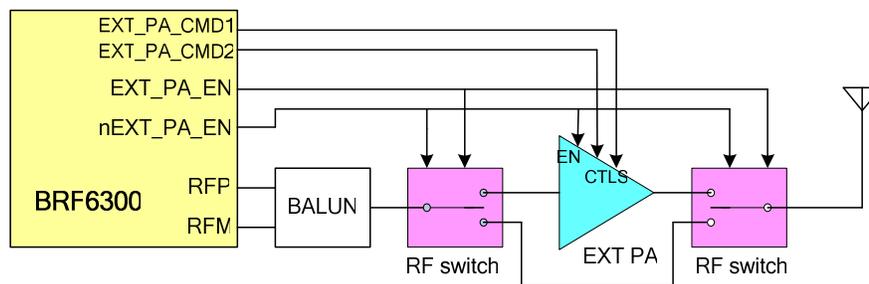


Figure 1 : Digital control of external PA

Table 1 illustrates the 2-bit power level control command for digitally-controlled PA.

Table 1 : Power level control of digital PA

EXT_PA_CMD2	EXT_PA_CMD1	Power Level
0	0	1
0	1	2
1	0	3
1	1	4

2.2. Analog-Controlled External PA

There are two possible options for interfacing an analog PA.

- Analog control via PWM: *This is option to provide compatibility with BRF6150 analog control method.* Pulse width modulation using the EXT_PA_CMD1 and EXT_PA_CMD1 and an RC filter to create one analog level control signal. (The EXT_PA_EN and nEXT_PA_EN control the RF switch just as in the digital PA solution)
- Analog control via internal DAC: Built in DAC allows use of a dedicated output line, usually without any external components (one capacitor required if noisy DAC supply), to create analog level control signal. Separate supply required for DAC - up to 3.3V for maximum PA control. *This method is the preferable when analog external PA is used.* Figure 2 depicts the interface to control an analog PA.

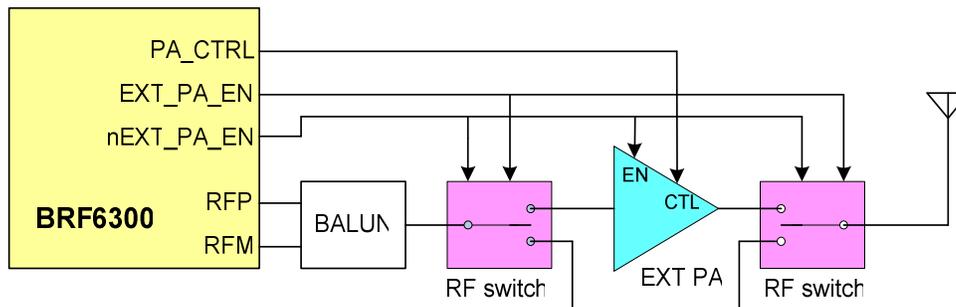
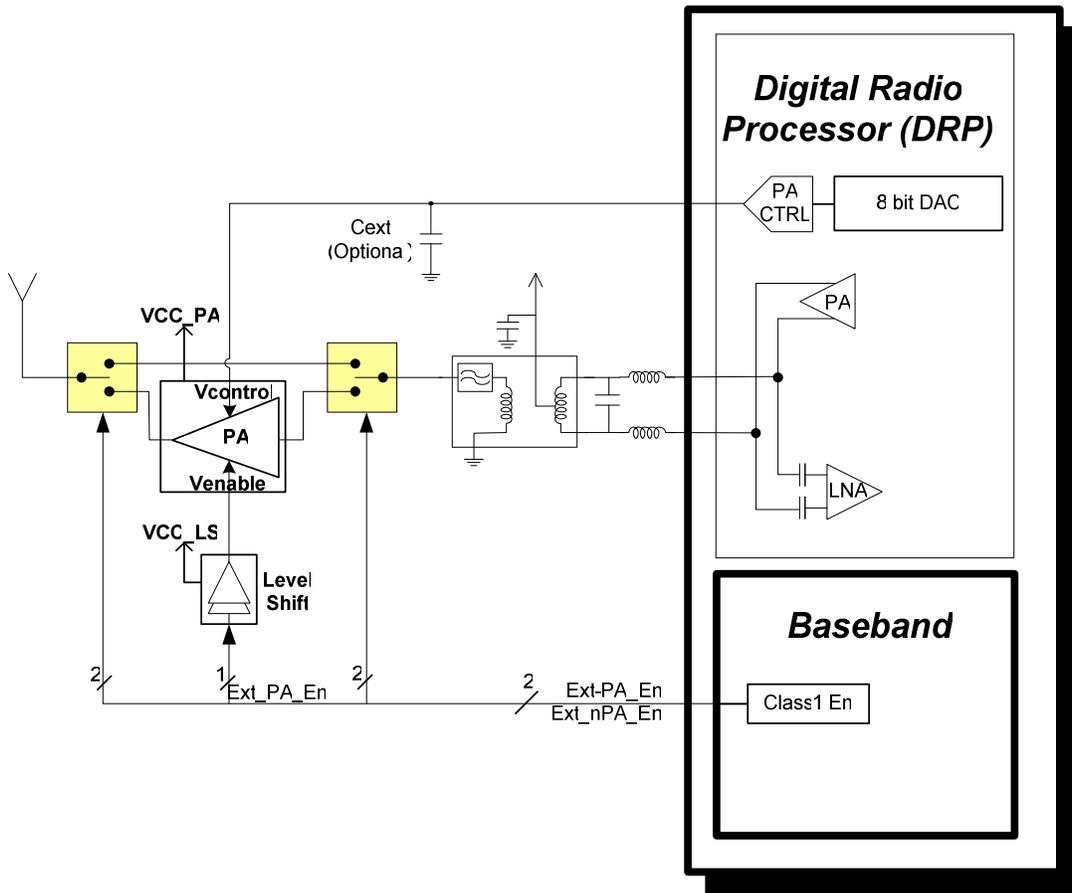


Figure 2 : Analog control of external PA

Figure 3 further explains the PA control circuit, with analog level control by the DAC. An 8-bit internal DAC outputs a varying-voltage analog signal that controls the external PA output power. The external PA is disabled/enabled depending on the polarity of EXT_PA_EN or nEXT_PA_EN (refer to Section 2.4).



Note An additional Level shifter (for the nEXT_PA_En) might be needed depending on the RF switches used and the BRF6300 minimum IO supply voltage

Figure 3: Analog PA - DAC gain mode

The 3 connectivity options for digital and analog PAs are described in more detail in Figure 4, Figure 6 and Figure 5.

2.3. RF Switches Control

The switches require two control signals – one is the inversion of the other. In order to avoid undefined states, the same signal – EXT_PA_EN will be used, with an inverter to create nEXT_PA_EN. The states of the BT channel according to EXT_PA_EN and nEXT_PA_EN signals detailed in *Table 2* (with reference to schematics in section 6 below):

Table 2 : RF switches control

State	EXT_PA_EN	nEXT_PA_EN	OUTPUT1	OUTPUT2	PA
Class2 TX /RX	0	1	ON	OFF	OFF
TX	1	0	OFF	ON	ON

The switch to Class2 TX path is used for current consumption optimization (the external PA shall be enabled/used only when output power needed requires a use of external PA) and it shall be performed based on the power control. Usually while in Class2 applications, the external PA will be disabled.

2.4. External PA Enable / Disable

For this purpose, one of the above signals (EXT_PA_EN, nEXT_PA_EN) will be used, according to the type of the PA used (active high or low enable pin). Since most PA known in the market have active high enable, the **default value** of EXT_PA_EN should be low (PA disabled).

3. Signals

The required signals for using an external power amplifier are detailed in the table below. The recommended pins marked in bold blue.

Table 3 : Class1 Signals

Signal name	BRF6300 pin	Description
EXT_PA_EN	IO_14	The signal enables the external power amplifier and also controls the external switches to RX/TX states.
nEXT_PA_EN	IO_15 IO_16 TX_DBG	The signal is complementary to the EXT_PA_EN signal. It controls the external switches to RX/TX states, together with EXT_PA_EN signal.
Ext_PA_CMD1	IO_2 IO_4 IO_17 TX_DBG	The LSB of the 2-bit control command to the digital PA., used for external Digitally-controlled Pas and for PWM-analog-control PA option
Ext_PA_CMD2	IO_3 IO_7 IO_15 TX_DBG	The MSB of the 2-bit control command to the digital PA., used for external Digitally-controlled Pas and for PWM-analog-control PA option
PA_CTRL	PA_CTRL	Analog signal that is used for voltage control of the DAC-analog control external PA option

4. HCI VS Commands

There are two commands used to control the class 1 application: “HCI_VS_DRP_Set_Power_Table” and “HCI_VS_DRP_Set_External_PA_Mode”.

The “*HCI_VS_DRP_Set_Power_Table*” command sets the internal and external PA power tables values. A power table specifies the output power for each of the seven possible power levels. In the BRF6300, there are 60 available tables (there is a dedicated for each process (weak, nominal or strong) for the different temperature ranges and for the different modulation scheme (GFSK, 2M EDR and 3M EDR). According to the process and temperature burned in the DIE the relevant power table is automatically selected. There is also a separate power table for the external PA.

The command also sets the activation of each the 7 power level of the external PA (not all power levels have to be on, for example- level 7 can be on, and level 6 off).

The “*HCI_VS_Set_Power_Calibration_Matrix*” has the following functionalities:

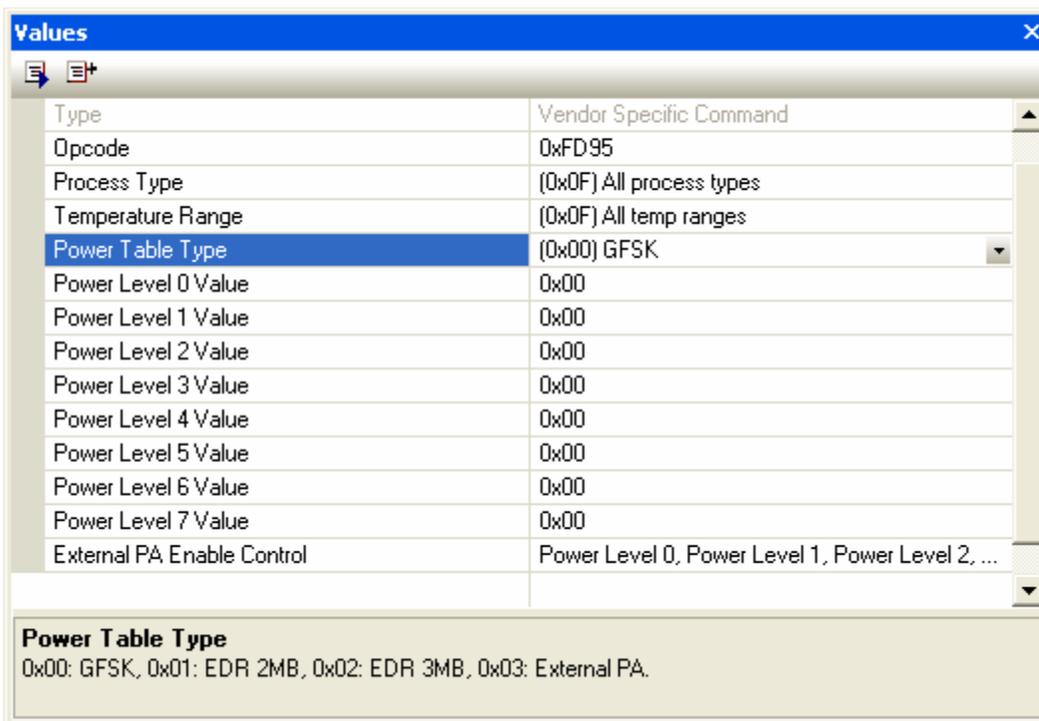
- a) Determine the external PA control mode (digital, PWM or DAC).
- b) Determine the different setting parameters for a specific mode.
- c) Mux select of the IO pins.

In order to get the dedicated init script for every customer’s application, please refer to the local FAE.

4.1. HCI_VS_DRP_Set_Power_Table

Table 4 : HCI_VS_DRP_Set_Power_Table command parameters

Command	Opcode	Command Parameters	Return Parameters
HCI_VS_DRP_SET_POWER_TABLE	0XFD95	Process Temperature Type GFSK / 2-EDR / 3-EDR/Ext PA Level 0 value Level 1 value Level 2 value Level 3 value Level 4 value Level 5 value Level 6 value Level 7 value External PA Enable control	Status



Values	
Type	Vendor Specific Command
Opcode	0xFD95
Process Type	(0x0F) All process types
Temperature Range	(0x0F) All temp ranges
Power Table Type	(0x00) GFSK
Power Level 0 Value	0x00
Power Level 1 Value	0x00
Power Level 2 Value	0x00
Power Level 3 Value	0x00
Power Level 4 Value	0x00
Power Level 5 Value	0x00
Power Level 6 Value	0x00
Power Level 7 Value	0x00
External PA Enable Control	Power Level 0, Power Level 1, Power Level 2, ...

Power Table Type
 0x00: GFSK, 0x01: EDR 2MB, 0x02: EDR 3MB, 0x03: External PA.

Description:

This command sets the power table of the given process, temperature & type.

The "External PA Enable control" field is relevant only when the field "Power Table Type" is Ext PA.

Command Parameters:

Process Type	Parameter Description	Size: 1 Byte
Value	Parameter Description	
0x00 – 0x02	Update power table only if matches current process	
0x0F	Regardless of process.	

Temperature range		Size: 1 Byte
Value	Parameter Description	
0x00 – 0x04	Update power table for the relevant temperature range	
0x0F	Change for all temperatures (only if process matched)	

Power Table Type		Size: 1 Byte
Value	Parameter Description	
0x00	GFSK Power table	
0x01	2-EDR power table	
0x02	3-EDR power table	
0x03	External PA power table	

Level n value (n=0..7)	Size: 1 Byte
Value	Parameter Description
0x00 – 0xFF	Selects the value to set in the table entry.

External PA control	Size: 1 Byte
Value	Parameter Description
Bit 0	External PA activation for power level 0 (0 is off, 1 is on)
Bit 1	External PA activation for power level 1 (0 is off, 1 is on)
Bit 2	External PA activation for power level 2 (0 is off, 1 is on)
Bit 3	External PA activation for power level 3 (0 is off, 1 is on)
Bit 4	External PA activation for power level 4 (0 is off, 1 is on)
Bit 5	External PA activation for power level 5 (0 is off, 1 is on)
Bit 6	External PA activation for power level 6 (0 is off, 1 is on)
Bit 7	External PA activation for power level 7 (0 is off, 1 is on)

Return Parameters:

Status:		Size: 1 Byte
Value	Parameter Description	
0x00	Command Succeeded.	
0x01-0xFF	Command failed. See Error! Reference source not found.	

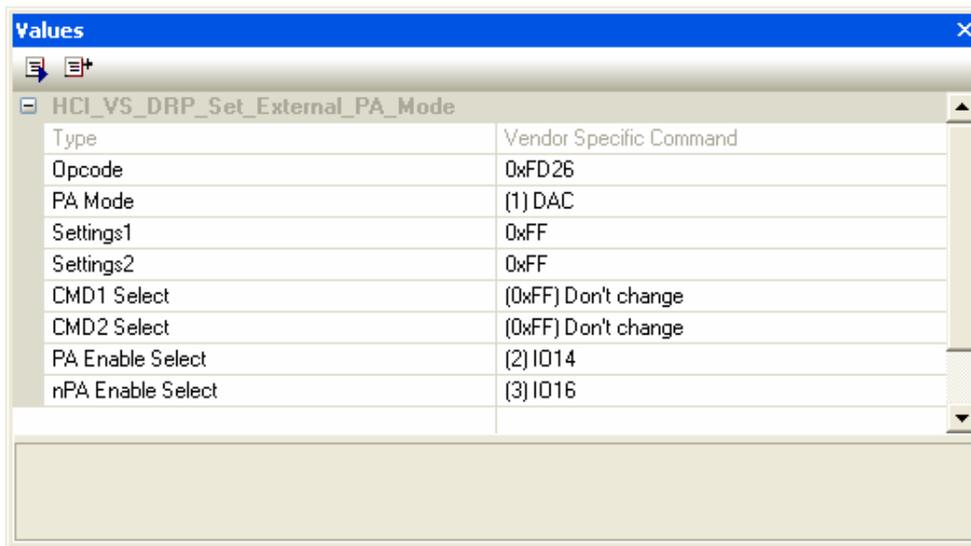
Events Generated:

Command Complete Event

4.2. HCI_VS_DRP_Set_External_PA_Mode

Table 5 : HCI_VS_DRP_Set_External_PA_Mode command parameters

Command	Opcode	Command Parameters	Return Parameters
HCI_VS_DRP_SET_EXTERNAL_PA_MODE	0xFD26	PA Mode Setting1 Setting2 EXT_PA_CMD1 Select EXT_PA_CMD2 Select EXT_PA_EN Select nEXT_PA_EN Select	Status



Values	
HCI_VS_DRP_Set_External_PA_Mode	
Type	Vendor Specific Command
Opcode	0xFD26
PA Mode	(1) DAC
Settings1	0xFF
Settings2	0xFF
CMD1 Select	(0xFF) Don't change
CMD2 Select	(0xFF) Don't change
PA Enable Select	(2) I014
nPA Enable Select	(3) I016

Description:

Controls MUX and activation for Analog / Digital PA.

OFF Mode – hardware is connected to external PA, but RF path is configured through RX path (so PA can be off all the time).

Command Parameters:

PA Mode	Parameter Description	Size: 1 Byte
Value	Parameter Description	
0x00	Class 2 configuration with class 1 hardware, External PA off route RF path to receive (switches set to RX, EXT_PA_EN low, nEXT_PA_EN is high).	
0x01	DAC controls analog PA	
0x02	PWM controls analog PA	
0x03	Digital PA	
0xFF	Don't change	

Setting1	Parameter Description	Size: 1 Byte
Value	Parameter Description	
When in DAC mode		
0x00 – 0xFE	Values for resistance trim	
0xFF	Don't change	

When in PWM mode	
0x00 – 0xFE 0xFF	Values for ramp up / down Don't change
When in Digital PA mode	
0x00 – 0xFE 0xFF	Values for ramp up / down step size Don't change

Setting2		Size: 1 Byte
Value	Parameter Description	
When in PWM mode		
0x00 – 0xFE 0xFF	Duration of fast charge activation Don't change	
When in Digital PA mode		
0x00 – 0x0FE 0xFF	Values for ramp down step size Don't change	

EXT_PA_CMD1 Select		Size: 1 Byte
Value	Parameter Description	
0	TX_DBG	
1	IO2	
2	IO4	
3	BT_WAKE_UP	
4	IO16	
5	IO17	
0xFF	Don't change	

EXT_PA_CMD2 Select		Size: 1 Byte
Value	Parameter Description	
0	TX_DBG	
1	IO3	
2	BT_WAKE_UP	
3	EXT_CLK_REQ	
4	IO14	
5	IO17	
0xFF	Don't change	

EXT_PA_EN Select		Size: 1 Byte
Value	Parameter Description	
0	IO1	
1	IO2	
2	IO14	
0xFF	Don't change	

nEXT_PA_EN Select		Size: 1 Byte
Value	Parameter Description	
0	TX_DBG	
1	IO3	
2	IO4	
3	IO16	
4	EXT_CLK_REQ	
0xFF	Don't change	

Return Parameters:

Status:	Size: 1 Byte
Value	Parameter Description
0x00	Command Succeeded.
0x01-0xFF	Command failed. See Error! Reference source not found.

Events Generated:

Command Complete Event

5. Debug and testing of class 1 section

This section details an example of the various stages of the operational testing and debug of a class 1 implementation.

5.1. Schematics and components review

The schematics should be reviewed, in order to verify correct wiring and correct values of the components.

5.2. Script preparation

In the script, the power steps are set according to the temperature and the chip production process. According to BT spec, the power steps should be between 2 to 8db.

- Script preparation – power steps setting
- Class 2 tests – Includes matching (TX: 2- 6dbm, RX: min -82dbm)
- Matching of external PA – S11 and S22 (S11& S22 – 50Ohm)
- Integration between BRF6300 and ext. PA – TX and RX tests
- Testing – according BT spec.
 - Frequency range parameter, Adjacent Channel Power etc
 - Complete BT qualification tests

6. Schematics

6.1. Digital External PA - Class 1 application

The schematics below introduce the connectivity to digital external power amplifier.

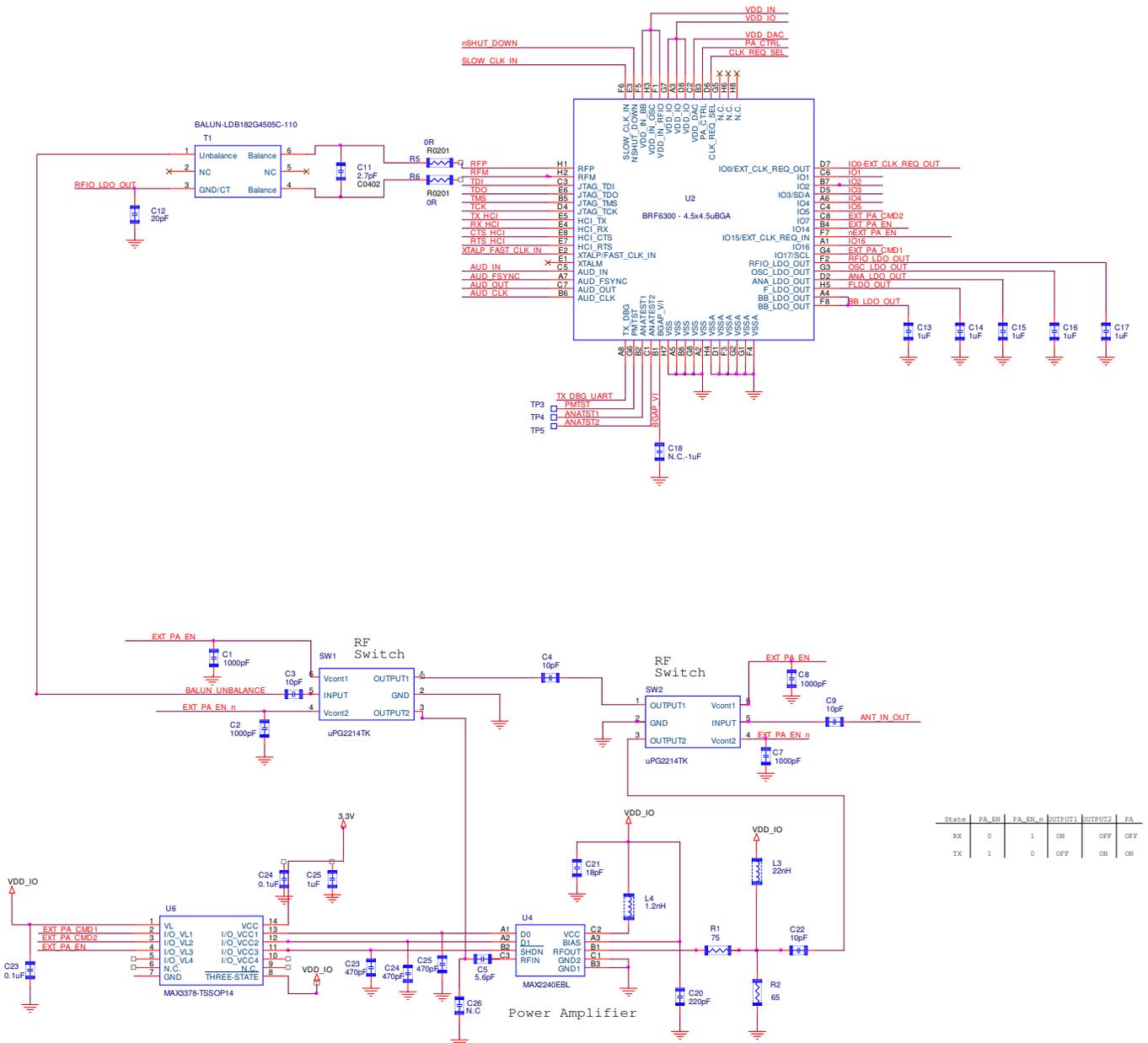


Figure 4 : Class 1 section schematics – Digital PA

6.2. Analog External PA, DAC connectivity - Class 1 application

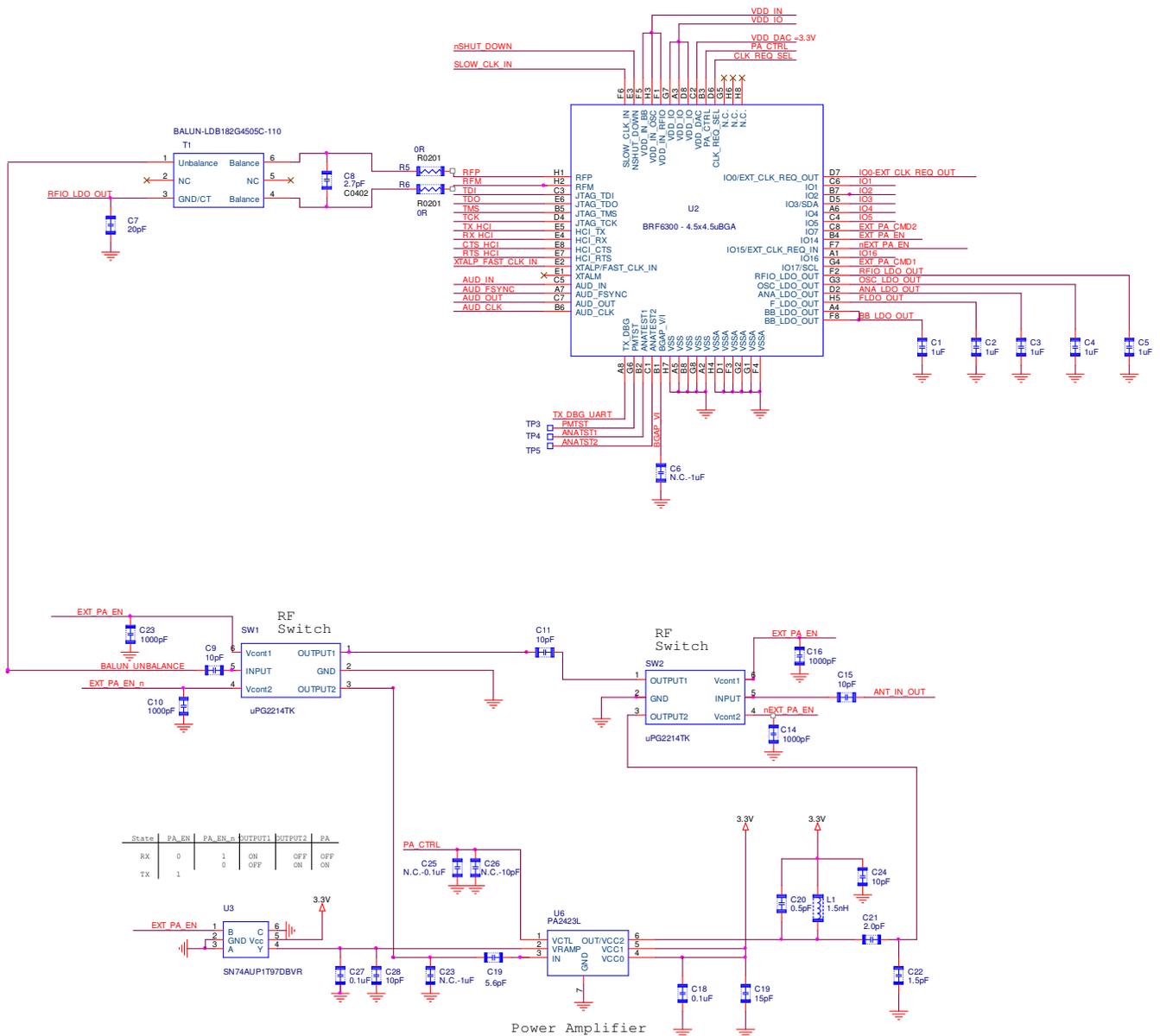


Figure 5 : Class 1 section schematics – Analog PA with DAC connectivity mode

6.3. Analog External PA, PWM connectivity - Class 1 application

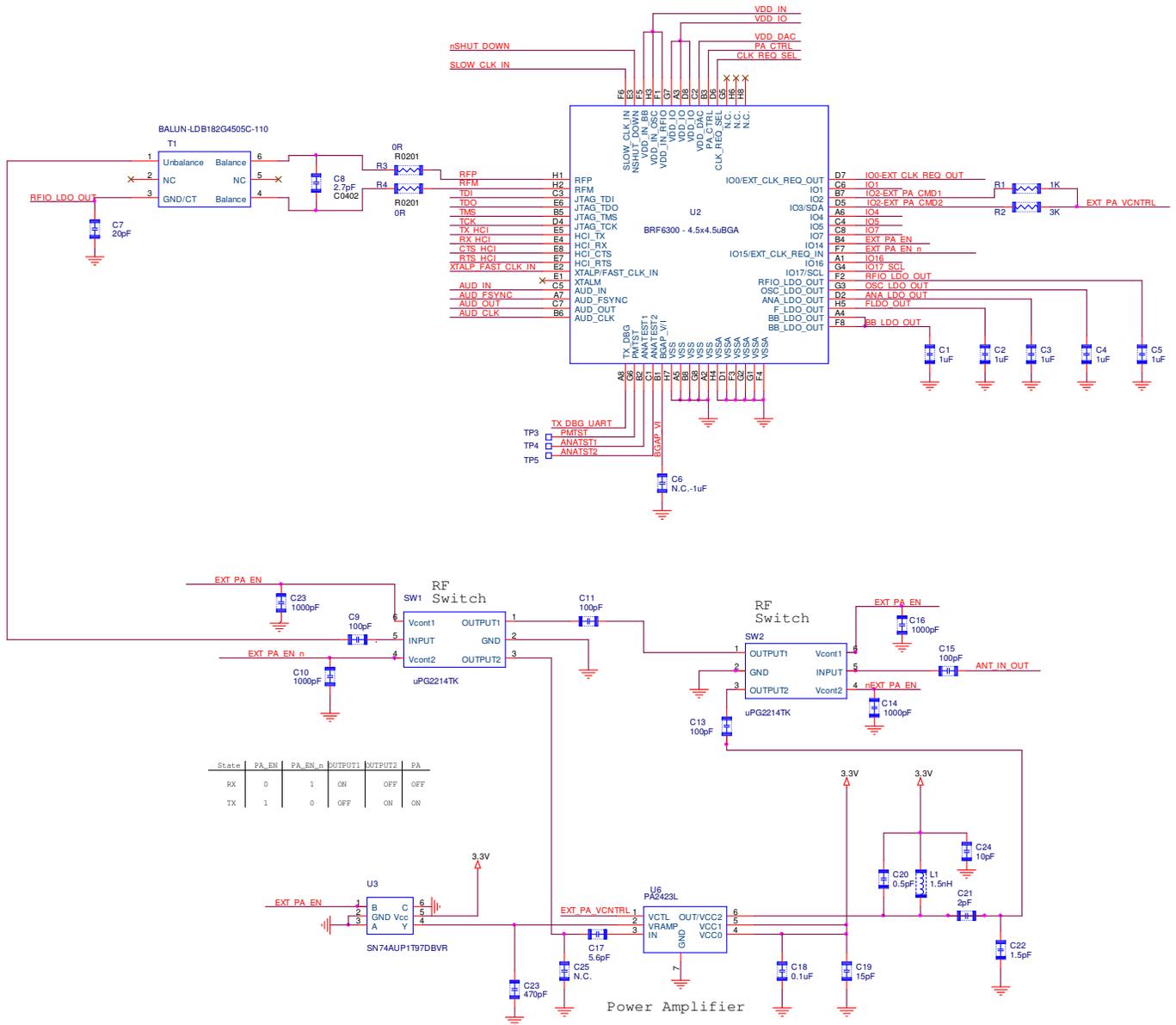


Figure 6 : Class 1 section schematics – Analog PA with PWM connectivity mode

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