EVM User's Guide: TRF1305X1-D2D-EVM

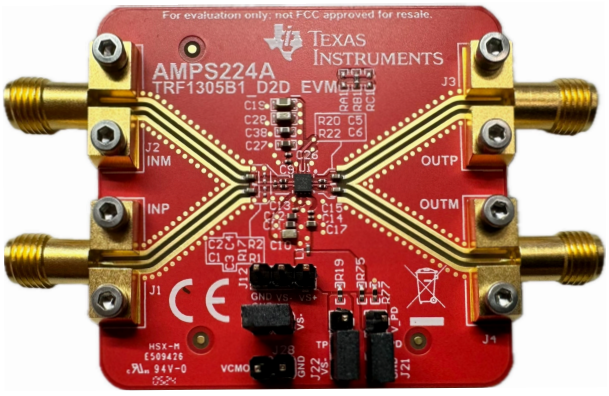
TRF1305x1-D2D Evaluation Module

Description

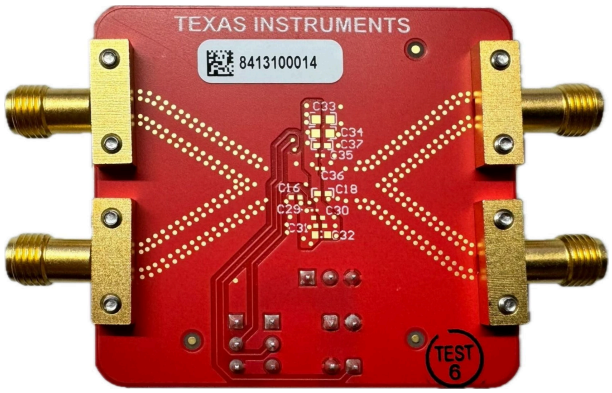
The TRF1305x1-D2D-EVM is designed to provide a quick setup to evaluate the TRF1305 series of fixed gain fully differential amplifiers (FDA) that have high linearity and operational bandwidth from true-dc to > 6.5GHz. The TRF1305 amplifiers are available in both single-channel and dual-channel packaging with three different fixed gains in each packaging. These amplifiers work with two flexible supply rails and can be dc-coupled and support a wide range of common-mode voltage. There are four types of EVMs that cover all device variants in the configurations.

Features

- Configured for split-supply operation and easily modified for single supply
- Single-ended or differential input signals
- Designed for easy connection to standard 50Ω input and output impedance test equipment
- Power-down option available onboard using a jumper connector



TRF1305B1-D2D-EVM Board (Top View)



TRF1305B1-D2D-EVM Board (Bottom View)

1 Evaluation Module Overview

1.1 Introduction

This document is the user's guide for the evaluation boards (EVMs) meant for testing single-channel TRF1305 series of amplifiers in D2D configuration. Table 1-1 lists the four types of TRF1305 EVMs that are meant to test all device variants in different I/O configuration.

Table 1-1. TRF1305 EVMs

EVM User's Guide	Device	Orderable Part No.	I/O Configurations	Comment
TRF1305x2-D2D	TRF1305A2	TRF1305A2-D2D-EVM	D2D, S2D(1)	Dual-channel amplifier - D2D (differential in, differential out) EVM
	TRF1305B2	TRF1305B2-D2D-EVM		
	TRF1305C2	TRF1305C2-D2D-EVM		
TRF1305x1-D2D	TRF1305A1	TRF1305A1-D2D-EVM	D2D, S2D	Single-channel amplifier - D2D (differential in, differential out) EVM
	TRF1305B1	TRF1305B1-D2D-EVM		
	TRF1305C1	TRF1305C1-D2D-EVM		
TRF1305x2-S2D	TRF1305A2	TRF1305A2-S2D-EVM	S2D	Dual-channel amplifier - S2D (single-ended in, differential out) EVM
	TRF1305B2	TRF1305B2-S2D-EVM		
	TRF1305C2	TRF1305C2-S2D-EVM		
TRF1305x1-S2D	TRF1305A1	TRF1305A1-S2D-EVM	S2D	Single-channel amplifier - S2D (differential in, differential out) EVM
	TRF1305B1	TRF1305B1-S2D-EVM		
	TRF1305C1	TRF1305C1-S2D-EVM		

(1) D2D EVMs can be configured in S2D by using a 50Ω SMA terminator on one of the inputs. For best performance, use an S2D EVM.

This document also includes schematic diagrams, a bill of materials (BOM), printed-circuit board (PCB) layouts, and test block diagrams. Throughout this document, the abbreviations *EVM, TRF1305x1-D2D-EVM* or the term *evaluation module* means any one of the four EVMs listed previously. This user's guide describes the basic steps and functions that are required for the proper operation and quick setup of the TRF1305x1-D2D-EVM. Many sections in this user's guide are common to all TRF1305EVMs. Throughout this document, TRF1305 or TRF1305x1 means TRF1305A1 or TRF1305B1 or TRF1305C1.

1.2 Kit Contents

The following tables list the contents of each EVM kit. Contact the Texas Instruments Product Information Center nearest you if any components are missing. TI highly recommends that users check the TI website to verify that the latest versions of the related software is being used.

Table 1-2. Kit Contents for TRF1305A1-D2D-EVM

Item	Quantity
TRF1305A1-D2D-EVM	1

Table 1-3. Kit Contents for TRF1305B1-D2D-EVM

Item	Quantity
TRF1305B1-D2D-EVM	1

Table 1-4. Kit Contents for TRF1305C1-D2D-EVM

Item	Quantity
TRF1305C1-D2D-EVM	1

1.3 Specification

Table 1-5. Key System Specifications

Connector	Parameter	Value
J1	RF Input INP1	Max 20dBm
J2	RF Input INM1	Max 20dBm
J3	RF Output OUTP1	
J4	RF Output OUTM1	
J5	J11.1 VS– J11.2 GND	Open in split-supply operation Short in single-supply operation
J12	J12.1 VS+ J12.2 VS– J12.3 GND	VS+ ≤ 5V VS– ≥ –2.5V (VS+) – (VS–) = 5V
J21	PD1 Select	Short 1,2 (V_PD) to disable Ch1. Short 2,3 (GND) to enable Ch1
J22	Mode Select	Open (default) See section 7.4.1 in data sheet for input common mode range extension
J28	J23.1 VCMO J23.2 GND	Open (default) Apply external voltage to set desired output common mode

1.4 Device Information

The TRF1305 is a very high performance, closed-loop, dual-channel RF amplifier that has an operational bandwidth from true-dc to > 6.5GHz. The device has excellent performance to drive high-speed, high-performance ADCs, such as the ADC12DJ5200RF and ADC32RF5x with a dc- or ac-coupled interface. The device is optimized for performance in the preset gain configuration. If a lower-than-preset gain is desired, then use external resistors. The TRF1305 features a VOCM pin that allows setting different output common-mode and input common-mode voltages (for example, for level-shifting or for most IQ down-converter ADC-interface applications that have differing dc common-mode voltages). The floating 2-rail split or single-supply option, and a MODE pin that allows extending the input common-mode range closer to the supplies. High channel-to-channel isolation allows the device to be used in a complex IQ transmit or receive signal chain without loss of signal integrity.

2 Hardware

2.1 General Usage Information

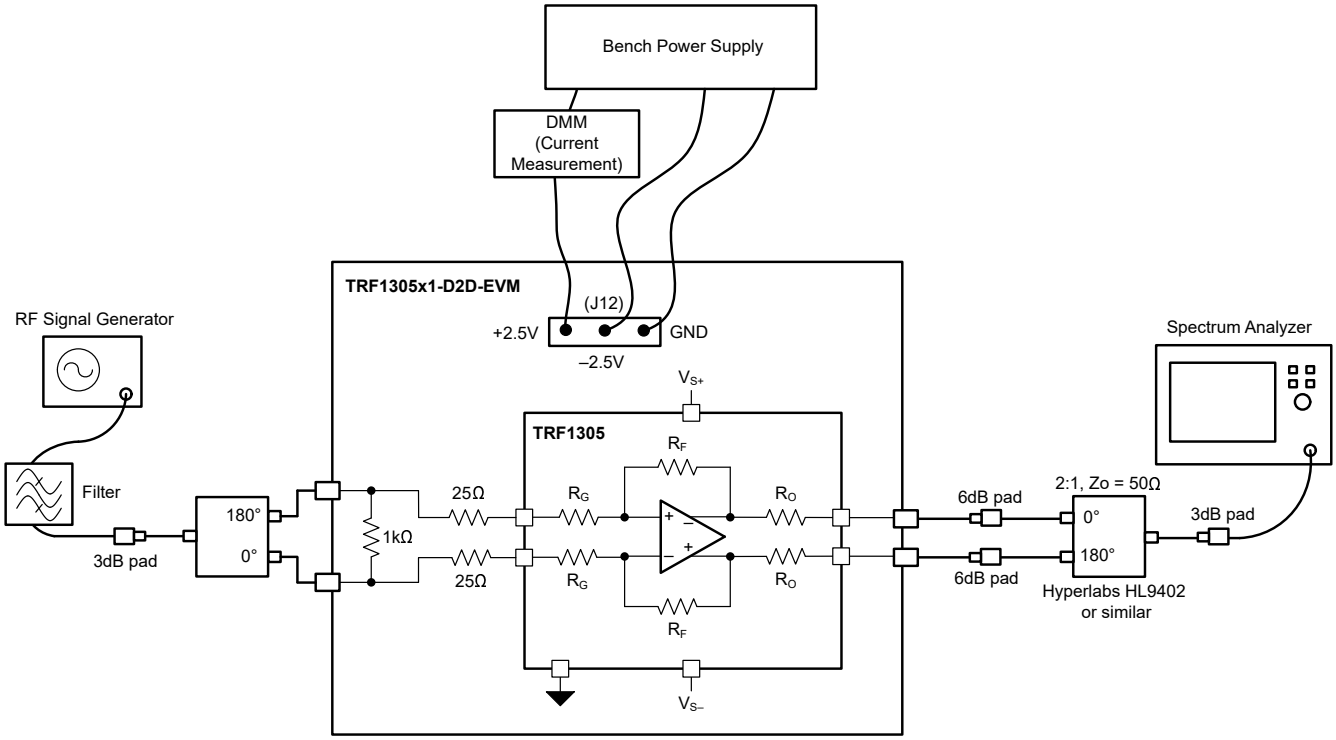


Figure 2-1. Single-Tone Setup for Gain and Output P1dB

This section provides general usage information for the TRF1305x1-D2D-EVM. See Figure 2-1 for a general single tone setup diagram as a reference point for the following instructions (some components, such as supply bypass capacitors, are omitted for clarity):

1. Recommended power up sequence:
   - Split-supply operation:
     a. To operate as split supply, apply the positive supply voltage to VS+, negative supply voltage to VS–, and the ground reference from supply to GND (J12). The supply voltages do not need to be symmetrical, provided that the total supply voltage is 5V, any combination of positive and negative supply voltages is acceptable. This feature is often used when the output common mode voltage must be set to a particular value. For best performance, the power supply voltages must be symmetrical around the desired output common-mode voltage.
     b. Set the current limit of the dc output power supply at 200mA.
     c. Making sure the supply is turned off, connect the power supply cables to the J12 connector of the EVM.
     d. Now turn on the dc power supply of VS+ = 2.5V and VS– = –2.5V. The supply current (I_Q) drawn from the power supply is approximately 100mA.
     e. If the supply current is low, then verify that the device is not disabled by the PD pin (J21).
   - Single-supply operation:
     a. To operate as single supply, connect jumper VS– to GND (J5), and apply the positive supply voltage to VS+ (J12). Inputs and outputs must be biased as in the TRF1305 data sheet specifications for proper operation.
2. Power-down option:
   - Connect 1.8V (logic-1) on PD pin to power-down the chip (J21). Ground the PD pin to enable the chip.
   - When the device is disabled, the supply current (I_Q) drawn from the power supply is approximately 25mA.

3. CM (output common mode voltage) input:
   - The TRF1305 device has an output common-mode control pin that sets the output common mode voltage. The output common-mode voltage at the output pins, OUTPx and OUTMx, defaults to the LDO output voltage of VS– + 2.5V when VOCM pin is floated.
   - If a different output common-mode voltage is specified, then the J28 jumper can be used to connect an external low-impedance voltage source. See the TRF1305 data sheet for performance curves that show how performance is impacted by an output common mode voltage that is not at the mid-supply voltage.
4. Single-tone measurement setup recommendation:
   a. Single ended signal from RF signal generator is converted to a differential signal using an external passive balun as shown in Figure 2-1. Differential signal is fed to input SMA connectors, J1, J2. When measuring single tone distortion, use an RF band pass filter as shown in Figure 2-1.
   b. The RF signal generator used must support up to 10GHz signal frequency for testing out the TRF1305x1-D2D-EVM EVM.
   c. The TRF1305x1-D2D-EVM device input is 50Ω in the pass-band. To minimize signal reflections due to impedance mismatch, use an attenuator pad of approximately 3dB to 6dB between the source and J4 SMA input.
   d. The EVM outputs are fully differential (or 180° out-of-phase) at J3 and J4 SMA connectors. The TRF1305x1-D2D-EVM device has low output impedance at dc and low frequencies.
   e. When connecting to a spectrum analyzer, the differential signal out of the EVM must be converted to a single-ended signal using an external passive balun as shown in Figure 2-1. Use of an attenuator pad of approximately 3dB to 6dB is recommended at the three terminals of the passive balun to minimize reflections.
   f. Lastly, properly characterize and account for the insertion loss of RF coaxial (coax) cables, attenuator pads, and passive baluns to measure accurate gain and power levels for the device.

3 Hardware Design Files

3.1 Schematic

Figure 3-1 shows the TRF1305x1-D2D-EVM EVM schematic.

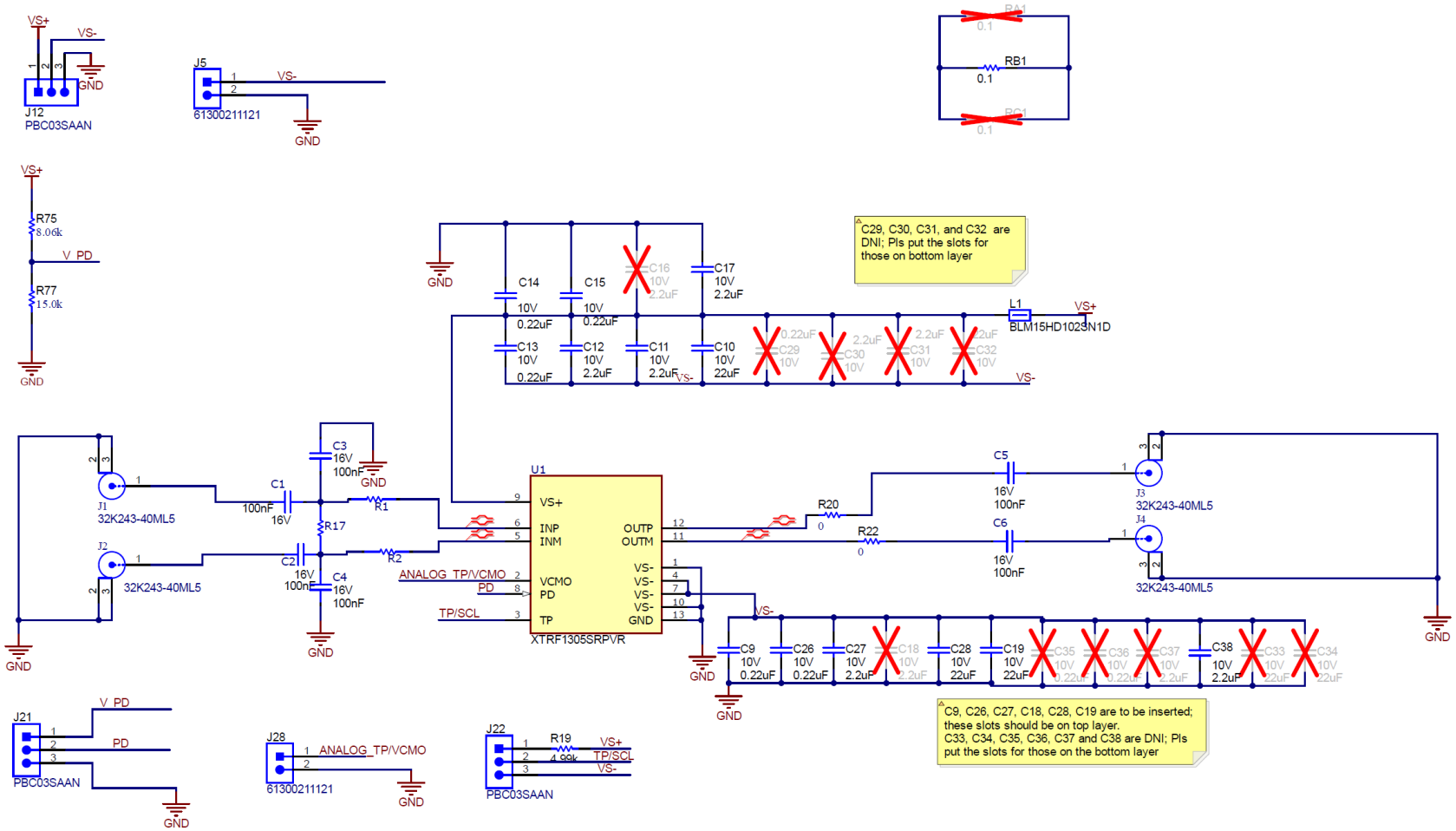


Figure 3-1. TRF1305x1-D2D-EVM Schematic

3.2 PCB Layout

Figure 3-2 through Figure 3-5 illustrate the PCB layers for this EVM.

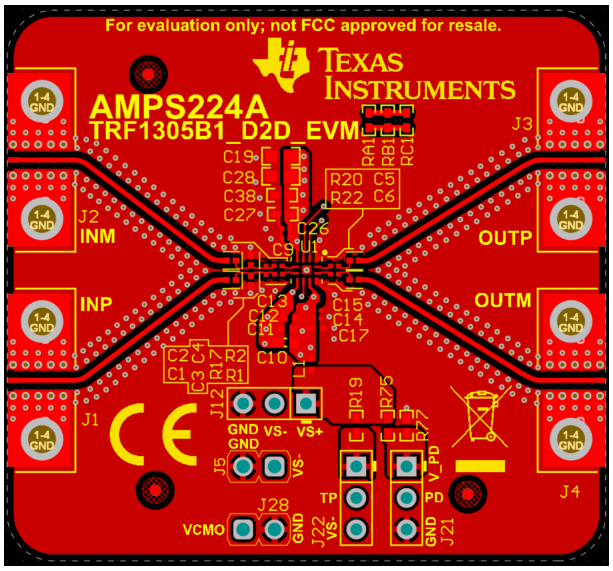


Figure 3-2. Top Layer

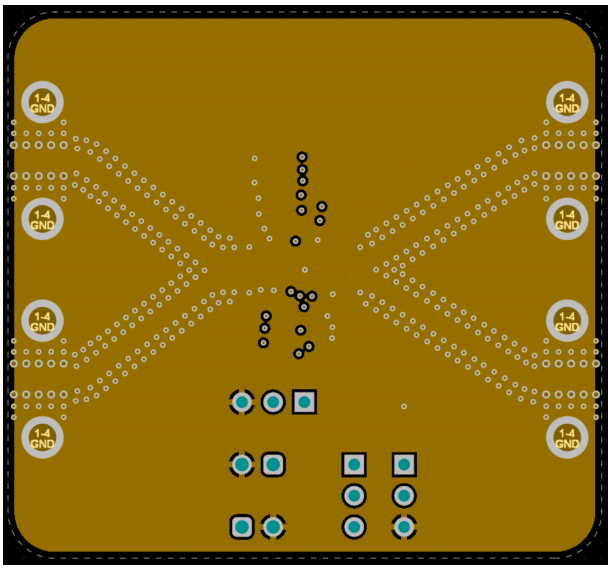


Figure 3-3. Layer 2

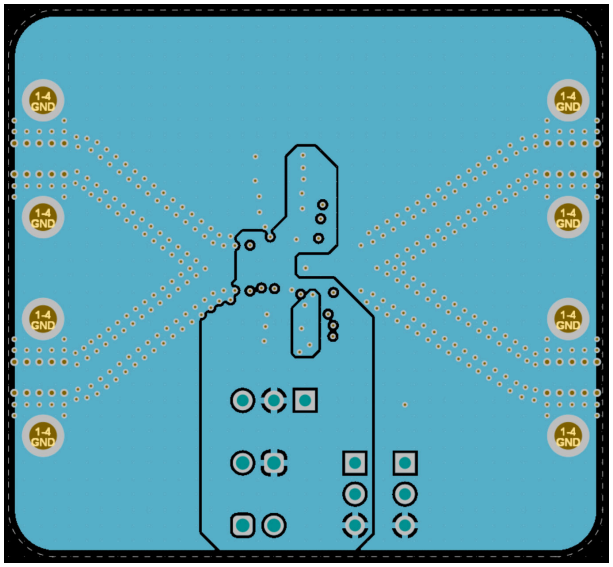


Figure 3-4. Layer 3

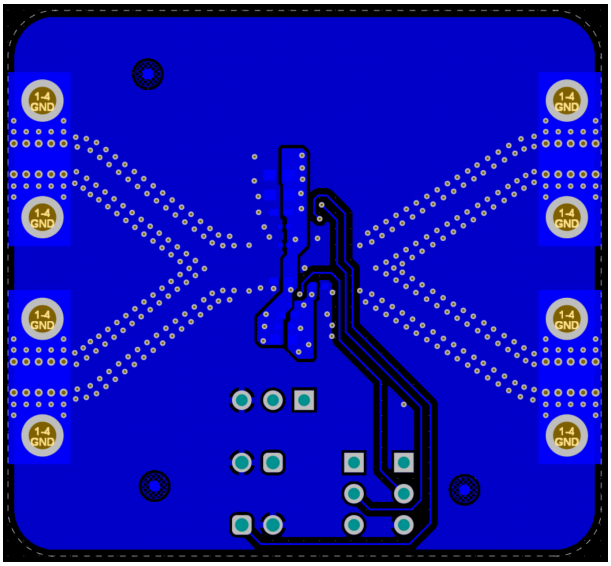
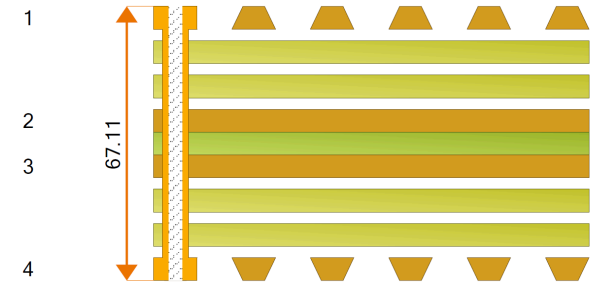


Figure 3-5. Bottom Layer

3.2.1 Stack-Up and Material

The TRF1305x1-D2D-EVM is a 67-mil, 4-layer board with material type Isola® 370HR. The top layer routes the power, ground, and signals between SMA connectors and the device. The second layer is the reference RF ground layer. The signal trace impedance is targeted at 50Ω. The bottom three layers are ground layers.



Layer	Supplier	Supplier Description	Description	Base Thickness	Processed Thickness	εr
1	GOULD	COPPER FOIL	12+35 m	1.850	2.559	
	ISOLA	185HR	#2116	5.000	4.966	4.320
	ISOLA	185HR	#2116	5.000	4.966	4.320
2				1.378	1.378	
	ISOLA	185HR	1.00 1.0/1.0	39.370	39.370	4.420
3				1.378	1.378	
	ISOLA	185HR	#2116	5.000	4.966	4.320
	ISOLA	185HR	#2116	5.000	4.966	4.320
4	GOULD	COPPER FOIL	12+35 m	1.850	2.559	

Figure 3-6. TRF1305x1-D2D-EVM Stack-Up (Units in Mils)

3.3 Bill of Materials (BOM)

Table 3-1. Bill of Materials for TRF1305A1-D2D-EVM

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB	1		AMPS224	Any	Printed Circuit Board	
2	C1, C2, C5, C6	4	100nF	ATC530L104KT16T	American Technical Ceramics	0.1µF ±10% 16V Ceramic Capacitor X7R 0402 (1005 Metric)	0402
3	C9, C13, C14, C15, C26	5	0.22uF	LMK063BJ224MP-F	Taiyo Yuden	CAP, CERM, 0.22 uF, 10 V, ± 20%, X5R, 0201	0201
4	C10, C19, C28	3	22uF	CL10A226MP8NUNE	Samsung Electro-Mechanics	CAP, CERM, 22 uF, 10 V, ± 20%, X5R, 0603	0603
5	C11, C12, C17, C27, C38	5	2.2uF	C1005X7S1A225K050BC	TDK	CAP, CERM, 2.2 uF, 10 V, ± 10%, X7S, 0402	0402
6	J1, J2, J3, J4	4		32K243-40ML5	Rosenberger	SMA JACK 50 OHM, R/A, SMT	SMA JACK, R/A, SMT
7	J5, J28	2		61300211121	Wurth Elektronik	Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH
8	J12, J21, J22	3		PBC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Gold, TH	PBC03SAAN
9	L1	1	1000 ohm	BLM15HD102SN1D	MuRata	Ferrite Bead, 1000 ohm @ 100 MHz, 0.25 A, 0402	0402
10	R1, R2	2	24.9	ERJ-1GNF24R9C	Panasonic Electronic Components	24.9 Ohms ±1% 0.05W, 1/20W Chip Resistor 0201 (0603 Metric) Thick Film	0201
11	R17	1	1k	ERJ-1GNF1001C	Panasonic Electronic Components	1 kOhms ±1% 0.05W, 1/20W Chip Resistor 0201 (0603 Metric) Automotive AEC-Q200 Thick Film	0201
12	R19	1	4.99k	RC0402FR-074K99L	Yageo America	RES, 4.99 k, 1%, 0.063 W, 0402	0402
13	R20, R22	2	0	ERJ-1GN0R00C	Panasonic	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	0201
14	R75	1	8.06k	CRCW04028K06FKED	Vishay-Dale	RES, 8.06 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402
15	R77	1	15.0k	CRCW040215K0FKED	Vishay-Dale	RES, 15.0 k, 1%, 0.063 W, 0402	0402
16	RB1	1	0.1	ERJ2BWFR100X	Panasonic	RES, 0.1, 1%, 0.25 W, 0402	0402

Table 3-1. Bill of Materials for TRF1305A1-D2D-EVM (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
17	U1	1		TRF1305A1RPVR	Texas Instruments	TRF1305A1RPVR	WQFN-FCRLF12
18	C3, C4	0	100nF	ATC530L104KT16T	American Technical Ceramics	0.1µF ±10% 16V Ceramic Capacitor X7R 0402 (1005 Metric)	0402
19	C16, C18, C30, C31, C37	0	2.2uF	C1005X7S1A225K050BC	TDK	CAP, CERM, 2.2 uF, 10 V, ± 10%, X7S, 0402	0402
20	C29, C35, C36	0	0.22uF	LMK063BJ224MP-F	Taiyo Yuden	CAP, CERM, 0.22 uF, 10 V, ± 20%, X5R, 0201	0201
21	C32, C33, C34	0	22uF	CL10A226MP8NUNE	Samsung Electro-Mechanics	CAP, CERM, 22 uF, 10 V, ± 20%, X5R, 0603	0603
22	FID1, FID2, FID3, FID4, FID5, FID6	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
23	RA1, RC1	0	0.1	ERJ2BWFR100X	Panasonic	RES, 0.1, 1%, 0.25 W, 0402	0402

Table 3-2. Bill of Materials for TRF1305B1-D2D-EVM

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB	1		AMPS224	Any	Printed Circuit Board	
2	C1, C2, C5, C6	4	100nF	ATC530L104KT16T	American Technical Ceramics	0.1µF ±10% 16V Ceramic Capacitor X7R 0402 (1005 Metric)	0402
3	C9, C13, C14, C15, C26	5	0.22uF	LMK063BJ224MP-F	Taiyo Yuden	CAP, CERM, 0.22 uF, 10 V, ± 20%, X5R, 0201	0201
4	C10, C19, C28	3	22uF	CL10A226MP8NUNE	Samsung Electro-Mechanics	CAP, CERM, 22 uF, 10 V, ± 20%, X5R, 0603	0603
5	C11, C12, C17, C27, C38	5	2.2uF	C1005X7S1A225K050BC	TDK	CAP, CERM, 2.2 uF, 10 V, ± 10%, X7S, 0402	0402
6	J1, J2, J3, J4	4		32K243-40ML5	Rosenberger	SMA JACK 50 OHM, R/A, SMT	SMA JACK, R/A, SMT
7	J5, J28	2		61300211121	Wurth Elektronik	Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH
8	J12, J21, J22	3		PBC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Gold, TH	PBC03SAAN
9	L1	1	1000 ohm	BLM15HD102SN1D	MuRata	Ferrite Bead, 1000 ohm @ 100 MHz, 0.25 A, 0402	0402
10	R1, R2	2	24.9	ERJ-1GNF24R9C	Panasonic Electronic Components	24.9 Ohms ±1% 0.05W, 1/20W Chip Resistor 0201 (0603 Metric) Thick Film	0201
11	R17	1	1k	ERJ-1GNF1001C	Panasonic Electronic Components	1 kOhms ±1% 0.05W, 1/20W Chip Resistor 0201 (0603 Metric) Automotive AEC-Q200 Thick Film	0201
12	R19	1	4.99k	RC0402FR-074K99L	Yageo America	RES, 4.99 k, 1%, 0.063 W, 0402	0402
13	R20, R22	2	0	ERJ-1GN0R00C	Panasonic	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	0201
14	R75	1	8.06k	CRCW04028K06FKED	Vishay-Dale	RES, 8.06 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402
15	R77	1	15.0k	CRCW040215K0FKED	Vishay-Dale	RES, 15.0 k, 1%, 0.063 W, 0402	0402
16	RB1	1	0.1	ERJ2BWFR100X	Panasonic	RES, 0.1, 1%, 0.25 W, 0402	0402
17	U1	1		PTRF1305B1RPVR	Texas Instruments	PTRF1305B1RPVR	WQFN-FCRLF12

Table 3-2. Bill of Materials for TRF1305B1-D2D-EVM (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
18	C3, C4	0	100nF	ATC530L104KT16T	American Technical Ceramics	0.1µF ±10% 16V Ceramic Capacitor X7R 0402 (1005 Metric)	0402
19	C16, C18, C30, C31, C37	0	2.2uF	C1005X7S1A225K050BC	TDK	CAP, CERM, 2.2 uF, 10 V, ± 10%, X7S, 0402	0402
20	C29, C35, C36	0	0.22uF	LMK063BJ224MP-F	Taiyo Yuden	CAP, CERM, 0.22 uF, 10 V, ± 20%, X5R, 0201	0201
21	C32, C33, C34	0	22uF	CL10A226MP8NUNE	Samsung Electro-Mechanics	CAP, CERM, 22 uF, 10 V, ± 20%, X5R, 0603	0603
22	FID1, FID2, FID3, FID4, FID5, FID6	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
23	RA1, RC1	0	0.1	ERJ2BWFR100X	Panasonic	RES, 0.1, 1%, 0.25 W, 0402	0402

Table 3-3. Bill of Materials for TRF1305C1-D2D-EVM

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB	1		AMPS224	Any	Printed Circuit Board	
2	C1, C2, C5, C6	4	100nF	ATC530L104KT16T	American Technical Ceramics	0.1µF ±10% 16V Ceramic Capacitor X7R 0402 (1005 Metric)	0402
3	C9, C13, C14, C15, C26	5	0.22uF	LMK063BJ224MP-F	Taiyo Yuden	CAP, CERM, 0.22 uF, 10 V, ± 20%, X5R, 0201	0201
4	C10, C19, C28	3	22uF	CL10A226MP8NUNE	Samsung Electro-Mechanics	CAP, CERM, 22 uF, 10 V, ± 20%, X5R, 0603	0603
5	C11, C12, C17, C27, C38	5	2.2uF	C1005X7S1A225K050BC	TDK	CAP, CERM, 2.2 uF, 10 V, ± 10%, X7S, 0402	0402
6	J1, J2, J3, J4	4		32K243-40ML5	Rosenberger	SMA JACK 50 OHM, R/A, SMT	SMA JACK, R/A, SMT
7	J5, J28	2		61300211121	Wurth Elektronik	Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH
8	J12, J21, J22	3		PBC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Gold, TH	PBC03SAAN
9	L1	1	1000 ohm	BLM15HD102SN1D	MuRata	Ferrite Bead, 1000 ohm @ 100 MHz, 0.25 A, 0402	0402
10	R1, R2	2	24.9	ERJ-1GNF24R9C	Panasonic Electronic Components	24.9 Ohms ±1% 0.05W, 1/20W Chip Resistor 0201 (0603 Metric) Thick Film	0201
11	R17	1	1k	ERJ-1GNF1001C	Panasonic Electronic Components	1 kOhms ±1% 0.05W, 1/20W Chip Resistor 0201 (0603 Metric) Automotive AEC-Q200 Thick Film	0201
12	R19	1	4.99k	RC0402FR-074K99L	Yageo America	RES, 4.99 k, 1%, 0.063 W, 0402	0402
13	R20, R22	2	0	ERJ-1GN0R00C	Panasonic	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	0201
14	R75	1	8.06k	CRCW04028K06FKED	Vishay-Dale	RES, 8.06 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402
15	R77	1	15.0k	CRCW040215K0FKED	Vishay-Dale	RES, 15.0 k, 1%, 0.063 W, 0402	0402
16	RB1	1	0.1	ERJ2BWFR100X	Panasonic	RES, 0.1, 1%, 0.25 W, 0402	0402
17	U1	1		TRF1305C1RPVR	Texas Instruments	TRF1305C1RPVR	WQFN-FCRLF12

Table 3-3. Bill of Materials for TRF1305C1-D2D-EVM (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
18	C3, C4	0	100nF	ATC530L104KT16T	American Technical Ceramics	0.1µF ±10% 16V Ceramic Capacitor X7R 0402 (1005 Metric)	0402
19	C16, C18, C30, C31, C37	0	2.2uF	C1005X7S1A225K050BC	TDK	CAP, CERM, 2.2 uF, 10 V, ± 10%, X7S, 0402	0402
20	C29, C35, C36	0	0.22uF	LMK063BJ224MP-F	Taiyo Yuden	CAP, CERM, 0.22 uF, 10 V, ± 20%, X5R, 0201	0201
21	C32, C33, C34	0	22uF	CL10A226MP8NUNE	Samsung Electro-Mechanics	CAP, CERM, 22 uF, 10 V, ± 20%, X5R, 0603	0603
22	FID1, FID2, FID3, FID4, FID5, FID6	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
23	RA1, RC1	0	0.1	ERJ2BWFR100X	Panasonic	RES, 0.1, 1%, 0.25 W, 0402	0402

4 Additional Information

4.1 Trademarks

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5 Related Documentation

For related documentation, see the following:

- Texas Instruments, *TRF1305B1 Single-Channel, DC to > 6.5GHz 3dB BW, Fully Differential Amplifier* data sheet

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