Project Code: APM_RADAR_2016

AHEAD OF WHAT'S POSSIBLE™

ADI RADAR SOLUTIONS

Radar Application Introduction

Radar, originally developed during World War II, has myriad applications today, such as defense, civilian (air traffic control and weather), and automotive. Its principle operation is to transmit an electromagnetic signal modulated with a particular type of waveform. The signal is reflected from the target and the reflected signal is detected by the radar receiver and analyzed to extract desired information, such as distance, bearing, and angular velocity.

Main Challenges and System Design Considerations

Range

A key objective of a radar system is to have maximum range to see things as soon as possible. So high power and high efficiency amplifiers are required to support long ranges.

Resolution

Another key objective of a radar system is to have maximum resolution to resolve closely spaced objects and pick out the true object of interest. To achieve greater resolution, greater modulation bandwidth is required.

Reliability

Reliability is a key factor for all industrial applications, and there are multiple approaches for improving reliability. Reducing the number of amplification stages can reduce complexity to improve reliability. Advanced semiconductor fabrication processes can make higher efficient amplifiers to reduce cooling requirements and increasing reliability. With those approaches, the size and weight can be reduced as well.

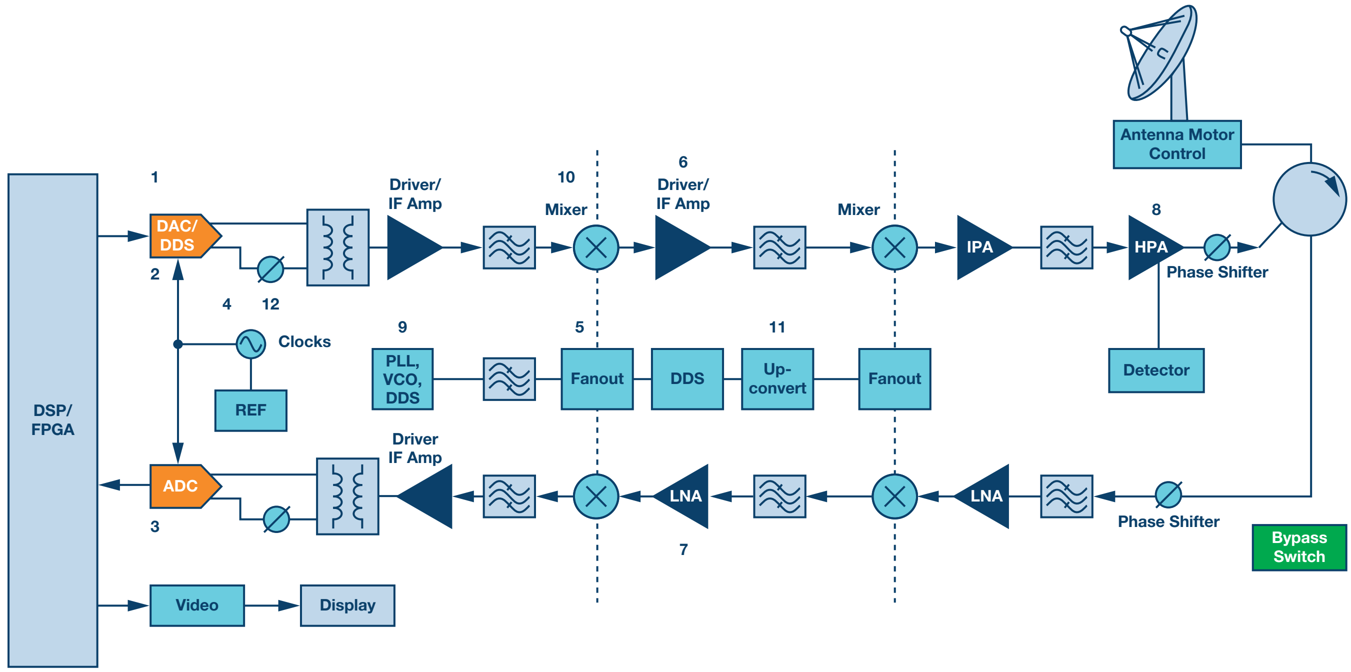
Why Choose ADI

- ADI's comprehensive portfolio provide complete RF-to-bits solutions for a wide range of commercial and defense radar systems.
- ADI empowers our customers to achieve the highest levels of performance while reducing size, weight, power, system cost, and development time.
- For over 50 years our commitment to performance, reliability, and sustainability has made ADI a preferred supplier.

Radar Signal Chains

Classic Radar Signal Chain (Super-Heterodyne Architectures)

Below is classic radar signal chain in super-heterodyne architecture with dual mixing stages to reduce data first to an IF and then to baseband.



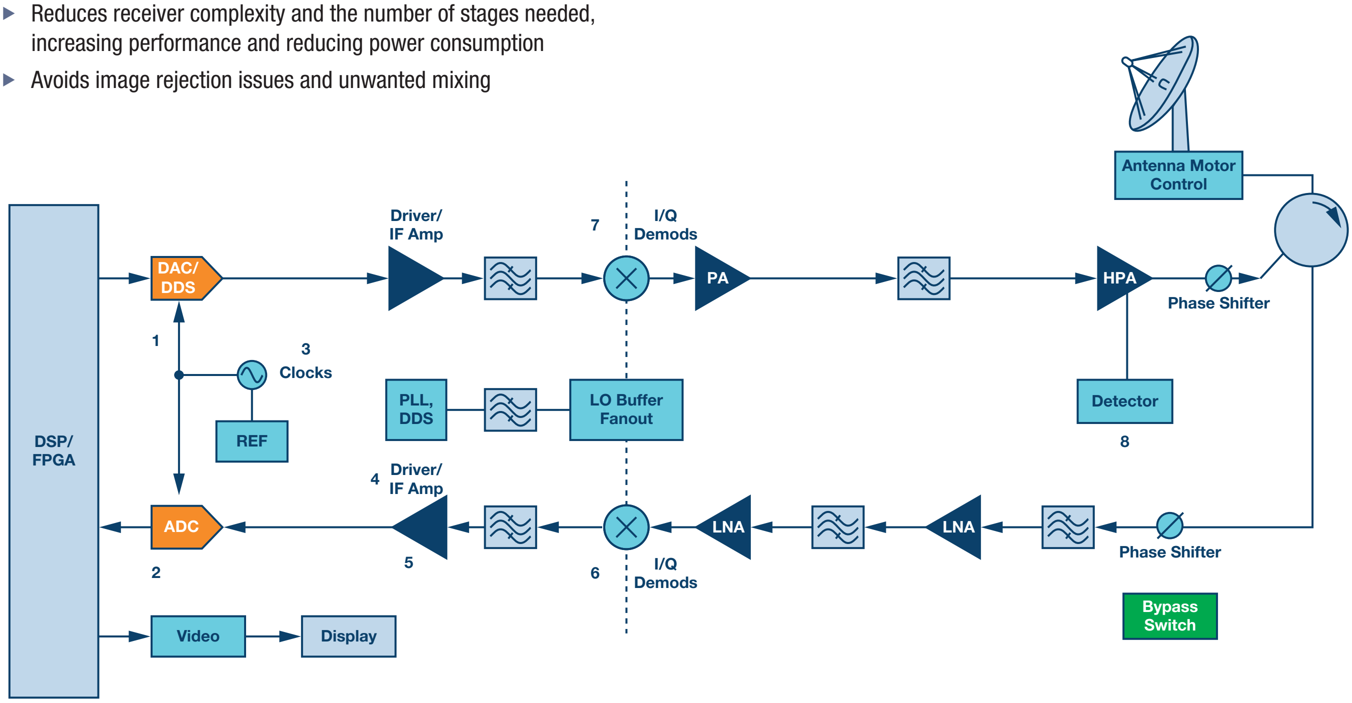
1. DACs	2. DDSs	3. ADCs	4. Clock Generators	5. Fanout Buffers	6. Drivers/IF Amplifiers
AD9129/AD9739	AD9914/AD9915	AD9652/AD9656/AD9250	AD9525/HMC1031/ HMC1032/HMC1033/ HMC1034/HMC1035	ADCLK944/HMC744	ADL5565/ADL5566/ ADL5610/ADL5611
7. Low Noise Amplifiers	**8. Power Amplifiers**	**9. PLLs with VCOs**	**10. Mixers**	**11. Multiplier**	**12. Phase Shifters**
HMC772/HMC460/ HMC516	HMC559/HMC797A/ HMC1114	HMC830/HMC831/ HMC832/HMC833/ ADF5355	ADL5353/HMC1056/ HMC773A	HMC443	HMC642A/HMC877

Next-Generation Radar Signal Chain (Direct RF and Higher IF Sampling)

Direct conversion radios perform just one frequency translation compared to a super-heterodyne receiver that can perform several frequency translations. One frequency translation is advantageous because it

- Reduces receiver complexity and the number of stages needed, increasing performance and reducing power consumption
- Avoids image rejection issues and unwanted mixing

Below is a next-generation I/Q radar signal chain example with direct RF synthesis and higher IF sampling to remove second IF stages.



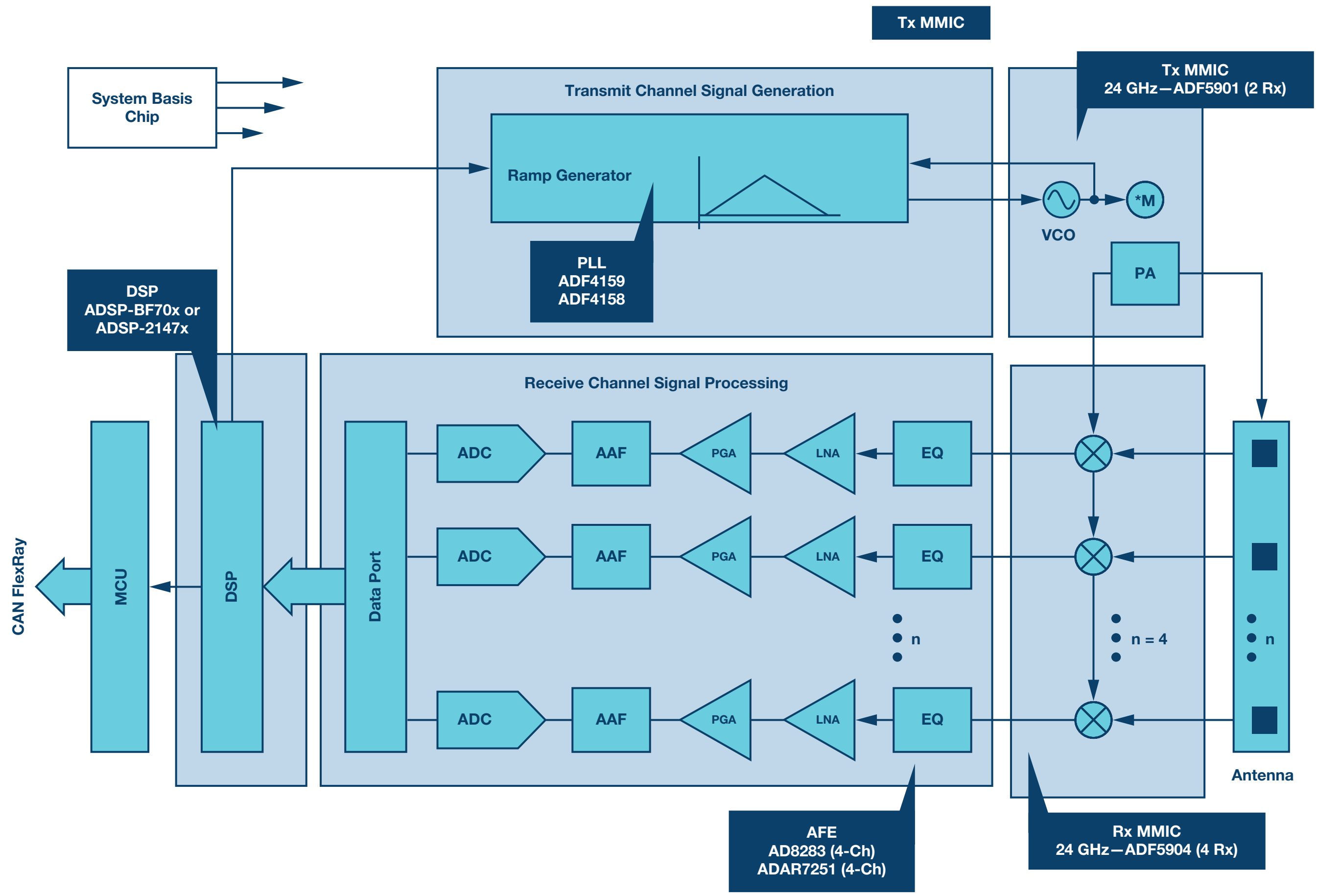
1. RF Agile Transceivers	2. ADCs	3. Clock	4. Digital Gain Amplifier
AD9361/AD9364	AD9625/AD9680	HMC7044	ADA4961

5. Track-and-Hold Amplifiers	6. Mixers	7. I/Q Demodulators	8. Detectors	9. Switches
HMC661/HMC1061	ADL5367/HMC558A/HMC773	ADL5363/ADL5380	ADL6010/HMC1094/HMC1013	HMC232A/HMC986A/ ADGM1304

24 GHz FMCW RADAR

ADI provides the whole signal chain chipsets for 24 GHz radar, which can be used in automotive ADAS and industrial applications. The high performance of the integrated chipset gives the radar designer at least 2× improvement in sensitivity and up to 1.5× better detection range with much lower overall power consumption, resulting in more robust, consistent performance from a small sized sensor that is easy to design.

Below is the 24 GHz chipset:



RF MMICs	PLLs	Analog Front Ends	DSP
ADF5901/ADF5904	ADF4158/ADF4159	AD8283/ADAR7251	ADSP-BF70x/ADSP-2147x

Featured Products

Part Number	Description	Key Features & Benefits	ECCN Code
DACs			
AD9739	14-bit, 2.5 GSPS, RF Digital-to-Analog converter	Direct RF synthesis at 2.5 GSPS update rate, dual-port LVDS data interface, industry leading single/multicarrier IF or RF synthesis, ability to synthesize high quality wideband signals with bandwidths of up to 1.25 GHz in the first or second Nyquist zone	3A001.a.5.b.2.b
AD9119/ AD9129	11-/14-bit, 5.7 GSPS, RF Digital-to-Analog Converter	DAC update rate: up to 5.7 GSPS, direct RF synthesis at 2.85 GSPS data rate, high dynamic range and signal reconstruction bandwidth support RF signal synthesis of up to 4.2 GHz	EAR99/3A001.a.5.b.2.b
IF Amplifiers			
ADL5565	6 GHz ultrahigh dynamic range differential amplifier	–3 dB bandwidth of 6 GHz (AV = 6 dB), pin strappable gain adjust: 6 dB, 12 dB, and 15.5 dB, differential or single-ended input to differential output	EAR99
Mixers			
HMC773A	GaAs MMIC fundamental mixer, 6 GHz to 26 GHz	Passive: no dc bias required, input third-order intercept (IP3): 20 dBm, local oscillator (LO) to radio frequency (RF) isolation: 37 dB, wide IF bandwidth: dc to 8 GHz	EAR99

Part Number	Description	Key Features & Benefits	ECCN Code
Power Amplifiers			
HMC559	GaAs pHEMT MMIC power amplifier, dc to 20 GHz	P1dB output power: 28 dBm, gain: 14 dB, output IP3: 36 dBm, supply voltage: 10 V @ 400 mA, 50 Ω matched input/output	EAR99
HMC797ALP5E	GaAs pHEMT MMIC 1 W power amplifier, dc to 22 GHz	High P1dB output power: 28 dBm, high P_{SAT} output power: 29.5 dBm, high gain: 13.5 dB, high output IP3: 39 dBm, supply voltage: 10 V @ 400 mA, 50 Ω matched input/output	EAR99
Clock Generators			
AD9525	Low jitter clock generator with eight LVPECL outputs	Integrated ultralow noise synthesizer, 8 differential 3.6 GHz LVPECL outputs and 1 LVPECL SYNC output or 2 CMOS SYNC outputs, 2 differential reference inputs and 1 single-ended reference input	EAR99
HMC1034	Clock generator with fractional-N PLL and integrated VCO, 125 MHz to 3000 MHz	Frequency range: 125 MHz to 3000 MHz, 78 fs rms jitter generation (typical), –165 dBc/Hz phase noise floor, maximum phase detector rate 100 MHz, figure of merit (FOM) –227 dBc/Hz, 24-bit step size, resolution 3 Hz typical	EAR99
DDSs			
AD9914	3.5 GSPS direct digital synthesizer with 12-bit DAC	3.5 GSPS internal clock speed, integrated 12-bit DAC, frequency tuning resolution to 190 pHz, 16-bit phase tuning resolution, 12-bit amplitude scaling, programmable modulus, automatic linear and nonlinear frequency sweeping capability, 32-bit parallel datapath interface, eight frequency/phase offset profiles, phase noise: –128 dBc/Hz (1 kHz offset @ 1396 MHz), wideband SFDR < –50 dBc, serial or parallel I/O control	3A001.a.13.b
PLLs with VCOs			
ADF5355	Microwave wideband synthesizer with integrated VCO	RF output frequency range: 54 MHz to 13,600 MHz, fractional-N synthesizer and integer-N synthesizer, high resolution 38-bit modulus, phase frequency detector (PFD) operation to 125 MHz, reference frequency operation to 600 MHz	5A991.b
HMC830	Fractional-N PLL with integrated VCO 25 MHz to 3000 MHz	RF bandwidth: 25 MHz to 3000 MHz, maximum phase detector rate 100 MHz, ultralow phase noise –110 dBc/Hz in band typ, figure of merit (FOM) –227 dBc/Hz	5A991.b
Multiplier			
HMC443	SMT GaAs HBT MMIC ×4 active frequency multiplier, 9.8 GHz to 11.2 GHz output	Output power: 4 dBm, subharmonic suppression: >25 dBc, SSB phase noise: –142 dBc/Hz, single supply: 5 V @ 52 mA	EAR99
Detectors			
ADL6010	Fast responding, 45 dB range, 0.5 GHz to 43.5 GHz envelope detector	Schottky diode detector with linearization, broadband 50 Ω input impedance, accurate response from 0.5 GHz to 43.5 GHz with minimal slope variation	5A991.b
HMC1013	Successive detection log video amplifier (SDLVA), 0.5 GHz to 18.5 GHz	High logging range: 67 dB (–62 dBm to +5 dBm), output frequency flatness: ±2 dB, log linearity: ±2 dB, fast rise/fall times: 5 ns/15 ns, single positive supply: 3.3 V	EAR99
ADCs			
AD9652	16-bit, 310 MSPS, 3.3 V/1.8 V dual analog-to-digital converter (ADC)	High dynamic range, SNR = 75.0 dBFS at 70 MHz (A_{IN} = –1 dBFS), SFDR = 87 dBc at 70 MHz (A_{IN} = –1 dBFS), noise spectral density (NSD) = –156.7 dBFS/Hz input noise at –1 dBFS at 70 MHz, NSD = –157.6 dBFS/Hz for small signal at –7dBFS at 70 MHz	3A001.a.5.a.5
AD9625	12-bit, 2.6 GSPS/2.5 GSPS/2.0 GSPS, 1.3 V/2.5 V analog-to-digital converter	12-bit 2.5 GSPS ADC, no missing codes, SFDR = 79 dBc, A_{IN} up to 1 GHz at –1 dBFS, 2.5 GSPS, SFDR = 77 dBc, A_{IN} up to 1.8 GHz at –1 dBFS, 2.5 GSPS, SNR = 57.6 dBFS, A_{IN} up to 1 GHz at –1 dBFS, 2.5 GSPS, SNR = 57 dBFS, A_{IN} up to 1.8 GHz at –1 dBFS, 2.5 GSPS, noise spectral density = –149.5 dBFS/Hz at 2.5 GSPS, differential analog input: 1.2 V p-p	3A001.a.5.a.3
Track-and-Hold Amplifiers			
HMC661	Ultrawideband 4 GSPS track-and-hold amplifier dc to 18 GHz	18 GHz input bandwidth (1 V p-p full scale), 4 GSPS maximum sampling rate, 68 dB SFDR (4 GHz/0.5 V p-p input, CLK = 1 GSPS), 57 dB SFDR (4 GHz/1 V p-p input, CLK = 1 GSPS), direct-coupled I/O, ultraclean output waveforms, minimal glitching, >60 dB hold mode feedthrough rejection, 1.05 mV rms hold mode output noise, single/dual rank evaluation boards are available	EAR99
HMC1061	DC to 18 GHz, ultrawideband, dual rank 4 GSPS track-and-hold amplifier	18 GHz input bandwidth (1 V p-p full scale), 4 GSPS maximum sampling rate, 67 dB SFDR (4 GHz/0.5 V p-p input, CLK = 1 GSPS), 56 dB SFDR (4 GHz/1 V p-p input, CLK = 1 GSPS), direct-coupled I/O, ultraclean output waveforms, minimal glitching, >65 dB hold mode feedthrough rejection, 1.5 mV rms hold mode output noise	EAR99

Part Number	Description	Key Features & Benefits	ECCN Code
Low Noise Amplifiers			
HMC460	GaAs pHEMT MMIC low noise amplifier, dc to 20 GHz	Noise figure: 2.5 dB @ 10 GHz, gain: 14 dB @ 10 GHz, P1dB output power: 16.5 dBm @ 10 GHz, supply voltage: 8 V @ 60 mA, 50 Ω matched input/output	EAR99
HMC516LC5	Smt phemt low noise amplifier, 9 GHz to 18 GHz	Noise figure: 2 dB, gain: 20 dB, OIP3: 25 dBm, single supply: 3 V @ 65 mA, 50 Ω matched input/output	EAR99
Switches			
HMC232A	GaAs MMIC SPDT non-reflective switch, dc to 12 GHz	Isolation: 57 dB @ 3 GHz, 50 dB @ 6 GHz, input P1dB: 30 dBm, insertion loss: 1.5 dB typical @ 6 GHz, nonreflective design	EAR99
HMC986A	GaAs MMIC reflective spdt switch, 0.1 GHz to 50 GHz	Wideband performance: 0.1 to 50 GHz, low insertion loss: 1.9 dB at 40 GHz, high isolation: 31 dB at 40 GHz, fast switching speed: 10 ns	EAR99

Design Resources

Circuits From the Lab® Reference Circuits for Radar

- **AD-FMCOMMS6-EBZ**—*https://wiki.analog.com/resources/eval/user-guides/ad-fmcomms6-ebz*
- **AD-FMCOMMS5-EBZ**—*https://wiki.analog.com/resources/eval/user-guides/ad-fmcomms5-ebz*
- **More reference circuits are available at** *www.analog.com/en/circuits*

Technical Articles/Application Notes

- **Technical Article:** MT-085, Fundamentals of Direct Digital Synthesis—*www.analog.com/en/training-seminars/tutorials/MT-085.pdf*
- **Application Note:** AN-1039, Correcting Imperfections in IQ Modulators to Improve RF Signal Fidelity—*www.analog.com/en/AN-1039.pdf*
- **Webinar:** Technologies and Solutions for Radar System Applications—*www.analog.com/en/technologies-solutions-for-radar-system-applications.html*
- **Brochure:** Aerospace and Defense Capabilities Brochure—*www.analog.com/en/Aerospace-and-Defense-brochure.pdf*
- **Brochure:** RF and Microwave IC Selection Guide 2015—*www.analog.com/en/RF-and-Microwave-ICs-Selection-Guide.pdf*
- **Technical Article:** High Performance Integrated 24 GHz FMCW Radar Transceiver Chipset for Auto and Industrial Sensor Applications—*www.analog.com/en/High-Performance-Integrated-24-GHz-FMCW-Radar-Transceiver-Chipset.pdf*

Design Tools/Forums

- **ADIsimPE powered by SIMetrix/SIMPLIS**—*www.analog.com/en/adisimpe.html*
- **VisualAnalog®:** ADC simulation tool—*www.analog.com/en/visualanalog.html*
- **ADIsimRF™:** RF signal chain calculator tool—*https://form.analog.com/Form_Pages/RFComms/ADISimRF.aspx*
- **ADIsimCLK™:** Clocks products design and evaluation tool—*www.analog.com/en/adisimclk.html*
- **ADIsimPLL™:** PLL circuit-design and evaluation tool—*https://form.analog.com/Form_Pages/RFComms/ADISimPll.aspx*
- **Export and Import Classification Information**—*www.analog.com/en/view-export-classification.html*

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www.analog.com/en/applications/markets/aerospace-and-defense/radar.html

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