

# AES-GCM

## AES-GCM Authenticated Encrypt/Decrypt Core

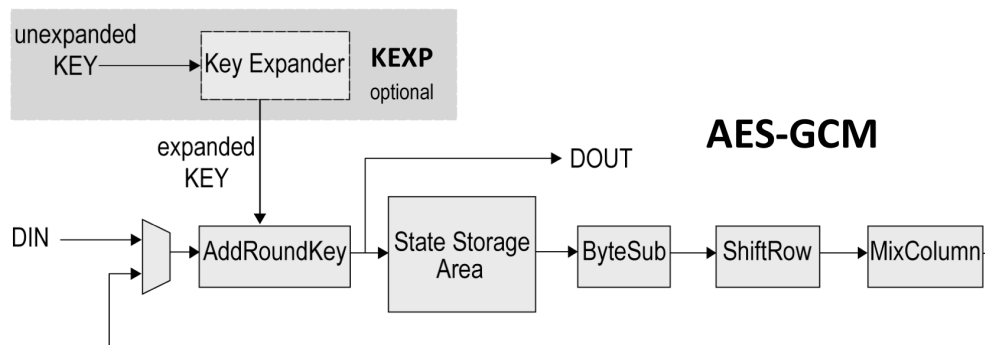


The AES-GCM encryption IP core implements Rijndael encoding and decoding in compliance with the NIST Advanced Encryption Standard. It processes 128-bit blocks, and is programmable for 128-, 192-, and 256-bit key lengths.

Four architectural versions are available to suit system requirements. The **Standard** version (AES-GCM-S) is more compact, using a 32-bit datapath and requiring 44/52/60 clock cycles for each data block (128/192/256-bit cipher key, respectively). The **Fast** version (AES-GCM-F) achieves higher throughput using a 128-bit datapath and requiring 11/13/15 clock cycles for each data block depending on key size. For applications where throughput is critical there are two additional versions. The **High Throughput** AES-GCM-X can process 128 bits/cycle and the **Higher Throughput** AES-GCM-X2 can process 256 bits/cycle respectively independent of the key size.

GCM stands for Galois Counter. GCM is a generic authenticate-and-encrypt block cipher mode. A Galois Field (GF) multiplier/accumulator is utilized to generate an authentication tag while CTR (Counter) mode is used to encrypt.

### Block Diagram



### FEATURES

- Encrypts and decrypts using the AES Rijndael Block Cipher Algorithm
- NIST-Validated
- Implemented according to the National Institute of Standards and Technology (NIST) Special Publication 800-38D
- Processes 128-bit data in 32-bit blocks
- Employs user-programmable key size of 128, 192, or 256 bits
- Any size IV length
- Easy integration & implementation
  - Works with a pre-expanded key or can integrate the optional key expansion function
  - Fully synchronous, uses only the rising clock-edge, single-clock domain, no false or multi-cycle timing paths, scan-ready, LINT-clean, reusable design
  - Simple input and output interface, optionally bridged to AMBA™ interfaces or integrated with a DMA engine.
- Available in VHDL or Verilog source code format, or as a targeted FPGA

### Applications

The AES-GCM can be utilized for a variety of encryption applications including protected network routers, electronic financial transactions, secure wireless communications, secure video surveillance systems, and encrypted data storage.

### Verification

The core has been verified through extensive synthesis, place and route and simulation runs. It has also been embedded in several products, and is proven in FPGA technologies.

### Support

The core as delivered is warranted against defects for ninety days from purchase. Thirty days of phone and email technical support are included, starting with the first interaction. Additional maintenance and support options are available.

### Key Expander

The AES algorithm requires an expanded key for encryption or decryption. The KEXP AES key expander core is available as an AES-GCM core option for the standard and fast versions. It is included for the higher throughput versions.

During encryption, the key expander can produce the expanded key on the fly while the AES core is consuming it. For decryption, though, the key must be pre-expanded and stored in an appropriate memory before being used by the AES core. This is because the core uses the expanded key backwards during decryption. In some cases a key expander is not required. This might be the case when the key does not need to be changed (and so it can be stored in its expanded form) or when the key does not change very often (and thus it can be expanded more slowly in software).

## Implementation Results

The AES-GCM can be mapped to any Altera® FPGA device (provided sufficient silicon resources are available). The following are sample results with all core I/Os assumed to be routed on-chip and throughput for a 128-bit key size.

### AES-GCM Standard (-S)

Technology	Logic Resources	Memory Resources	Freq. (MHz)	Throughput (Mbps)
Agilex (-1)	868 ALMs	4 RAMB	425	1,236
Arria 10 GX (-1)	697 ALMs	4 RAMB	325	945
Cyclone V (-7)	669 ALMs	4 RAMB	175	509
MAX 10 (-7)	1,336 LEs	2 M9K	125	364
Stratix V (-1)	666 ALMs	4 RAMB	375	1,091

### AES-GCM Fast (-F)

Technology	Logic Resources	Memory Resources	Freq. (MHz)	Throughput (Mbps)
Agilex (-1)	1,806 ALMs	16 RAMB	400	4,655
Arria 10 GX (-1)	1,604 ALMs	16 RAMB	300	3,491
Cyclone V (-7)	1,556 ALMs	16 RAMB	175	2,036
MAX 10 (-7)	2,453 LEs	16 M9K	125	1,455
Stratix V (-1)	1,552 ALMs	16 RAMB	350	4,073

### AES-GCM High Throughput (-X)

Technology	Logic Resources	Memory Resources	Freq. (MHz)	Throughput (Gbps)
Agilex (-1)	9,381 ALMs	112 RAMB	375	48.0
Arria 10 GX (-1)	9,543 ALMs	112 RAMB	200	25.6
Cyclone V (-7)	8,662 ALMs	112 RAMB	125	16.0
MAX 10 (-7)	16,156 LEs	112 M9K	100	12.8
Stratix V (-1)	8,940 ALMs	112 RAMB	250	32.0

### AES-GCM Higher Throughput (-X2)

Technology	Logic Resources	Memory Resources	Freq. (MHz)	Throughput (Gbps)
Agilex (-1)	18,537 ALMs	224 RAMB	375	96.0
Arria 10 GX (-1)	20,262 ALMs	224 RAMB	225	57.6
Cyclone V (-7))	17,678 ALMs	224 RAMB	125	32.0
Stratix V (-3)	18,238 ALMs	224 RAMB	200	51.2

The provided figures do not represent the higher speed or smaller area for the core. Please contact CAST to get characterization data for your target configuration and technology.

## Related Products

AES in CBC, CFB, CTR, ECB, GCM, LRW, OFB and XTS modes are also available as stand-alone cores.

AES-P: run-time programmable AES core supporting ECB, CBC, CFB, OFB and CTR modes.

## Export Permits

This core implements encryption functions and as such it is subject to export control regulations. Export to your country may or may not require a special export license. Please contact CAST to determine what applies in your specific case.

## Deliverables

The core is available in ASIC (RTL) or FPGA (netlist) forms, and includes everything required for successful implementation:

- Sophisticated HDL Testbench (self-checking)
- C Model & test vector generator
- Simulation script, vectors & expected results
- Synthesis script
- User documentation