



Actual sizes



3mm x 3mm

2mm x 2mm

Green Arrays™ GA4

4-Computer Chip

FEATURES

- 4 independent F18B computers
- Choice of two inexpensive packages
- Suitable for inexpensive, 2-layer PCBs
- Up to 2.8 billion operations per second
- Instantaneous power ranges from 400 nanowatts to 18 milliwatts.
- Energy consumed depends on each computer's duty cycle, controlled by software and events, with granularity in picoseconds
- Negligible time and energy expended starting and stopping each node
- Suspended nodes respond to internal events in picoseconds and external events in nanoseconds
- High impedance (<3pF, >200MΩ) inputs
- Two analog pins: One input, one in/out
- 5 or 8 programmable digital I/O pins
- Bootable via SPI (DFN12) or either of two serial protocols; custom ROM available
- 256 words RAM and 256 words ROM distributed among four nodes (up to 2048 instructions)
- Minimal external components needed to build a working system

APPLICATIONS

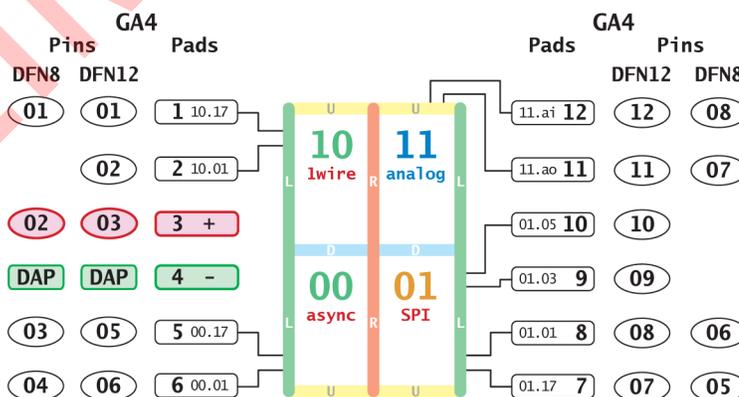
- Embedded systems
- Energy harvesting applications
- Portable devices
- Basic building block for managing I/O surface area and bandwidth in systems
- Intelligent agents to offload systems
- Distributed I/O to simplify systems
- Smart Sensors and actuators
- Simple control systems
- Robotics, MEMS machines
- LED video signs (one per pixel)
- Battery management systems
- Wearable distributed systems
- Trauma detection and telemetry
- Advanced RFID
- Conserving energy by replacing continuous power analog circuits with low duty cycle digital methods

OVERVIEW

This unprecedentedly small, inexpensive, energy-efficient chip consists of a 2x2 array of architecturally identical, independent, complete F18B computers, or *nodes*, each operating asynchronously. Each computer is capable of performing a basic ALU instruction in ≈ 1.4 nanoseconds for an energy cost on the order of 7 picojoules.

The GA4 is intended to perform simple tasks that nevertheless call for the attention of an intelligent device; for example, controlling and monitoring a sensor, or running a simple control loop. In cases such as these, it is acting as a "smart sensor" or "smart device"; by performing its simple tasks autonomously, it acts as proxy for a central system and in so doing it can considerably reduce the volume and rate of data needing to be sent back and forth with the central system. In many cases only relatively low bandwidth data such as supervisory control and summary or exception reports need be interchanged, with correspondingly simple wiring and offloading of central system I/O.

To facilitate this autonomous operation and to encourage designers to place these chips freely wherever intelligence is needed, the GA4 needs no other components to function as a computer. In distributed systems, a simple one wire daisy chain can be used to load software, transmit commands, and collect data. In a completely autonomous application, software may be manufactured into ROM or loaded from a simple SPI flash device. The four nodes have a balanced repertoire of peripherals:



All nodes are suspended after reset, prepared to execute instructions coming from any neighbor node via a comm port. Three of the nodes are capable of booting software: Node 01 (in the DFN12 package) can boot from SPI; Node 00 can boot from RS232 framed async, and Node 01 supports the reset function as well as the GreenArrays high speed 1-wire protocol for booting.

One way to employ the GA4 in a distributed system is to build a simple, one wire daisy chain; node 10 would serve as protocol receiver, node 00 as transmitter to the next chip, and nodes 01 and 11 would be available to interact with local sensors and control devices. This daisy chain structure also supports booting all chips from the central system, and inexpensive DC isolation is feasible with capacitive coupling.

Node 11 has one dedicated analog input; its other pin may be used as an analog output, as a second multiplexed input, or as a bidirectional analog line. All of the remaining digital I/O pins are fully programmable.

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SUITABILITY: The GA4 can be used all by itself, with software in ROM or loaded (or streamed) from an SPI device, to good advantage for relatively small and simple applications. This chip truly shows its character in simplifying knotty problems with broad I/O fan-out such as, for example, the distribution of video to the pixels of a high resolution LED display, managing a series-parallel stack of Lilon batteries, or collecting and processing high-speed data from large sensor arrays. An array of GA4 devices can substantially simplify such designs, and countless others in which a single computer is neither fast enough nor has enough input/output capability to solve the problem. Further, by distributing computing capabilities to the periphery of such systems, desirable functions that are simply impractical to perform centrally at the required frequencies are feasible; for example with 2 million pixels in an LED sign, there are only 8 nanoseconds available per pixel at a central system for managing individual LED and package considerations at 60 Hz, while with just one node at each pixel there are 16 ms processing time available per pixel, and with two nodes there are 33 ms.

SOFTWARE SUPPORT: A complete arrayForth™ software development platform is available free of charge on our website. arrayForth includes a compiler for machine code, an interactive simulator and an interactive development and debugging environment. Complete source language is provided so that all components of this platform are extensible by the user.

PACKAGE: The GA4 is available in either a 2x2mm, 8-pin DFN with 0.5mm pin pitch, or a 3x3mm, 12-pin DFN with 0.45mm pitch. All ground connections are made to the central Die Attach Paddle.

Sym	Description	Min	Typ	Max	Units	Test Condition
Cpin	I/O pin capacitance with Vdd = 0V		2.95		pF	I/O to Vss
ILI	Input leakage current (tristate)		7.5		nA	Vin to Vdd or Vss
IR	Effective input resistance (tristate)		240		MΩ	
ILpd	Weak pulldown current (in saturation)		38		μA	Vin to Vdd
VIH	Input high level	0.865	1.0		V	≈30mV hysteresis band centered .85V
VIL	Input low level		0.7	0.835	V	
ISH	Max current sourced (in saturation)		23.6		mA	Vout to Vss
ISL	Max current sunk (in saturation)		22.4		mA	Vout to Vdd
ROH	Output source res. for 0.5 Vdd @ Vout		44		Ω	Vout to Vss
ROL	Output sink res. for 0.5 Vdd @ Vout		41.5		Ω	Vout to Vdd
ICC	Core current, all nodes running		10		mA	Vdd to VddC
ICCs	Core current, all nodes suspended	0.164	0.220	0.332	μA	
ICCG	Core current per running F18		2.5		mA	
ICCGs	Core current per suspended F18	41	55	83	nA	
Vdd	Supply voltage	1.7	1.8	1.95	V	Below @ these Vdd
Voh	Output high sourcing 10 mA		1.493		V	Vout to Vss
Vol	Output low sinking 10 mA		0.233		V	Vout to Vdd

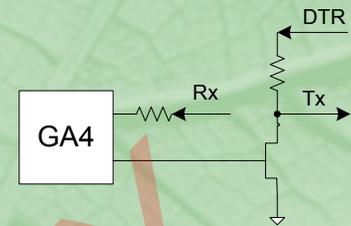
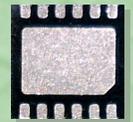
For more information, visit www.GreenArrayChips.com

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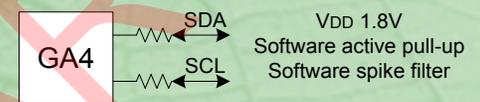


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Practical RS232 Transceiver



Software Intensive I²C Master

GreenArrays, Inc.
 774 Mays Blvd #10 PMB 320
 Incline Village, NV 89451
 (775) 298-4748 voice
 (775) 548-8547 fax
sales@GreenArrayChips.com