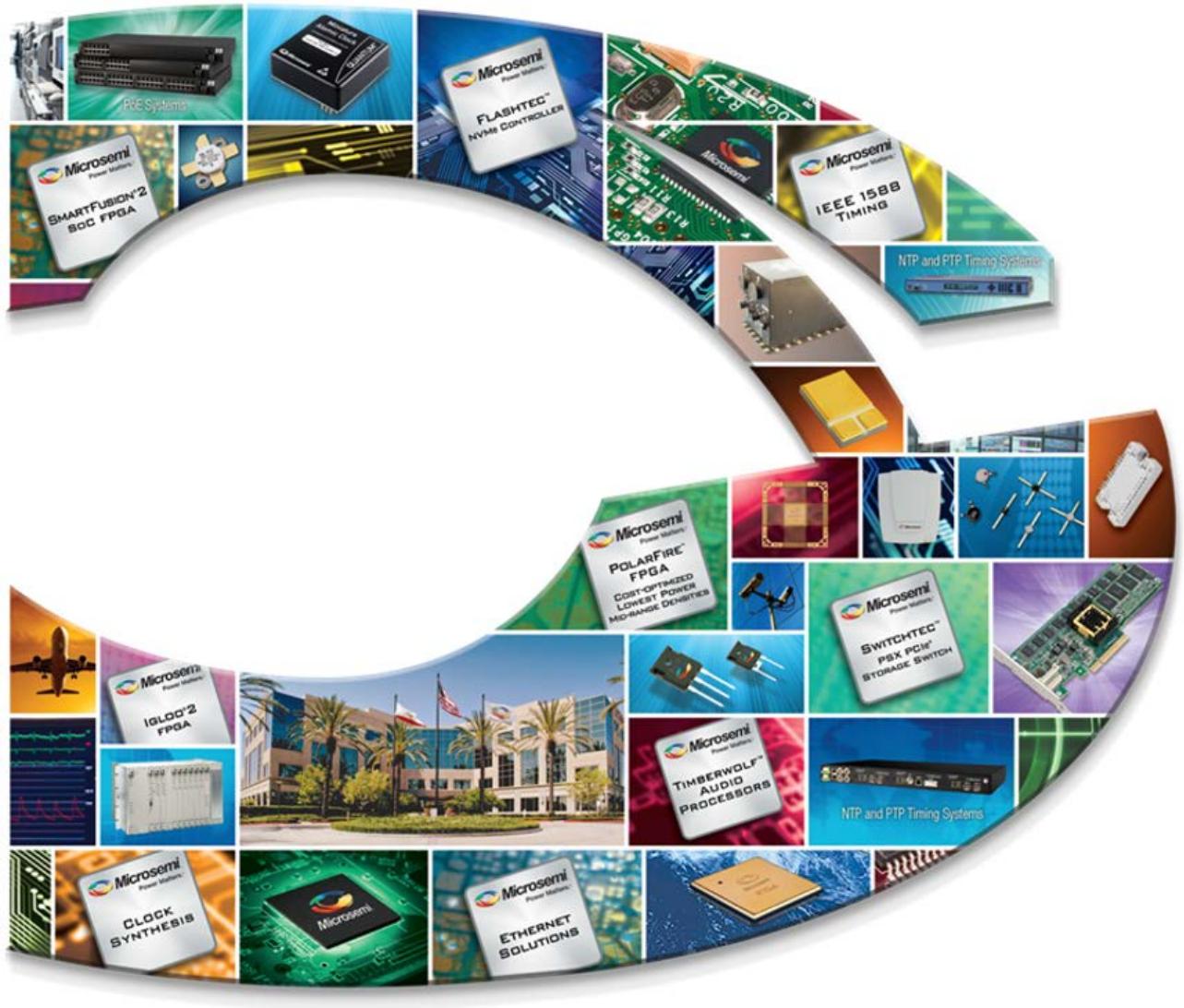
Power Matters.™

Mixed Signal Solutions for Space Space Forum 2017

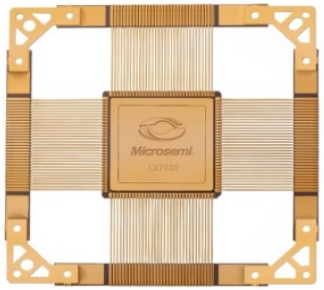
Dorian Johnson
Product Marketing Manager

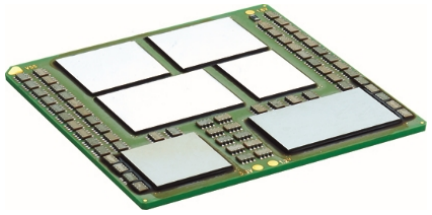
Company Overview

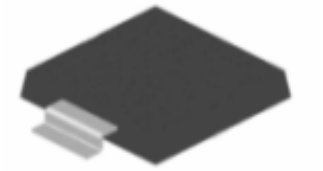


- Leading-edge semiconductor solutions differentiated by:
  - Performance
  - Reliability
  - Security
  - Power
- Solid financial foundation
  - FY2016 Revenue: $1.6B
  - 4800 employees today
- Major focus products
  - FPGAs and ASICs
  - Timing and OTN
  - Mixed-signal and RF
  - Switches and PHYs
  - Storage controllers
  - Discretes and integrated power solutions

Microsemi's Space Pedigree







Extensive Space Heritage

- Developing space solutions for six decades
- Proven track record of innovation, quality, and reliability

Broad Solutions Portfolio

- Power, mixed-signal, and digital, for bus and payload applications

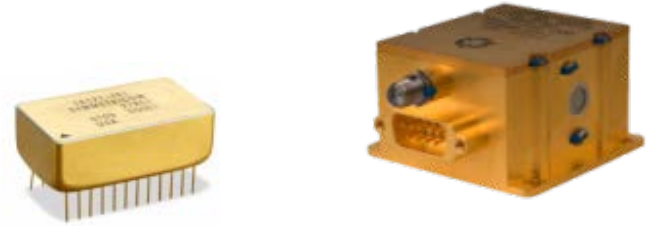
Expanding our Product Portfolio through Continuous Innovation

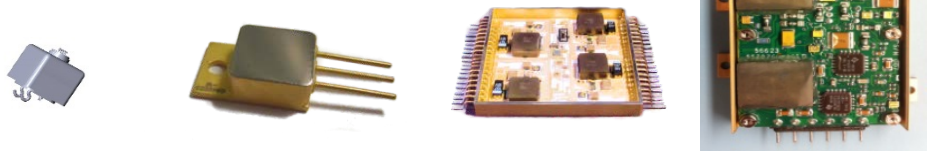
A Partner for the Long Run

- 60-year space heritage

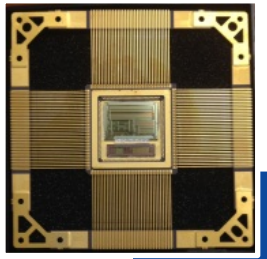
Delivering A Comprehensive Space Portfolio

Radiation-Tolerant FPGAs	High performance, high density, low power TID up to 300 Krad, SEL immune RTG4 FPGAs up to 300 MHz and 150K LE RTProASIC3, RTAX, and RTSX-SU QML qualified
Rad-Hard Mixed Signal Integrated Circuits	Telemetry and motor control space system managers High-side drivers Regulators and PWMs Extensive custom IC capability
Space-Qualified Oscillators	Ovenized Quartz oscillators Hybrid voltage controlled and temperature-compensated crystal oscillators Cesium clocks
Rad-Hard Power Solutions	Rad-hard JANS diodes, bi-polar small signal transistors, and MOSFETs Rad-hard isolated DC–DC converter modules Custom power supplies: 2 W to > 5 KW Linear and POL hybrids Electromechanical relays



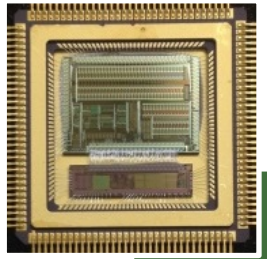


Mixed-Signal Space Portfolio



New Products

- SSM
- Telemetry
- Motor control
- High-side driver
- Diode array
- Latchable current limiter
- QML listed



Custom

- 20+ years
- Drivers
- Controllers
- Amplifiers
- Relays
- Telemetry
- Sensor interface
- Motor control

Microsemi Analog Mixed-Signal ICs for Space Applications

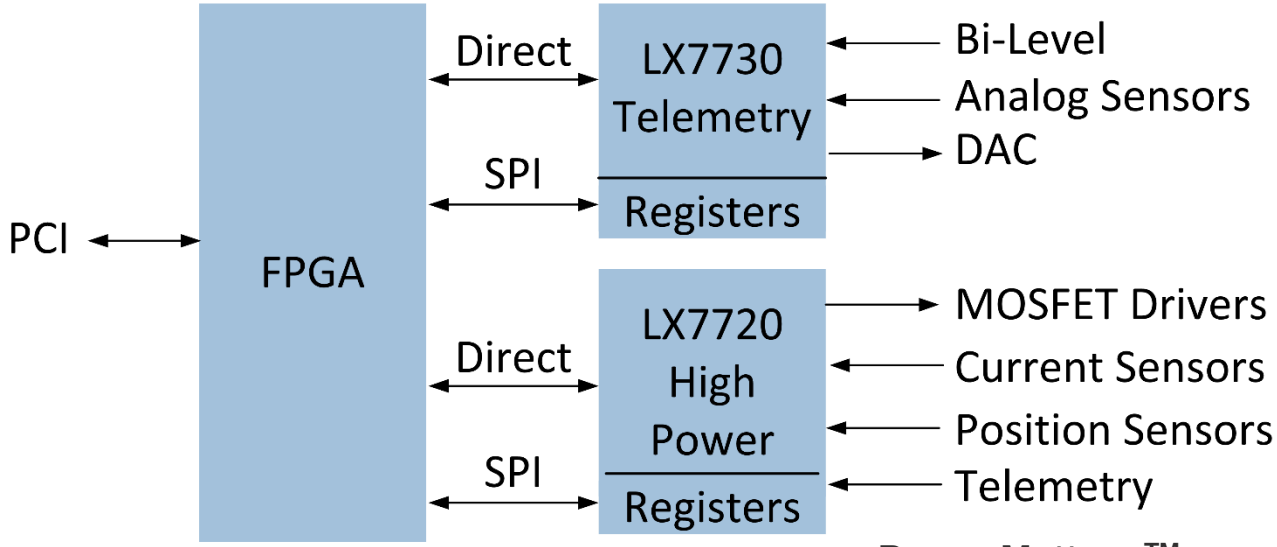
Part Number	Description	Status
In Production		
LX7730	RT telemetry controller SSM	Qual complete
AAHS298B	RT 8 channel high side driver	QML certified Q & V
LX7710	RT 8 pair diode array	QML certified Q & V
Legacy and derivatives	SGR117, SGR137 voltage regulators, SGR1845, SGR1846 PWM controllers	Production
In Qual		
LX7720	RT motor/position controller SSM	First silicon
Sneak Peak	**What's In Development**	
LX7712	RT power line protection device	In design
LX7714	Fault tolerant satellite power bus controller	In design

Space System Managers

Space System Manager Concept

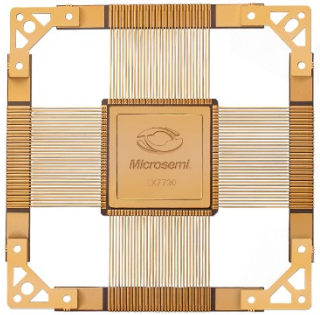
- The Space System Manager (SSM) is a special purpose analog mixed-signal IC that is used with an FPGA
- The SSM ICs add power and mixed-signal capability to supplement the digital functionality and flexibility of the FPGA
- SSMs provide a higher level of integration than basic devices by specifically focusing on common spacecraft interfaces
- The goal is to reduce part count for a smaller size and weight and increased reliability
- We have two products:

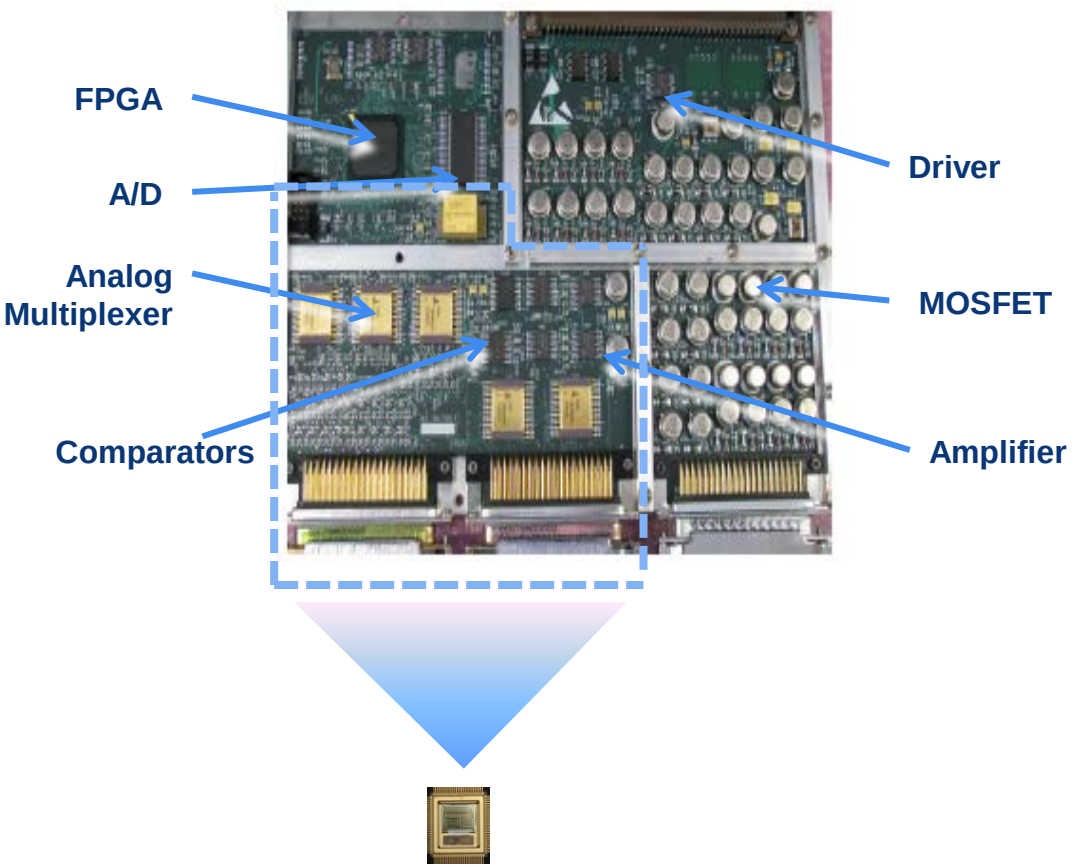
LX7730 Telemetry	V flow in production–Qual complete.
LX7720 Motor Control	First silicon sampled. Final rev silicon sampling October.



SSM—Weight and Board Space Reduction

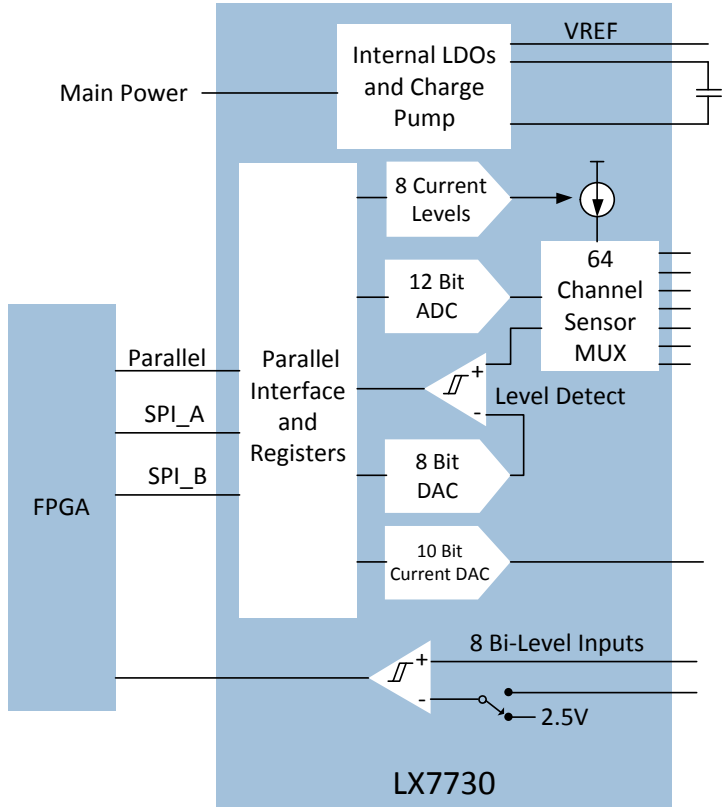
- **Reduced Board Space**
  - 50–75%
- **Reduced Weight**
- **Increased Reliability**





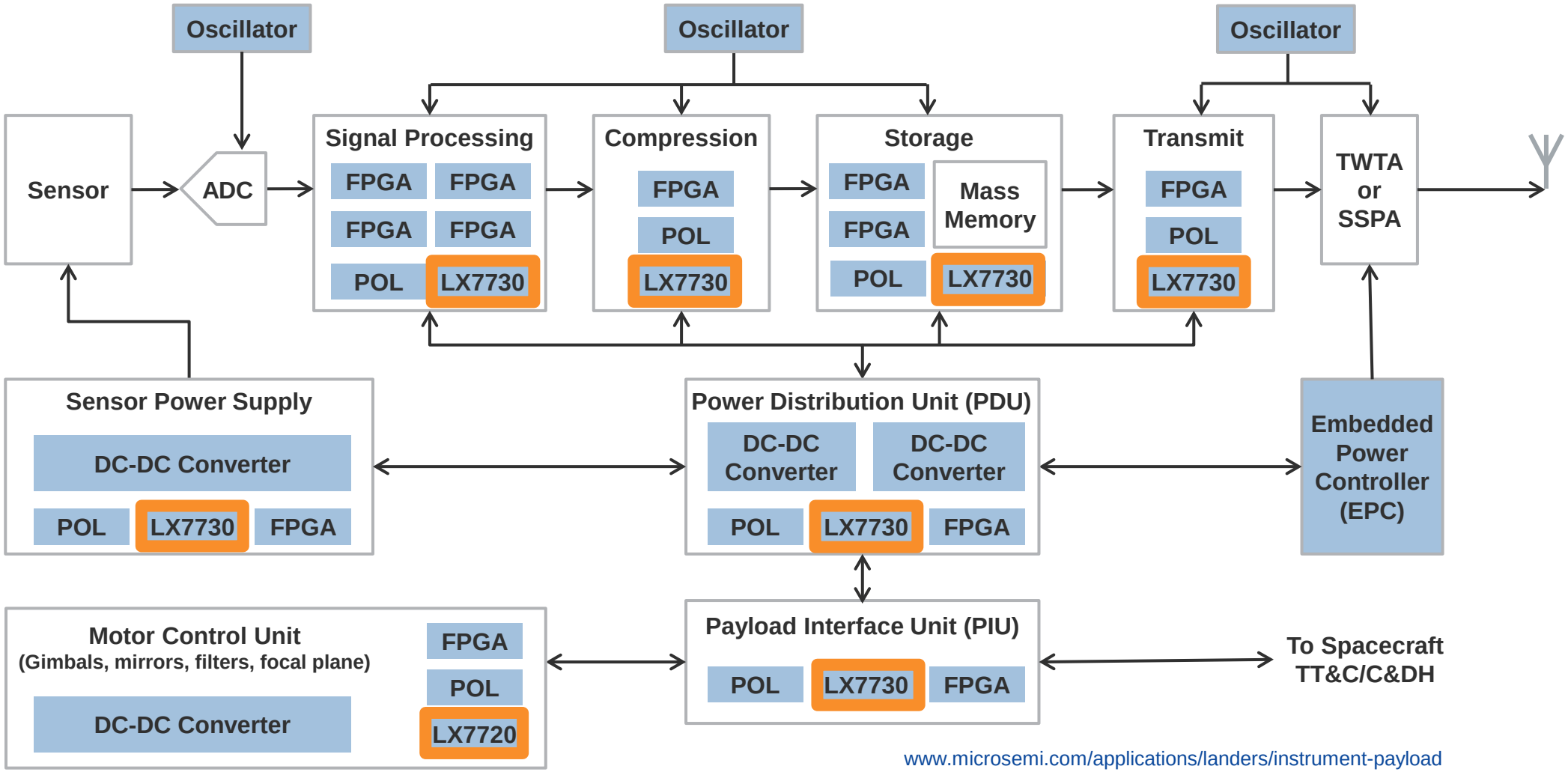
LX7730 Overview
64 Analog Input Telemetry Controller

- Features
  - 64-channel MUX
  - Break-before-make switching
  - 13 kSPS 12-bit ADC
  - 2% precision adjustable current source
  - 1% precision 5.00 V source
  - Threshold monitoring
  - 8x bi-level logic
  - 10-bit DAC
  - Parallel or dual SPI interface
  - Radiation tolerant: 100 krad TID, 50 krad ELDRS
  - **In Production**. Class V qual report, sample eval board and dev board are available



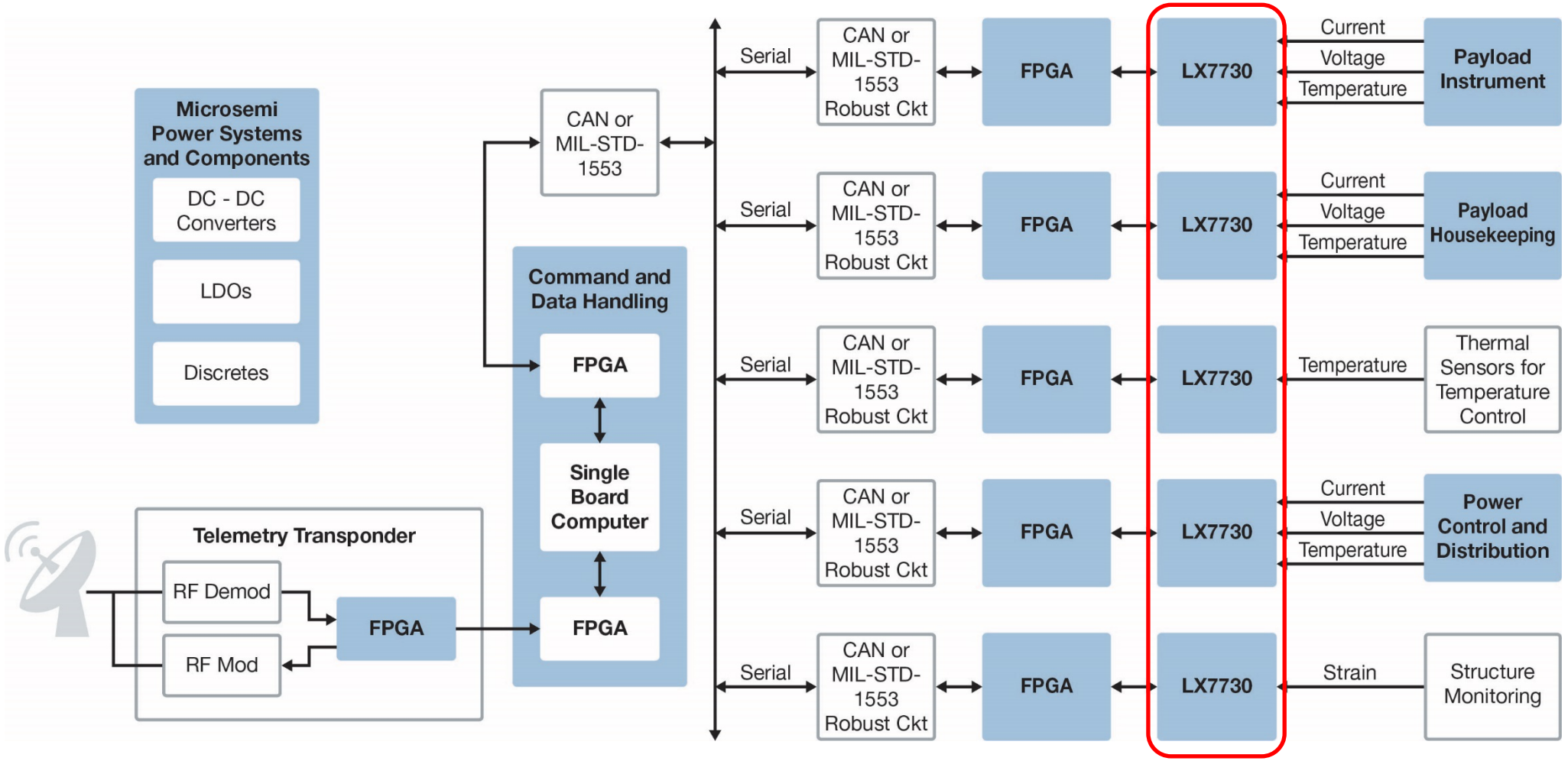
Portfolio Breadth: Example Signal Processing Payload

- Mixed Signal ICs



www.microsemi.com/applications/landers/instrument-payload

Telemetry Tracking and Control Application



LX7730 Availability Update

- In production
- Space—Level (V flow) qual with life test of 4000 hours complete
- Qual report available

Part Number	Silicon	Availability
LX7730-ES, -EVB, and -DB	Engineering samples	Now
LX7730MFQ-EV Class V flow	Qual complete/production	Now
LX7730MFQ-EQ Class Q flow	Qual complete/production	6/30/17

- Lead times—can be up to 26–30 weeks ARO.
- We are submitting qual data to the DLA for QML-V certification. Dependent on DLA lead time.
- Product numbers will change to LX7730MFQ-V and LX7730MFQ-Q once QML listing is given.

LX7730MFQ-EV Qualification Results: Pass

Group	Subgroup	Comment	Result
B	1 2 3	Resistance to solvents Bond strength, die shear/substrate attach Solderability	Pass (0 Reject)
C	1	Steady state life (initial 4000 hrs, recurring 1000 hrs) End point electrical	Pass (0 Reject)
D	1 2 3 4 5 6 7 9	Physical dimensions Lead integrity, Seal (fine/gross) Thermal shock, temp cycling, moisture res, visual, lead Integrity, seal (fine/gross) Mech shock, vibration, variable freq, constant accel, seal, visual, end point electrical Pre-seal, salt, visual, post-seal Water vapor (RGA) Adhesion to lead finish Solder heat, seal, visual, end point electrical	Pass (0 Reject)
E	2 5	TID 100 krad, end point electrical ELDRS 50 krad, end point electrical Single event	Pass (0 Reject)

LX7730 Radiation Test Results

- TID to minimum of 100 krad
- ELDRS to minimum of 50 krad
- Single event:
  - All blocks evaluated after exposure up to 83 MeV.cm^2/mg including internally regulated currents and voltages and the complete telemetry chain
  - SEL immune up to 87 MeV.cm^2/mg and 125°C (fluence of 1e8 particles/cm^2)
- Radiation reports are on the product webpage at https://www.microsemi.com/product-directory/space-system-managers/3575-telemetry-controller-ic#radiation-data

LX7730 Ordering Part Numbers

Part number	Description
LX7730MFQ-ES	Engineering samples (using production silicon).
LX7730MFQ-EQ	Built per QML-Q flow. This will convert to LX7730MFQ-Q once QML certification is achieved and parts will also be orderable by SMD number.
LX7730MFQ-EV	Built per QML-V flow. This will convert to LX7730MFQ-V once QML certification is achieved and parts will also be orderable by SMD number.
LX7730-EVB	Evaluation board. Allows user to exercise LX7730 features when coupled with USB to serial interface. Application software provided. Includes cable assembly.
LX7730-DB	Daughter board for RTG4 development kit. Allows user to connect the LX7730 to the RTG4 FPGA dev kit and evaluate key functions.

LX7730 Support Material

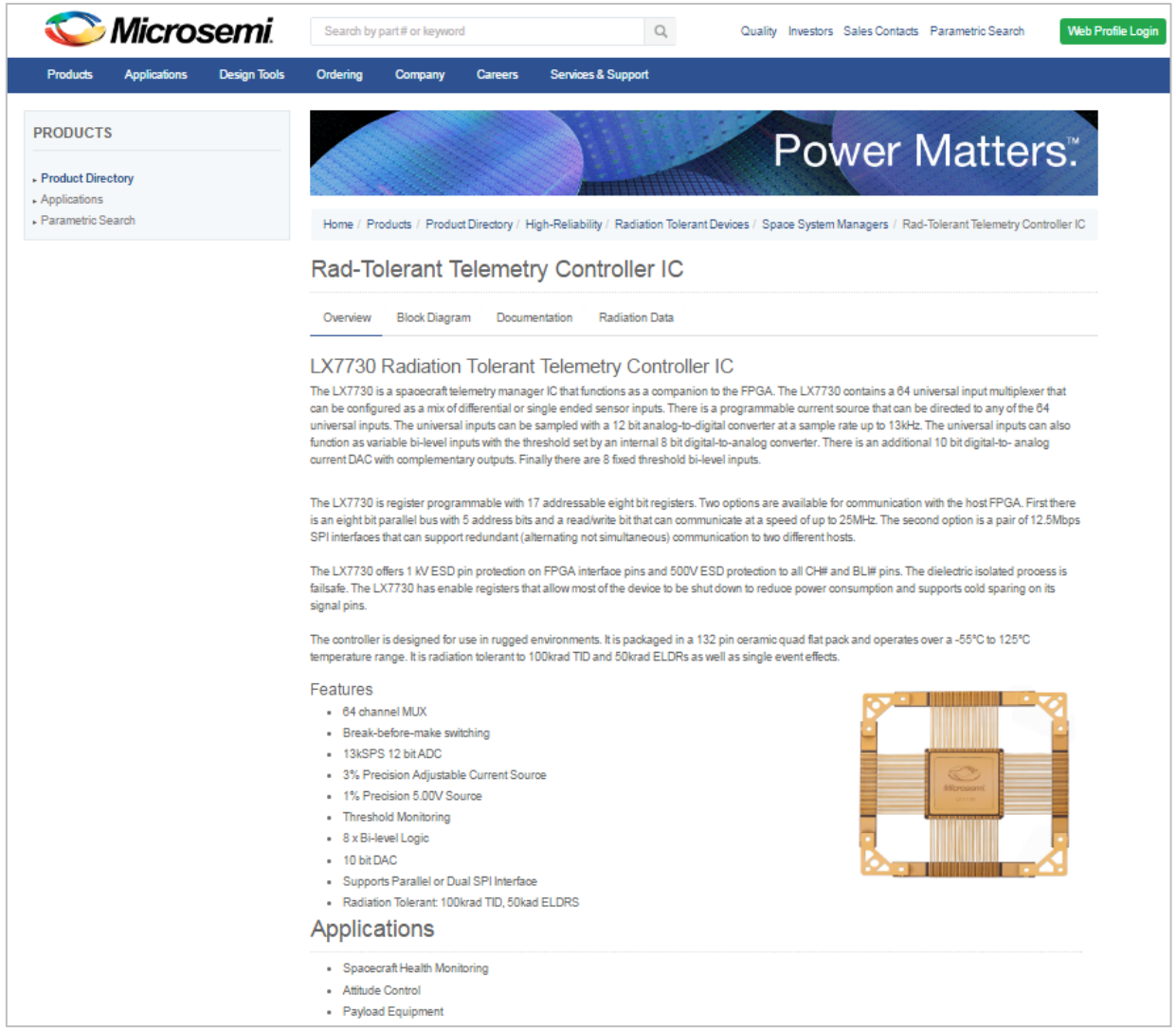
Product Webpage:

http://www.microsemi.com/product-directory/space-system-managers/3575-telemetry-controller-ic

Documentation Available:

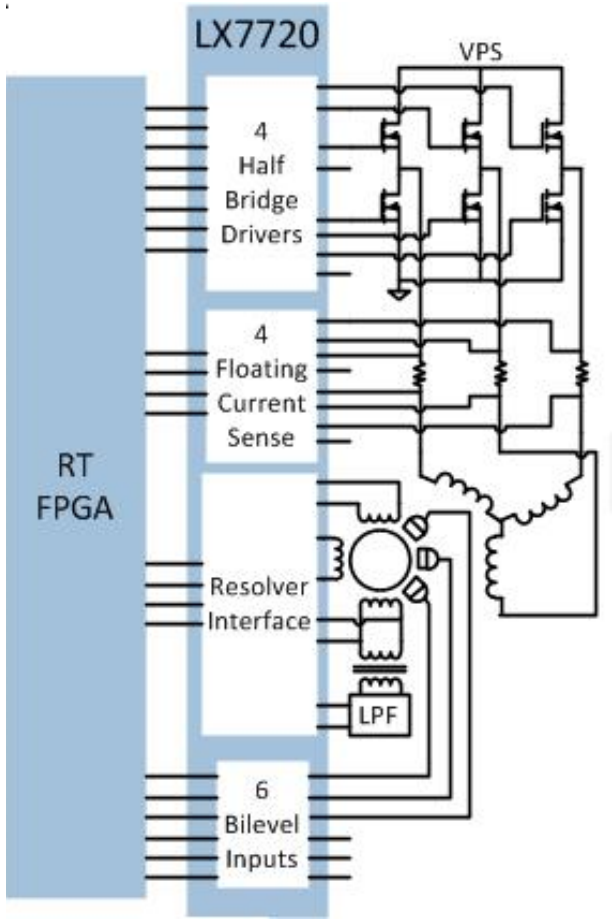
- LX7730 Datasheet
- LX7730 Application Note: Eval Board User Guide
- Analog Front End Integrated Circuits for Mixed Signal Spacecraft Applications
- LX7730 TID Report
- LX7730 Single Event Radiation Test Report
- LX7730 Grounding Architecture & Notes
- SSM Availability
- RADECS 2016 - Total Dose and Single Event Effects Hardening and Testing on Mixed Signal Telemetry LX7730 Controller

For technical help, submit questions to AMSTech@microsemi.com

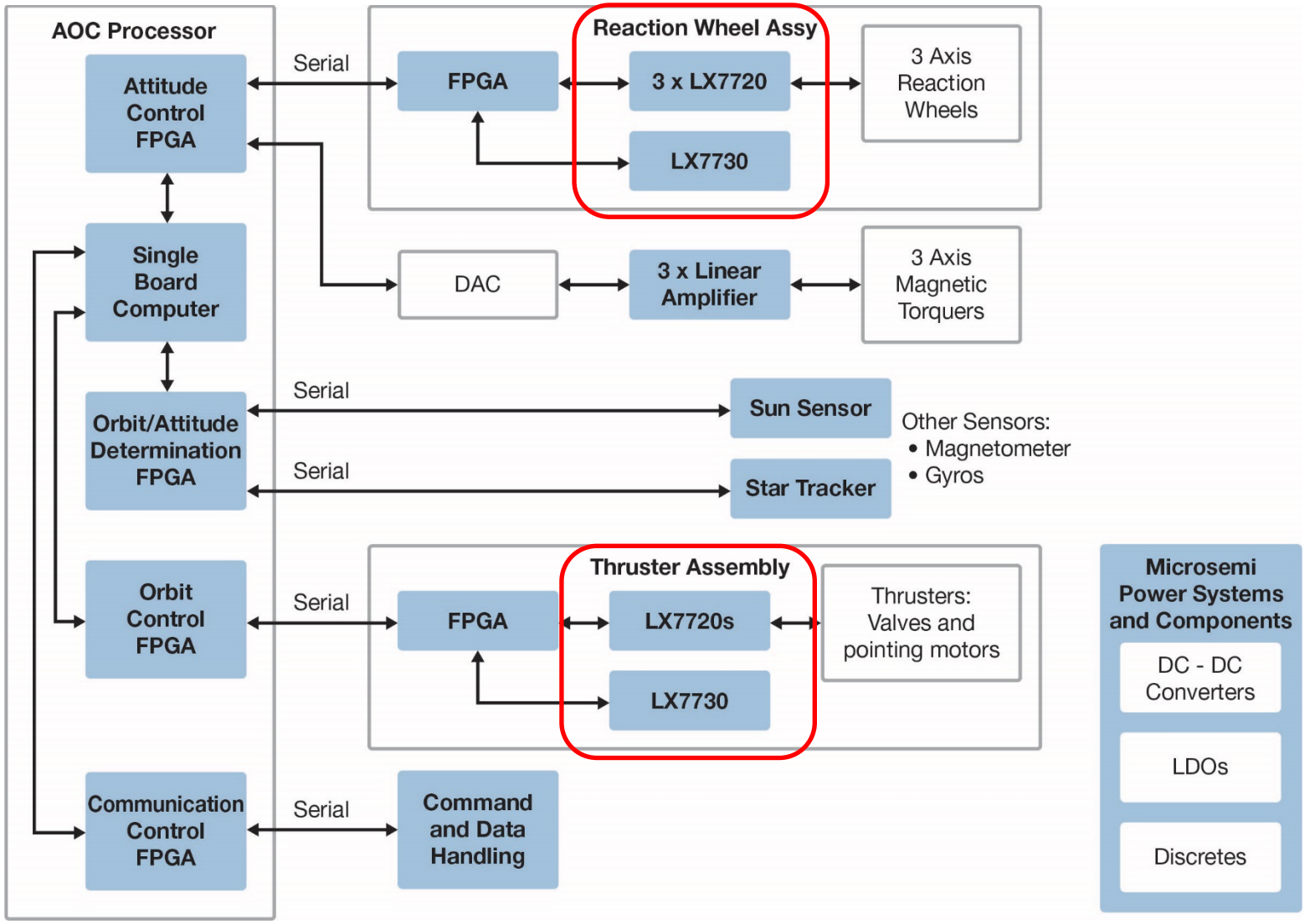


LX7720 Overview
Power Driver with Rotation and Position Sensing

- Features
  - Four half-bridge N-ch MOSFET drivers
  - Four floating differential current sensors
  - Pulse modulated resolver transformer driver
  - Three differential resolver sense inputs
  - Six bi-level logic inputs
  - Fault detection
  - Radiation tolerant: 100 krad TID, 50 krad ELDRS
  - Preliminary silicon sampled. Production silicon sampling October.



Attitude and Orbit Control Application



LX7720 Availability Update

Part Number	Silicon	Availability
LX7720-ES and DB	Engineering samples using production version silicon	CQ4 2017
LX7720MFQ-EQ	Production. Qual complete. Consult factory for lead times ARO*	CQ2 2018
LX7720MFQ-EV	Production. Qual complete. Consult factory for lead times ARO*	CQ4 2018

- Lead times ARO are 26–30 weeks.
- As with the LX7730, we will submit qual data and seek QML certification.
- Product numbers will change to LX7720MFQ-V and LX7720MFQ-Q once QML listing is given.

LX7720 Ordering Part Numbers

Part number	Description
LX7720MFQ-ES	Engineering samples.
LX7720MFQ-EQ	Built per QML-Q flow. This will convert to LX7720MFQ-Q once QML certification is achieved and parts will also be orderable by SMD number.
LX7720MFQ-EV	Built per QML-V flow. This will convert to LX7720MFQ-V once QML certification is achieved and parts will also be orderable by SMD number.
LX7720-DB	Daughter board for RTG4 development kit. Allows user to connect the LX7720 to the RTG4 FPGA dev kit and evaluate key functions.

LX7720 Support Material

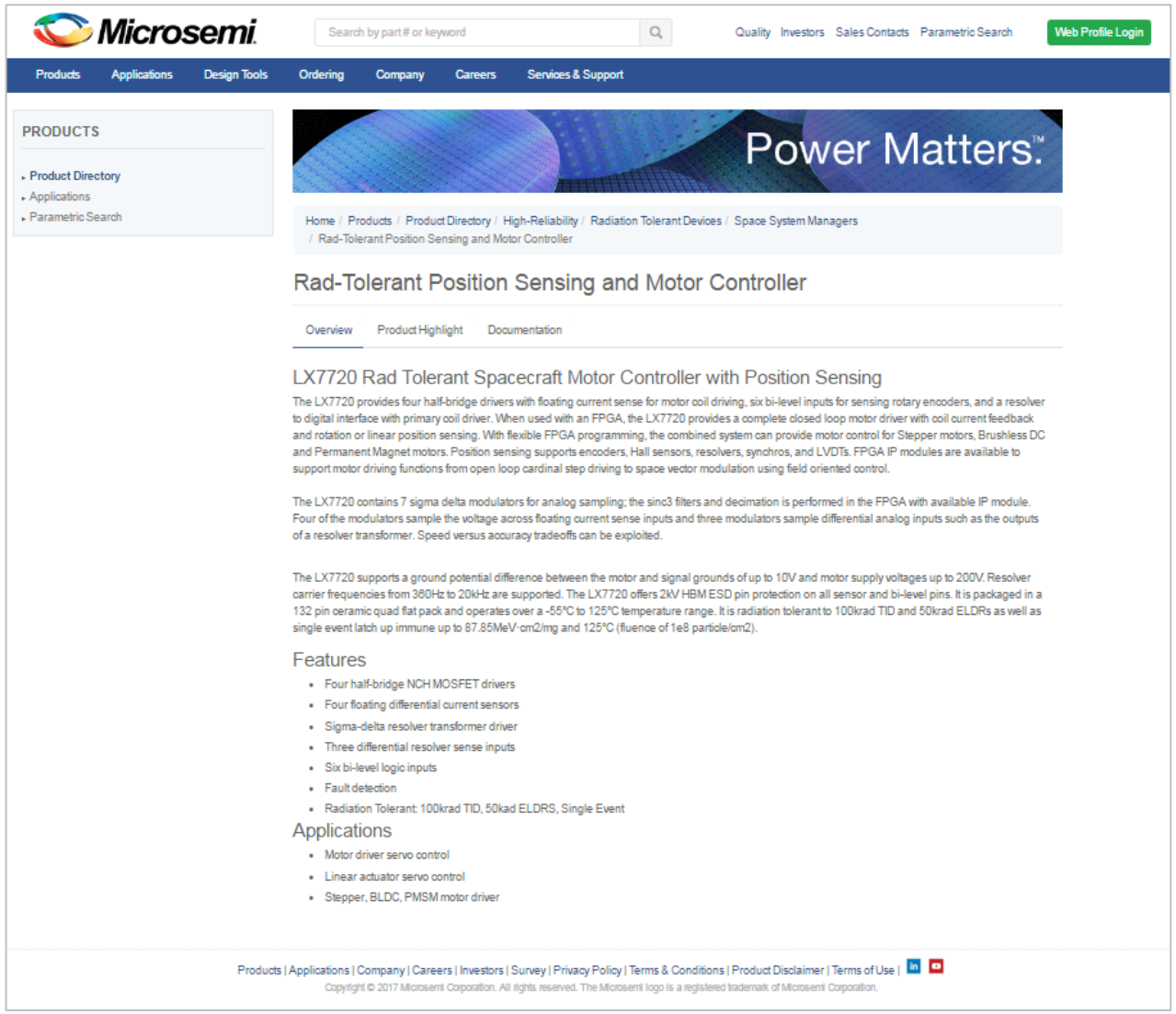
Product Webpage:

http://www.microsemi.com/product-directory/space-system-managers/3708-position-motor-controller-ic

Documentation Available:

- LX7720 Full-Prelim Specification
- LX7720 Product Brief
- SSM Availability
- White Paper: _Challenges of Designing a Radiation Tolerant Motion Control System on Chip

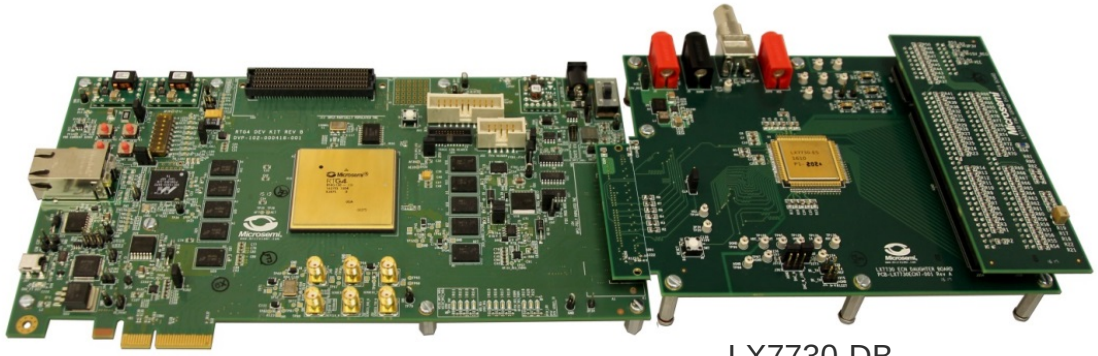
For technical help, submit questions to AMSTech@microsemi.com



Space System Manager Development Tools

Daughter boards for use with RTG4 Development Kit

Allows user to connect the LX7730 and LX7720 to the RTG4 development board and evaluate key functions.

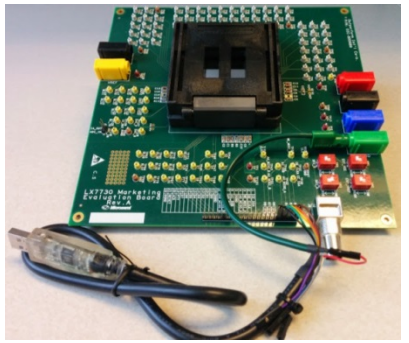


LX7730-DB

LX7720-DB

LX7730 Evaluation Board

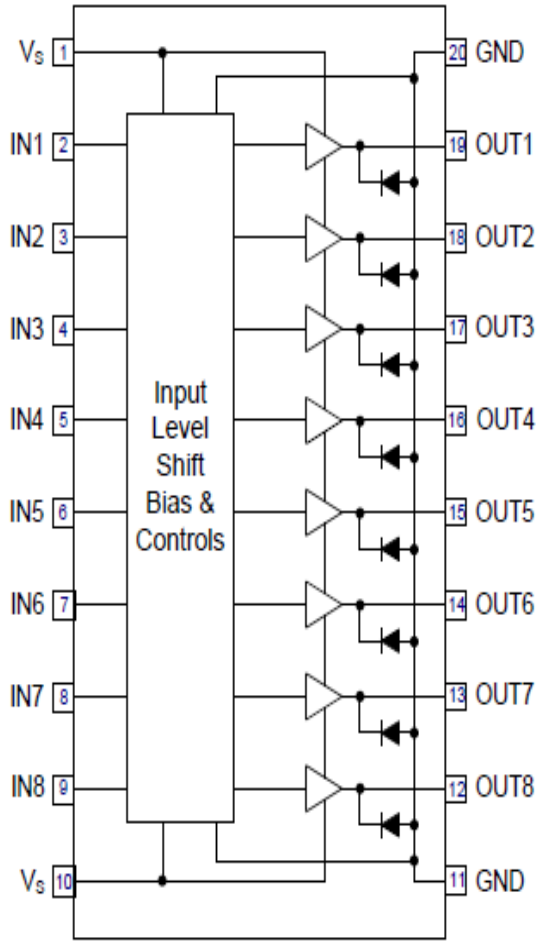
Allows user to exercise LX7730 features when coupled with a USB to serial interface. Application software is provided and includes cable assembly.



In Production

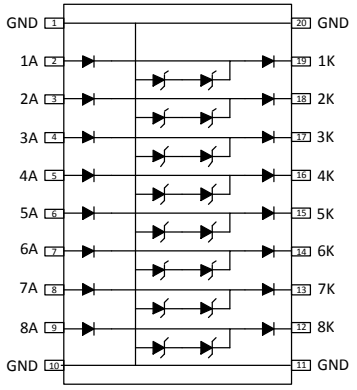
LX7798 (AAHS298B)—Rad Tolerant 8-Channel Source Driver

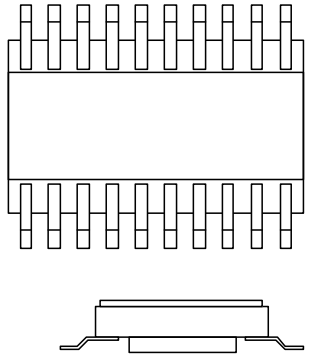
- Features
  - 700 mA per output source current
  - Fully isolated channels with DI process
  - 100 krad TID, SEL immune
  - 80 V minimum output breakdown
  - Low quiescent current consumption
  - Internal ground clamp diodes
  - Internal thermal shutdown
  - TTL, 5 V, and 12 V logic compatible
  - DLA certified with 4 SMDs
    - SMD 5962-1523101VXC, SMD 5962-1523101VYC(V)
    - SMD 5962-1523101QXC, SMD 5962-1523101QYC(Q)
- Applications
  - Relay/solenoid drivers
  - Lamp/LED drivers
  - Stepper and/or servo motor drivers

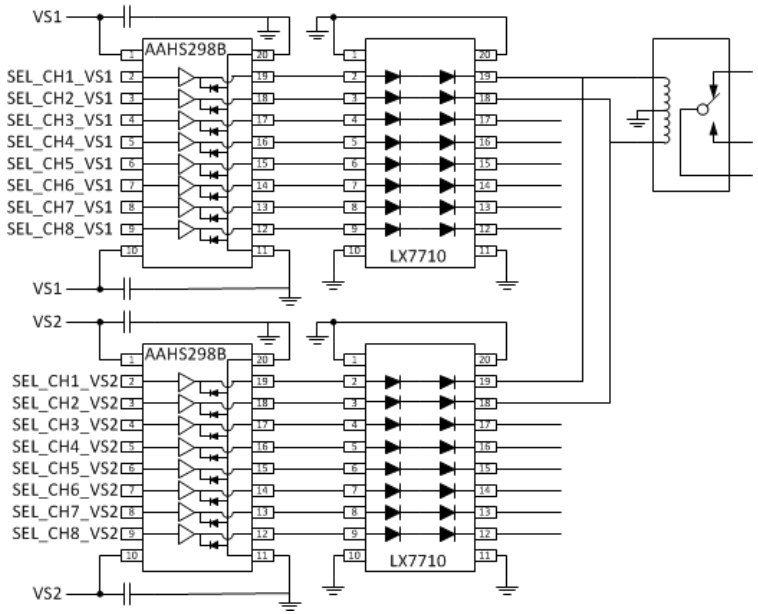


LX7710—Rad-Tolerant Octal Diode Array with Redundancy

- Features
  - 125 V min breakdown voltage
  - 1 A current rating/diode
  - 2800 mA combined rating
  - Redundancy if one diode fails
  - Discharge path for inductive kick
  - –55 °C to 125 °C ambient
  - 20 lead ceramic SOIC
  - DLA certified
    - 5962-1621001QXC
    - 5962-1621001VXC
- Applications
  - Relay driver
  - Uninterruptable power
  - Redundant power sourcing
  - Prevents channel backflow







Hi-Rel Industry Standard ICs—Overview

Linear Voltage Regulators

SG109	Positive, Fixed
SG117/SG117A	Positive, Adjustable
SGR117/SGR117A	Positive, Adjustable, Rad Hard
SG120/SG120A	Negative, Fixed
SG137/SG137A	Negative, Adjustable
SG140/SG140A	Positive, Fixed
SG723	Precision, Positive or Negative Adjustable
SG1532	Precision, Positive or Negative Adjustable
SG78xx/SG78xxA	Positive, Fixed
SG79xx/SG79xxA	Negative, Fixed

PWM Controllers

SG1524/SG1524B	Voltage Mode
SG1525A	Voltage Mode, Dual Sink/Source
SG1526/SG1526B	Voltage Mode, Dual Sink/Source
SG1527	Voltage Mode, Regulating, Dual Sink/Source
SG1529	Voltage Mode, Regulating
SG1731	DC Motor Controller
SG1825C	High Speed, Current Mode
SG1842	Off-line, Current Mode, 16V UVLO, 100% Max Duty Cycle
SG1843	Off-line, Current Mode, 8V UVLO, 100% Max Duty Cycle
SG1844	Off-line, Current Mode, 16V UVLO, 50% Max Duty Cycle
SG1845	Off-line, Current Mode, 8V UVLO, 50% Max Duty Cycle
SG1846	Current Mode, Dual Sink/Source

Linear Circuits

Interface

SG2000 Series	Driver Array - 7 NPN
SG2800 Series	Driver Array - 8 NPN

MOSFET Drivers

SG1626	Dual High-Speed, Inverting
SG1644	Dual High-Speed, Non-inverting

Op Amps

SG143	High-Voltage, Low-Current
SG1436	High-Voltage, Low-Current
SG1536	High-Voltage, Low-Current, Low-Offset
SG2101	Dual, Compensated

Voltage Reference

SG1503	Precision 2.5V Reference

Supervisory

SG1543	Power Supply Output Control Circuit
SG1544	Low-Voltage Power Supply Output Control Circuit
SG1548	Quad Power Fault Monitor
SG1549	Current Sense Latch, 100mV Input Threshold, 180nS delay

SGR Product Offerings

Microsemi offers new radiation-tolerant enhancements to our popular industry-standard products: SGR1846, SGR1845, SGR117, and SGR137

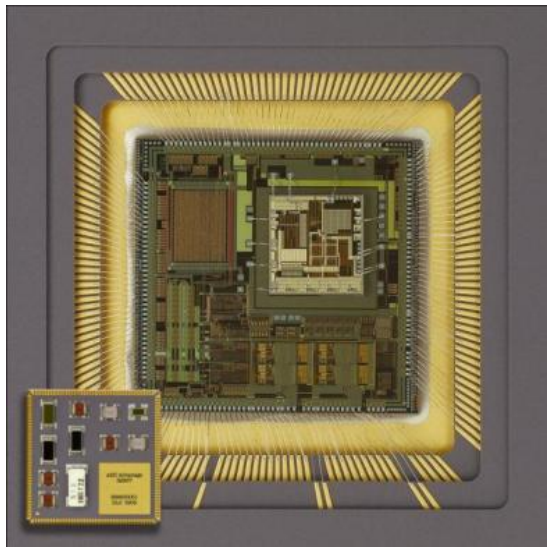
- Guaranteed radiation tolerance performance—(test data available)
  - TID to a minimum of 100 krad(Si)
  - ELDRS to a minimum of 50 krad(Si)
  - SEL immunity to a minimum of 87 MeV cm^2/mg
- EV= Microsemi equivalent QML-V flow
- Fit, form, and function (FFF) equivalent of industry-standard SG product
  - Process change only*
  - No design change*
- No changes to SG product line. Still fully supported.
- Currently sampling and in production.

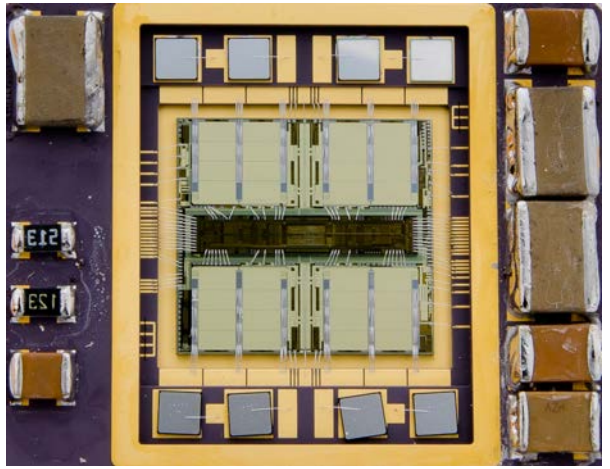
**The SGR117 is a design change from the SG117 and has extensive space heritage.*

Custom Capabilities

Custom Integrated Solutions

- Full custom designs from specification to production
  - 20 years of custom ASIC development
  - Expertise in Space and Aviation applications
  - Over 9 years of flight heritage
- Challenging operating conditions
  - Radiation tolerance by design for 100 kRad TID minimum, SEL/SEU immunity
  - Cold-sparing on I/Os for redundant applications
  - Extreme temperature environment (225 °C)
- Screening to MIL-PRF requirements
  - (Class Q, Class V, etc. as specified by customer)
- Custom packaging





Business Guidelines and History

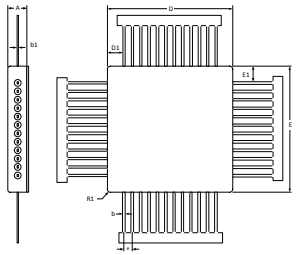
Custom Development Rqmt
Development + production commit
Customer funded NRE
Strategic alignment
Technology alignment

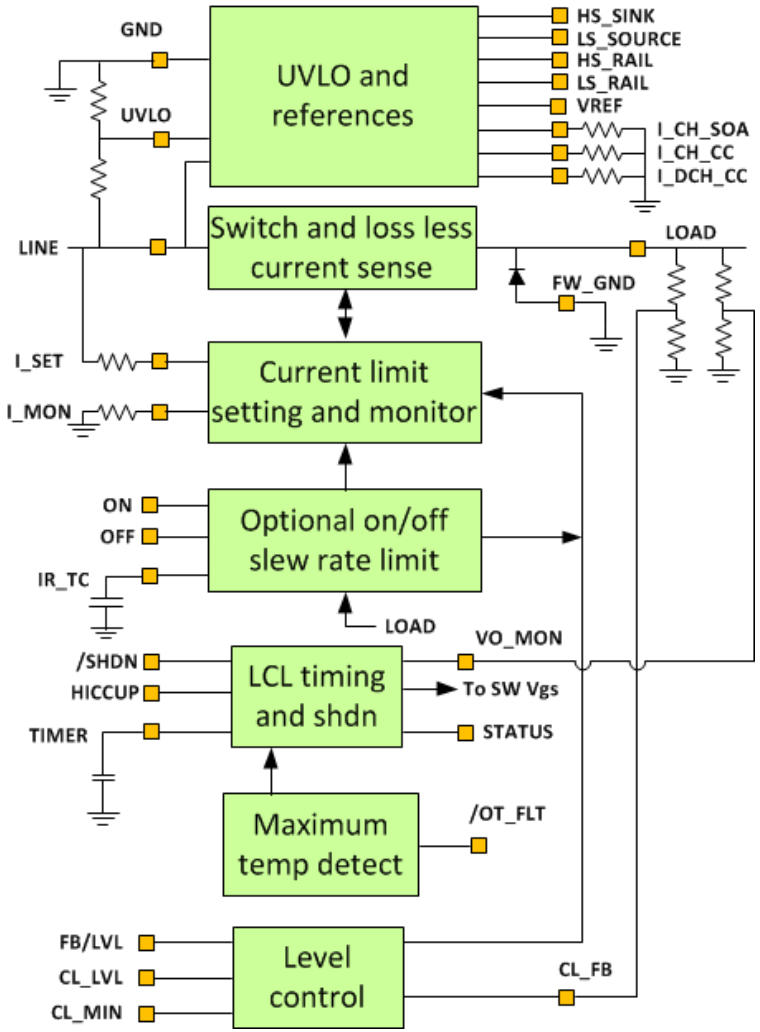
Past Developments	
RT telemetry controller	Solid-state relays
RT high-side drivers	ARINC 429 TX/RX/ID
RT motor controller with 2 A driver	Cockpit light dimmers
RT RS485 transceiver	5-MHz oscillator driver
Aircraft LVDT controller	15 A SiC JFET driver
Navigation gyro controllers	MOSFET RF driver
Solid-state LED drivers	55-MHz buffer amplifier
Solid-state circuit breakers	Log amplifier
Pin-diode drivers	

What's Next?
In-Development and Concept Products

LX7712: Power Line Protection Device Latchable Current Limiter

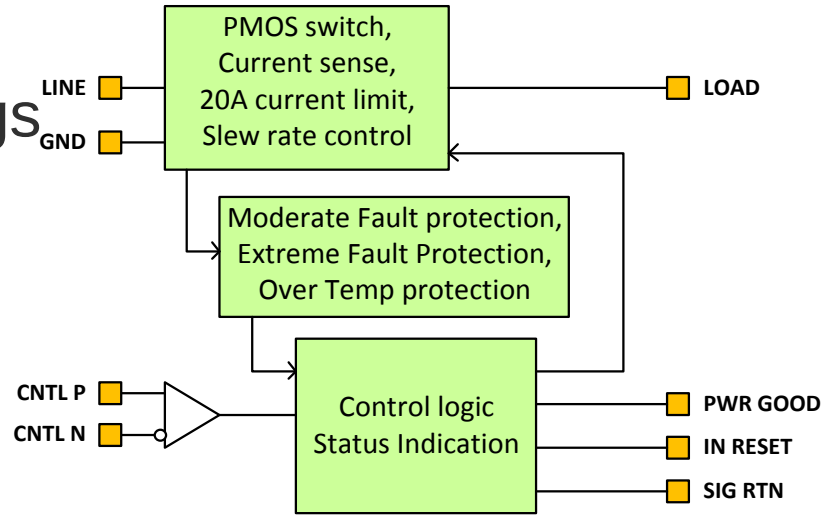
- Internal 5 A PMOS switch and diode
- 120 V rated
- LCL or FCL configurable
- ON, OFF, and STATUS pins
- Programmable UVLO and STATUS
- Parallel-able for higher currents
- Current limit and monitor
- Current slew rate limit: on and off
- Chip temp monitor
- 48-lead metal HTF package
- Test chip evaluated. In design

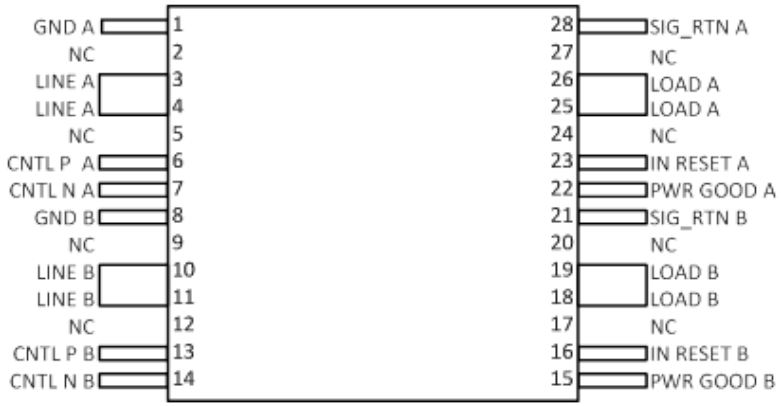




LX7714: RT Satellite Power Bus Controller Resettable Fuse + Relay

- Internal 5 A/125 V rated power switch and fuse
- Mimics fuse melting point with 1, 2, 3, 4, or 5 A ratings
- Hiccup mode to enable recovery from shorts
- Efficient current sharing when paralleled
- Internal output rise time control
- LVTTL and TTL on/off control
- Power Good and In-Reset status telemetry
- Thermal shutdown for back-up protection
- 4 devices per package
- Radiation tolerant





New Mixed Signal ICs for Space Brochure

Topics covered:

- Leading Space Innovation for Sixty Years
- Space System Manager ICs
- Development Tools
- Radiation-Tolerant Source Drivers and Diode Arrays
- Radiation-Tolerant Voltage Regulators and PWM Controllers
- Custom Solutions for Space

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