Standardization of MS Kennedy Rad-Hard Microcircuits

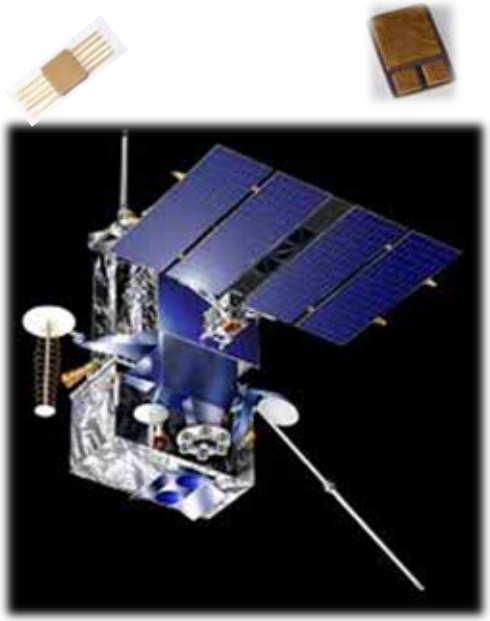
MSK
A Subsidiary of Anaren

….but first let’s answer the question:

“M.S. Who??”

MSK Market Position

MSK designs and manufactures high performance Hi-Rel and true Rad-Hard analog, mixed signal and power micro-circuits.



LM's A2100 and Boeing 720 bus use MSK custom hybrids and standard Voltage regulators

Aircraft and UAV's use MSK's precision Hi Rel Motor-Controllers and LDOs

Orbital Sciences Corp. Upper Stage Thrust Vector Actuator uses MSK Motor Controllers

2012

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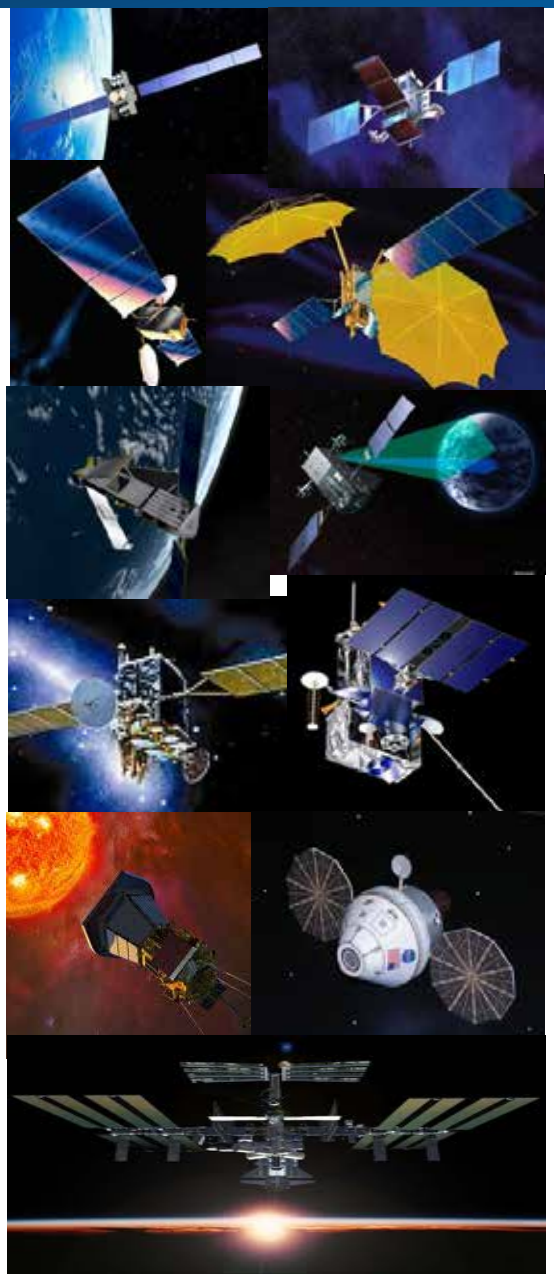
Select programs using MSK ...

- WGS
- GPS III
- A2100
- ACeS
- Iridium
- SBIRS
- AEHF
- GOES-R
- Solar Probe
- ISS



- Alphasat
- Galileo
- Bepicolombo
- Solar Orbiter
- Hayabusa 2
- E-Rosita
- Meteosat
- Exomars
- Loutch-M
- Express AM6
- ISS
- Dubaisat 2
- Musis
- Egyptsat
- Radarsat (CA)

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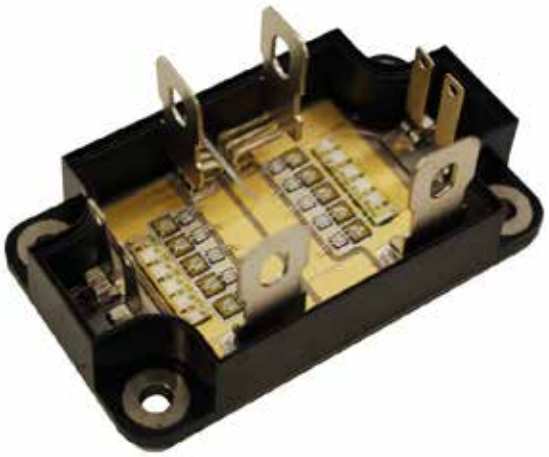
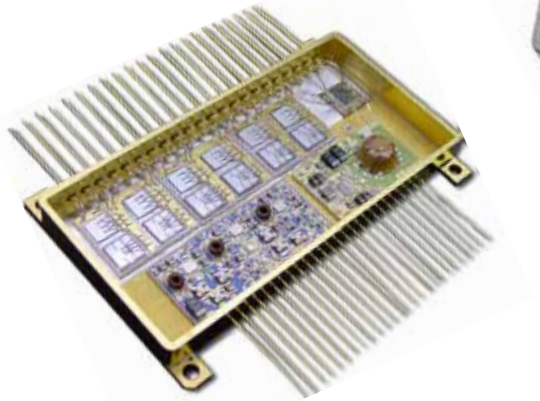
MSK Products

- Space Products are the largest and fastest growing segment of MSK
- Voltage regulators, POL/Switching Regulators, Amplifiers, Comparators, References, Multiplexers and Circuit Breakers
- Motor controllers
- Power modules up to 1700V / 1200A
- High Power/High Speed Amplifiers
- (MIL-Grade) RF modules





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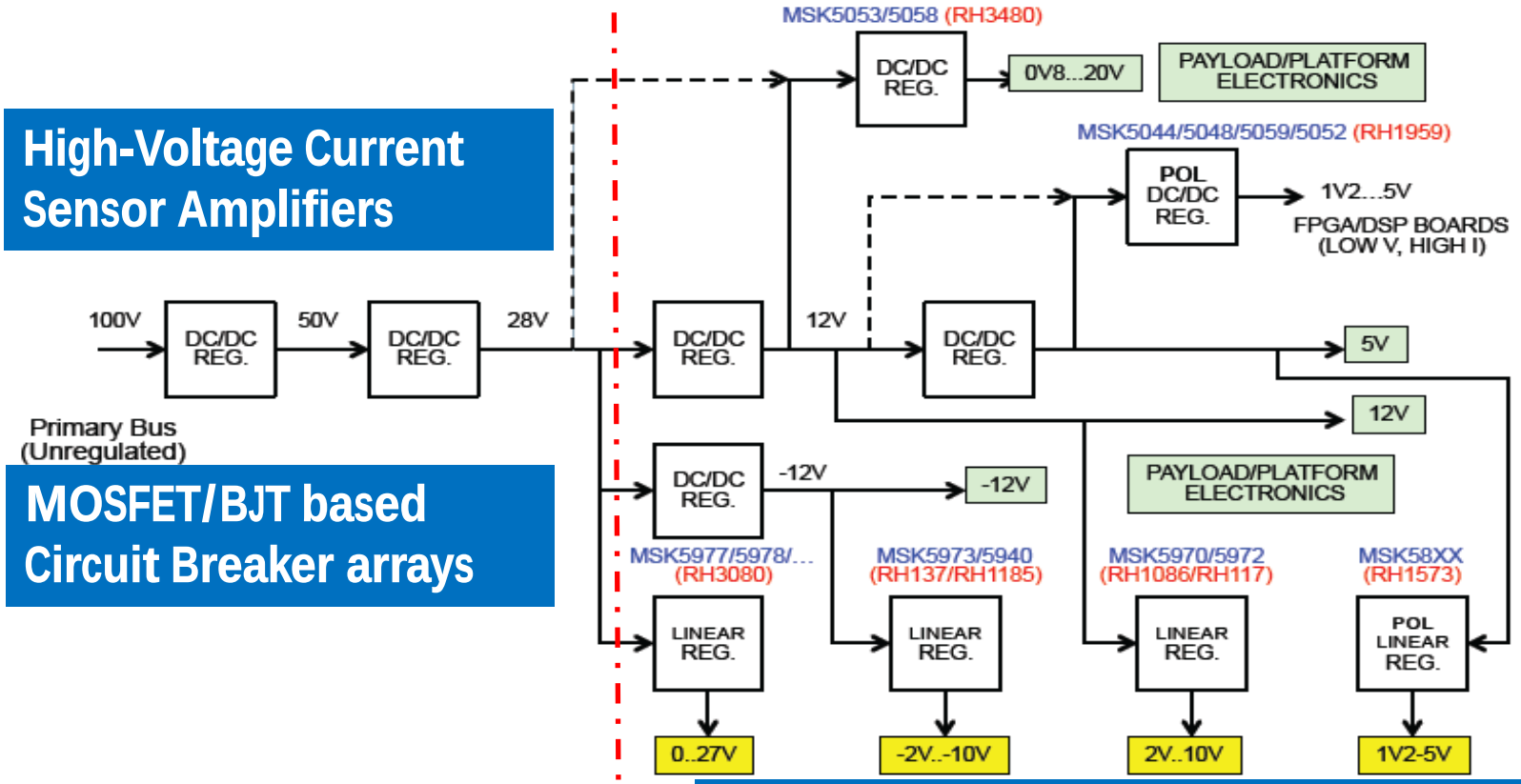
Where MSK plays: a) Power Management

Main bus, DC/DC, PMDU

Board Mounted & Payload Power

PWM/Linear (Pre-)regulators for bus/digital ICs

High-Voltage Current Sensor Amplifiers



MOSFET/BJT based Circuit Breaker arrays

Very low noise LDO's for RF/Analog

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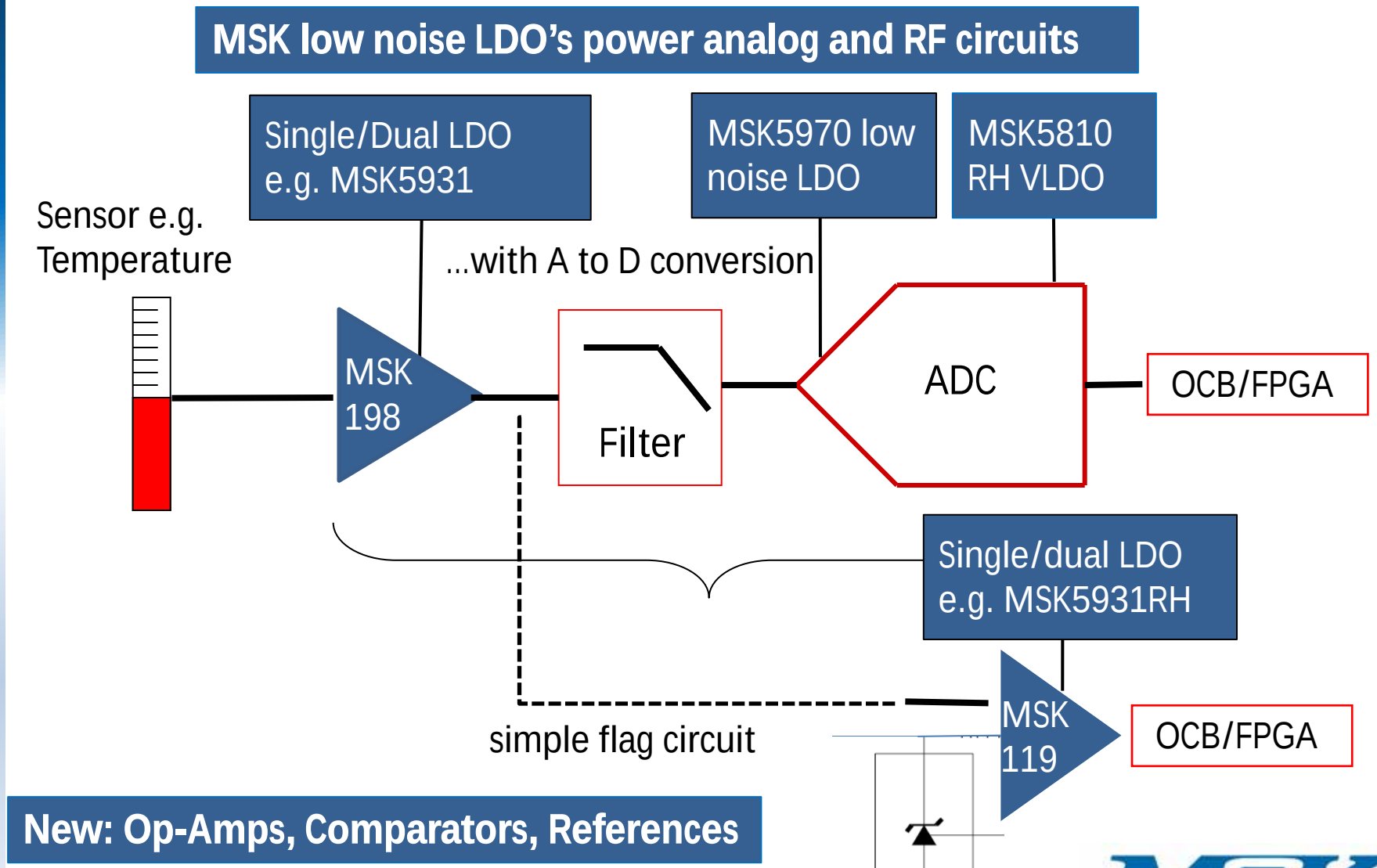
Where MSK plays: b) Analog signal chain



New: Op-Amps, Comparators, References

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MSK facilities and certifications

43,000 sq. ft. overall area

16,500 sq. ft. state-of-the-art clean room

- Class II, ISO-7, 10,000 particle/cu ft, general manufacturing area
- Class I, ISO-5, (100 particle/cu ft.) laminar flow area for pre-seal inspection

Certifications:

- MII-PRF-38534 to class K, MIL-PRF-38535 class V
- Calibration to ANSI compliant Z540-3
- Certification to AS9100 awarded February 2006

Company Size:

- *160 employees*
- *Est $40M sales in 2012-13 FY, Solid growth for >10 years*
- 60% space, 30% defense, 10% commercial aerospace
- 70% custom/semi -custom, 30% standard products

- All assembly processes are in house, few exceptions
- Multiple analog/power assembly technologies
- In-House Screening; T-C, Burn-In, X-Ray, CSAM, Fine-Leak, Gross-Leak, Centrifuge, Thermal shock, PIND

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Standardize, Focus, Accelerate

Beyond MIL-PRF-38534 and MIL-PRF-38535….other kinds of standardizing

Main themes today – in analog RH microcircuits

High qualification cost, Low quantities, chip obsolescence and new knowledge of radiation environments drive us to…:

1. QML certified Hi-Rel microcircuits and processes to reduce time, risk and cost of qualification and purchase/ownership. More true for research missions where quantities are very small.
2. Close Cooperation: Chip-, & MCM Module/IC manufacturers and Researchers partner, share costs & work improving results, e.g. SEE
3. Flexible components and satellite systems, e.g. Programmable Satellite with FPGA's, one Voltage regulator for many applications.
4. Supply Chain Aspects: Serve customers more effectively with focused dedicated reps/distributors and

1) Implementing a broad product range - LTC & MSK

Focusing the strengths of two industry leaders to bring new broadly usable products to the Space Market

LINEAR TECHNOLOGY

"RH Dice Inside™"

MSK

- Leading edge analog circuit design
- Focused on widely used analog functions
- Extremely robust, rad hard wafer fab process
- Strong analog and power circuit design
- Leading edge, Hi-Rel micro-circuit packaging specialist
- Focused quality compliance to MIL-PRF-38534/5 Class K/V

Access potential future LTC Rad-Hard dice and MSK packages

>70 total part numbers>30 SMDs

LINEAR TECHNOLOGY

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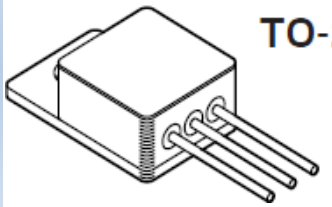
1) The result of good cooperative implementation

In short time, popular ICs were jointly qualified by two solid companies with stable production, Q&R and R&D systems. Both companies have a strong non-obsolescence policy

- **Proven, improved 100-300kRAD versions of heritage Voltage Regulators equivalent to LM117, 137, LM1085, LM1185**
- **Very popular Singe/Dual 1A...3A LDO's, like the low noise MSK5970RH**
- **Not up-screened but true Rad-Hard dice from LTC**
- **Released to production as RHA Certified QML listed parts 5962R...**



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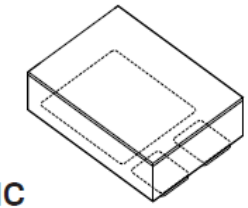
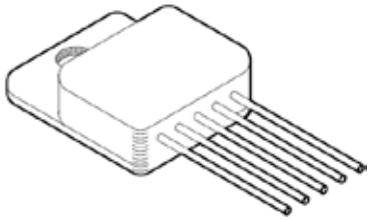


SMD-1
3 PAD
CERAMIC



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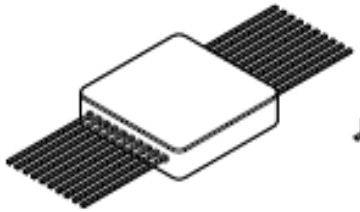
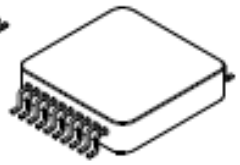


MSK591XRH



MSK591XRHG

LINEAR TECHNOLOGY

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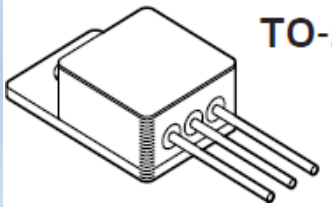
1) Benefits of widely usable analog QML IC's

- Tiny quantity shipments for R&D spacecraft like Exomars, Solar Probe, Lunar Resurs. Suppliers get distracted by 100's of standard priority IC's.
- Less Lot Acceptance Testing, destruct units, risk of failure and delay
- 3 Years experience show Asia, EU, Russia lean to ward QML IC.
- Some customers add tests like DPA, Life or domestic standard testing
- Broad use of standard High Performance QML parts make the product line more viable, less likely to be obsoleted
- Our MIL-PRF-38534 class H certification allows us to add more tests as needed by customers = Flexibility
- More detail and about MIL-PRF-38534 and MIL-PRF-38535 Qualification during the next session by Dan Miller



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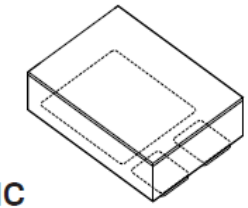
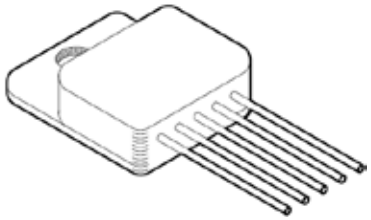


SMD-1
3 PAD
CERAMIC



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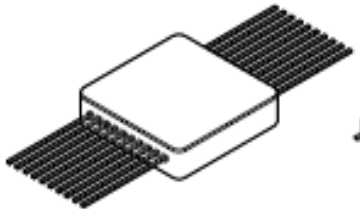
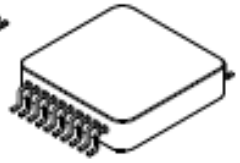


MSK591XRH



MSK591XRHG

LINEAR TECHNOLOGY

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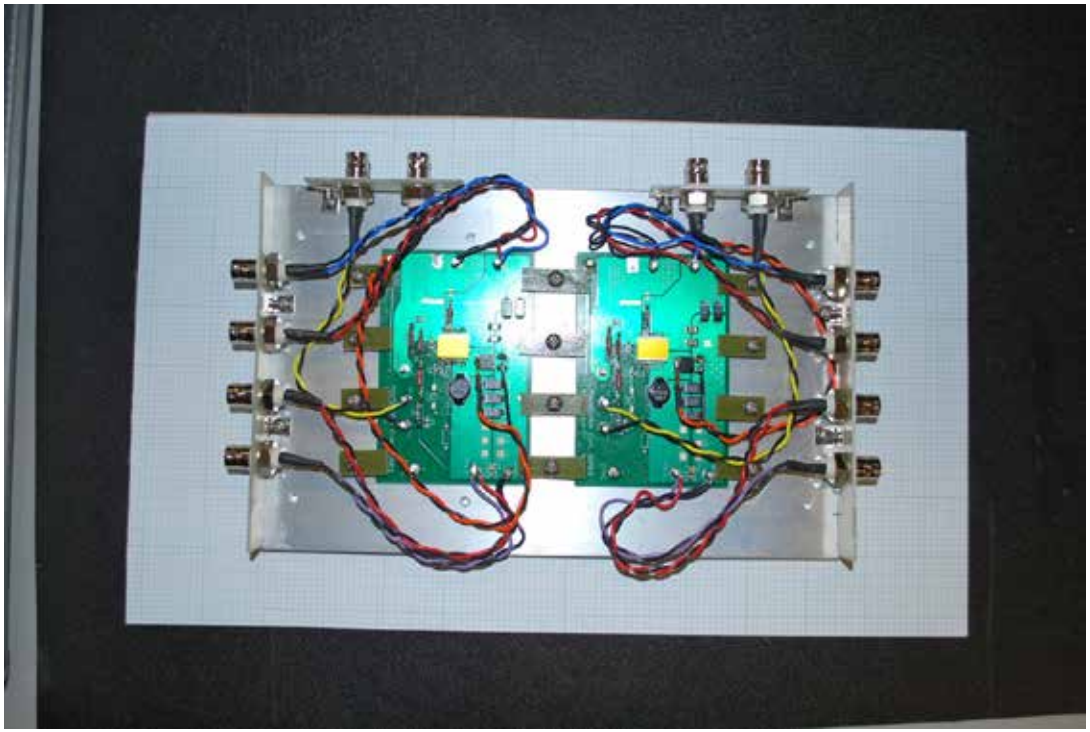
2. Cooperation in testing, Reduces cost, better results

The Challenge, e.g. Single Event Transient testing:

- Results can vary non-linearly with operating conditions
- External components need to be specified accurately
- Both need to be varied within typical operating ranges
- Power parts in a Thermal vacuum may overheat faster
- Chip manufacturer knows chip technology
- Packaging and circuit designers know the subcircuit
- customers know their system
- Research/Test facilities know Physics of Radiation better
- Why re-invent the (space)wheel?

2. Better results, less test cost

- MSK developed evaluation board on a cooling-plate
- LTC brought in chip-expertise
- Thanks to NASA and/or LBNL for the accelerator/physics background
- Excellent results, less repetition needed
- Operation was stable, clean and there were zero transients up to 114 MeV*cm2/mg even at high operating temperatures



Don't do-it-yourself in a "Vacuum" (Pun!), cooperate…

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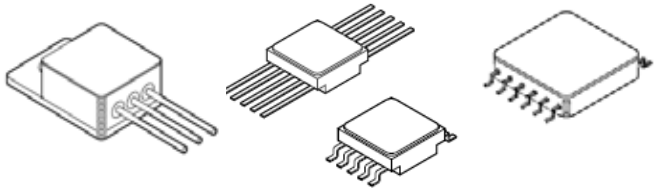
3) Flexible: Broad specifications = Many applications

Novel LDO Architecture: RH3080 chip based 1Amp LDO's: combines many features for many applications = versatility



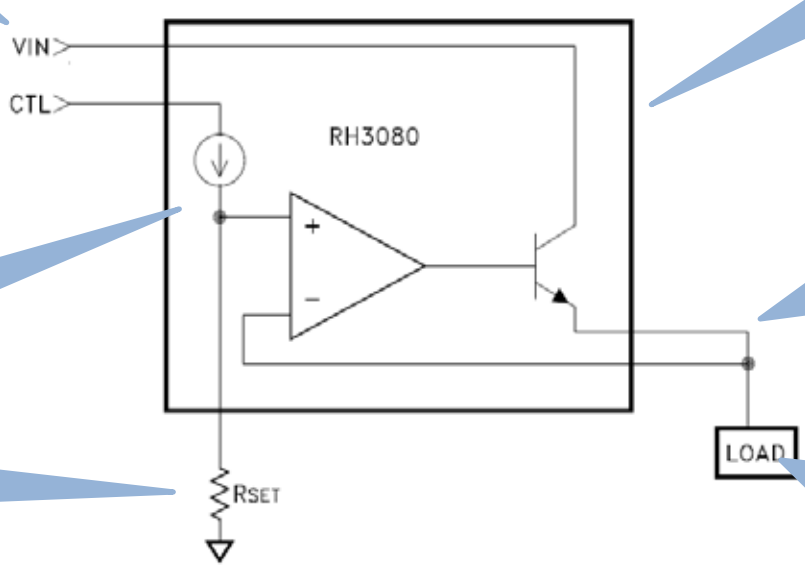
Single MSK5976, -7, 8 dual MSK5953KRH

Wide V_{in}: 1.5 - 40V, Can add R-drop to redistribute losses

Separate bias pin for low V_{in}-V_o dropout

"0" T_c 10µA current source instead of reference .

"Voltage Follower" Single resistor programmable output



Low $V_{ce(on)}$ BJT = 30 - 500mV dropout from V_{in}

V_o equals inverting input =>0....Vin-Vdo

Fast transient response keeps digital load supplies stable

300kRAD TID, Low noise, wide Input/output voltage range, high ripple rejection, good transient response, low power consumption are features previously only found in multiple IC's.

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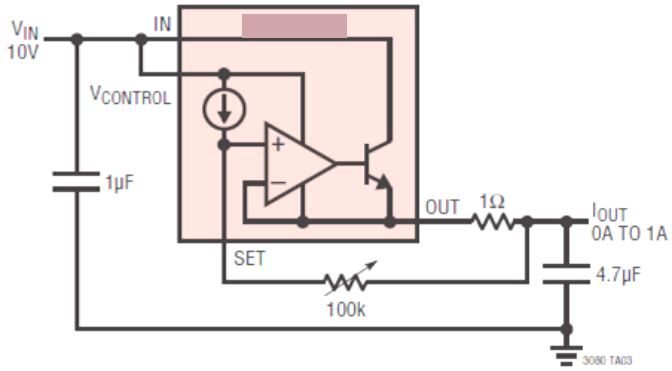
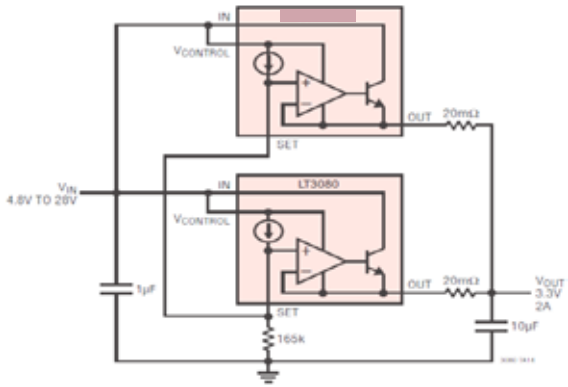
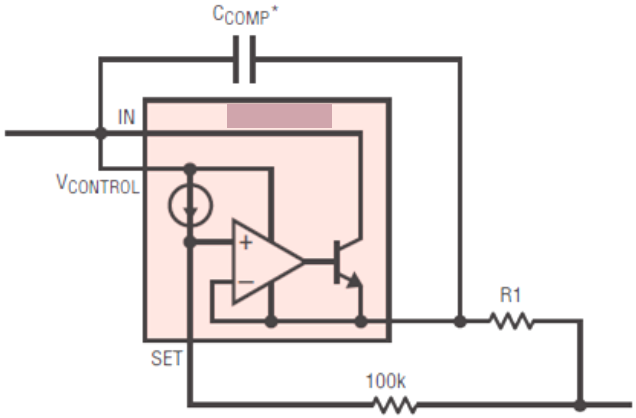
3) Flexible: It's a building block, not just another LDO



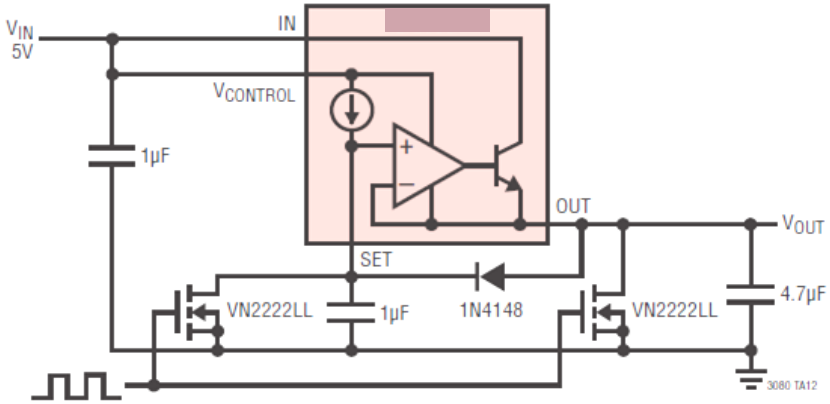
Current Source



Paralleling with good current sharing



Two Terminal Current Source



Ramp Generator

Most Requests come as "I need a part like…" or "I need a quote for MSK59xx", but discussions with creative designers, EEE component engineers and supplier application engineers reveal so much more

3) Flexible: Wide Vin/Vo 4A RH switching regulator

MSK5059/5052 100KRAD, 50K LDR tested, SEE 160MeV*cm2/mg

Fast current mode architecture = fast transient response, easy compensation, stability, small solution

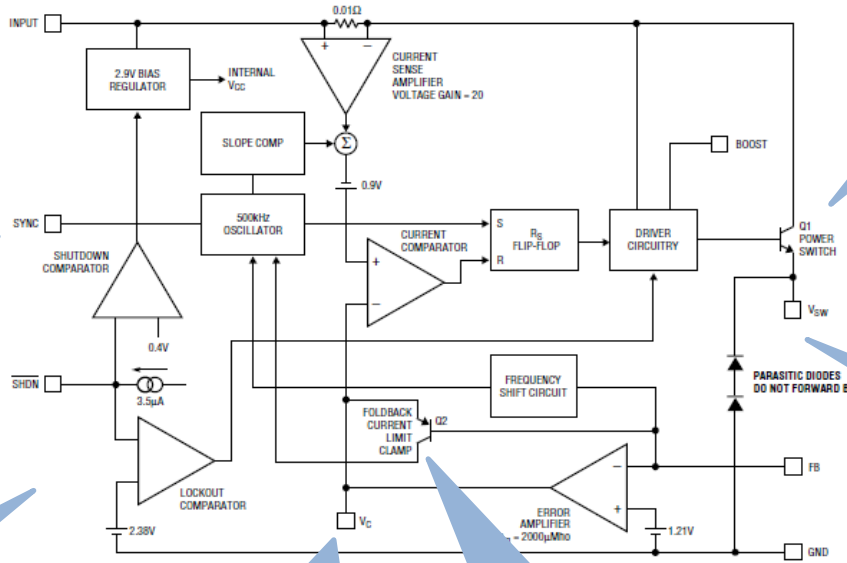
4.3 - 16V V_{in}

Fixed 500kHz f_{sw} for easy filtering

Sync-pin up to 1 MHz helps control noise

Enable pin

0.25 – 35mA quiescent current for good efficiency at low current



Rugged rad hard bipolar design with 150-500mV $V_{ce(on)}$, 70 mΩ

Over temp and overload protected

V_o = 1.21V min
4.5A I_{pk} limit

External compensation / EA output allows flexible output filter choices

Frequency / Current foldback over current protection, fault tolerant

Most POL's have limited Vin/Vo range

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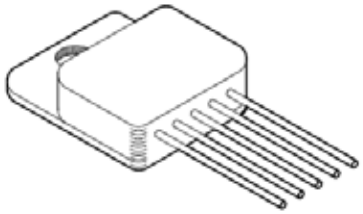
3) Solid Specs and design tools for Switching Regulator

New, available!

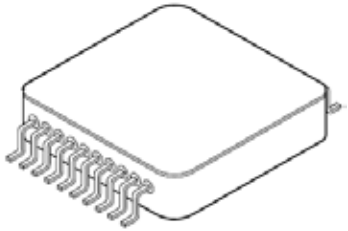
- 100 KRad TID, 50 KRad ELDRS
- SEE >160MeV*cm2/mg tested for SET/SEL
- Robust rad hard low cost bipolar design
- Multiple packages to meet needs such as cooling
- Evaluation boards support design with varying parameters

An idea picked up from Linear Technology Corp (thanks! "©") : hare evaluation board IP.

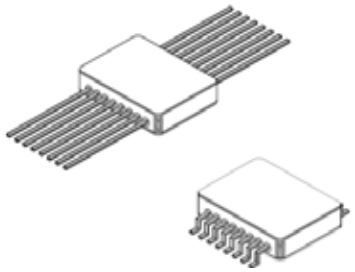


MSK5044RH (5962R11231)
Isolated case

MSK5048RH (5962R11232)
Case = GND
With sync pin



MSK5052RH
C_{in}, C_o HF filter, sync, external V_c included
SMD available soon



MSK5059RH
16-pin flatpak, single chip
Available as 5962R11234

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Flexible Ideas: MCM and Chip supplier cooperation

- An analog chip supplier is set up to design, fabricate and sell chips by the 10's of thousands
- A certified Hybrid manufacturer may add value and flexibilities on the back end such as:
  - Laser-Trim adjustable Voltage regulators, References or uP-supervisors
  - Combine chips into standard functions e.g. a window comparator (2 comparators+reference), driver + MOSFET
  - Perhaps a certified MCM manufacturer can be to a semiconductor supplier what an Alpina is to a BMW!?

4. Supply Chain Aspects

Sales force
Distribution
ITAR Processes
Addressing the world

Using a dedicated sales force

Timely and accurate Communication of market specific technical information is crucial:

Reputable local sales force – Distributors focused on Space

- knows or happily learns what we are talking about, what QCI, MIL-PRF-38534 is, Group A, B, C tests etc.
- Proper handling and adhering to Export Control Regulations is easier, less ITAR fear, DDTC Registered(!)
- No distraction when Apple or Nokia calls J
- Does not need re-training with every PO.
- Does not faint at the sight of of a $10,000 price tag for an "IC", or a 30 week lead time, or a 50 page Quality report etc.

Living and coping with challenges ITAR poses

MSK focus: Majority World Industry, so…

- **Definition:** RH product =“designed/modified for space” = ITAR Cat XV(e)
- Recently more US suppliers are affected than thought
- Limits use of ITAR EEE parts to Spacecraft not for/through China, Iran etc.
- The paperwork for complex route or end use of EEE parts is painful
- ITAR technical data needs Export license, Technical Marketing license
- End Use Statements provided by the buyer need to be complete….with info outside of his company or realm
- Every “sample order” needs an ITAR license

Positive Aspects and non-issues of ITAR Export licensing:

- 100% approval rate for Russia, India, Taiwan, Dubai, Egypt etc.
- Many High performance R&D missions have no substantial ITAR limitation
- ESA, Astrium, TESAT, TAS etc. provide professional End Use statements.
- Much Technical data is already public…just visit, Radecs, NSREC etc.

ITAR Challenges – relief with standardized processes

HOW?

- If space agencies and prime contractors distribute “broad” EUS’s to sub- and sub-sub…-contractors….MORE?
- A manufacturer, exporter or CPPA can get a “blanket Export license” covering many PO’s and products, -families for much of a program, using a Letter of Intent.
- ITAR free sampling of EM’s: Many MSK RH parts have non rad-hard MIL-grade equivalents

- It can help especially universities, institutes, subcontractors AND their purchasing agents (CPPAs) get parts faster and easier
- It may un-clog trans-shipping parts to down-stream parties
- It helps customers with limited program knowledge get ITAR parts.

Analog Product viability - Addressing the world

Definition: Cost effectively address a broad user base

1. **Geography:**
   a) Don't limit yourself to a fraction of the market. Like we did in USA….and excessive ITAR didn't help!!! Focus on the world.
   b) Scattered far and apart customers need good communication
2. **Evolving industries:** small quantities, education in all above aspects, very long time for program success.
3. "**Small customers"** R&D projects like Solar Orbiter, Lunar Resurs may be a spring-board for new or old in new areas

- Aspects mentioned may help wide acceptance of products
- A manufacturer's focus on the space industry and efficient set-up is needed: Support…or disappoint painfully
- Efficiency in addressing aspects is a must, to not disappoint a broad base of engineers
- MSK is experimenting with and working with CPPA's for efficiency

Summary

We addressed principles Qualification Cost, Low Quantities, Obsolescence of Chips and space market economies of scale (if there is such thing)

- Flexible QML certified components improve sustainability and reduce cost of ownership, delivery and hassle especially for high-performance small quantity missions.
- Forming partnerships between focused chip suppliers, focused QML certified manufacturers, and researchers can reduce cost, time and headaches and improve results.
- Partnering with dedicated field sales and distributors to support and service users and avoid disappointing customers…or industries
- A focused manufacturer for the world space market has “luxuries” of educating markets in product, procurement, export control etc. Other suppliers may be distracted or won’t afford, flip-flop in and out of a market.

Thank you!

Steve Dokopoulos
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Questions?