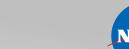
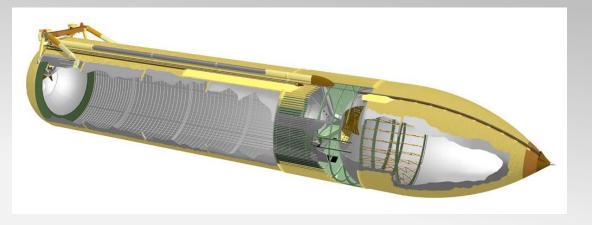
Advanced Wireless Sensor Nodes -MSFC 2016 Kosta Varnavas -Electronic Design Branch - ES 36



Jeff

Richeson -ES35 ESSSAI Jacobs

National Aeronautics and Space Administration





Sensor proliferation is exploding...



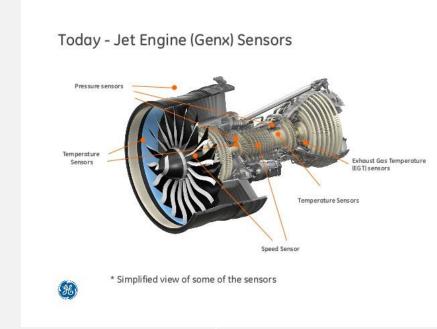
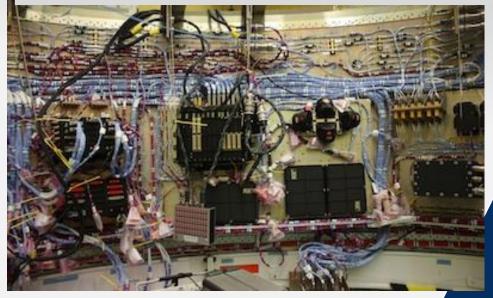
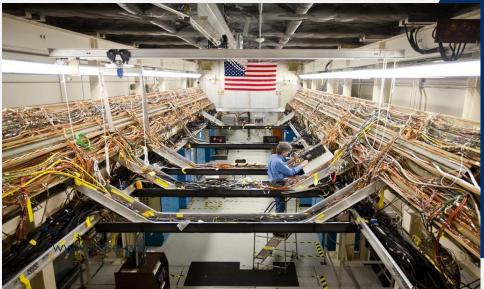


Image Sources: Google Images

DRAWBACKS TO HARDWIRED SPACECRAFT BUS ARCHITECTURES





Failures of wires and connectors

Mass of cabling and electrical interfaces

Physical restrictions on wired sensor placements (tankage, bulkhead penetrations, etc)

Undesired ground loops on the communication paths; long wire runs acting as antennas

Image Sources: Google Images

ADVANTAGES OF WIRELESS TECHNOLOGY

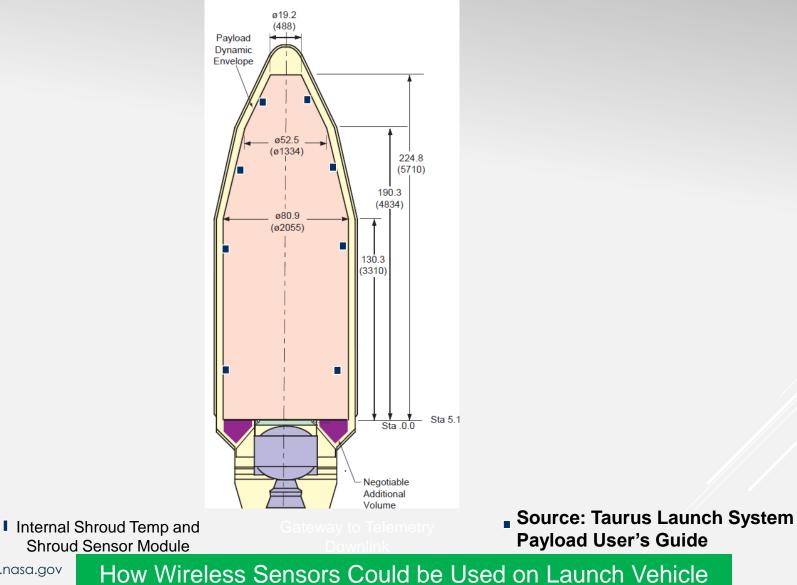
Covers common-mode faults due to structural failure that may affect critical wiring!

Lower mass

Redundant data access nodes improves robustness

Low-power battery-powered sensor packages can last years and be placed in difficult locations for wires to reach (penetrations, high vibration, rotating structures and components)

for Launch System Technology Development



The Chosen ZigBee Module

 The Synapse RF200
 Modules, contain a complete
 A/D, Microcontroller
 ,802.15.4 radio and
 Mesh Protocol
 Software Stack.

 Capable of uploading new software into each module over the air (OTA). RF200P81 / SM200 Synapse 2.4 GHZ IEEE 802.15.4/ZIGBEE® RF TRANSCEIVER

RX: 22.5 mA (@ 3.3 V)

TX: 22.5 mA (@ 3.3 V)

33.86mm x 33.86mm

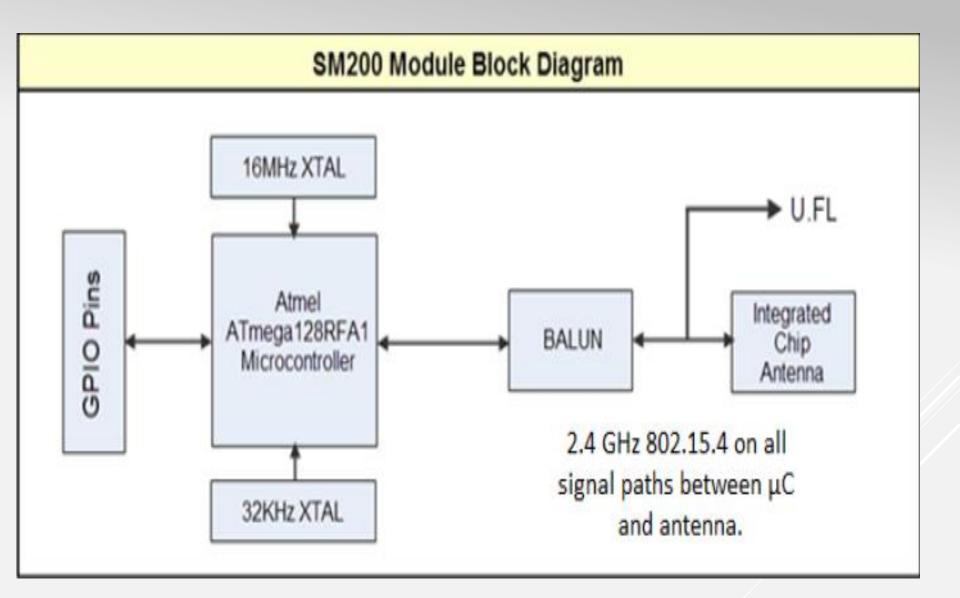
20 GPIO and up to 7 A/D inputs

SN132 SNAPstick USB module









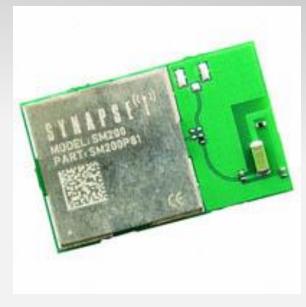
WIRELESS SYNAPSE FOOTPRINTS

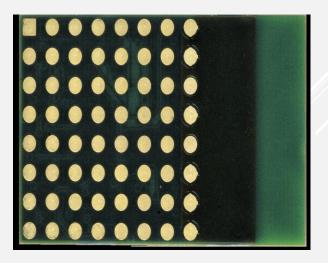
Through Hole (DIP)





Surface mount





Comparing the two generations



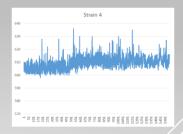
GEN 1

- 6 gauges all powered at same time.
- Strain gauged excitation voltage is straight off main battery rail.
- Op amp only has a 200 gain. This is a fixed gain set by on board resistor.
- No shunt or other method for onboard calibration.
- No Power Management.



- Only 1 Gauge • Each strain gauge has an independent constant voltage eneration regulator driving the excitation voltage.
 - Power management hardware.
 - Op Amp has much larger and adjustable gains.
 - Power management software.







SYSTEMS DEVELOPMENT



www.nasa.gov

Wireless Strain gauge At Materials Lab Pull Tes

Chart Title

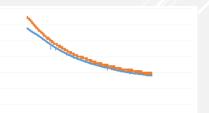
Chart Title





1





Combined wireless and measurements.



Gen 2 Wireless Strain Gauge

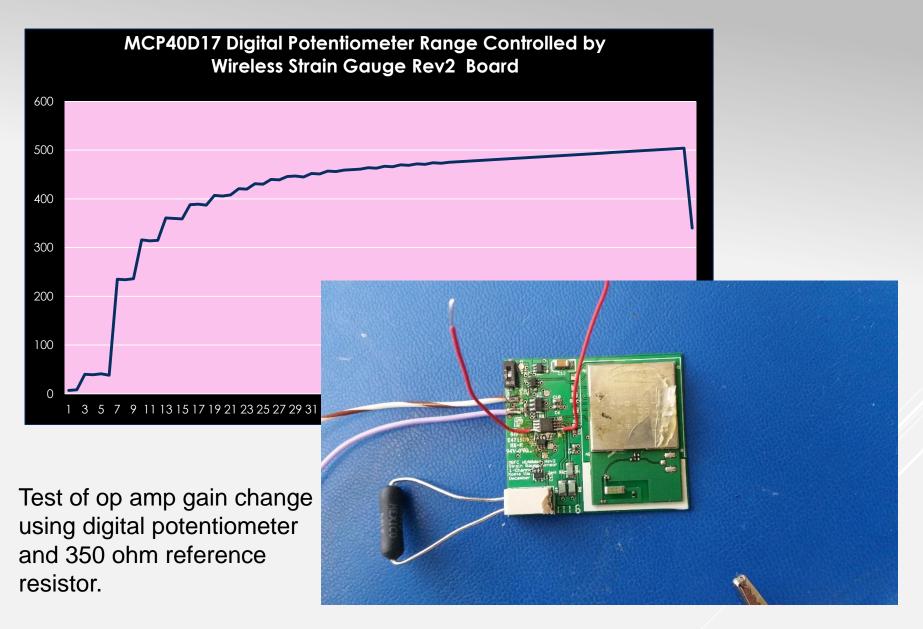
- * 1 Channel
- * With Battery
- * 1.5 " x 1.3 " without case.

Gen 2 Wireless Strain Gauge with power leads And strain gauge Attached.

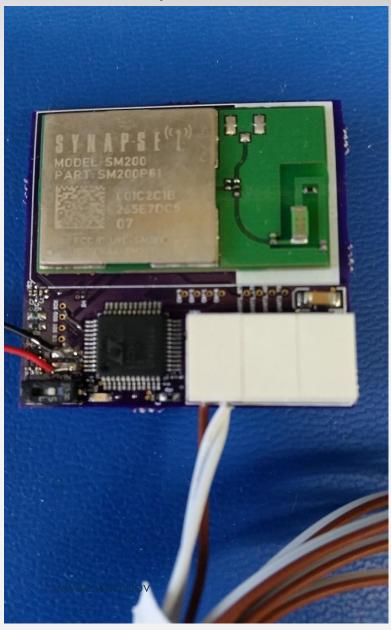


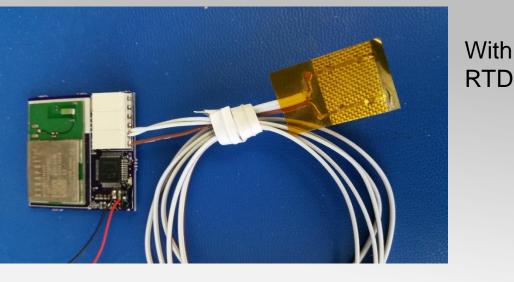
Power Management Synapse SM200 Wireless Analog Microcontroller Front End Module (AFE)

BLOCK DIAGRAM WIRELESS STRAIN GAUGE



Wireless Temp Board



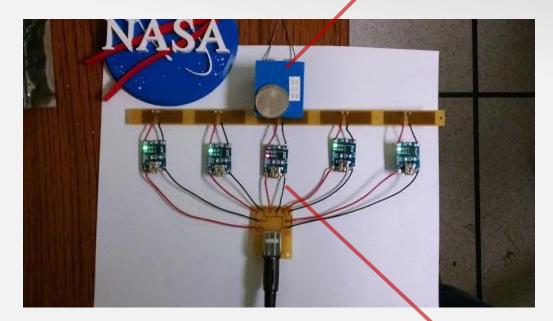


Can measure :

- virtually all standard (type B,
 - E, J, K, N, S, R, T) or custom thermocouples.
- Automatically compensate for cold junction temperatures and linearize the results.
- 2-, 3-, or 4-wire RTDs.
- Thermistors.
- Diodes.
- SPI bus controlled.

3-D printed (additive manufactured) casing for the 5-bay charging system was designed and created. Same as the blue housing for sensor node.

This is one wireless module on charging circuit. Charging bay has room for 5 modules.

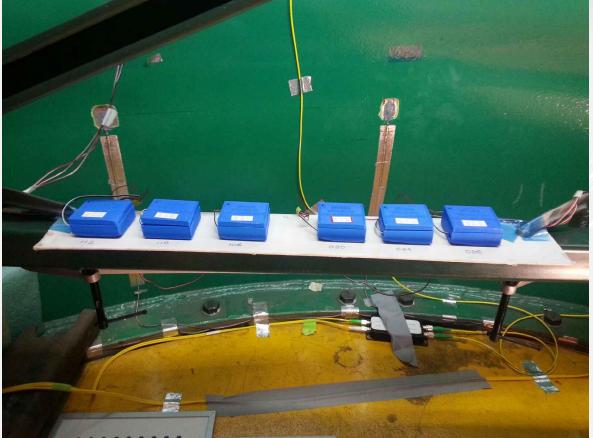


Commercial charging nodes , are specific for charging and preventing over charging of Li-ion batteries.



Composite Shell Buckling Test

20 – 1 Channel MSFC Wireless Sensor inside Composite shell

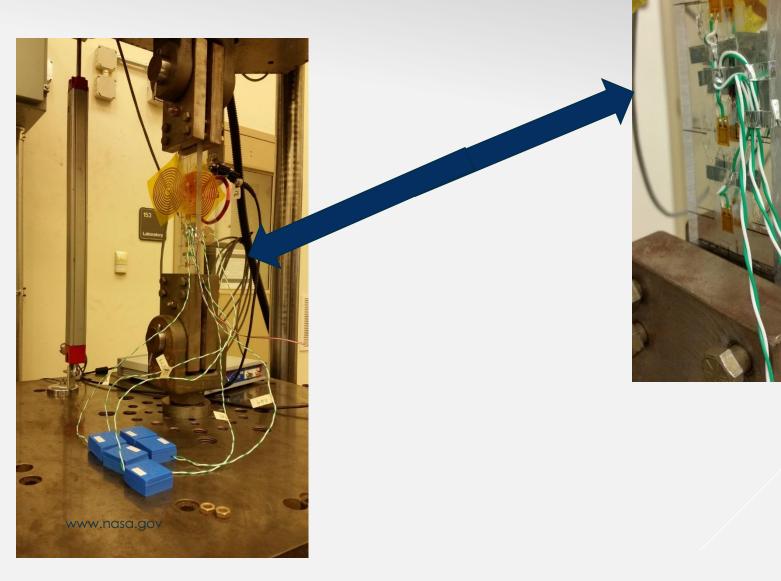


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File	View Ontion	s Network	Help				

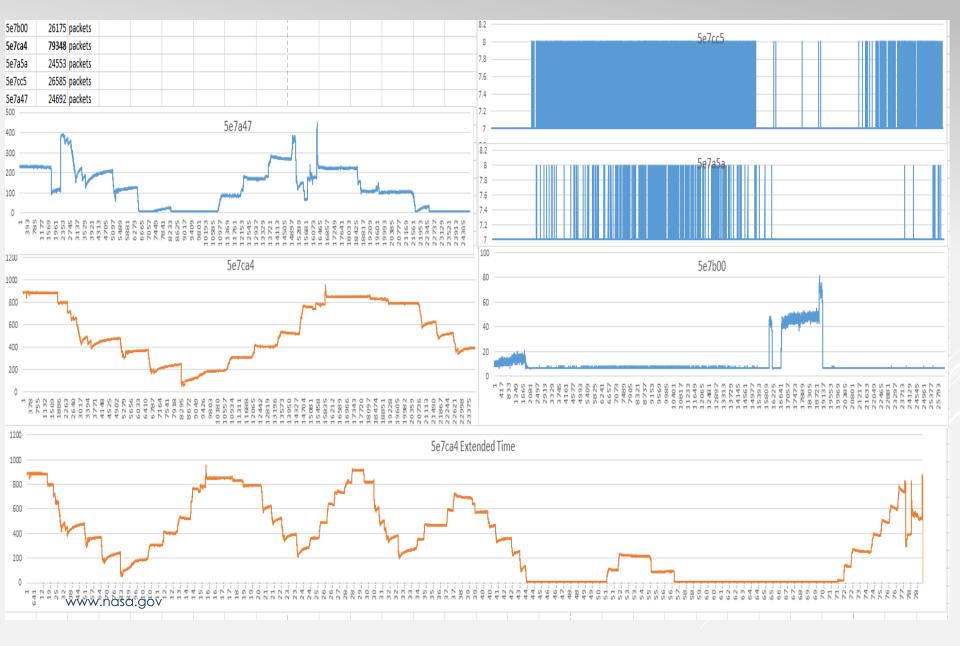
Portal 00.00.01 Master, NodeLogg Portal Bridge SC.DB.98 BridgeNodeBroadc 6% Nome NodeL9 SE79.40 MSFC_Strain_1-Cha 7% Nome NodeL0 SE79.74 MSFC_Strain_1-Cha 7% Nome NodeL0 SE79.74 MSFC_Strain_1-Cha 7% Nome NodeL0 SE79.74 MSFC_Strain_1-Cha 7% Nome NodeL8 SE7.74.7 MSFC_Strain_1-Cha 7% Nome NodeL8 SE7.74.7 MSFC_Strain_1-Cha 7% Nome NodeL6 SE7.74.7 MSFC_Strain_1-Cha 7% Nome NodeL6 SE7.74.7 MSFC_Strain_1-Cha 6% Nome NodeL6 SE7.74.4 MSFC_Strain_1-Cha 7% Nome NodeL2 SE7.74.4 MSFC_Strain_1-Cha 7% Nome NodeL3 SE7.74.4 MSFC_Strain_1-Cha 7% Nome NodeL2 SE7.74.4 MSFC_Strain_1-Cha 7% No	ode Views 🔿	Master_Node_Logger	.py BridgeNodeBroa	dcaster.py	BridgeNode1.py	Node Info
Portal 00001 Master, Node, Loga Portal SciD838 Bidgehodebroadc 6% None Nodel4 St73A9 MKSC Strain_1-Cha 7% Nodel4 St73A5 MKSC Strain_1-Cha 7% Nodel5 St73A5 MKSC Strain_1-Cha 7% Nodel4 St73A5 MKSC Strain_1-Cha 7% Nodel5 St73A5 MKSC Strain_1-Cha 7% Nodel6 St73A5 MKSC Strain_1-Cha 7% Nodel5 St7A47 MKSC Strain_1-Cha 7% Noded5 St7A48 MKSC Strain_1-Cha 7% Noded5 St7A47 MKSC Strain_1-Cha 7% Noded5 St7A48 MKSC Strain_1-Cha 7% Noded5 St7A44 MSSC Strain_1-Cha 7% Noded St7CA4 MSSC Strain_1-Cha 5% Noded St7CA4 MSSC Strain_1-Cha 5% Noded5 St7DA5 MKSC Strain_1-Cha 5% None No	i: 🗟 🥥	Active Nodes 🔹	13 nodes			🔿 🤗 🌫 🖪 🗟 🚳 🔶 👘 📼 🗙 🤉 🏕
Portal DUUUUI Master vooe coge Portal Ridge CDD8268 BridgeVodeGrodeL 6% None Node19 5E.79.49 MSFC, Strain, 1-Cha 7% None Node10 5E.79.49 MSFC, Strain, 1-Cha 7% None Node20 5E.79.47 MSFC, Strain, 1-Cha	de	Network Address	Device Image	Link Quality	Device Type	Bridge
Nodel SE79.40 MSFC_Strain_1-Cha 78% None Nodel SE79.53 MSFC_Strain_1-Cha 6% None Into Nodel SE79.54 MSFC_Strain_1-Cha 76% None Into Nodel SE79.54 MSFC_Strain_1-Cha 76% None Into Nodel SE70.54 MSFC_Strain_1-Cha 76% None Into Nodel SE7A.54 MSFC_Strain_1-Cha	Portal	00.00.01	Master_Node_Logg		Portal	
Index Starse Index Index Index Index Nodel Starse MSC Stain 1-Cha 7% None MACA ddress: 0612C21B265C0B98 Nodel Starse MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Starse MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Starse MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Starse MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Starse MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Strase MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Strase MSC Stain 1-Cha 7% None MacA ddress: 0612C21B265C0B98 Nodel Strase MSC Stain 1-Cha 7% None Channel MacA ddresse 0612C21B265C0B98	Bridge	5C.DB.98	BridgeNodeBroadc	68%	None	
NodeJ0SE/JSFAMSFC_Strain_1-Cha.%%NoneMAC Address:0:1:02:C1B265:CDB98EnableBroadcastichNodeJ0SE/JSFEMSFC_Strain_1-Cha.%NoneDevice Image:BridgeNodeBroadcasterImage (RC:0:E00Node8SE/JAA7MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node7SE/JAA5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node16SE/JAA4MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node16SE/JAA4MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node3SE/JCA4MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node15SE/JCC5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node23SE/JCA5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node25SE/JCA5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node25SE/JDA5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node25SE/JDA5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC:0:E00Node3SE/JDA5MSFC_Strain_1-Cha.%NoneImage (RC:0:E00Image (RC: <td< td=""><td>Node19</td><td>5E.79.A9</td><td>MSFC_Strain_1-Cha</td><td>79%</td><td>None</td><td></td></td<>	Node19	5E.79.A9	MSFC_Strain_1-Cha	79%	None	
Node20 SL73/K Mix _ During ' Uning '	Node14	5E.79.C3	MSFC_Strain_1-Cha	6%	None	
NodelS2P.FEMSFC Strain 1-Cha7%NoneNodelsS27.A3MSFC Strain 1-Cha7%Nonemacket 0.52S6800Balter 1.52Balter 1	Node10	5E.79.FA	MSFC_Strain_1-Cha	76%	None	MAC Address: 00:102018:26:5008:98
Nodel35E7.A33MSFC_Strain_1-Cha76%NoneImage CRC:0.6800Image C	Node20	5E.79.FE	MSFC_Strain_1-Cha	76%	None	Province Images
Nobe Str.A47 Misr.C.strain.JCha I/i.% None Nobe/S Str.A5X MSFC,Strain.JCha %% None Image Size: 1914 bytes (%) minuges Size: 1914 bytes (%) Node/S Str.A5X MSFC,Strain.JCha %% None Image Size: 1914 bytes (%) minuges Size: 1914 bytes (%) Node/S Str.A4 MSFC,Strain.JCha %% None Image Size: 1914 bytes (%) minuges Size: 1914 bytes (%) Node/S Str.A4 MSFC,Strain.JCha %% None Image Size: 1914 bytes (%) Image Size: 1914 bytes (%) Node/S Str.CA MSFC,Strain.JCha %% None Image Size: 1914 bytes (%) Image Size: 1914 bytes (%) Node/S Str.CA MSFC,Strain.JCha %% None Image Size: 1914 bytes (%) Image Size: 1914 bytes (%) Image Size: 1914 bytes (%) Node/S Str.Ots MSFC,Strain.JCha %% None Image Size: Image Size:	Node18	5E.7A.33	MSFC_Strain_1-Cha	76%	None	timercvent() < 1s timer
Node/ SE/ASIG Misc_Strain_1-Cha. 7% None Node/5 SE/ASIG MSrC_Strain_1-Cha. 7% None Channel Channel Node/6 SE/ASIG MSrC_Strain_1-Cha. 7% None Channel A Node/1 SE/ASIG MSrC_Strain_1-Cha. 7% None Odd Node/1 SE/ASIG MSrC_Strain_1-Cha. 7% None Note Odd SE/ASIG MSrC_Strain_1-Cha. 6% None Note Note Odd/2 SE/ASIG MSrC_Strain_1-Cha 6% None Note Note <t< td=""><td>Node8</td><td>5E.7A.47</td><td>MSFC_Strain_1-Cha</td><td>71%</td><td>None</td><td></td></t<>	Node8	5E.7A.47	MSFC_Strain_1-Cha	71%	None	
Nodel6SE7.A94MSFC_Strain_1-Cha80%NoneChannel:4Node4SE7.B0.0MSFC_Strain_1-Cha7%NoneNoneNodeNodeSE7.CA4MSFC_Strain_1-Cha8%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha6%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha6%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha6%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha6%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha6%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha7%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha7%NoneNoneNodeSE7.CA5MSFC_Strain_1-Cha7%NoneNoneNodeNodeNoneNodeNoneNoneNoneNodeNoneNodeNone <td>Node5</td> <td>5E.7A.5A</td> <td>MSFC_Strain_1-Cha</td> <td>6%</td> <td>None</td> <td>Image Size: 1914 bytes (3%)pinWakeupATmega128RFA1</td>	Node5	5E.7A.5A	MSFC_Strain_1-Cha	6%	None	Image Size: 1914 bytes (3%)pinWakeupATmega128RFA1
Nodel52R8.00MSFC_Strain_1-Cha72%NoneNode352.7C.A4MSFC_Strain_1-Cha53%NoneNetwork ID:0.d1C2CNode1152.7C.C5MSFC_Strain_1-Cha6%NoneNoneNode2252.7C.05MSFC_Strain_1-Cha6%NoneNoneNode252.7C.05MSFC_Strain_1-Cha6%NoneNoneNode252.7C.05MSFC_Strain_1-Cha6%NoneNoneNode452.7D.5CMSFC_Strain_1-Cha7%NoneNoneNode552.7D.5CMSFC_Strain_1-Cha7%NoneNoneNode452.7D.5CMSFC_Strain_1-Cha7%NoneNoneNode552.7D.5CMSFC_Strain_1-Cha7%NoneNoneNode452.7D.5CMSFC_Strain_1-Cha7%NoneNoneNode552.7D.5CMSFC_Strain_1-Cha6%NoneNoneNode152.7D.5CMSFC_Strain_1-Cha6%NoneNoneNode152.7D.5CMSFC_Strain_1-Cha6%NoneNoneNode152.7D.5CMSFC_Strain_1-Cha6%NoneNoneNode152.7D.5CMSFC_Strain_1-Cha6%NoneNoneNode152.7D.5CMSFC_Strain_1-Cha	Node7	5E.7A.5B	MSFC_Strain_1-Cha	75%	None	License: Permanent
Node3SE/C.A4MSFC_Strain_1-ChaaS8%NoneNode11SE/7C.C5MSFC_Strain_1-Chaa6%NoneNode25SE/7C.CAMSFC_Strain_1-Chaa6%NoneNode26SE/7C.D5MSFC_Strain_1-Chaa6%NoneNode27SE/7C.D5MSFC_Strain_1-Chaa6%NoneNode2SE/7C.D5MSFC_Strain_1-Chaa7%NoneNode4SE/7D.11MSFC_Strain_1-Chaa7%NoneNode5SE/7D.25MSFC_Strain_1-Chaa7%NoneNode6SE/7D.36MSFC_Strain_1-Chaa7%NoneNode7SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.35MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode2SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNode1SE/7D.36MSFC_Strain_1-Chaa6%NoneNoneSE/7D.36 <td>Node16</td> <td>5E.7A.94</td> <td>MSFC_Strain_1-Cha</td> <td>80%</td> <td>None</td> <td>Channel: 4</td>	Node16	5E.7A.94	MSFC_Strain_1-Cha	80%	None	Channel: 4
Node3SF.7C.A4MSFC_Strain_1-ChaS8%NoneNode11SE.7C.C5MSFC_Strain_1-Cha6%NoneNode23SE.7C.C3MSFC_Strain_1-Cha7%NoneNode23SE.7C.D5MSFC_Strain_1-Cha7%NoneNode24SE.7D.05MSFC_Strain_1-Cha7%NoneNode25SE.7D.05MSFC_Strain_1-Cha7%NoneNode2SE.7D.05MSFC_Strain_1-Cha7%NoneNode3SE.7D.05MSFC_Strain_1-Cha7%NoneNode4SE.7D.05MSFC_Strain_1-Cha7%NoneNode2SE.7D.05MSFC_Strain_1-Cha7%NoneNode3SE.7D.05MSFC_Strain_1-Cha7%NoneNode4SE.7D.05MSFC_Strain_1-Cha7%NoneNode4SE.7D.05MSFC_Strain_1-Cha7%NoneNode4SE.7D.05MSFC_Strain_1-Cha7%NoneNode12SE.7D.05MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNoNoNoneNoneNone <t< td=""><td>Node4</td><td>5E.7B.00</td><td>MSFC_Strain_1-Cha</td><td>72%</td><td>None</td><td></td></t<>	Node4	5E.7B.00	MSFC_Strain_1-Cha	72%	None	
NodeliSr. C.S.MSFC_Strain_1-Cha% NoneNodeliSr. ZC.ASMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZC.BSMSFC_Strain_1-Cha7%NoneNodeliSr. ZD.BSMSFC_Strain_1-Cha6%NoneNodeliSr. ZD.BSMSFC_Strain_1-Cha6%NoneNoneMSFC_Strain_1-Cha6%<	Node3	5E.7C.A4	MSFC_Strain_1-Cha	58%	None	
Node23SF.7C.03MSFC_Strain_1-Chaa74%NoneNode22SF.7C.05MSFC_Strain_1-Chaa75%NoneNodeSF.7D.11MSFC_Strain_1-Chaa70%NoneNode20SF.7D.6CMSFC_Strain_1-Chaa74%NoneNode21SF.7D.9CMSFC_Strain_1-Chaa74%NoneNode22SF.7D.9CMSFC_Strain_1-Chaa74%NoneNode23SF.7D.9CMSFC_Strain_1-Chaa6%NoneNode14SF.7D.9CMSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode12SF.7D.86MSFC_Strain_1-Chaa6%NoneNode13SF.7D.86MSFC_Strain_1-Chaa7%NoneNode14SF.7D.86MSFC_Strain_1-Chaa7%NoneNode15SF.7D.86MSFC_Strain_1-Chaa6%NoneNode16SF.7D.86MSFC_Strain_1-Chaa7%NoneNode17SF.7D.86MSFC_Strain_1-Chaa7%NoneNode18SF.7D.86MSFC_Strain_1-Chaa7%NoneNode19SF.7D.86MSFC_Strain_1-Chaa7%NoneNo	Node11	5E.7C.C5	MSFC_Strain_1-Cha	6%	None	Path
Node22SE.7C.D5MSFC_Strain_1-Cha67%NoneNodeSE.7D.11MSFC_Strain_1-Cha70%NoneNode6SE.7D.6CMSFC_Strain_1-Cha74%NoneNode21SE.7D.96MSFC_Strain_1-Cha71%NoneNode7SE.7D.85MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%NoneNode12SE.7D.86MSFC_Strain_1-Cha6%None	Node15	5E.7C.CA	MSFC_Strain_1-Cha	67%	None	
Node5F.7D.11MSFC_strain_1-Cha70%NoneNode55F.7D.6CMSFC_strain_1-Cha74%NoneNode215F.7D.95MSFC_strain_1-Cha71%NoneNode475F.7D.85MSFC_strain_1-Cha6%NoneNode175F.7D.85MSFC_strain_1-Cha6%NoneNode125F.7D.85MSFC_strain_1-Cha6%NoneNode125F.7D.85MSFC_strain_1-Cha6%NoneNode125F.7D.85MSFC_strain_1-Cha6%None	Node23	5E.7C.D3	MSFC_Strain_1-Cha	74%	None	
Node6 5E,7D.6C MSFC_Strain_1-Cha 74% None Node21 5E,7D.9C MSFC_Strain_1-Cha 74% None Node2 5E,7D.9C MSFC_Strain_1-Cha 6% None Node17 5E,7D.8S MSFC_Strain_1-Cha 6% None Node17 5E,7D.85 MSFC_Strain_1-Cha 6% None Node17 5E,7D.85 MSFC_Strain_1-Cha 6% None Node12 5E,7D.86 MSFC_Strain_1-Cha 6% None	Node22	5E.7C.D5	MSFC_Strain_1-Cha	67%	None	
Node21 5E.7D.96 MSFC_strain_1-Cha 71% None Node9 5E.7D.9C MSFC_strain_1-Cha 6% None Node17 5E.7D.85 MSFC_strain_1-Cha 6% None Node12 5E.7D.86 MSFC_strain_1-Cha 6% None Node12 5E.7D.86 MSFC_strain_1-Cha 6% None	Node	5E.7D.11	MSFC_Strain_1-Cha	70%	None	
Nodel St.7D.9C MSFC_strain_1-Cha 6% None Nodel7 St.7D.85 MSFC_strain_1-Cha 6% None Nodel2 St.7D.86 MSFC_strain_1-Cha 6% None Nodel2 St.7D.86 MSFC_strain_1-Cha 6% None Nodel2 St.7D.86 MSFC_strain_1-Cha 6% None	Node6	5E.7D.6C	MSFC_Strain_1-Cha	74%	None	
Nodel7 5E.7D.B5 MSFC_Strain_1-Cha 68% None Nodel2 5E.7D.B6 MSFC_Strain_1-Cha 68% None Info	Node21	5E.7D.96	MSFC_Strain_1-Cha	71%	None	
Nodel2 5E.7D.B6 MSFC_Strain_1-Cha 68% None Info Info Info Info Info Info Info Info Info	Node9	5E.7D.9C	MSFC_Strain_1-Cha	6%	None	
Info In your Portal script, use remoteNode.setColumn(name, value)	Node17	5E.7D.B5	MSFC_Strain_1-Cha	68%	None	
In your Portal script, use remoteNode.setColumn(name, value)	Node12	5E.7D.B6	MSFC_Strain_1-Cha	68%	None	
remoteNode.setColumn(name, value)						Info
to dispay information rece						
						to display information here
	Event Log					
ventLog		Event Dev	vice Type			Value
	16-05-12 14:43:			0x1C2C		
Time Event Device Type Value	16-05-12 14:43:	6 NV PARAM Node19	MAC Address	00:1C:2C:1B:2	5:5E:79:A9	
Time Event Device Type Value	16-05-12 14:43:	6 QUERY Node19	SNAPpy Space	59903		
Time Event Device Type Image: Comparison of the time of tim		6 NV PARAM Node19	Device Type	N		

Control GUI – Large amount of interference caused all of the nodes to drop out shortly after test began. The test article was in a safety keep out zone so there was no way to fix or restart with fewer nodes after testing started.

Test Lab Pull Test July 2016 Setup



Test Lab Pull Test July 2016 Data Results





Better Battery and Power Management

Calibration shunt that can be switched in and out of circuit by software.





Coming In Gen 3

Advanced Software Controls



- Kosta Varnavas ES36
 - <u>kosta.varnavas@nasa.gov</u>
 - 256-544-2638
- Jeff Richeson ES35
 - James.j.richeson@nasa.gov
 - > 256-961-0128

Back Up Charts

SM200 Specifications

Table 1.0 Sp	ecifications	SM200P81/PU1	RF200P81/PU1		
	Outdoor LOS Range	Up to 1500/2500 feet at 250Kbps			
Performance	Transmit Power Output	3 dBm			
Ferrormance	RF Data Rate	250Kbps, 500Kbps, 1Mbps, 2Mbps			
	Receiver Sensitivity				
	Supply Voltage	1.8 - 3.6 V			
Denne	Transmit Current (Typ@3.3V)	22.5 mA			
Power Requirements	Idle/Receive Current (Typ@3.3V)	20.5 mA			
	Power-down Current (Typ@3.3V)	0.37 μA			
	Frequency	ISM 2.4 GHz			
	Spreading Method	Direct Sequence (DSSS)			
General	Modulation	O-QPSK			
General	Dimensions	29.8mm x 19mm	33.86mm x 33.86mm		
	Operating Temperature	- 40 to 85 deg C.	-		
	Antenna Options	Integrated Chip Antenna / E	External Antenna		
	Topology	SNAP			
Networking	Error Handling	Retries and acknowledgem	ent		
	Number of Channels	16			
Available I/O	UARTS with HW Flow Control	2 Ports - 8 total I/O			
	GPIO	38 total; 7 can be analog- in with 10bit ADC	20 total; 7 can be analog- in with 10bit ADC		
Agency	FCC Part 15.249	FCC ID: U9O-SM200	FCC ID: U9O-SM200		
Agency Approvals	Industry Canada (IC)	IC: 7084A-SM200	IC: 7084A-SM200		
Abbiogais	CE Certified	Yes	Yes		

Generation 2

Only 1 Gauge

 Another version coming with 3 gauges for 3-dimensionl measurements

Each strain gauge has an independent constant voltage regulator driving the excitation voltage

• This provides solid voltages for more accurate measurements.

Power Management Hardware

• The power for each gauge sub circuit can be turned on or off by software saving battery power.

Op Amp has much larger and adjustable gains

- Gains up to 1000 and is variable under
- software control via digital potentiometer.

Power Management Software

• Software can control power management



DRAWBACKS TO HARDWIRED SPACECRAFT BUS ARCHITECTURES

Failures of wires and connectors

Mass of cabling and electrical interfaces

High cost of late design changes in hardwired bus architectures; DFI change costs

Development time overhead for allocating routes and places, shields, connectors, brackets, cable trays, fasteners, supporting structure, etc.

Physical restrictions on wired sensor placements (tankage, bulkhead penetrations, etc)

Undesired ground loops on the communication paths; long wire runs acting as antennas

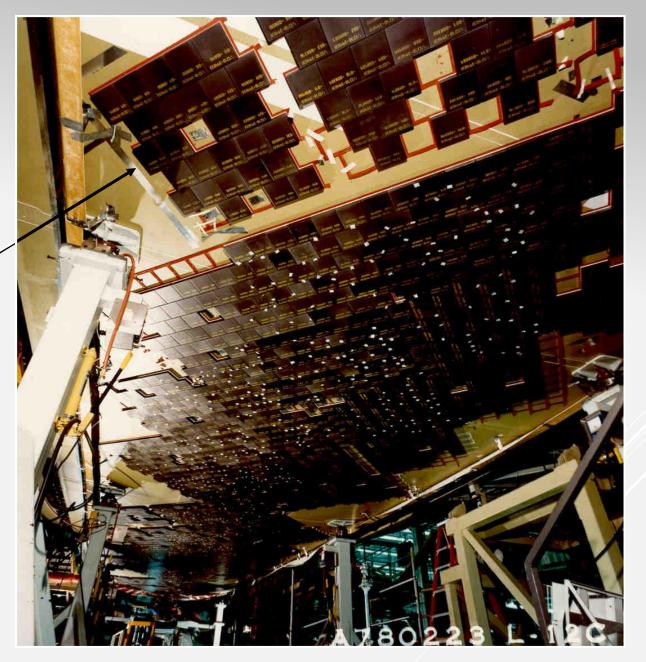
Electromagnetic compatibility issues (EMC), crosstalk, solar flux across wires

(from Amini, et al 2007)

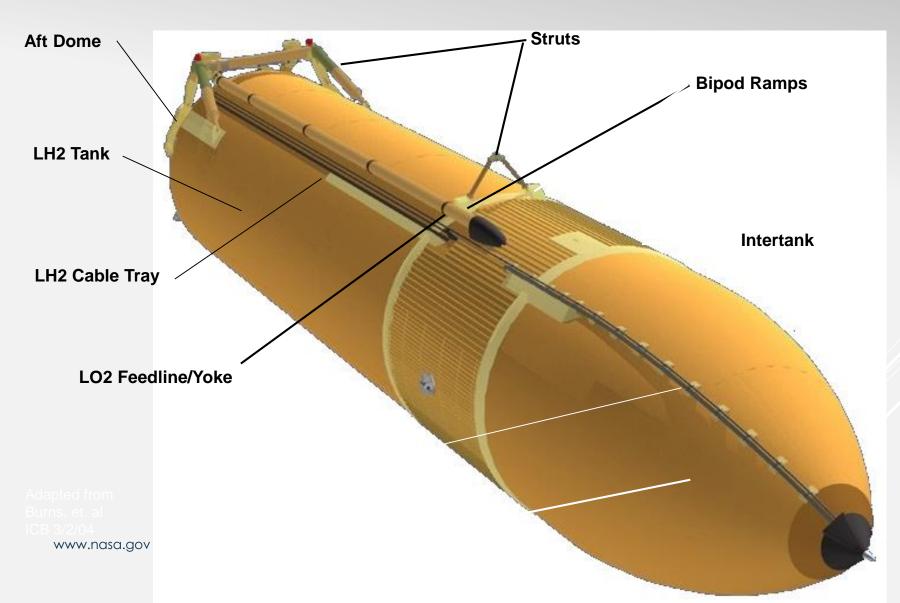


TILES DURING INSTALLATION ON THE SPACE SHUTTLE

Note grouping of tiles by array



ET CAPABILITIES & CONSTRAINTS



SPACE SHUTTLE DURING REENTRY

The tiles prove to be "one of the most successful subsystems on the Orbiter."

-- Aaron Cohen, Orbiter Project Manager

Success of the tiles is a tribute to Robert Beasley, Inventor

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nttp://www.lr.tudelft.nl/live/binaries/72bd2130-888f-4040-8997-fb2245aa24a2/doc/Delft_

Wireless Sensors for Automobiles

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