UNIVERSAL EMERGENCY SHUTDOWN SUBSYSTEM FOR AMATEUR RADIO SATELLITES

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OVERVIEW

What will be covered in this session

• Introduction
• IARU Regulations
• Difficulties
• Achieving Universal Compliance
• Availability
• Q&A
INTRODUCTION
What is emergency shutdown and why is it important?

- **Your operation**
  - Is important
  - Is expensive
  - Depends on maximal downlink and/or uplink opportunity
  - Is often bound to one fixed frequency band

- **Your satellite**
  - Has the ability to transmit
  - Is run by a microcontroller
  - Is operating outside of physical reach
INTRODUCTION

What is emergency shutdown and why is it important?

• Somebody else’s operation
  – Is important
  – Is expensive
  – Depends on maximal downlink and/or uplink opportunity
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• Somebody else’s satellite
  – Has the ability to transmit
  – Is run by a microcontroller
  – Is operating outside of physical reach
INTRODUCTION

What is emergency shutdown and why is it important?

• Why?
  – “Enlightened self-interest”
  – International treaty law

• What?
  – The ability to turn off a space station transmitter immediately
  – By telecommand (*)
  – Immediately: Now? Minutes? Hours?
IARU REGULATIONS
IARU REGULATIONS

Space station control requirements

• Independency
  – The controller enabling emergency shutdown should be completely independent of the satellite’s main controller
  – The telecommand receiver (and its frequency) should be different than the satellite’s main receiver
  – Emergency shutdown telecommand should always be receivable

• Coverage
  – Gaps between satellite passes should be short
  – Number and locations of ground stations depend on satellite’s orbit
  – Ground telecommand stations should be far apart
• **Exception**
  - A space station
    - in LEO
    - only transmitting over a small number of ground stations
  - Can use a transmission time-out timer as its ‘emergency shutdown subsystem’
  - Timer should trigger after x minutes, where x is the length of a single pass over a ground station
  - Independency requirement remains

• **Re-enabling the transmitter**
  - Should not happen automatically
  - Should only be possible by telecommand (in all cases)
DIFFICULTIES
DIFFICULTIES
Challenges involved with the implementation of emergency shutdown

• Independency
  – How do you ensure that your subsystem controller is actually completely independent?
  – Concurrency: Two controllers have simultaneous control over one transmitter
  – What if you can’t afford an additional receiver?

• Reliability
  – Typically, software components are the weakest links in safety-critical systems
  – How does adding an additional microcontroller help?
  – Generally, how do you ensure that your emergency shutdown subsystem always responds reliably?
  – What if the transmitter is malfunctioning instead of the microcontroller?
DIFFICULTIES

Challenges involved with the implementation of emergency shutdown

• Cost
  – Do you have budget in your design for an additional subsystem?
  – Designing a new subsystem, tailored to your exact space station, is expensive
  – What are the implications on safety-analysis and testing? How many additional states are added to each subsystem in your design?

• Complexity
  – How do you keep your emergency shutdown subsystem simple and fast?
  – How do you implement a shutdown telecommand protocol that is both simple and reliable (e.g. no false positives)?
  – How do you incorporate the shutdown subsystem early on in the design?
ACHIEVING UNIVERSAL COMPLIANCE
ACHIEVING UNIVERSAL COMPLIANCE

A Universal Emergency Shutdown Subsystem (UESS) IC

- One single hardware component (IC)
- Satisfies all IARU requirements
- Can be configured for both telecommand and time-out timer
- No microcontroller is involved at all
- No software is involved at all
- Built-in telecommand protocol that is configurable and extensible
- Supports multiple receiver/transmitter/amplifier configurations
- Supports two levels of emergency
- Compatible with virtually all amateur radio satellite designs
- Extremely easy to integrate
ACHIEVING UNIVERSAL COMPLIANCE

A Universal Emergency Shutdown Subsystem (UESS) IC

- One single hardware component (IC)
ACHIEVING UNIVERSAL COMPLIANCE
A Universal Emergency Shutdown Subsystem (UESS) IC

• Satisfies all IARU requirements
  – Completely independent
  – Fast, reliable and simple
  – Supports independent receiver
  – Will not automatically re-enable the transmitter
  – Supports transmitter time-out timer for LEO satellites that qualify
  – Capable of turning off malfunctioning transmitter
  – Easy-to-control, also by third parties
  – Allows for full control over who can shutdown the space station
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A Universal Emergency Shutdown Subsystem (UESS) IC

- Can be configured for both telecommand and time-out timer

TMRS works completely independent of TCM!

However, TCM triggers TMRS
ACHIEVING UNIVERSAL COMPLIANCE
A Universal Emergency Shutdown Subsystem (UESS) IC

• Built-in telecommand protocol that is configurable and extensible

P1-P6 and Preg are mutually exclusive
UESS versions with and without Preg
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A Universal Emergency Shutdown Subsystem (UESS) IC

- Supports multiple receiver/transmitter/amplifier configurations

PTT_in1 will influence PTT_out1
PTT_in2 will influence PTT_out2

PTT_in2/PTT_out2 are optional

PTT_in/PTT_out support transmitter, transceiver or amplifier
• Supports two levels of emergency
  – Level A: At this level, only the PTT line output is interrupted, so that any ongoing transmissions stop immediately. The transmitter remains powered on.
  – Level B: At this level, the power line to the transmitter is interrupted, shutting down immediately any transmitter activity. This is done by driving the transmitter power line driver output low, thereby interrupting the Vcc line to the transmitter.

• Pre-set Emergency Shutdown code is appended with two additional bits to differentiate between Level A and Level B.
How does it work?

- PTT line of the transmitter is an input (PTT line interrupted by UESS)
- Decoded/formatted telecommand is an input
- Each PTT/Vcc has a simple transistor switch circuit
- On each incoming telecommand, contents is checked against pre-set code
  - No match: transmitter functions normally
  - Match Level A: PTT is shut off
  - Match Level B: Vcc is shut off
- In case of Level A shutdown, the transmitter is only restarted on reception of a ‘restart’ signal
- In case of Level B shutdown, the transmitter is only restarted on reception of a ‘restart’ signal
- What if you only support a single transceiver and do a Level B shutdown?
  - TMRR (optional) will restart the transceiver
  - PTT remains shut off
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A Universal Emergency Shutdown Subsystem (UESS) IC

- Sample configuration 1

Note: PTT is active Low!

<table>
<thead>
<tr>
<th>PTT_in (from μC)</th>
<th>Emergency code A?</th>
<th>PTT_out</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No</td>
<td>1</td>
<td>PTT is off</td>
</tr>
<tr>
<td>0</td>
<td>No</td>
<td>0</td>
<td>PTT is on</td>
</tr>
<tr>
<td>1</td>
<td>Yes</td>
<td>1</td>
<td>PTT is off</td>
</tr>
<tr>
<td>0</td>
<td>Yes</td>
<td>1</td>
<td>PTT is off</td>
</tr>
</tbody>
</table>
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A Universal Emergency Shutdown Subsystem (UESS) IC

- **Sample configuration 2**

<table>
<thead>
<tr>
<th>PTT_in1 (from µC)</th>
<th>PTT_in2 (from µC)</th>
<th>Emergency code A?</th>
<th>PTT_out1</th>
<th>PTT_out2</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| 1                 | 1                 | No                | 1        | 1        | PTT1 is off  
|                   |                   |                   |          |          | PTT2 is off  |
| 0                 | 1                 | No                | 0        | 1        | PTT1 is on  
|                   |                   |                   |          |          | PTT2 is off  |
| 1                 | 0                 | No                | 1        | 0        | PTT1 is off  
|                   |                   |                   |          |          | PTT2 is on   |
| 0                 | 0                 | No                | 0        | 0        | PTT1 is on  
|                   |                   |                   |          |          | PTT2 is on   |
| 1                 | 1                 | Yes               | 1        | 1        | PTT1 is off  
|                   |                   |                   |          |          | PTT2 is off  |
| 0                 | 1                 | Yes               | 1        | 1        | PTT1 is off  
|                   |                   |                   |          |          | PTT2 is off  |
| 1                 | 0                 | Yes               | 1        | 1        | PTT1 is off  
|                   |                   |                   |          |          | PTT2 is off  |
| 0                 | 0                 | Yes               | 1        | 1        | PTT1 is off  
|                   |                   |                   |          |          | PTT2 is off  |
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A Universal Emergency Shutdown Subsystem (UESS) IC

https://www.youtube.com/user/OfficialSpaceBooth
AVAILABILITY
AVAILABILITY

How do I get one?

• Two different versions available: with and without Preg
• Available as an IC with SOIC-18 package
• Available as compiled VHDL/Verilog design units
• Schematic/HDL code available under certain conditions
How do I get one?

<table>
<thead>
<tr>
<th></th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC (SOIC-18)</td>
<td><em>In production</em> (end of September)</td>
</tr>
<tr>
<td>IC (SOIC-18) w/ Preg</td>
<td><em>In production</em> (end of October)</td>
</tr>
<tr>
<td>VHDL/Verilog design unit</td>
<td>Available</td>
</tr>
<tr>
<td>VHDL/Verilog design unit w/ Preg</td>
<td><em>Currently testing</em> (mid-September)</td>
</tr>
<tr>
<td>Source</td>
<td><em>TBD</em></td>
</tr>
<tr>
<td>Source w/ Preg</td>
<td><em>TBD</em></td>
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Enquiries: info@spacebooth.org
Q&A

What was that all about??
UNIVERSAL EMERGENCY SHUTDOWN SUBSYSTEM FOR AMATEUR RADIO SATELLITES

Twitter: @Spacebooth_org
Website: www.spacebooth.org

THANK YOU