

# Intrinsic Safety (IS) Design Principles

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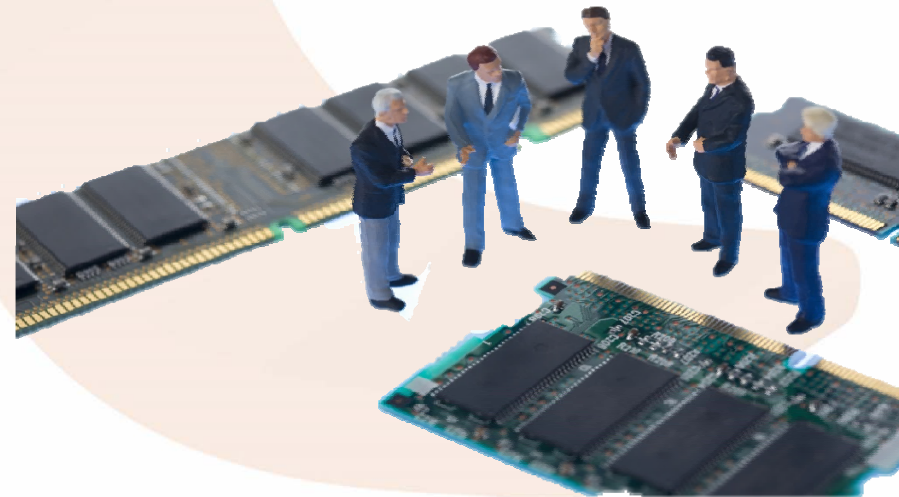
- Overview of design principles
- Approach to IS assessment
- Controls needed in production

# What is intrinsic safety?

- Non-physical type of protection
- Simple models or principles
- Two types of ignition source
  - Spark ignition
  - Thermal ignition – temperature of every component

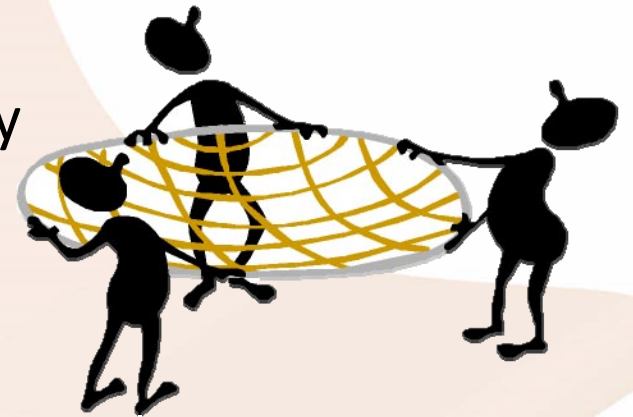
# Fault analysis

- Fault modes
- Fault classification
  - Infallible against fault
  - Failure of safety component or construction: provides EPL
  - Other faults
- Most onerous fault conditions
- Theoretical analysis
- Many “most onerous” fault conditions
- Not time dependent – no failure rates



# Safety Factor

- Generally a 1.5 safety factor, or 50% margin of error
- Used for rating of safety components
- A 9W rated component must not dissipate more than 6W under fault conditions.
- Used for spark ignition risk
- Not applied for thermal assessment nor non-safety related components.



# Sources of energy

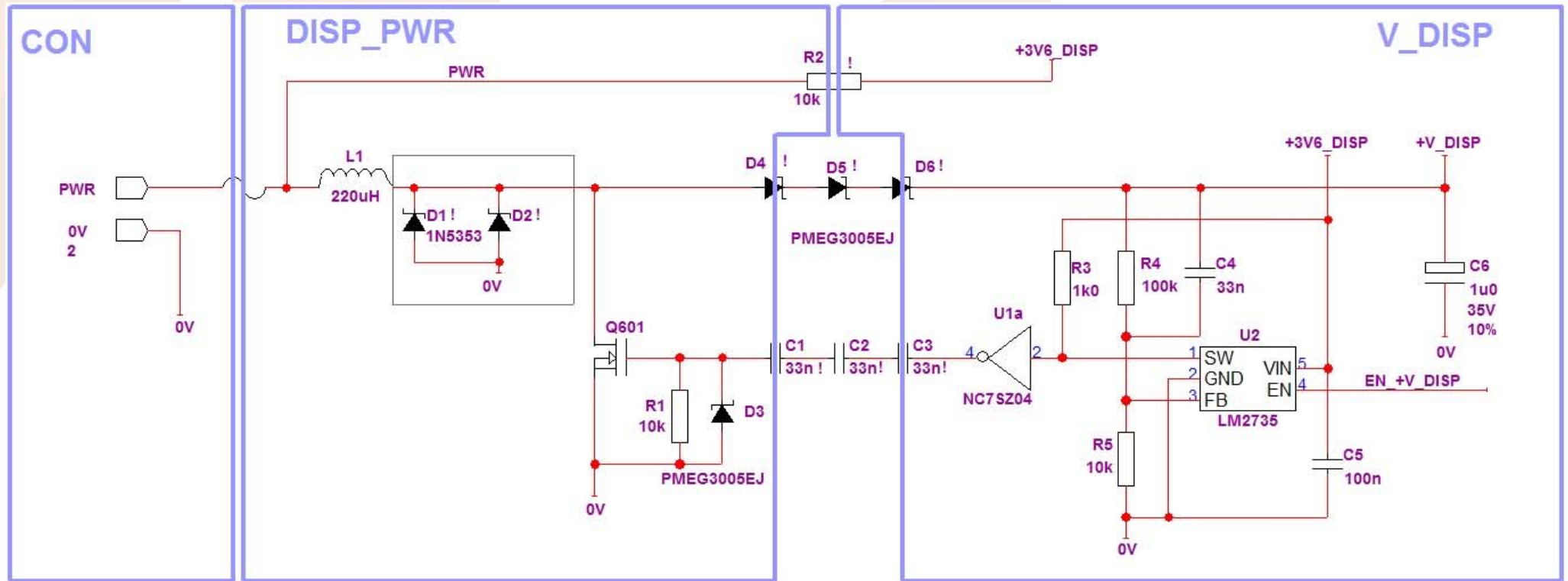
- Batteries
  - Short circuit test
  - Spark risk
  - Charging in hazardous area
- Magnetic field (inductive)
- Electric field (capacitive)
- External - including unintentional sources
- Cables



# Energy limitation

- Current limitation
  - Fuse (thermal)
  - Resistor (spark + thermal)
- Voltage limitation
- Separation
- Encapsulation
- More complex functional blocks

# Safety Areas





# IS spreadsheet – safety components

Safety Components		Nominal Limits				IS Parts List				Calc							
Reference	Name	Nom	Tol / Unit	Safety	Min	Max	IS Min	IS Max	Unit	In Part	Unit	Formula / Name	Package	Package Rating	Safety Margin	Comment	
<b>ib Limit Inputs</b>																	
Umac	Um	250	V						250	V							1.0 Rated Sec
Umpk		353.5534							354	V							
<b>ic Normal operation</b>																	
Vin	Vin	24	V	20%	19.2	28.8	19.2	28.8	V								
<b>Fuses</b>																	
FS101	FsPowerIn	0.16	A	70%	0.048	0.272	-	0.272	A			Breaking capacity voltage and current for each					Only a safety factor of 1 required
		3	R		3	3	2	-	R			250 V =Um	LF242	250	1.00		
FS201	FsZ2SZ20	0.08	A	70%	0.024	0.136		0.136	A			68.9387 A =Umpk/(FsPowerInRMin+scRPinSCRMIn)	LF242	4000	58.02	Resistance estimate for min	
		6	R		6	6	4	-	R			250 V =Um	LF242	250	1.00		
FS601	FsZ1SRTD	0.08	A	70%	0.024	0.136	-	0.136	A			88.5 A =Umpk/FsZ2SZ20RMin	LF242	4000	45.20		
		6	R		6	6	4	-	R			31 V =PinClmpVMax	LF242	250	8.06		
												7.75 A =PinClmpVMax/FsZ1SRTDRMin	LF242	4000	516.13		
<b>Trans Formers</b>																	
L201	PSUIso	1	-														Requires testing in accordar
<b>Isolation Blocking Capacitors</b>																	
C505,C506	BCZ1SZ20A	4.7	nF	10%								1770 V =MAX(1000+2*(Umpk+PinClmpVMax),1500)	CB\2kV	2000	1.13	1.8mm between pads, for o	
C505,C506	BCZ1SZ20B	4.7	nF	10%								1770 V =MAX(1000+2*(Umpk+PinClmpVMax),1500)	CB\2kV	2000	1.13	Max voltage is the dielectric	
<b>Inter Area Resistors</b>																	
R101	RPinSC	3.3	R	5%	3.135	3.465	3.135	3.465	R			Power					Safety factor of 1.5 required
R503	RZ1SSBA	10000	R	1%	9900	10100	9900	10100	R			0.25635 W =FsPowerInIMax^2*scRPinSCRMIn	SMW2	1.7254902	6.73	Rated for the transient curre	
R517	RZ1SSBB	10000	R	1%	9900	10100	9900	10100	R			0.09707 W =PinClmpVMax^2/scRZ1SSBARMIn	R1206	0.25	2.58		
R415	RDCPDA	470000	R	1%	465300	474700	465300	474700	R			0.00207 W =PinClmpVMax^2/scRZ1SSBBRMin	R1206	0.25	2.58		
R430	RDCPDB	470000	R	1%	465300	474700	465300	474700	R			0.00207 W =PinClmpVMax^2/scRDCPDARMIn	R0805	0.125	60.52		
R606	RRtdInIo	100	R	1%	99	101	99	101	R			0.29455 W =PinClmpVMax^2/scRDCPDBRMin	R0805	0.125	60.52		
R608	RRtdInVp	100	R	1%	99	101	99	101	R			0.29455 W =RtdPwrClmpVMax^2/scRRtdInIoRMin	R2010	0.5	1.70		
R610	RRtdInVm	100	R	1%	99	101	99	101	R			0.29455 W =RtdPwrClmpVMax^2/scRRtdInVpRMin	R2010	0.5	1.70		
<b>Zener Voltage Clamps</b>																	
D101	PinTZClmp								45.4	V		Power					Safety factor of 1.5 required
D403-D406	InAfrdSeries	0.8	V		0.8	0.8		0.8	V			0.1242 A =InABiasLimIMax+PinClmpVMax/Par2R(scRZ1SSBARMIn,scR	SMCJ				Rating ensured by testing in
												9.27 V	BAT54	0.2	1.61		
D601-D602	RtdPwrClmp	5.1	V	5%	4.845	5.355	4.845	5.4	V			0.7344 W	BAT54	30	3.24		
													1N5300	2.2	3.00		



# IS spreadsheet – energy storage components

Energy Storage Components										
Refs	Nominal	Tol	Qty	Limit	IS Parts List	Parts List Total	Unit	Voltage	Limit	% of Lim
<b>Z2_OUTPUTS Area (ic, normal operation Only)</b>										
C201, C503, C512	1.00E-05	20%	3	1.2E-05	1.2E-05	3.6E-05	F			
C203, C205, C709	1.00E-06	20%	3	1.2E-06	1.2E-06	3.6E-06	F			
C204, C701, C703, C706, C707, C708, C710, C711	1.00E-07	20%	8	1.2E-07	1.2E-07	9.6E-07	F			
C502, C511, C702, C704, C705	1.00E-08	20%	5	1.2E-08	1.2E-08	6.0E-08	F			
<b>Total Capacitance</b>						<b>4.1E-05</b>	F	5.1	1.00E-03	4.06%
L701	1.00E-05	20%	1	1.2E-05	1.2E-05	9.8E-06	J			
<b>Total Inductive Energy</b>						<b>9.8E-06</b>	J	5.1	1.60E-04	6.11%
<b>SIG_BIAS_A Area (ic, normal operation Only)</b>										
C402	1.00E-06	20%	1	1.2E-06	1.2E-06	1.2E-06	F			
C401	1.00E-07	20%	1	1.2E-07	1.2E-07	1.2E-07	F			
C302, C413, C521	1.00E-08	20%	3	1.2E-08	1.2E-08	3.6E-08	F			
C404	4.70E-09	20%	1	5.6E-09	5.6E-09	5.6E-09	F			
C403, C405, C406	2.20E-10	20%	3	2.6E-10	2.6E-10	7.9E-10	F			
<b>Total Capacitance</b>						<b>1.4E-06</b>	F	12.54823	6.60E-05	2.06%
L401	4.40E-03	20%	1	5.3E-03	5.3E-03	3.9E-05	J			
<b>Total Inductance</b>						<b>3.9E-05</b>	J	12.54823	1.60E-04	24.67%

# Descriptive document

## 3 Details of safety areas

### 3.1 PWR\_IN and TRANS\_CLAMP

#### 3.1.1 Operation

This is a simple circuit consisting of a connector, fuse, current limit resistor and Zener diode.

#### 3.1.2 Separation distances

Since input power is not from an intrinsically safe supply, the input power terminals and components through to Zener diode D101 use creepage and clearance distances from IEC 60079-7 Table H.1 for  $\leq 355$  V (since  $U_m = 250$  Vac) and material group III (FR4), i.e. creepage = 2.5mm, clearance = 1.25 mm and distance under coating = 0.85 mm. This in effect provides Ex “ec” separation protection for location in Zone 2.

For separation distances for the purposes of the [ib] connections, separation prior to INPUT\_CLAMP\_1 and 2 is only required around FS101. This does not need to meet IEC 60079-11 Table 5 for “ib” at 375 V, although the design does meet this in case conformance to ISA 60079-11 is required for USA / Canada. FS101 does not need to be encapsulated since it is located in a Zone 2 area so only needs to be intrinsically safe to level of protection “ic” for the purposes of spark or thermal ignition purposes (in effect it is associated apparatus so far as the [ib] connections are concerned). See IEC 60079-11 7.3.

#### 3.1.3 Transient protection

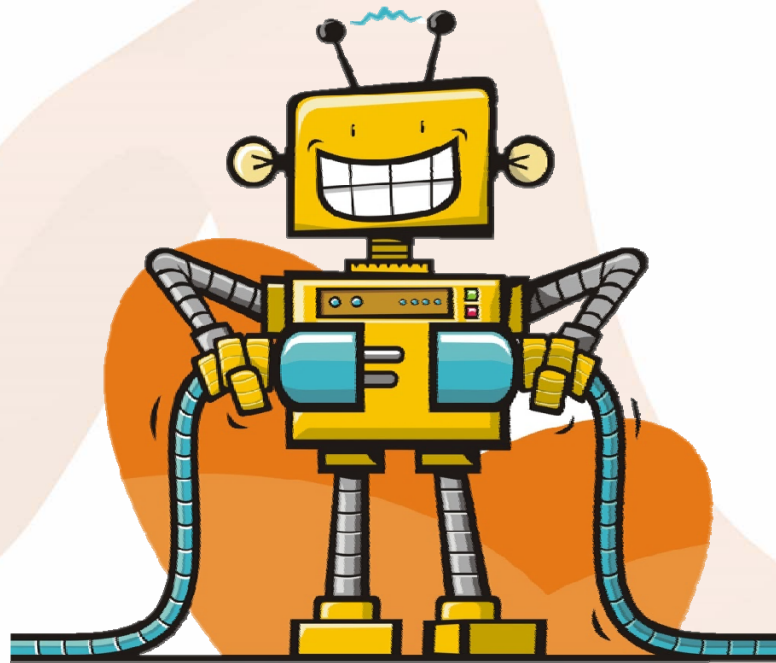
This is achieved with a Zener diode protected fuse (F101 and D101). The Zener diode has to be shown to be able to survive application of the peak of  $U_m$  (354 V) for the duration of the fuse opening time as otherwise the type of protection is invalidated. This is done using the tests in IEC 60079-11 10.8 and resistor R101 is included for the purposes of protecting the Zener diode during this test.

# Spark test apparatus



# Connecting IS equipment in the field

- $U_o = 6.51 \text{ V}$
- $I_o = 1.3 \text{ mA}$
- $P_o = 1,57 \text{ W}$
- $L_o = 100 \text{ mH}$
- $C_o = 300 \text{ }\mu\text{F}$
- $U_i = 16.5 \text{ V}$
- $C_i = 120 \text{ nF}$



# Controls needed in manufacturing

- ISO /IEC 80079-34
- Communicate
- Competence
- Traceability
- Component handling – safety components, energy storage components
- Verify 100% of safety components
- Routine tests
- Test Functional blocks
- Encapsulation
- Enclosure

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*Thankyou  
for  
listening*

