Lead Acid Battery Protection

ELEN4006: Measurement Systems

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Outline

Aim
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- Protect Lead Acid Batteries.

- ## Why?
  - If lead-acid battery is overcharged, the water in the battery begin to convert to unbounded hydrogen and oxygen. In the presence of a spark, this will produce an explosion.
  - In a case where few batteries are recharged at a time, a ventilation system can exchange an adequate amount of fresh air. However, places like mines and factories where batteries are recharged in large quantities, battery protection is necessary.

- ## How?
  - Overcharge and discharge protection.
  - Overcurrent and Overvoltage protection.

Explosive Environment

- Explosive gases are released to the atmosphere (hydrogen and oxygen)
- Classified as an explosive atmosphere (**zone 0**) according to **SANS 60079-10-1**: Classification of areas — Explosive gas atmospheres
- **SANS 62060:** Monitoring of lead acid stationary batteries - Protection against float current – AC component (super-imposed ripple current)

Existing solutions & Proposed Solution

- Existing Solutions
  - Overcurrent relay
- Proposed Solution
  - LA 55-P/SP1 Current transducer
  - Microcontroller

Current Transducer LA 55-P/SP1

Static specifications

Electrical data

I_{PN}	Primary nominal current rms		50				A
I_{PM}	Primary current, measuring range		0 .. ± 100				A
R_M	Measuring resistance		T_A = 70°C		T_A = 85°C		
			$R_{M\,min}$	$R_{M\,max}$	$R_{M\,min}$	$R_{M\,max}$	
	with ± 12 V	@ ± 50 A $_{max}$	0	215	0	210	Ω
		@ ± 100 A $_{max}$	0	35	0	30	Ω
	with ± 15 V	@ ± 50 A $_{max}$	0	335	30	330	Ω
		@ ± 100 A $_{max}$	0	95	30	90	Ω
I_{SN}	Secondary nominal current rms		25				mA
K_N	Conversion ratio		1 : 2000				
V_C	Supply voltage (± 5 %)		± 12 .. 15				V
I_C	Current consumption		10 (@ ± 15 V) + I_S				mA

Current Transducer LA 55-P/SP1

Dynamic specifications

Accuracy - Dynamic performance data

X	Accuracy @ $\mathbf{I}_{PN}$, $\mathbf{T}_A$ = 25°C @ ± 15 V (± 5 %)	± 0.65		%
	@ ± 12 .. 15 V (± 5 %)	± 0.90		%
ε_L	Linearity error	< 0.15		%
		Typ	Max	
$\mathbf{I}_O$	Offset current @ $\mathbf{I}_P$ = 0, $\mathbf{T}_A$ = 25°C		± 0.10	mA
$\mathbf{I}_{OM}$	Magnetic offset current [1)] @ $\mathbf{I}_P$ = 0 and specified $\mathbf{R}_M$, after an overload of 3 x $\mathbf{I}_{PN}$		± 0.15	mA
$\mathbf{I}_{OT}$	Temperature variation of $\mathbf{I}_O$ - 25°C .. + 85°C	± 0.05	± 0.30	mA
	- 40°C .. - 25°C	± 0.10	± 0.50	mA
$\mathbf{t}_{ra}$	Reaction time to 10 % of $\mathbf{I}_{PN}$ step	< 500		ns
$\mathbf{t}_r$	Response time [2)] to 90 % of $\mathbf{I}_{PN}$ step	< 1		µs
di/dt	di/dt accurately followed	> 200		A/µs
BW	Frequency bandwidth (- 1 dB)	DC .. 200		kHz

Additional requirements

General data

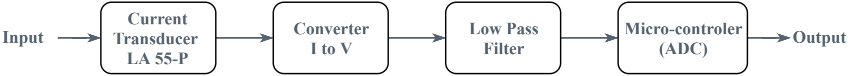
T_A	Ambient operating temperature		- 40 .. + 85	°C
T_S	Ambient storage temperature		- 40 .. + 90	°C
R_S	Secondary coil resistance	@ T_A = 70°C	145	Ω
		@ T_A = 85°C	150	Ω
m	Mass		18	g
	Standards		EN 50178: 1997	

Further requirements

- **ATmega16/32** micro-controller with 10-bit ADC
  - with approx 200mA max sink in current
- A current to voltage converting circuit
- A Low Pass Filter (LPF)

Design Overview

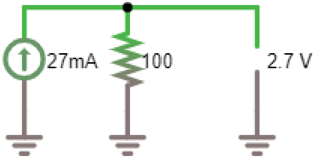
System Block Diagram



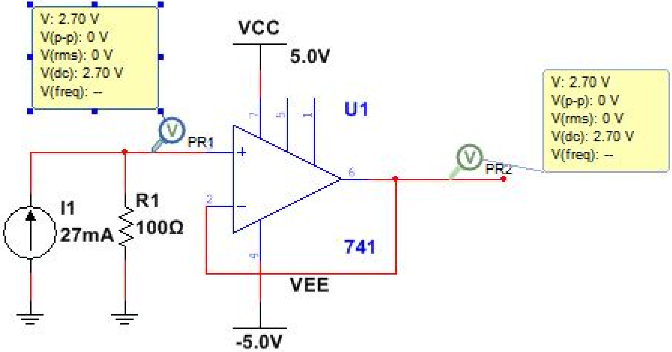
- The **input** is the current (*stepped down*) going to the batteries.
- The **output** is a digital signal which can the be used to control the power supply and other systems.

Converting Current to Voltage

- It is assumed that RITAR 12V180A batteries are used and the scope of this investigation will be on one battery.
- The battery has a maximum charging current of 54A.
- Nominal current of LA 55-P current transducer is 50A.
- The transducer has a conversion ratio of 1:2000.

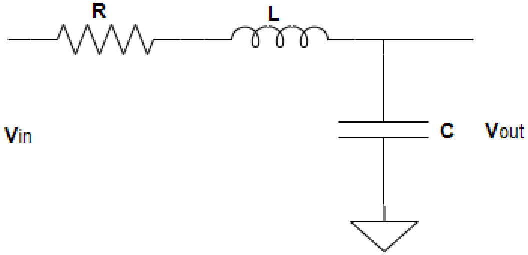


Converting Current to Voltage



Low Pass filter

- The LA 55-P current transducer has a bandwidth of 200kHz.



Standards Consulted
SANS

- **SANS 60079-0:Explosive atmospheres Part 0: Equipment — General requirements**
  -Temperature –20 ℃ to +60 ℃
- System components
  - The current sensor has an operating temperature of about -40 ℃ to 85 ℃
  - The op-amp has an operating temperature of –50 ℃ to 125 ℃
  - The pic micro-controller: -55 ℃ to +125 ℃
- **Explosive Atmospheres, Part 25: Intrinsically safe electrical systems (SANS 60079-25:2010)**
  - General overview of systems

Standards Consulted cont..
SANS

- **SANS 60079-11: Explosive atmospheres Part 11: Equipment protection by intrinsic safety "i"**
  - Enclosures
  - Components on which intrinsic safety depends (e.g Ratings, etc).
  - Filter capacitors

Thank you

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