ACCUMULATOR SUPLY FOR DEFECTOSCOPY SYSTEM

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Summary. The conventional method for measuring the composite materials mechanical stress is in many cases inadequate. Usual methods are limited on surface monitoring or cannot be provided at field conditions. A suitable alternative is to use a contactless measurement method using magnetic microwires. This is a relatively new method that is still the subject of experimental research. An experimental device for non-contact mechanical stress measurement is located in the the Laboratory of Magnetometry at the Department of Aviation Technical Studies at the Faculty of Aeronautics. The disadvantage of this device is its dependence on the power supply powered by the electrical network. The primary goal was to design and build an accumulator-powered power supply that allows the use of the laboratory equipment in the field. The design required to use DC / DC converters to ensure the conversion of the accumulator voltage to a voltage suitable for powering the laboratory equipment with good efficiency. The control of the source activity is realized by a microcontroller. The construction of the source is described in the presented paper.

Keywords: accumulator, supply source, DC/DC converter, defectoscopy, magnetic microwires

1. INTRODUCTION

The composite materials are frequently used in aeronautics constructions nowadays. Their non-destructive testing (NDT) during the operation of construction is impossible in most cases. The magnetic microwires offer the NDT possibility for the composite materials. Their mechanical dimensions are comparable with the dimensions of the material textile and their magnetic properties depend on the mechanical stress. The magnetic microwires can be the solution of many problems of the composite constructions operation thanks to these qualities.

The system for contactless the NDT of composite materials based on magnetic microwires has been developed at the Faculty of Aeronautics [1, 2, 3]. This system was tested in laboratory conditions on several dozens of the different composite materials and several types of the microwires. The laboratory tests proved the possibility of the NDT of the composite structures into depth up to 5 mm under the surface. The measuring method is now ready for the tests on the composite structures of the real plane.

To make the flight tests possible, the measurement system has to be portable to give us the possibility of the in-flight testing. For this purpose, the specialized accumulator power supply (APS) was developed. The first step was to specify the properties of the accumulator power supply. The necessary voltages and currents were measured on the existing laboratory power supply. The original power supply was combination of an AC line transformer with analogue conditioning circuits and AC/DC switching power supply. The accumulator power supply has to replace the power of both original power supplies.

The accumulator power supply philosophy is based on the operation of the measurement system and its structure. The system consists of the power supply, the industrial personal computer (IPC), the magnetometer board (MB) and the analogue electronics circuits board (AE). The AE needs for its correct operation clock signal produced by the MB. Thus the AE have to be powered after the other parts of the system are already working correctly. Based on this particularity of the measurement system, the APS has to be controlled by a microcontroller to act like a sequence automat. The microcontroller use gave us the possibility to create the system with self-diagnostics capability. The capacity of the accumulators can be monitored by the microcontroller and power supply can be switched off to protect the accumulators in case of low capacity operation.

The required capacity of accumulators was achieved by parallel connection of the two 12 V accumulators. To achieve different voltage output of the APS we have chosen several DC/DC converters. Whole operation of APS is controlled by one pushbutton starting the programmed sequences in the microcontroller. The microcontroller software can be upgraded and loaded into the system by the USB interface. The whole microcontroller is on an embedded board. In such way, the microcontroller can be changed in case of the modifications of APS or the whole measurement system.

2. APS CONCEPT

The design of the APS depended on the analysis of the existing power supply. Critical parameters are the supply voltages of individual subsystems of the measurement device. The MB generates the clock signal for AE. This clock signal is the time base for the excitation field. The second role of the MB is to measure the response of the magnetic microwire that is sensed and amplified in the AE. From the power supply point of view, the MB requires ±12 V and +5 V supply power.

Measured signals are gathered by MB, which support the communication with the superior system, IPC. The measurement software is running on IPC, data are filtered, displayed and stored to local memory. Power requirements of the IPC are ±12 V and +5 V.

Critical part of the system, from the power supply point of view is the AE board. This board consist of sensing electronics, excitation signal conditioning electronics and voltage to current converter (U/I converter). This converter requires higher non-standard supply voltage ±40 V. The required supply voltages are summarized in Table. 1.

Table 1 Required supply voltages of individual subsystems [4]

Subsystem	Required supply voltage [V]		
MB	+5	±12	
IPC	+5	±12	
AE		±12	±40

The review of the required power of individual voltage outputs of the power supply are summarized in Table. 2.

Table 2 Required power of individual voltage outputs [4]

Power supply	Voltage [V]	Current [mA]	Power [W]
AC/DC switching	12	150	1,8
	-12	95	1,14
	5	1000	5
AC line transformer	40	150	6
	40	220	8,8

Two parameters are critical, available output voltage at required power and required input voltage range. The power of each supply voltage output has to be higher than the measured value presented in Table 2. The IPC and MB have the same supply voltages and are turned on and off at the same time. These components can be powered by single DC/DC converter. From commercially available converters the TEN 30 WIN-2431 was the optimal choice for us. The converter offers three voltage outputs, +5V, +12 V and -12 V. The input voltage range is between 9 V and 36 V. Overall power of the converter is 30 W. This converter offers enough power for both powered devices and can overcome the turn on power peaks.

The DC/DC converter for AE was not commercially available due to the higher requested output voltages. This problem was solved by connecting of three DC/DC converters in serial. The selected converters were DKE10A-12 and SKE10A-24. All of the DC/DC converters, including TEN 30 WIN-2431, have galvanic separated outputs from the input power supply. This allows us to connect the outputs of these power supplies in series, or parallel, depending on the required voltage or power. The DKE10A-12 converter offers two output voltages +12 V and – 12 V with common GND pin. The SKE10A-24 offers single output 24 V. One 24 V converter is connected in serial with +12 V output and second 24 V converter is connected in serial with -12 V output. This combination offers us the ±36 V output, which is the nearest possible voltage lower than 40 V. Higher voltage is important for the power operational amplifier assembled in U/I converter at AE board to overcome the coil's inductance during generation of the excitation signal. The parameters of the selected DC/DC converters are summarized in Table. 3.

Table 3 Parameters of selected DC/DC converters [4]

converter	imput voltage U_{IN} [V]	output 1 U_{OUT} / I_{OUT} [V/A]	output 2 U_{OUT} / I_{OUT} [V/A]	output 3 U_{OUT} / I_{OUT} [V/A]	efectivity η [%]	power P [W]
TEN 30WIN 2431	9 - 36	5 / 4	+12 / 0.4	-12 / 0.4	88	30
DKE10A-12	9 - 18	+12 / 0.4	-12 / 0.4	-	80	10
SKE10A-24	9 - 18	24 / 0.4	-	-	81	10

Principal schematic of measuring device with APS integrated is presented on the Fig. 1.

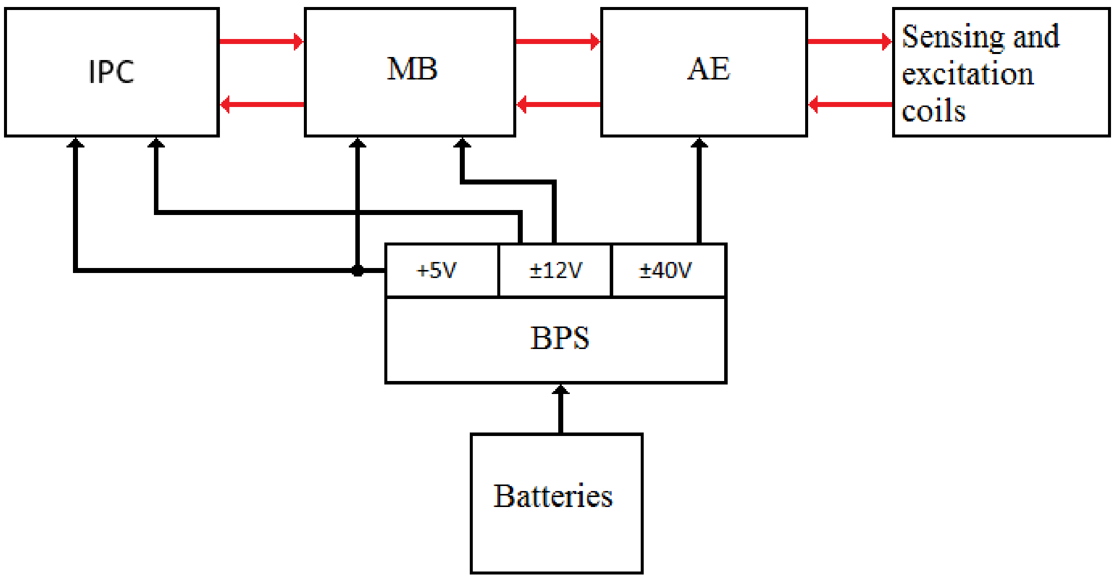

Figure 1 The block diagram of the measuring device equipped with the APS. The red lines represent the information exchange between the individual subsystems of the device [4]

3. APS DESIGN

The circuitry of the APS were designed with respect to the maximal protection of the supply accumulators. When the APS is turned off, all electronic circuits are disconnected from the accumulators. This protects the accumulators against discharging when the measurement system is not in use. After the pushbutton is pressed, the bistable relay connects the controller to the accumulators and controller is turned on. When the controller boots, its first task is to check the accumulator's voltage. The accumulator's voltage is measured by 10-bit internal A/D converter of the microcontroller. If the voltage is in the operating range, the first DC/DC converter is turned on by the microcontroller. The circuit diagram of the bistable relay connections is in the Fig. 2.

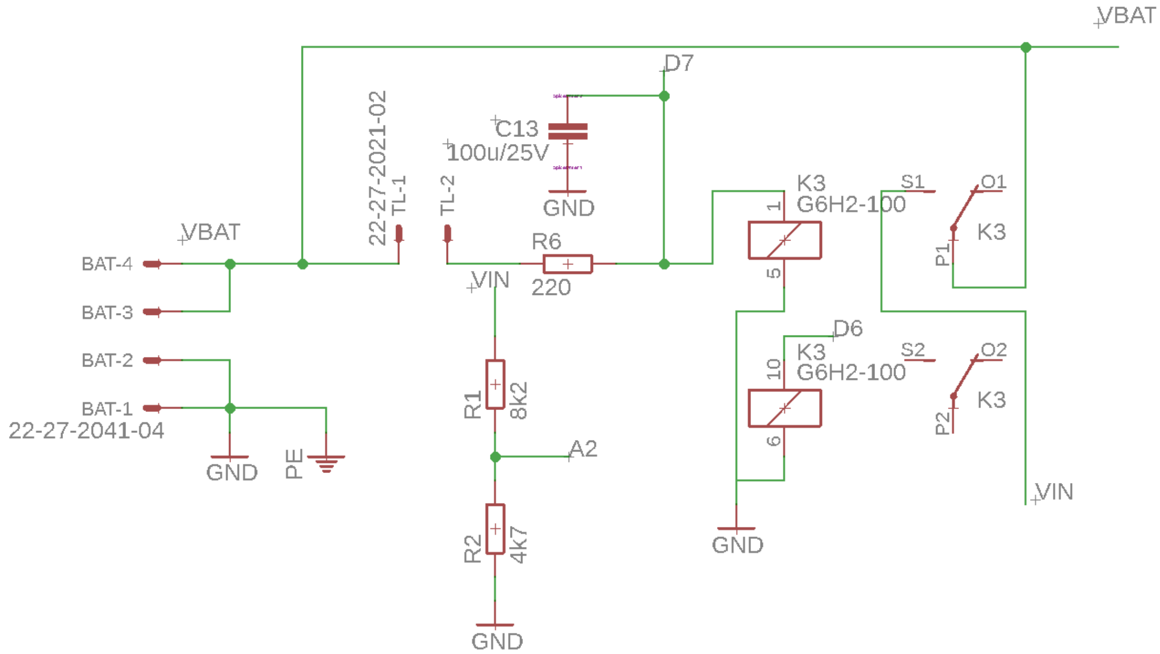

Figure 2 The circuit diagram of the power control circuit created by bistable relay, pushbutton connected to the ports TL-1 and TL-2 and accumulator's voltage is measured on port A2 [4]

The first powered DC/DC converter is the TEN30 WIN2431, which powers up the MB and IPC. The converter offers the remote on/off function which can be controlled by logic signal from the microcontroller.

The inputs and outputs of each DC/DC controller are equipped with filters, see Fig. 3. The filters are created by serial-parallel connections of the capacitors and inductors. The specialty of the used filters is in the order of the components. The inductors are connected next to the DC/DC converter. This is caused by internal connection of converter, where the filtering capacitances are connected. Connecting the filtering capacitances next to the DC/DC converter will acts as the parallel connection of capacitances and change the tuning of the DC/DC converter internal circuits. Thus, the inductance acts as well as filter and as a separating stage, see Fig. 3.

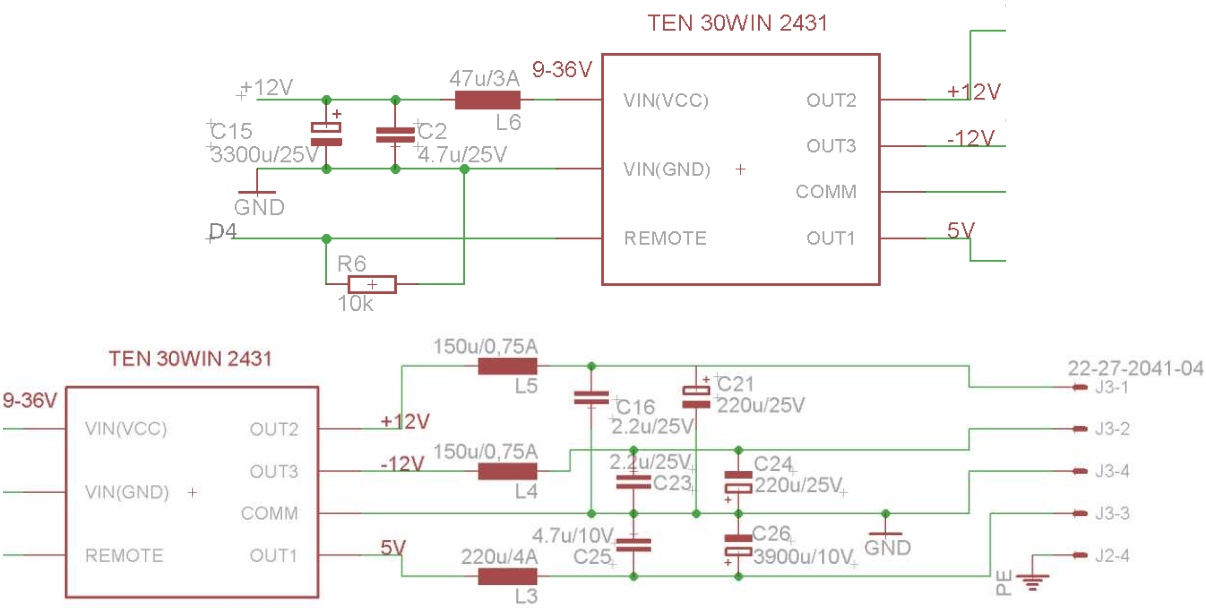

Figure 3 The circuit diagram of input and output filters at DC/DC converter TEN 30WIN 2431. Each filtering capacity is created as parallel combination of the electrolytic (slow) and the ceramic (fast) capacitor [4]

After the first converter is powered on, the timer is turned on to measure the time delay before the rest of the converters will be turned on. These converters are not equipped by the remote on/off control and are controlled by FET transistors. The circuit diagram of this stage is presented on Fig. 4. As can be seen, this stage is created by the serial connection of the DC/DC converters. As it was described before, this connection was selected to achieve the higher output voltage as is usual.

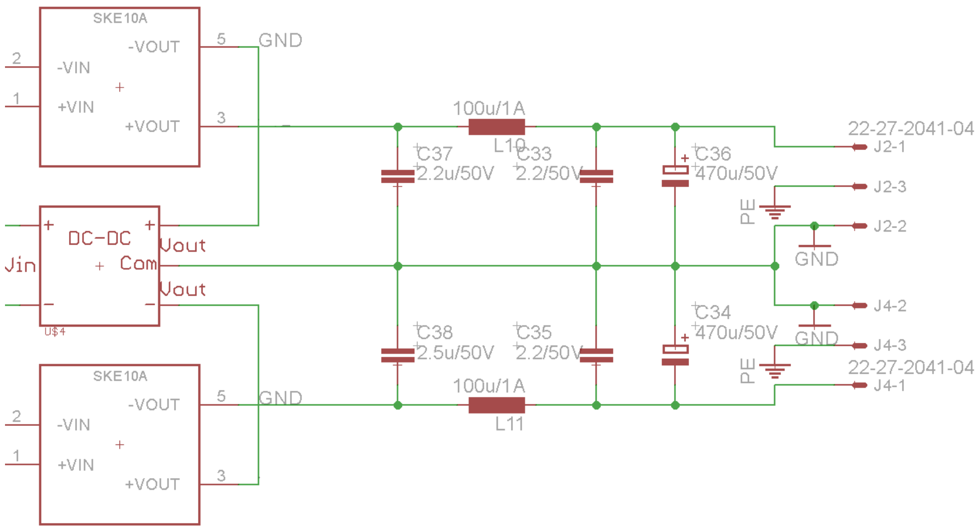

Figure 4 The circuit diagram of high voltage power supply stage, created by serial connection of the DC/DC converters [4]

The first powered converter is the symmetrical output DKE10A and then the both SKE10A are powered simultaneously. The time delay between them is in order of milliseconds, but this delay is enough for stabilization of the converter's output and prevents the powered circuits from voltage peaks. The second converters start with stabilized voltages and are not disturbed by changes of the first converter.

CONCLUSION

The presented paper describes the design of the accumulator powered power supply for the laboratory measurement system. The work was motivated by the need for the measurements in the field. The long term work is focused on the contactless measurement of the tensile stresses in the composite constructions. The need of accumulator power supply was obvious after the success of the laboratory tests.

The design of the APS was based on the idea to make it as simple as possible, while the whole system was required to be fully compatible with the original one. The DC/DC converters were selected first, with respect to the required voltages and powers. Then the APS control was integrated into the circuit diagram structure. The various DC/DC converters have to be turned on in specified order. This is given by the dependence of the AE board on the signal from the MB. All used converters can be controlled separately by the embedded microcontroller unit. The all circuits are disconnected from the accumulator power when the APS is turned off. This is provided by the use of the bistable relay in power circuit.

The microcontroller unit controls the sequence of the DC/DC converters switching during both turning on and off of the APS. If the accumulator voltage is insufficient, the APS will be turned off, or the turning on sequence will be discontinued. The presence of the micro-controller in the APS gives us the opportunity for further improvement of the APS functionality.

Our further work will be focused on the field tests of the measurement system equipped with the presented APS. The tests results will show us the way for further improvement of the APS. The APS can be connected to the IPC via the RS232 or RS485. The accumulator status can be signalized to IPC and prevent the loss of the measured data due to the discharge of the accumulator.

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