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SELECTED PROBLEMS OF ONE-CHIP MICROCOMPUTERS' APPLICATIONS IN DC/AC CONVERTING CIRCUITS

Keywords: one-chip microcomputer, DC/AC inverter, inverter's load capacity, E.M.C.

The paper presents problems connected with generation of sin – and trapezoidal signals as basic ones in the DC/AC energy conversion process. Questions on loads of various characters while alimented with sine – and trapezoidal voltages have been outlined.

Basic construction features of both types microcomputer equipped inverters have been discussed, in particular those dealing with a significant number of safety measures and with characteristic attributes of final power stages, determining the behaviour of inverters in various output power conditions. On examined sample inverter types of own design a complete compliance with requirements of electromagnetic compatibility standards has been pointed out thanks to proper planning and structural solutions.

1. INTRODUCTION

The development of one-chip microcomputers together with the reduction of their market price was a significant step to many circuit solutions in the entire electronics, automation and power engineering. Former analogue solutions had to be much more complicated and expensive and thus deceptive. Many parameters of a device may be the subject of the microcomputer controlled processes, connected with each other or self-dependent. Abundant choice possibilities among the microcomputers' circuit solutions dealing with their functioning speed, number of AC and CA converters, number of ports and additional outfits (communication ports, supervising circuits, programme code copying protection etc.) make them universal tools of features exceeding far beyond the hitherto existing designing possibilities and of much wider functional abilities. Beside the internal structural attributes – the microcomputers also owe many of their features to the quality of the programme solutions.

The actual progress in the development of electronic devices and of programmes enabling easy putting them into service, easy access to technical documentation, complex test outfits offered by producers, microcomputer programming possibilities by means of high definition languages (C, C++) – all these are factors making programming much easier and less complicated. A precise recognition of the chosen microcomputer's architecture and of its commands' list permits the application to be effectively created. In order to protect the intellectual values implemented in the programme – microcomputers are furnished with a programming blockade, not permitting to read the programme code by unauthorised persons.

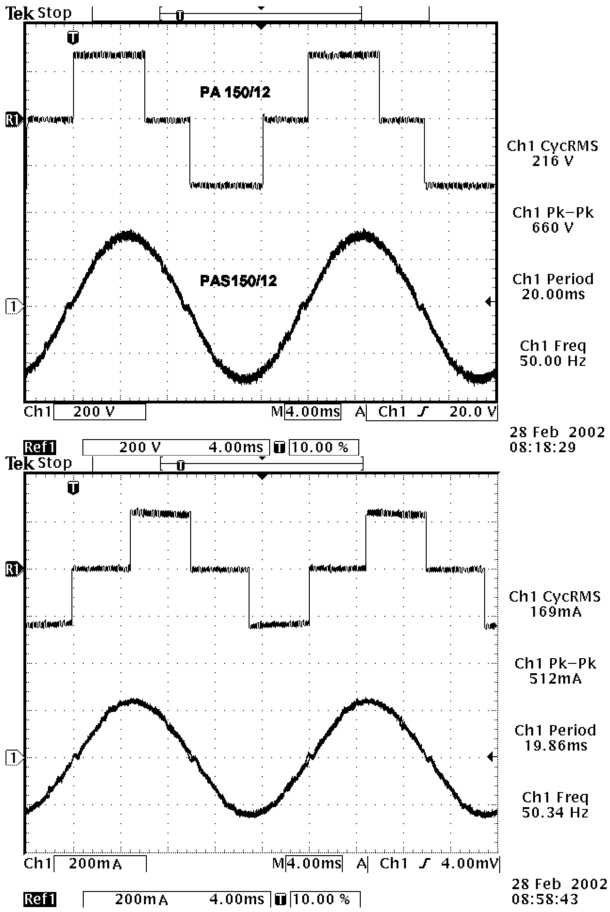
The DC/AC inverters create a sphere, where the microcomputers were recently widely employed [1]. These inverters are applied in small water-, wind- and solar power plants as well as in all places, where electric devices are exposed on frequent cases of line electric energy interruptions. In these cases the inverters furnished with a DC battery are acting as a substitute AC energy source. The DC/AC inverters become irreplaceable devices everywhere, where the line energy is inaccessible and the only energy source is a stationary or mobile DC battery. In such a situation they permit a wide variety of popular electric devices predestined for 220V AC alimentation to be fully exploited.

2. CONSTRUCTION AND EXPLOITATION PROBLEMS IN DC/AC INVERTERS

The electronic DC/AC inverters converting the DC voltage 12 or 24V to 220V 50Hz may be divided into two basic groups, according to the shape of the generated output voltage. The first, characterized by the sinusoidal shape of this voltage (PAS type), delivers the output voltage of the very same shape and frequency as those of the line voltage (Fig.1a, PAS 150/12). In the second inverter group of a trapezoidal output voltage shape (PA type) – a series of practically rectangular pulses of alternated polarity is generated and their width, amplitude and repetition frequency is adjusted in a manner, assuring the r.m.s. voltage and frequency values strictly equal the line voltage parameters (Fig.1a, PA 150/12). Since the sine type inverters application area is practically the same as in the case of industrial line energy and of conventional energy consuming devices – the trapezoidal type applications are apparently not so wide. The purpose is the manner according to which a steep output voltage value change in PA type influences the output energy receiver, often characterized by significant inductive and capacitative components. In particular – in this last case steep output voltage shapes cause steep current pulses in the energy receiver's input as well as in output inverter's circuits. These pulses may easily exceed the permissible values and may be dangerous for the inverter, or cause the implemented current safety measures to react. Additionally both inverter types are exposed to danger or to an automatic switch-off if some burden types of high initial starting energy consumption, such as tungsten bulbs or motors are connected to the inverter's output. These effects are widely confirmed in numerous experiments.

During the presented experimental attempts a conventional lighting set equipped with a 36W fluorescent tube and an inductive choke was tested. The PAS type sinusoidal inverter enabled a fluent and fast ignition of the tube and obtaining then full brightness conditions. A pure sine current course (Fig.1b, PAS 150/12) confirms the proper cooperation of the inverter and the fluorescent tube. In case of PA type inverter the tube ignition process was significantly prolonged and then after lighting stabilization – not the full brightness could be obtained. The effect may be explained by the current course of the set and by voltage course existing on the inverter's output (Fig.1a, b, PA 150/12). The voltage shape considerably differs from that of an unballasted output or of ballasted, but with a purely resistive load. Momentary voltage peaks or impulse current overtensions are the effect of reactive burden character's influence on the inverter's functioning. This influence is not caused by the sole fluorescent tube, but by its alimentation circuit, particularly by the stabilizing choke and filtering condenser. Similar problems appeared with PA type inverter while alimenting devices of nominal power nearly equal the inverter's nominal one, if equipped with transformers, chokes, motors etc. Tests proved, that in the case of such type devices' alimentation the efficiency of the sole inverter lowers and an additional effect of noisy devices' functioning may often be found.

a)



b)

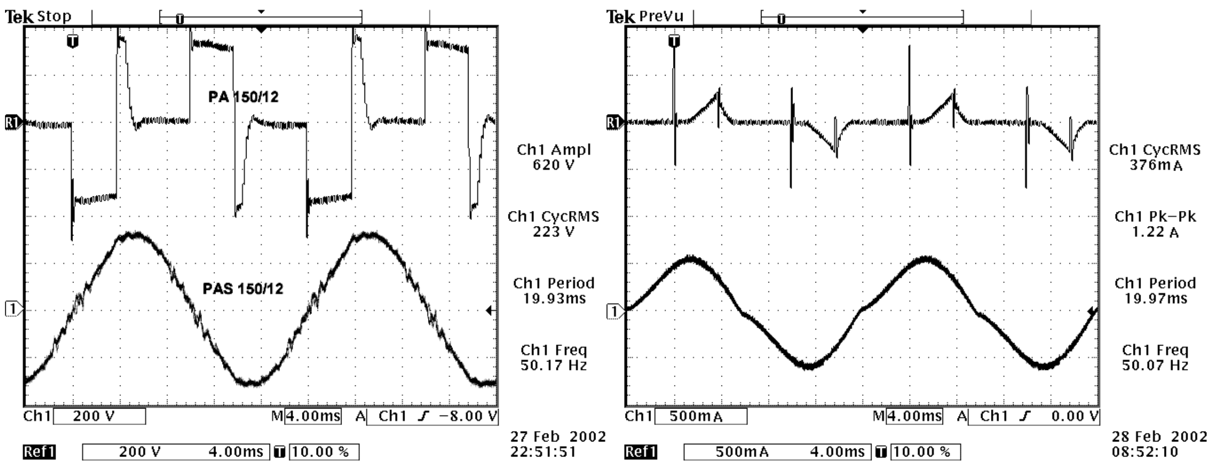


Fig.1 Voltage and current vs.time plots for PA and PAS type inverters charged with an ohmic resistor (a) and fluorescent tube set (b)

The properties of each inverter, if complete characteristics have to be defined, are additionally described by parameters such as nominal and peak load capacity, DC to AC power converting efficiency, idle – running power consumption, the output voltage and frequency dependency on DC input voltage, the alimentation ability of loads characterized with high reactive component of their impedance, resistance to momentary and long-term overload or output short-circuiting and resistance to disturbances coming from input or output devices as well as radio disturbances' emission to the DC input line. All these parameters significantly define the inverters' usable abilities. The introducing of a microcomputer for controlling purposes permits to optimise most of these abilities.

3. MOMENTARY PEAK OUTPUT POWER

For all DC/AC inverter types a common problem is the construction of final power stage, generally a conventional one, consisting of a typical push-pull- or bridge circuit generally equipped with an output transformer.

The nominal inverter's load capacity means a maximal AC power, which may be delivered in a long-term manner to the resistive load while the DC input- and AC output voltages, as well as power, are nominal. This parameter may be sometimes also dependent on climatic conditions.

The peak load capacity of an inverter is on the other hand a manifold notion, susceptible of various interpretations. Here two most typical cases of resistive nonlinear energetic line burdens may be mentioned. The first case includes popular tungsten bulbs of common use, the second – practically all TV sets, computers, radio receivers as well as single-phased AC motors, especially initially ballasted mechanically. The common characteristic feature of these both dominating burden groups is a very high power delivered from the energetic line in the moment of switching on, asymptotically lowering towards the nominal level after several or more periods of line voltage frequency 50Hz. In the case of tungsten bulbs the initial to nominal power ratio is 8 to 10, while in the second case this ratio may even reach the value of 20. These circumstances considerably influence the behaviour and constructional features of inverters. Important fact has to be considered, that problems connected with starting power values while switching on are rather generally omitted and not taken into account in the case of getting use of the energetic line, the internal impedance of which is almost zero and fuses, mostly thermal ones, are characterized by a significant thermal inertia and thus by delayed action. A conventional home line installation is then able to deliver even very high momentary starting power without any problems.

In the case of DC/AC inverters this situation becomes completely different [2]. As mentioned above – the persistent nominal power of inverters is specified according to the linear resistive burden. If omitted a certain safety margin, permitting a long-term and still safe inverter's exploitation while a 20% output power higher than nominal is delivered – permissible is such an inverter designing manner, which makes possible obtaining only 100% or 120% nominal power and not a bit more. In such a situation the main and most expensive inverter's elements like output transformer and transistors may have only small dimensional electric features, according to the accepted power of nominal value or slightly higher.

Another designing extremes are created, when the alimentation necessity of highly nonlinear resistive burdens is the matter of concern. Since a relatively slow lighting up a tungsten bulb is possible until reaching its full brightness – so in case of TV-sets and certain motor types it is completely impossible, because their starting process needs almost no momentary power limitations. An attempt of forcing a slow starting manner may often cause damage of the so alimented device or of the inverter itself. That means a necessity of such kind of inverter's designing, which permits to deliver a 10 to 20 times higher momentary starting power than the nominal one. This in turn requires an output transformer and output transistors of parameters similarly higher than those needed for nominal inverter's output power. This problem is unavoidably connected with a remarkable inverter costs' increase and thus generally is not solved in the manner mentioned above. As a reasonable compromise an overcharging product of 2,5 to 5 is usually admitted. These are values still satisfactory in case of tungsten bulbs and of most radio- and TV- sets and computers. One must however reconsile to the fact, that certain, not numerous types of devices will not be able to start in such conditions, unless – if the costs level is of no importance – for alimentation purposes are used inverters of many times higher nominal output power value than nominal nonlinear burden, represented by the device of difficult starting conditions.

The discussed problems of inverters' loading abilities are strictly connected with microcomputer supervision the impassable current values, permitted for the use in expensive elements of the final power stage. This supervision includes also a wide variety of load levels and their duration times, conditioning fast or delayed protective switching-off the inverter. Especially important is the protective function in case of short circuiting the output terminals, when the effective microcomputer's. reaction must take place in microseconds.

The experience gathered while designing and exploiting the PAS type single-phased microcomputer inverters becomes at present a base for initial efforts on 3-phase DC/AC inverter construction. In spite of considerable request for such devices – they are completely absent on our market, as well as on most foreign ones.

4. ELECTROMAGNETIC COMPATIBILITY TESTS ON INVERTERS

The requirements fulfilling the electromagnetic compatibility dealing with devices acting as inverters, stabilizers and energy stores is connected with such a state, in which these devices only in a minimal extent are influencing the environment and at the same time are little sensitive to the environment's influence. All the manufactures are strictly obliged to meet the requirements of proper law acts, like the 336/89 Directions of European Union dealing with electric and electronic devices and systems as well as the 95/54 Directions on motorization accessories. This subject matter is fully actual in dealing with the analysed DC/AC inverters. An inverter cooperating with a battery station, car board network etc. must have an operational resistance on this environment's disturbances, and being numbered to the receiving group of devices must not emit disturbances, influencing negatively other devices, belonging to the alimentation system (PN-ISO 7637/1997) [4].

On the other hand, a DC/AC inverter being a device delivering the energy in the transformed form – must secure its proper quality. An example of an appropriate fulfilling this requirement is the construction of the PAS type inverter of a sine output voltage. Its small dependence of the output voltage as a function of load, excellent output voltage stabilization, small content of output voltage harmonics and cooperation possibilities with most devices of nominal input power reaching 800VA – fulfil the electromagnetic compatibility requirements dealing with the quality of delivered energy. In such type inverters the energy transforming process is associated with problems of limiting the emission of generated disturbances through the inverter's input network. In the inverter output stages high frequency disturbances are generated as a result of fast commutation processes in power transistors. These disturbances in form of conducted energy are influencing the input network and other devices connected to it.

Assuming that the tested inverters may cooperate with the car board network – according to the PN-ISO 7637/1997 norm the measurement of disturbance level emitted by PA and PAS type inverters (Fig. 2.) was accomplished. For the conducted disturbance measurements in the 0,1 to 108MHz frequency range an artificial 50Ω/5μH network was used.

The obtained measuring results for PA and PAS type inverters indicate the influence of the energy transforming method on the level of generated disturbances in the frequency region up to 30MHz (Fig. 3.)

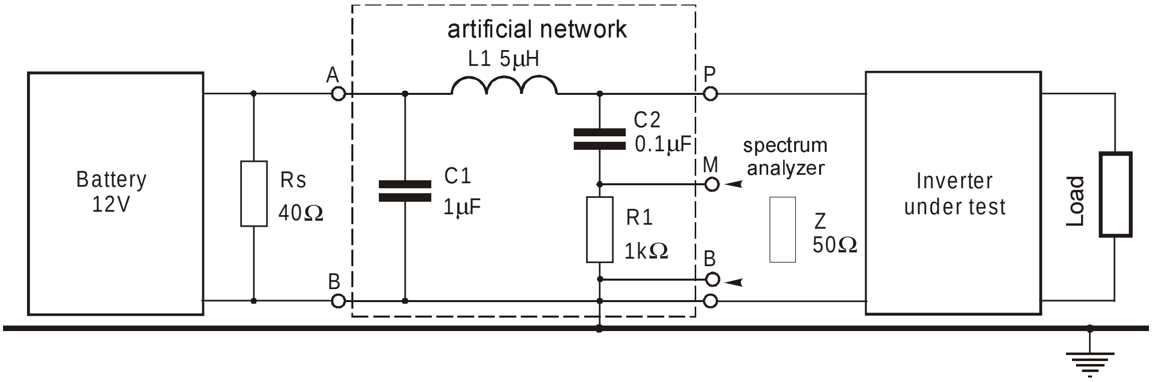


Fig. 2. Inverter h.f. conducted disturbances test measuring circuit

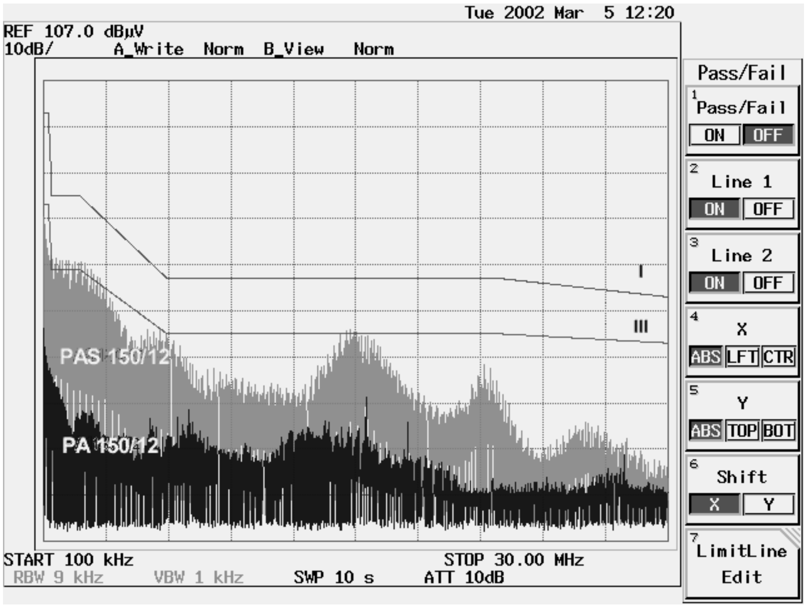


Fig. 3. H.f. disturbances emitted to DC energy source by PA and PAS type inverters nominally loaded in the frequency range 0,1 to 30MHz (R3132 Advantest Analyser used)

According to the limit line (III) at the appointed level of emitted conducted disturbances – the PAS type inverters may be classified to the third class of emission conditions [5]. The marked line (I) shows the permissible, maximal conducted disturbance value, which may appear in the car board network. Because of the circumstance, that the energy transformation occurs at low frequency – the PA type inverter does not produce any radio frequency disturbances. No disturbance emission, caused by tested inverters, was found in the 30-108MHz frequency range.

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MULTIPURPOSE SOLID-STATE INTEGRATED CIRCUITS FOR SENSOR TRANSFER CHARACTERISTIC FORMATION

Keywords: integrated circuits, transfer characteristic, signal processing, linearizator, thermocompensator

The design philosophy and elaboration results for multipurpose solid-state integrated circuits for sensor transfer characteristic formation are considered in the paper. The circuits for linearization and thermocompensation of transfer function and for multiplication of temperature coefficient are presented. Elaborated integrated circuits are characterized by simplicity and operation with low-voltage unipolar supply sources and they allow to improve precision and widen functional applications of new generation sensor devices.

1. INTRODUCTION

The evolution of up-to-date measuring and sensor devices especially for production process automation, medical electronics, ecological monitoring systems is close concerned with design of new element base. Together with basic units for integrated circuits (IC) such as operational amplifiers, stabilizers, digital electronics elements the intensive development of specialized ICs takes place recently. Incorporated into fully integrated microelectronics devices specialized ICs ensure improvement in measurements and widen functional applications [1, 2]. However, in contrast to signal amplification or stabilization of electrical regimes of primary transducers such important tasks as linearization or thermocompensation of transfer function can not be efficiently achieved on the basis of previously designed multipurpose ICs.

In this paper we propose design philosophy for series of multipurpose ICs intended for sensor technique. These multipurpose ICs ensure efficient linearization and thermocompensation [3] of transfer function and they are simple in use and operate with low-voltage unipolar supply sources.

2. MULTIPURPOSE IC FOR LINEARIZATION OF TRANSFER CHARACTERISTIC

Granting nonlinear nature of primary transducers for measuring device the linearization of transfer function is important problem for all metrological tasks. New primary transducers such as chemical and chemical-biological sensitive elements based on modern physic approaches were