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*Term paper assignments*

Pages

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IAN RS 310

**Term paper assignments**

**Student: Babych D.V.**

**The theme of course project:** the calculation of coherent and radio location transmitters with following parameters:

1. The term of preparation of the project from
2. Initial data

Frequency band – 118..135 MHz

Antenna’s power – 200Wt

Modulating factor – 0.9

Frequency greed step – 0.1 kHz

1. Course paper performance stages
* structural scheme calculation
* quarts generator calculation
* transmitter’s output stages calculation
1. The list of obvious graphical material:
* Transmitter’s structural scheme
1. The task is given by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Lyubimov O.D.)

 “\_\_\_”\_\_\_\_\_\_\_\_\_\_\_\_2010

1. Task is performed by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**The course project is defended with the mark** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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ABSTRACT

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ABSTRACT

Explanation note for term work contains 28 pages A4

Structural circuit of the high frequency radio transmitter with 200 W aerial power, and operating frequencies 118... 135 MHz, designed for amplitude modulation and generating and output stages calculation.

Investigation object - high frequency transmitter. Aim of term paper - with help of theoretical knowledge determine some concrete engineering problem and learn elaboration radio transmitters. Method of investigation - digital mathematic calculation. Tasks of the term paper are:

To study modem tendency in creation radio transmitters region with different frequency range.

To learn calculation methods of main nodes of transmitters. To get acquainted with modern aviation radio technical base. To get experience in working with additional literature.

Introduction

Radio transmitting device - is the complex system of individual junctions, which are interact. It is contains high-frequency highway, low-frequency highway for controlling high-frequency oscillations (modulator) according to informational signal, power source, cooler device, device of controlling and protection.

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Introduction

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The construction of radio transmitting devices is based on tactic-technical requirements, which are created taking into account conditions of exploitation of constructed transmitter. These conditions had to determine all basic electrical, electro acoustical, technological-constructive, and economical and exploitation characteristics of constructed transmitter.

Radio transmitting devices are classified by destination, working waves\* band, the power of radiation in the aerial, work conditions. Such dimensions cause the specificity of transmitters' construction. For example, the type of amplified elements, oscillating systems their cost and so on, depend on transmitter's power and working waves' band. The design of exciter has great dependence on the width of working waves' bands and on their quantity. The exciter contains one generator as well as multitude of generators, containing mixer, frequency transformer, complex filters for obtaining the greed of necessary frequencies with given stability. If there are great number of channels, the digital composer of frequencies are used, which are satisfy all described dimensions. The frequency stability of such exciters depends on one supportive generator, which is usually realized with quarts stabilization and thermo-stabilization. Then the filtration of the signal takes place (if it is necessary) and previously the amplification of oscillations with the help of wideband amplifier. For realization of necessary stability of amplitude of oscillations exciter became powerless, with following amplification of oscillations with the help of many-cascade amplifiers. The important requirement for constructing is the kind of modulation and work regime of transmitter. If transmitter is working in single-band mode, then the exciter of single-band signal is constructed, which is operate on intermediate frequency (filter method) with following signal transformation to necessary frequency and amplification of already modulated oscillations. There are high requirements for linearity of output stage, which are produced to such transmitters.

At that for realization of amplitude modulation the additional modulator doesn't constructed, as amplitude modulation is easy for realization in single-band exciter.

The maim electric parameters are: transmitter's power, working waves' band, frequency stability, industrial efficiency and filtration of highest harmonics. The electro-acoustical parameters are: amplitude modulation's depth, the level of frequency and non-linearity distortions and undesirable modulation.

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Calculation of the many-periods transmitters begins from output stage. Let's calculate minimal power of output stage by given power in load (aerial), taking into account looses of power in aerial and intermediate circuits and also in filter of incidental radiation. By this data we choose the type of amplified element, taking into account the frequency parameter of electric devices.

The calculation of many-periods transmitters begins from output stage. Let's calculate minimal power of output stage by given power in load (aerial), taking into account looses of power in aerial and intermediate circuits and also in filter of incidental radiation. By this data we choose the type of amplified element, taking into account the frequency parameter of electric devices.

At that for realization of amplitude modulation the additional modulator doesn't constructed, as amplitude modulation is easy for realization in single-band exciter.

The main electric parameters are: transmitter's power, working waves' band, frequency stability, industrial efficiency and filtration of highest harmonics. The electro-acoustical parameters are: amplitude modulation's depth, the level of frequency and non-linearity distortions and undesirable modulation.

Calculation of the many-periods transmitters begins from output stage. Let's calculate minimal power of output stage by given power in load (aerial), taking into account looses of power in aerial and intermediate circuits and also in filter of incidental radiation. By this data we choose the type of amplified element, taking into account the frequency parameter of electric devices.

The calculation of many-periods transmitters begins from output stage. Let's calculate minimal power of output stage by given power in load (aerial), taking into account looses of power in aerial and intermediate circuits and also in filter of incidental radiation. By this data we choose the type of amplified element, taking into account the frequency parameter of electric devices.

Structural scheme calculation

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Structural scheme calculation

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 1.1 General information. The calculation of block-diagram scheme of transmitter is an important stage of radio transmitting device's construction. Modern transmitter contains two main channels - channel of high-frequency oscillations and the channel of operating (modulating) low-frequency oscillations. Channel of high-frequency oscillations has no less than three basic elements: exciter, intermediate amplifier and output power amplifier, working on feeder line or aerial. Such construction conditioned on necessity of relaxation of output stage's and aerial's influence on exciter with the aim of rise of amplitude and frequency stability of oscillations.

The number of stages in intermediate amplifier and in output stage, its power, are determine by the value of maximal useful power, given in technical requirements and chosen type of modulation.

Technical requirements:

Frequency band – 118-135 MHz

Antenna's power - 200 Wt

Modulation factor - 0,9

The step of frequency greed – 0.1 kHz

1.2 The choice of electrical device type.

As the type of electrical device (amplification element) is absent in technical requirements, so we'll choose it in accordance to recommendations. But at first, let's calculate nominal and maximal power of output stage, taking into account losses of energy in output oscillating system (aerial and intermediate circuit). Originating from typical meanings, let's take the efficiency of aerial circuit equal to - 60%, and the efficiency of intermediate circuit - 85%. So the nominal power of output stage will be equal to- 941.176 Wt. Such calculation formulas are represented in "Calculation of output stage'' chapter.

The output stage of given power can be successfully realized as on valves, as well as on transistor. But taking into account requirements to sizes of output stage and the whole transmitter, I am constructing the transmitter on transistor, because in transistor variant it is not necessary to use non-standard high-voltage power source, and also we can economize on sizes of heat-rejection, using the transistor with grounded emitter or insulated frame. At that, instead heat-rejecter we can use transmitter's frame. Additional cooling we can realize with the help of additional heat-rejecters that are connected to the back side of transmitter's frame, in such a

way we solve the problem of transmitter's cooling. The choice of certain type of transistor is realized in chapter ”The calculation of output stage".

1.3 The choice and substantiation of stages' number.

It is necessary to realize preliminary calculation of quantity of stages of single-period stage's linear amplifier. Taking into account, that the power of exciter is choosing in limits from 0,05 to 0,5 Wt, and common coefficient of amplification of amplifier highway :

$K\_{y}=\frac{P\_{1(1)}}{P\_{1(exc)}}$*,*

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where P1(1) – power of output stage.

$$P\_{nom}=(1+m)^{2}\frac{P\_{0}}{ηf∙ηtr∙ηks}=(1+0.9)^{2}×\frac{200}{0.95×0.95×0.85}=941.176$$

In the note P1(n)- index n is the number of output stage, beginning from output. Let's take the power of exciter equal to P1(exc)=0.05W.

Then $K\_{y}=\frac{941.176}{0.05}=1.882\*10\^4$

For the amplification stage on transistor by switching scheme with common emitter the coefficient of amplification according to power is 5..7.Let the coefficient of amplification for all stages of linear amplifier be K=7. It is explained by the fact, that output stage has the reactive resonance load, which is characterized by high efficiency. In same time wideband adjust transformer, which is used in intermediate stages, have low efficiency, but transistors of these stages have the less power and the more coefficient of amplification. That is why all stages of linear amplifier have approximately the same coefficient of amplification. The output power of last but one stage is determined by formula:

$$P\_{1(2)}=\frac{P\_{1(1)}}{K\_{p1}∙η\_{mp}}$$

where Kp1- is the coefficient of amplification of output stage, ηmp - efficiency of adjust transformer of but one stage,
$$P\_{1\left(2\right)}==\frac{941.176 }{7×0.9}=149.39 Wt$$

Let's calculate the power of third intermediate stage:

$P\_{1(3)}=\frac{P\_{1(2)}}{K\_{p2}∙η\_{mp}}$=$\frac{149.39 }{7×0.9}=23.71 Wt$

Let’s calculate the power of signal which is necessary to render on input of third stage

$P\_{1(4)}=\frac{P\_{1(3)}}{K\_{p3}∙η\_{mp}}$=$\frac{23.71}{7×0.9}=3.76Wt$

The fourth stage:

$P\_{1(5)}=\frac{P\_{1(4)}}{K\_{p4}∙η\_{mp}}$==$\frac{3.76}{7×0.9}=0.6Wt$

We can see from the calculations that the power is approximately equal to the power of exciter, taking into account the losses in adjust transformer. This transformer is used for matching of transistor's input resistance with resistance of feeder line. As all high-frequency signals between separate coaxial cables are transmitted with the help of coaxial cables (feeder line, wave load in microwave transmitters).

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1.4 The modulation's type determination.

Amplitude modulation is the work mode which is given in technical requirements for transmitter. In nowadays amplitude modulation (AM), as the type of controlling of high-frequency oscillations are widely used. In spite of all methods of AM in transmitters on transistors, the collector modulation and amplification of modulated oscillations are always used.

1.5 Exciter's type.

The transmitter's exciter is constructing according to technical requirements of frequency band and permissible non-stability of oscillations. If we have less quantity of fixed frequencies, the exciter is constructing by principle "quartz-wave '\it's mean that trough each channel of transmitter own quartz generator is created and the quantity of channels corresponds to the quantity of quartz generators. Such construction of exciter is used in transmitters, which have more than 10 fixed frequencies If the quantity of channels is more than 10, then the exciter is constructing by generator of harmonics principle, or by interpolation principle. The division and multiplication of frequencies are used in such exciters, but the frequency multiplication can cause the raise of level of secondary components (harmonics).That s why the usage of functional schemes preferable with frequency In our case the quantity of channels:

$$n=\frac{f\_{max}-f\_{min}}{∆n}=\frac{135000-118000}{0.1}=170 kHz$$

where Δn – the step of reed’s frequencies.

That is why expediently to use the digital synthezator of frequency. Its work is based on phase-impulse automatically turning of frequency (PATF).The structural scheme of digital synthezator of frequency is shown on figure 1.1



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Conditional designations in structural scheme on fig.2.; 1 pulse former (limiter or Shmitt's trigger ); 2 -the frequency divider of strong generator with divider coefficient n; 3 -frequency-phase detector(FPD); 4 divider with alternating dividing factor (DADC); 5 - pulse former; 6 - lower frequencies filter(LFF); 7 - voltage controlled generator (VCG); 8 - buffer's stage; 9 - controlling device.

1.6 Work description.

The base oscillations are creates in generator, controlled by voltage. Comparison of frequencies takes place in block, from one side- produced by strong generator by 500 kHz, from another side-produced by generator, controlled by voltage (GCV).The comparison take place on concerning low frequency f Value of which depends on step of frequency's greed, and also

on coefficients of division of digital frequency dividers. All frequency dividers are digital devices also, so the signals came in their inputs from impulse formers. The changing of divider's coefficient (DADC) is realized with the help of digital code produced by controlling device. In the role of GCV we can use auto generator on LC elements, controlled with help of varicap Direct voltage on varicap is fed from FPD's output through LFF and turns it during the action of destabilizing factors or in the time of changing of divider coefficient DADC with the help of controlling device.

Let's consider the principle of automatical turning of frequency of a given functional scheme Let the frequency GCV be changed in action mode as a result of action of destabilizing factors that immediately cause the changing of frequency, acting on FPD. And it'll cause the appearance of direct analogue signal on the output of FPD and in varicap also. The varicap will change the frequency of turning GCV to previous meaning, another words it will compensate the action of destabilising factor The тісто schemes of K133 type can be the element's base of frequency synthezator, but for minimizing of using power, device's sizes, it is expediently to use modern micro schemes IMS type, for example K555,K56l and so on. The best synihezator's characteristics can be obtained using special micro schemes as the base block of synthezator, and also programmed micro controllers as controlling device. It gives an ability to increase the functionality of synthezator and the whole transmitter. For example: frequency (channel) turning with the help of keyboard, fast march from one channel to another, programming of fixed channels on necessary frequencies, scanning of all frequency band (used in receivers).

We'll use quartz generator on 500 kHz, which is used in single-band former, as a strong generator. It gives us an ability to reduce the quantity of transmitter's junctions.

1.7 Sub bands division, The maintenance of necessary covering by working frequency band is the next step of our scheme's calculation and construction. There are hard requirements concerning to radiation power of secondary frequencies (harmonics) of modern radio transmitters. The realization of such requirements is possible with usage of filter systems. In our case the filtration will be realized only in output stage, to carry out the requirements of minimal quantity of controlling organs (only in output stage and exciter). As the filter systems have concerning little bandwidth, so it is necessary to reorganized them along all band on necessary frequency. In our transmitter in output stage it is usedП-type filter of lower frequencies ("П-circuit"), which it is complicated in reorganizing through whole band (118-135 MHz.). That is why the division on sub bands is necessary; it will allow filters to be switched over, during the work in concrete band. It is necessary to sign, that the exciter will not be dividing on sub bands, as it provides necessary characteristics in whole operating region.

According to working frequency, only output filter systems will be switched over. It is necessary to note, that these filters can be switched over by controlling device from part of frequency synthezator, written above. Besides it switching over can be realized in automatic mode during frequency reorganization. It is considerably raise the convenience of transmitter's usage and service, reduce the tuning time of whole transmitter, which have an important meaning for portable radio station, used in aviation.

Calculation of sub bands quantities. The covering coefficient v by band is chosen in limits 1,5....2 Let v = 1.5 Then the common covering coefficient is determined by formula:

$$K=\frac{f\_{max}}{f\_{min}}=\frac{135}{118}=1.144$$

The quantity of sub bands are equal:

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$$n=\frac{lgK}{lgυ}=\frac{lg1.144}{lg1.5}=0.899$$

Let’s specify the converting coefficient:

$$υ=10\^\frac{lgK}{n}=\sqrt[n]{K}=1.144$$

Let’s determine the frequencies of sub bands:

$f\_{min1}^{'}=$118 MHz

$$f\_{max1}^{'}=υf\_{min1}^{'}=1.144×118=135 MHz$$

Taking into account that coverings at the ends of sub bands are 5%.Let’s specify the limits of sub bands:

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|  |  |
| --- | --- |
| 1 sub band | $$f\_{min1}=f\_{min1}^{'}∙0.95=118×0.95=112.1 MHz$$$$f\_{max1}=f\_{max1}^{'}∙1.05=135×1.05=141.75 MHz$$ |

From all calculations, which are already done, we can construct detailed structural scheme of all transmitter, to draw graphically all connections of separated blocks. The block-diagram of transmitter is shown on drawing.

The quartz frequency stabilization of auto generator is widely used in exciters of radio transmitting devices, which frequency non-stability during long period of time no more then 10-4

During calculations quartz generator is substituted by equivalent scheme, effective on frequencies up to 150mHz.

Depending on necessary frequency of generating, quartz can be used as on base frequency, as well as on its harmonics. From scheme's decision the most popular is the scheme of quartz switching between collector and base



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Oscillator

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Transistor is choosen by condition



This condition satisfy transistor 2T610B

Its main parameters:

























Let's choose the standart quarts on 150 MHz. The main parameters:















For increasing of stability let's choose next generator's parameters:























Order of calculations

The power, calculated on quarts:













Approximation of transistor parameters:



Lets take the coefficient - 0.6







































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Oscillation system parameters:













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The inductivity is determined from condition:



















Correction to the oscillating frequency:













The mode transistor's parameters:

The voltage amplitude on collector:





















The consant component of base current and shift on base:





































Let it be Re=50 Ohm According to recommendation, the resistance R6 will defined from correlation Rb=(10..20)X2. Let's take:





















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Let's find the current from divider:









The resistance of divider in power circuit:

















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Output stage calculation

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Output stage calculation

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The calculation of nominal power of transmitters the main task during their calculation. For communicational transmitters Pnom is given in carrier mode. In my case it is the top power in t mode. In time of silence, the transmitter almost doesn't radiate the signal and its power is equal to several miliWatts.





The power in ariel



modulating factor



efficiency of filter



efficiency of matching filter



efficiency of oscillating system

Lets calculate the nominal mode









Transistor 2T970A satisfy the given condition

Let’s choose the active element. As it was signed above, that it is expediently to use transistor, if we have less power.

I choose the scheme of output stage



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**Let’s choose the transistor’s type**

Transistor 2T970A satisfy the given condition

It main parameters:





































































































The output stage calculations











Lets calculate the collectors resistanco of loses in parallel circuit











The coefficient of usage of collector's voltage in limited mode











The amplitude of voltage on load reducted to eguivalent generator









The first garmonic of load current









Useful load









The whole resistance of collector's load









The first harmonic amplitude:







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The steepness by march







Recombination resistance









The steepness of statical characteristic of collector's current







To determine the coefficient of decay for the first garmonic let's determine the meanings of coefficients



the limitted frequency of the current transmitting factor in CE circuit















Delay coefficient

As the shift voltage in power stages is equal to 0, we have:









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Amplitudes of base current:







Current gain factor, reduced to equivalent generator







The component of input resistance of transistor for the first harmonic













Power gain factor:







The constant component of collector current









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The power used by power source









Collector's efficiency









Input power









The power dissipated by transistor:



The components of load resistanses, redused to external withdrawal of collector in parallel equivalent











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As resistance have positive sign, then







Calculating of block capacity



























Induction determine by the condition









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Let find current through drvider

















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Conclusion

In this term work I have designed a structural scheme of aviation communication transmitter that operates in frequency range - 115... 135 MHz. This transmitter consist of some separate units which connection between themselves. Term paper includes electrical circuits calculation for quartz generator and output stage.

Radiotransmitter satisfies to all of initially given technical requirements, requirement of frequency and power stabilization.

Radiotransmitter can at the airplane; it has output power 100 W. If output

power will be grater it will call mass increasing and more powerful methods of cooling will be required. Calculating radiotransmitter can be used for telephony. In radiotransmitter used amplitude modulation.

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Conclusion

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*Quarts generator*

Design.

Title

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Num.

**Transistor ГОСТ 10862-72**

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2T610B

VT1

1

**Resistors МЛТ ГОСТ 71130-66**

*5 kOhm*

R1

1

2 kOhm

R2

1

50 Ohm

Rb

1

100 Ohm

Re

1

**Capacitors ГОСТ 2569-56**

8 nF

Ce

1

*0.5 pF*

C1

1

4 nF

C2

1

3.9 nF

Cb

1

**Quartz ГОСТ 159-25**

Обертон1ю 150MHz

*SB1*

*1*

**Inductivity ГОСТ 458-26**

2 nHn

L1

1

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*Output stage*

Designation

Title

Notes

Num.

**Transistor ГОСТ 10862-72**

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2T970A

VT1

1

**Capacitors ГОСТ 2569-56**

*1.5 nF*

C1

1

2.5 nF

*C2*

1

4 mkF

*C3*

1

2 mkF

*C4*

1

**Inductivity ГОСТ 458-26**

200 mkHn

L1

1

*100 mkHn*

L2

1

200 mkHn

*L3*

1

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*HF Radio*

*Transmitter*

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