Санкт-Петербургский национальный исследовательский университет информационных технологий, механики и оптики

УЧЕБНЫЙ ЦЕНТР ОБЩЕЙ ФИЗИКИ ФТФ

УНИВЕРСИТЕТ ИТМО

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ИЗУЧЕНИЕ ЭЛЕКТРИЧЕСКИХ СИГНАЛОВ С ПОМОЩЬЮ ЛАБОРАТОРНОГО ОСЦИЛЛОГРАФА

Санкт-Петербург 2023

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1 Экспериментальные данные

1.1 Теория

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

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1.2 Практика

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Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

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2 Обработка экспериментальных данных

2.1 Результаты

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula. [Col21] [Бей16]

Канал I	**ЗГ-1**
Цена деления Y – шкалы осциллографа , В/дел	2
Амплитуда сигнала, измеренная с помощью осциллографа, дел	3
Амплитуда сигнала, измеренная с помощью осциллографа, U, В	5,6
Погрешность измерения амплитуды с помощью осциллографа ΔU, В	1
Амплитуда сигнала, измеренная с помощью вольтметра, U, В	5,77
Погрешность измерения амплитуды с помощью вольтметра ΔU, В	0,01
Относительное отклонение показаний осциллографа от показаний вольтметра, %	3

Таблица 1: Моя подпись

Measure	**Abs_err**	**Full text**
−0.000489	0.000009	$(-489 \pm 9) \cdot 10^{-6};\ \varepsilon = 1.8\%;\ \alpha = 0.95$
−0.00021	0.00008	$(-21 \pm 8) \cdot 10^{-5};\ \varepsilon = 38\%;\ \alpha = 0.95$
0.00002	0.00008	$(2 \pm 8) \cdot 10^{-5};\ \varepsilon = 400\%;\ \alpha = 0.95$
0.000077	0.000039	$(7.7 \pm 3.9) \cdot 10^{-5};\ \varepsilon = 50\%;\ \alpha = 0.95$
0.00029	0.00007	$(29 \pm 7) \cdot 10^{-5};\ \varepsilon = 24\%;\ \alpha = 0.95$
−0.000214	0.000022	$(-21.4 \pm 2.2) \cdot 10^{-5};\ \varepsilon = 10\%;\ \alpha = 0.95$
−0.00035	0.00009	$(-35 \pm 9) \cdot 10^{-5};\ \varepsilon = 26\%;\ \alpha = 0.95$
−0.000378	0.000033	$(-37.8 \pm 3.3) \cdot 10^{-5};\ \varepsilon = 9\%;\ \alpha = 0.95$
−0.00013	0.00006	$(-13 \pm 6) \cdot 10^{-5};\ \varepsilon = 50\%;\ \alpha = 0.95$
−0.000453	0.000018	$(-45.3 \pm 1.8) \cdot 10^{-5};\ \varepsilon = 4\%;\ \alpha = 0.95$
−0.00003	0.00010	$(-0.3 \pm 1.0) \cdot 10^{-4};\ \varepsilon = 330\%;\ \alpha = 0.95$
−0.000404	0.000005	$(-404 \pm 5) \cdot 10^{-6};\ \varepsilon = 1.2\%;\ \alpha = 0.95$
0.00026	0.00006	$(26 \pm 6) \cdot 10^{-5};\ \varepsilon = 23\%;\ \alpha = 0.95$
−0.00025	0.00009	$(-25 \pm 9) \cdot 10^{-5};\ \varepsilon = 36\%;\ \alpha = 0.95$
−0.00018	0.00006	$(-18 \pm 6) \cdot 10^{-5};\ \varepsilon = 33\%;\ \alpha = 0.95$
−0.00034	0.00008	$(-34 \pm 8) \cdot 10^{-5};\ \varepsilon = 24\%;\ \alpha = 0.95$
−0.000039	0.000034	$(-3.9 \pm 3.4) \cdot 10^{-5};\ \varepsilon = 90\%;\ \alpha = 0.95$
0.000126	0.000020	$(12.6 \pm 2.0) \cdot 10^{-5};\ \varepsilon = 16\%;\ \alpha = 0.95$
−0.000265	0.000015	$(-26.5 \pm 1.5) \cdot 10^{-5};\ \varepsilon = 6\%;\ \alpha = 0.95$
−0.00019	0.00005	$(-19 \pm 5) \cdot 10^{-5};\ \varepsilon = 26\%;\ \alpha = 0.95$
−0.000344	0.000021	$(-34.4 \pm 2.1) \cdot 10^{-5};\ \varepsilon = 6\%;\ \alpha = 0.95$
−0.000262	0.000009	$(-262 \pm 9) \cdot 10^{-6};\ \varepsilon = 3.4\%;\ \alpha = 0.95$

0.000301	0.000022	$(30.1 \pm 2.2) \cdot 10^{-5};\ \varepsilon = 7\%;\ \alpha = 0.95$
0.00011	0.00008	$(11 \pm 8) \cdot 10^{-5};\ \varepsilon = 70\%;\ \alpha = 0.95$
0.000156	0.000034	$(15.6 \pm 3.4) \cdot 10^{-5};\ \varepsilon = 22\%;\ \alpha = 0.95$
-0.000244	0.000017	$(-24.4 \pm 1.7) \cdot 10^{-5};\ \varepsilon = 7\%;\ \alpha = 0.95$
0.000202	0.000032	$(20.2 \pm 3.2) \cdot 10^{-5};\ \varepsilon = 16\%;\ \alpha = 0.95$
0.00002	0.00006	$(2 \pm 6) \cdot 10^{-5};\ \varepsilon = 300\%;\ \alpha = 0.95$
0.00029	0.00009	$(29 \pm 9) \cdot 10^{-5};\ \varepsilon = 31\%;\ \alpha = 0.95$
0.00029	0.00006	$(29 \pm 6) \cdot 10^{-5};\ \varepsilon = 21\%;\ \alpha = 0.95$
0.00021	0.00007	$(21 \pm 7) \cdot 10^{-5};\ \varepsilon = 33\%;\ \alpha = 0.95$
0.00028	0.00005	$(28 \pm 5) \cdot 10^{-5};\ \varepsilon = 18\%;\ \alpha = 0.95$
0.00017	0.00006	$(17 \pm 6) \cdot 10^{-5};\ \varepsilon = 35\%;\ \alpha = 0.95$
-0.00006	0.00008	$(-6 \pm 8) \cdot 10^{-5};\ \varepsilon = 130\%;\ \alpha = 0.95$
-0.0001	0.00009	$(-10 \pm 9) \cdot 10^{-5};\ \varepsilon = 90\%;\ \alpha = 0.95$
-0.00032	0.00009	$(-32 \pm 9) \cdot 10^{-5};\ \varepsilon = 28\%;\ \alpha = 0.95$
0.00048	0.00008	$(48 \pm 8) \cdot 10^{-5};\ \varepsilon = 17\%;\ \alpha = 0.95$
0.00025	0.00008	$(25 \pm 8) \cdot 10^{-5};\ \varepsilon = 32\%;\ \alpha = 0.95$
0.000406	0.000014	$(40.6 \pm 1.4) \cdot 10^{-5};\ \varepsilon = 3.4\%;\ \alpha = 0.95$
-0.00032	0.00008	$(-32 \pm 8) \cdot 10^{-5};\ \varepsilon = 25\%;\ \alpha = 0.95$
0.0004478	$8E-7$	$(4478 \pm 8) \cdot 10^{-7};\ \varepsilon = 0.18\%;\ \alpha = 0.95$
0.00013	0.00007	$(13 \pm 7) \cdot 10^{-5};\ \varepsilon = 50\%;\ \alpha = 0.95$
0.0004	0.00009	$(40 \pm 9) \cdot 10^{-5};\ \varepsilon = 23\%;\ \alpha = 0.95$
0.00004	0.00007	$(4 \pm 7) \cdot 10^{-5};\ \varepsilon = 180\%;\ \alpha = 0.95$
0.000412	0.000033	$(41.2 \pm 3.3) \cdot 10^{-5};\ \varepsilon = 8\%;\ \alpha = 0.95$
-0.00037	0.00009	$(-37 \pm 9) \cdot 10^{-5};\ \varepsilon = 24\%;\ \alpha = 0.95$
-0.00013	0.00008	$(-13 \pm 8) \cdot 10^{-5};\ \varepsilon = 60\%;\ \alpha = 0.95$
0.00019	0.00008	$(19 \pm 8) \cdot 10^{-5};\ \varepsilon = 40\%;\ \alpha = 0.95$
-0.000231	0.000014	$(-23.1 \pm 1.4) \cdot 10^{-5};\ \varepsilon = 6\%;\ \alpha = 0.95$
0.00046	0.00005	$(46 \pm 5) \cdot 10^{-5};\ \varepsilon = 11\%;\ \alpha = 0.95$

Таблица 2: Моя подпись

$$\sqrt{\left(\frac{\partial}{\partial R}\sqrt{R^2 + W^2}\right)^2 \Delta_W^2 + \left(\frac{\partial}{\partial W}\sqrt{R^2 + W^2}\right)^2 \Delta_R^2} = \sqrt{\frac{R^2\Delta_W^2}{R^2 + W^2} + \frac{W^2\Delta_R^2}{R^2 + W^2}} = 2.56 \cdot 10^{-1}$$

Этот текст ссылается на Таблицу 2

The next code will be directly imported from a file

```python
#!/usr/bin/python

# complex_report.py

import random
from pylatex import Document, LongTable, Math, MeasurementsRepr, Label, Marker, Ref, THREE_DIGITS_AFTER_COMMA, NoEscape
from pylatex.utils import bold
from sympy import *
from sympy.abc import W, R
import pandas as pd


def generate_unique():
    geometry_options = {
        "head": "40pt",
        "margin": "0.5in",
        "bottom": "0.6in",
        "includeheadfoot": True
    }
    doc = Document(geometry_options=geometry_options, language='russian')

    t_head_names = ["chanel", "measurement"]
    table_1 = pd.read_csv("../data/table_1.csv", sep=";", names=t_head_names)

    # Add statement table
    with doc.create(LongTable("| l | c |")) as longtable_1:
        longtable_1.add_hline()
        for index, row in table_1.iterrows():
            if index == 0:
                longtable_1.add_row([row.chanel, row.measurement],
                                    mapper=bold,
                                    color="lightgray")
            else:
                print(row.chanel)
                longtable_1.add_row([NoEscape(row.chanel), row.measurement])
            longtable_1.add_hline()

        label = Label(Marker("table:1"))
        longtable_1.add_caption("       ")
        longtable_1.append(label)

    with doc.create(LongTable("| l | c | r |",
                              row_height=1.5)) as data_table:
        data_table.add_hline()
        data_table.add_row(["Measure", "Abs_err", "Full text"],
                           mapper=bold,
                           color="lightgray")
        # data_table.add_empty_row()

        data_table.add_hline()

        for i in range(50):
            measures_config = {
                "show_rel_err": True,
                "no_exp": True,
```

```
                "only_measured_val": True,
                "only_err": False,
                "change_exp": 0,
                "factor_out_err_exp": False,
            }

            mea_repr = MeasurementsRepr((random.random() - 0.5) * 10 ** -3, (random.random()) * 10 ** -4)
            mea_repr.set_config(**measures_config)
            measure = Math(data=[mea_repr.latex()], escape=False, inline=True)

            measures_config.update(only_measured_val=False,
                                   only_err=True)
            mea_repr.set_config(**measures_config)
            abs_err = Math(data=[mea_repr.latex()], escape=False, inline=True)

            measures_config.update(only_measured_val=False,
                                   only_err=False,
                                   factor_out_err_exp=True,
                                   no_exp=False)
            mea_repr.set_config(**measures_config)
            full_line = Math(data=[mea_repr.latex()], escape=False, inline=True)

            row = [measure, abs_err, full_line]
            data_table.add_row(row)
            data_table.add_hline()

        label = Label(Marker("table:2"))
        data_table.add_caption("      ")
        data_table.append(label)

    # doc.append(NewPage())
    f = sqrt(W ** 2 + R ** 2)
    delta_R = IndexedBase(r"\Delta")
    delta_W = IndexedBase(r"\Delta")

    delta_f = sqrt((Derivative(f, W) * delta_R[R]) ** 2 + (Derivative(f, R) * delta_W[W]) ** 2)
    sub = {
        R: 3,
        W: 2,
        delta_R[R]: 0.1,
        delta_W[W]: 0.3
    }
    derivatives = delta_f.doit()
    evaluated = derivatives.evalf(subs=sub)

    mea_repr = MeasurementsRepr(float(evaluated), THREE_DIGITS_AFTER_COMMA)
    measures_config.update(only_measured_val=True, only_err=False, factor_out_err_exp=True, no_exp=False)
    mea_repr.set_config(**measures_config)

    doc.append(Math(data=[
        f"{latex(delta_f)} = {latex(derivatives)} = {mea_repr.latex()}",
    ],
        escape=False)
    )
    doc.append("                   ")
```

```python
    doc.append(Ref(Marker("table:2")))
    doc.generate_tex("../pages/complex_report")


if __name__ == '__main__':
    generate_unique()
```

Список литературы

[Бей16] Кристина Бейбл. «Monte Carlo Simulation and Analysis of the $t\bar{t}H$ Process With the ATLAS experiment at $\sqrt{s} = 13$ TeV». BA thesis. Школа, 2016.

[Col21] CMS Collaboration. «Обширное описание издания at $\sqrt{s} = 13$ TeV Using Effective Field Theory». В: *Journal of High Energy Physics* 2021, 95 (2021). DOI: `10.1007/JHEP03(2021)095`. arXiv: `2012.04120 [hep-ex]`.

Subbibliography

[Бей16] Кристина Бейбл. «Monte Carlo Simulation and Analysis of the $t\bar{t}H$ Process With the ATLAS experiment at $\sqrt{s} = 13$ TeV». BA thesis. Школа, 2016.

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