2016 TITLE 24, PART 6
RESIDENTIAL

HIGH EFFICACY LIGHTING

Sample MATLAB Fourier Low Pass Filter Routine

for Reporting Flicker Measurements in Accordance
with Title 24, Part 6 JA10 and JA8

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The report provides information on best-practice approaches related to compliance with the California's 2016 Building Energy Efficiency Standards (Title 24, Part 6).

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California's 2016 Title 24, Part 6 Building Energy Efficiency Standards (Energy Standards) (effective January 1, 2017) require all light sources installed in new residences to be "high efficacy" as defined by the by Table 150.0-A in these standards. Except for some legacy high efficacy light source types (e.g., pin-based linear fluorescent lamps, pin-based CFLs and pulse start metal halide), most other light sources installed in new residences are required to comply with the Energy Standards Reference Joint Appendix JA8 (JA8), Qualification Requirements for High Efficacy Light Sources, in order to be considered high efficacy. Light sources meeting JA8 must be marked "JA8-2016" or, for light sources rated for use at elevated temperatures, "JA8-2016-E".

Light sources compliant with JA8 must also be certified to the California Energy Commission as having a source efficacy greater than or equal to 45 lm/W and must meet various quality criteria including low flicker operation. "Low flicker operation" is defined as amplitude modulation (Percent Flicker) lower than 30% at frequencies less than 200 Hz. A test method for flicker measurements is specified in the Energy Standards Reference Joint Appendix JA10 (JA10), Test Method for Measuring Flicker of Lighting Systems and Reporting Requirements. This test method includes a data processing standard that requires low pass filtering of data using Fourier transforms so that amplitude modulation of light sources can be reported below certain cut-off frequencies. This is important for understanding the amount of flicker generated by a given light source as humans are more sensitive to light amplitude modulation at lower frequencies than at higher frequencies.[1] The 2016 JA8 database contains amplitude modulation data for different frequencies to better understand the flicker characteristics of various complying light sources.

Accompanying this report are three files which can be downloaded from EnergyCodeAce.com:

- A sample data header ("sample-header.csv") to which you can append test data
- A sample data file ("sample-datafile.csv") with both the header information and sample data, we have included the filtered amplitude modulation information in this file so you can compare your results
- MATLAB script M-file ("JA10FourierFilter.m") that will import this source data and export two files into the same file folder as the original file:
  - One file with data in the identical format as the source data but containing the calculated amplitude modulation results after filtering the data for various cut-off frequencies.
  - Another file containing the flicker (amplitude modulation) results in the MSEXCEL format used for uploading data into the 2016 JA8 database. Most of the rest of the results still need to be filled in, but the data is in the correct format (including headers) as required for uploading to the 2016 JA8 database.

Included below on page 3 of this document is the header information to which the raw high speed photometric data is appended. This simplifies the process of placing the data in the correct format, processing the data for the 2016 JA8 database, and having on-hand all the data in the JA10 format, including the raw photometric data ready in case requested by the Energy Commission. JA10.7, Test Report and Data Format states the following regarding the storage of the raw photometric data:

> For all systems where reporting of flicker is required, the test data shall be submitted to the California Energy Commission in the format specified in Table JA-10. For two years from the date of certification, the entity submitting the test report shall keep all documentation required for compliance, stored and shall provide copies of this documentation to the Energy Commission within 10 days of written request received from the Commission. This documentation shall also include for each measured system, a digital file containing the raw photometric data as described in Section JA10.5.

[1] For more information, see IEEE Standard PAR 1789-2015: Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers. Institute of Electrical and Electronics Engineers. New York.

Format of Source Data in Modified JA10 Format

Table 1 below indicates the format of the source data table that is compatible with the associated sample MATLAB command window language provided in this document. The red underlined text indicates areas that were added to the original Table JA-10-1. These additions enhance the clarity of the data and also include the raw photometric data. In this format, the data is all in one place for future retrieval needs as previously described.

Row No.	Data Label (first column)	Units/Format (data in following columns)	Data Format
1	Test Date	mm/dd/yyyy	1 text+ 1 text
2	Test Operator	Company Name, Contact Name, Address, Phone Number, e-mail address	1 text+ 5 text
3	Entity submitting results	Company Name, Contact Name, Address, Phone Number, e-mail address	1 text + 5 text
4	Rated Product	Dimmer, light source, ballast or driver Manufacturer or Brand	1 text + 1 text
5	Tested lighting system component: Dimmer	Dimmer type, Manufacturer, or Brand, model number Dimmer Type (use following codes): FPC - Forward Phase Cut Controls RPC - Reverse Phase Cut Controls PLC - Powerline Carrier Controls DDC - Direct Digital Controls VDC - 0-10 Volt DC Controls	1 text + 4 text
6	Tested lighting system component: light source (lamp or light engine)	Light source type (lamp, light engine, etc), Manufacturer, or Brand, model number	1 text + 4 text
7	Tested lighting system component: Ballast or Driver	Ballast or Driver, Manufacturer, or Brand, model number (enter NA if not applicable also applies to integral lamps)	1 text + 4 text
8	Recording interval (sec)	sec (no greater than 0.00005 sec)	1 text + 1 number
9	Equipment Measurement Period (sec)	sec (no less than 1 second)	1 text + 1 number
10	Count of data points	number of measurements, (no less than 20,000)	1 text + 1 number
11	Nominal Fraction of Max Light Output	"Nominal 100% Output, Nominal 20% Output, Minimum Rated Output"	1 text + 3 text
12	Measured fraction of max output	Fraction of rated light output integrated over measurement period at: 100%, 20% and minimum fraction of light output.	1 text + 3 number
13	Amplitude modulation unfiltered	calculated percent amplitude modulation unfiltered for each dimming level (100%, 20% and minimum fraction of light output). Percent amplitude modulation values are calculated in decimal fraction format: 1.00 = 100% amplitude modulation.[1]	1 text + 3 number
14	Amplitude modulation with 1000 Hz cut-off	calculated percent amplitude modulation, data filtered with a 1,000 Hz cut-off frequency for each dimming level: (100%, 20% and minimum fraction of light output)	1 text + 3 number
15	Amplitude modulation with 400 Hz cut-off	calculated percent amplitude modulation, data filtered with a 400 Hz cut-off frequency for each dimming level: (100%, 20% and minimum fraction of light output) [Units = Decimal Fraction, 100% AM = 1.0]	1 text + 3 number
16	Amplitude modulation with 200 Hz cut-off	calculated percent amplitude modulation, data filtered with a 200 Hz cut-off frequency for each dimming level: (100%, 20% and minimum fraction of light output) [Units = Decimal Fraction, 100% AM = 1.0]	1 text + 3 number
17	Amplitude modulation with 90 Hz cut-off	calculated percent amplitude modulation, data filtered with a 90 Hz cut-off frequency for each dimming level: (100%, 20% and minimum fraction of light output) [Units = Decimal Fraction, 100% AM = 1.0]	1 text + 3 number
18	Amplitude modulation with 40 Hz cut-off	calculated percent amplitude modulation, data filtered with a 40 Hz cut-off frequency for each dimming level: (100%, 20% and minimum fraction of light output) [Units = Decimal Fraction, 100% AM = 1.0]	1 text + 3 number
19	Reserved for Future Use	Placeholder for future implementation of global flicker metric such as normalized modulation, one value for each dimming level	1 text + 3 number
20	Reserved for Future Use	Placeholder for future global flicker metric such as frequency weighted amplitude modulation, one value for each dimming level	1 text + 3 number
21	Raw data below: Time Stamp	"Nominal 100% Output, Nominal 20% Output, Minimum Rated Output"	1 text + 3 text
22+ num data pts	Time	Raw photometric data for each dimming level: (100%, 20% and minimum fraction of light output) (at least 20,000 rows)	1 number + 3 numbers

[1] In JA10, the Percent Amplitude Modulation equation yields a value between 0 and 100. For submitting Amplitude Modulation values to the JA8-2016 section of the MAEDBS, the values for amplitude modulation are specified to be in decimal fraction format between 0.00 and 1.00. As a result, all amplitude modulation calculations in the tools provided here are formatted to yield a decimal fractional result between 0.00 and 1.00 instead of between 0 and 100. Original Equation for Percent Amplitude Modulation in JA10.6: Percent Amplitude Modulation = (Max-Min) / (Max + Min) x 100. The following Amplitude Modulation equation is used for reporting to 2016 JA8 section of the MAEDBS and is also used in the Modified JA10 file format. Amplitude Modulation = (Max-Min) / (Max + Min).

Table 1: Modified TABLE JA-10-1. FLICKER DATA TO BE RECORDED AND SUBMITTED TO THE CALIFORNIA ENERGY COMMISSION

The source data file and the modified processed JA10 data files are designed in identical formats. The original source data file contains dummy values (not yet calculated in the source data file but serve as placeholders) for the amplitude modulation at various cut-off frequencies. Two lines of placeholder values are included below the amplitude modulation values for future use. Amplitude modulation values are calculated when the source data is imported by the MATLAB program and a nearly identical file is exported with the calculated amplitude modulation values. It is recommended to place zeros in all amplitude modulation fields in the source data file, or leave these fields blank in the original data file so it is clear that amplitude modulation and normalized modulation have not been calculated in the source data file. When the data is processed, the zeros or blanks will be overwritten with the calculated amplitude modulation and normalized modulation values (rows 13 through 20). In the exported file, the rest of the original data will be unchanged outside of amplitude modulation, values for unfiltered data as well as data filtered below: 1,000 Hz, 400 Hz, 200 Hz, 90 Hz and 40 Hz. The amplitude modulation values associated the 200 Hz cut-off frequency are used for showing compliance with the JA8 requirements. The amplitude modulation values for other cut-off frequencies can be compared against the frequency dependent maximum amplitude modulation recommendations in IEEE PAR 1789 or other standards.

The modified file name has "ModifiedJA10-" appended to the beginning of the original file name. For example, if the original filename is "ABClamp.csv" the modified filename will be "ModifiedJA10-ABClamp.csv." The "ModifiedJA10-ABClamp.csv" has the identical file structure as the original "ABClamp.csv" file. As a result, if the original file is mislaid, one can use this program to reprocess the "ModifiedJA10-ABClamp.csv" file and the newly processed file will be called: "ModifiedJA10- ModifiedJA10-ABClamp.csv." When calculated a second time, the amplitude modulation values should not change.

Sample Input File

The following sample input file may be used as a template for inserting header information above the high frequency photometric data. At least 20,000 rows of data follow this header information. The number of rows of data must match the "count of data points" entry in row 10. This sample file ("sample-header.csv") can be downloaded from EnergyCodeAce.com.

```
Test Date,1/1/2017
Test Operator,AAAA Testing Labs,Joe Black,PO Box 2## Sacramento CA,916-555-1212,joeb@ xxxxx
Entity submitting results,ABC Lamps,Jane White,PO Box 3### Sacramento CA,916-555-1213,janew@ xxxxx
Rated Product,Lamp
Tested lighting system component: Dimmer ,FPC,DEF Electronics,DEF Dimmers,Forward120VXX
Tested lighting system component: light source (lamp or light engine),Light engine,ABC Lighting,ABC SmartLamp II,Down-I.1.19.4
Tested lighting system component: Ballast or Driver,Driver,GHI Electronics,Micro Driver,MDXX532
Recording interval (sec),-5E-05
Equipment Measurement Period (sec),2.00009995
Count of data points,40004
Nominal Fraction of Max Light Output,Nominal 100% Output,Nominal 20% Output,Minimum Rated Output
Measured fraction of max output,0.99,0.21,0.009
Amplitude modulation unfiltered,0,0,0
Amplitude modulation with 1000 Hz cut-off,0,0,0
Amplitude modulation with 400 Hz cut-off,0,0,0
Amplitude modulation with 200 Hz cut-off,0,0,0
Amplitude modulation with 90 Hz cut-off,0,0,0
Amplitude modulation with 40 Hz cut-off,0,0,0
Reserved for future use, 0, 0, 0
Reserved for future use, 0, 0, 0
Raw data below: Time Stamp,Nominal 100% Output,Nominal 20% Output,Minimum Rated Output
-1.00010002, 7.301304, 3.166831, 0.08796752
<followed by 40,003 additional data points>
```

*Note: If you use this text box to create an input file header in MS Excel, you will also need to "convert text to columns" using the comma delimiter. You may also choose to use the *.csv header file available on EnergyCodeAce.com at www.link.com.*

Figure 1 below is a screen shot of what this file looks like when opened in Microsoft Excel and with the column widths adjusted.

Example Modified JA10- Data File

Figure 2 below shows the exported "ModifiedJA10-[OriginalFilename.csv]" file. This file contains all the data needed to be stored for two years in accordance with the requirements of 2016 Title 24, Part 6 Joint Appendix JA10. This stored data has a history of who performed the test, what combination of products were combined to develop the data, the raw data collected, and the calculated amplitude modulation data for various cut-off frequencies.

This file is identical to the original data file except the amplitude modulation data (previously zeros) is filled in. The Fourier analysis used to filter the high speed photometric data can be re-run as all the original data is contained in this file and same format.

	A	B	C	D	E	F
1	Test Date	1/1/2017				
2	Test Operator	AAAA Testing Labs	Joe Black	PO Box 2## Sacrame	916-555-1212	joeb@ xxxxx
3	Entity submitting results	ABC Lamps	Jane White	PO Box 3### Sacram	916-555-1213	janew@ xxxxx
4	Rated Product	Lamp				
5	Tested lighting system component: Dimmer	FPC	DEF Electronics	DEF Dimmers	Forward120VXX	
6	Tested lighting system component: light source (lamp or light engine)	Light engine	ABC Lighting	ABC SmartLamp II	Down-I.1.19.4	
7	Tested lighting system component: Ballast or Driver	Driver	GHI Electronics	Micro Driver	MDXX532	
8	Recording interval (sec)	5.00E-05				
9	Equipment Measurement Period (sec)	2.00E+00				
10	Count of data points	40000				
11	Nominal Fraction of Max Light Output	Nominal 100% Outpu	Nominal 20% Output	Minimum Rated Output		
12	Measured fraction of max output	0.99	0.21	0.009		
13	Amplitude modulation unfiltered	0	0	0		
14	Amplitude modulation with 1000 Hz cut-off	0	0	0		
15	Amplitude modulation with 400 Hz cut-off	0	0	0		
16	Amplitude modulation with 200 Hz cut-off	0	0	0		
17	Amplitude modulation with 90 Hz cut-off	0	0	0		
18	Amplitude modulation with 40 Hz cut-off	0	0	0		
19	Reserved for Future Use	0	0	0		
20	Reserved for Future Use	0	0	0		
21	Raw data below: Time Stamp	Nominal 100% Outpu	Nominal 20% Output	Minimum Rated Output		
22	-1	3.870571	1.143578	1.143578		
23	-0.99995	3.782603	1.143578	1.143578		

*Figure 1: Screen shot of input file in MSExcel before saved as a *.csv (comma separated value) file.*

	A	B	C	D	E	F	G
1	Test Date	1/1/2017					
2	Test Operator	AAAA Testing Labs	Joe Black	PO Box 2## Sacrame	916-555-1212	joeb@ xxxxx	
3	Entity submitting results	ABC Lamps	Jane White	PO Box 3### Sacram	916-555-1213	janew@ xxxxx	
4	Rated Product	Lamp					
5	Tested lighting system component: Dimm	FPC	DEF Electronics	DEF Dimmers	Forward120VXX		
6	Tested lighting system component: light s	Light engine	ABC Lighting	ABC SmartLamp II	Down-I.1.19.4		
7	Tested lighting system component: Ballas	Driver	GHI Electronics	Micro Driver	MDXX532		
8	Recording interval (sec)	5.00E-05					
9	Equipment Measurement Period (sec)	2.00E+00					
10	Count of data points	40000					
11	Nominal Fraction of Max Light Output	Nominal 100% Outpu	Nominal 20% Output	Minimum Rated Output			
12	Measured fraction of max output	0.99	0.21	0.009			
13	Unfiltered Amplitude Modulation	0.611	0.167	0.167			
14	Amplitude Mod 1000 Hz cut-off	0.596	0.175	0.175			
15	Amplitude Mod 400 Hz cut-off	0.576	0.158	0.158			
16	Amplitude Mod 200 Hz cut-off	0.528	0.14	0.14			
17	Amplitude Mod 90 Hz cut-off	0.022	0.019	0.019			
18	Amplitude Mod 40 Hz cut-off	0.005	0.008	0.008			
19	Reserved for future use	0	0	0			
20	Reserved for future use	0	0	0			
21	Raw data below: Time Stamp	Nominal 100% Outpu	Nominal 20% Output	Minimum Rated Output			
22	-1	3.870571	1.143578	1.143578			
23	-0.99995	3.782603	1.143578	1.143578			

Figure 2: Screen view of Modified JA10.csv file – note this includes the calculated amplitude modulation*

Running Sample Fourier Filtering MATLAB script "JA10FourierFilter.m"

The sample Fourier Filtering MATLAB script "JA10FourierFilter.m" can be downloaded from EnergyCodeAce.com.

To use this script you must have a copy of MATLAB software. Click on the "JA10FourierFilter.m" script file and the MATLAB program will run with script file loaded or open the MATLAB program and open the script from within MATLAB. Once the script file is loaded press the "Run" button on the Editor tab of MATLAB.

When running this file, a pop-up box will open containing disclaimers about the program and will ask if you agree to use this program at your own risk. See Figure 3. If you click "No" or close this box up without responding "Yes" the program will not load. Only by clicking on the Yes button in the disclaimer pop-up box will the program run.

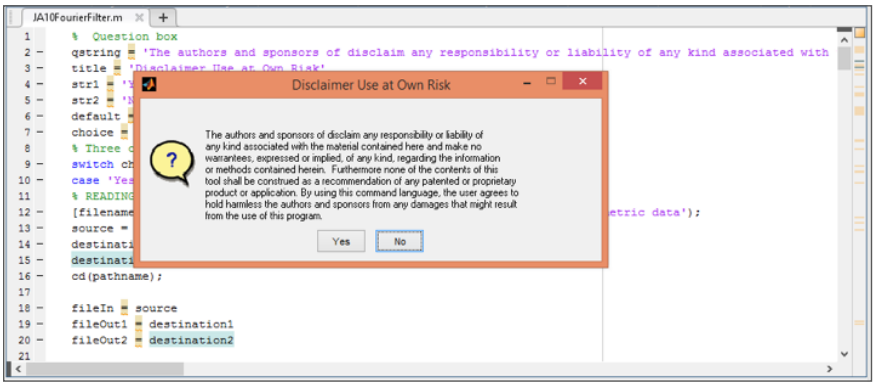

Figure 3: MATLAB program disclaimer pop-up

The program starts by opening a pop-up window with the heading "Select JA-10 csv file file with photometric data." Navigate through the file structure until you select your desired input file and double click on the filename of click the "open" button. The output files will be exported to this same directory and if the input file name is "TestLamp.csv,"the output file names will be "ModifiedJA10-TestLamp.csv" and "FlickerJA8-TestLamp.csv."

If you select a file type that is the wrong file structure, the command window will contain a series of error statements. If this occurs, close MATLAB and restart. If you selected the correct file and you received an error message, make sure that you have indicated the correct number of data points in the header as there are in the raw high frequency photometric data below. Also check that the format of the input data matches that in the sample header file.

Exported 2016 JA8 Database File Structure

Figure 4 below shows the file structure that is requested by the Energy Commission for uploading the data into the 2016 JA8 database. The resulting exported processed file will have all the file headers and available flicker data formatted appropriately. However, for data that is unrelated to the flicker testing, there are blanks in the correct locations for filling in later. Note that this particular tool will create one Flicker-JA8.csv (comma separated value) file for each file that is processed. However, the data from multiple processed JA8 .csv files can be combined by opening these files in MS Excel into one JA8 upload Excel file (with extension .xls) with a single header row and multiple rows of equipment data with one row of data (from each flicker JA8 csv file) for each product with a unique model number.[2]

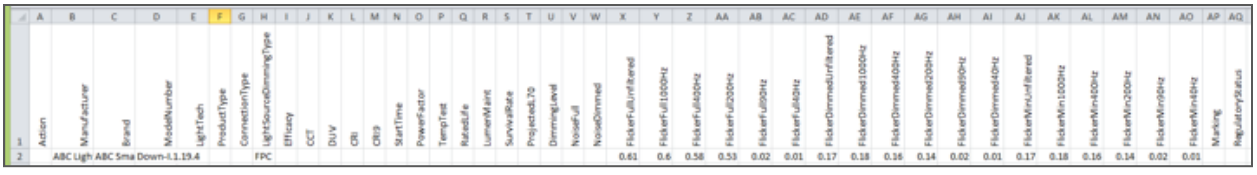

Figure 4: California Energy Commission's 2016 JA8 High Efficacy Lighting (JEFF) spreadsheet format for uploading JA8 certification data

[2] If the product is capable of being dimmed by more than one type of dimmer (e.g., Forward Phase Cut, Reverse Phase Cut, Powerline Carrier, Digital or 0-10 Volt controls), a separate test must be conducted for each type of dimmer and an added line included in the 2016 JA8 database.

The modified file name for this second exported file has "FlickerJA8- " appended to the beginning of the original file name. For example, if the original filename is "ABClamp.csv" the modified filename will be "FlickerJA8-ABClamp.csv."

The "FlickerJA8-," as seen in Figure 5, will have the following information pre-filled out:

- Column B – Light Source Manufacturer
- Column C – Light Source Brand
- Column D – Light Source Model Number
- Column H – Dimmer Type
- Columns X though AO – Three sets (full light output, 20% light output, and minimum light output) of flicker amplitude modulation for the following low pass cut off frequencies: unfiltered, 1,000 Hz, 400 Hz, 200 Hz, 90 Hz, and 40 Hz.

If a product tested at both full light output and 20% light output has an amplitude modulation at both of these dimming levels that is less than 30% (0.30) for the 200 Hz cut-off frequency, the tested product combination is considered to comply with the "low flicker operation" requirement. For example, if the values in both columns AA and AG are less than 0.30, those products will be in compliance with the 2016 JA8 "low flicker operation" requirement.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ
1	Action	Manufacturer	Brand	ModelNumber	LightTech	ProductType	ConnectionType	LightSourceDimmingType	Efficacy	CCT	DUV	CRI	CRI9	StartTime	PowerFactor	TempTest	RatedLife	LumenMaint	SurvivalRate	ProjectedL70	DimmingLevel	NoiseFull	NoiseDimmed	FlickerFullUnfiltered	FlickerFull1000Hz	FlickerFull400Hz	FlickerFull200Hz	FlickerFull90Hz	FlickerFull40Hz	FlickerDimmedUnfiltered	FlickerDimmed1000Hz	FlickerDimmed400Hz	FlickerDimmed200Hz	FlickerDimmed90Hz	FlickerDimmed40Hz	FlickerMinUnfiltered	FlickerMin1000Hz	FlickerMin400Hz	FlickerMin200Hz	FlickerMin90Hz	FlickerMin40Hz	Marking	RegulatoryStatus
2		ABC Lighting	ABC Smart Lamp II	Down-1.1.19.4				FPC																0.15	0.15	0.14	0.14	0.01	0	0.14	0.15	0.15	0.12	0.02	0.01	0.33	0.06	0.02	0.01	0.01	0		
3																																											

Figure 5: Flicker JA8-ABClamp.csv file in California Energy Commission Excel format for uploading to 2016 JA8 database

Sample Fourier Filtering Command Language for MATLAB

The data processing here is based upon the use of Fourier transforms to act as a low-pass filter and remove frequency components that are above a given cut-off frequency. Percent amplitude modulation (depth of modulation) is calculated for the filtered data below the cut-off frequencies. Manufacturers and test laboratories can opt to use the sample command language below or they can download the MATLAB script M-file ("JA10FourierFilter.m") on EnergyCodeAce.com.

```
%  Question box
qstring = 'The authors and sponsors of disclaim any responsibility or liability of any kind associated with the material contained here and make no warrantees, expressed or implied, of any kind, regarding the information or methods contained herein.  Furthermore none of the contents of this tool shall be construed as a recommendation of any patented or proprietary product or application. By using this command language, the user agrees to hold harmless the authors and sponsors from any damages that might result from the use of this program.'
title = 'Disclaimer Use at Own Risk'
str1 = 'Yes'
str2 = 'No'
default = 'No'
choice = questdlg(qstring,title,str1,str2,default)
% Three choices: Yes, No and Close the dialogue box without answering
switch choice
case 'Yes'    % Accept the disclaimer
% READING FILE DATA INTO ARRAYS
[filename, pathname] = uigetfile('*.csv', 'Select JA-10 csv file with photometric data');
source = strcat(pathname, filename);
destination1 = strcat(pathname,'ModifiedJA10-',filename);
destination2 = strcat(pathname,'FlickerJA8-',filename);
cd(pathname);
```

```
fileIn = source
fileOut1 = destination1
fileOut2 = destination2

fidIn = fopen(fileIn);
fidOut1 = fopen(fileOut1,'w+');

% Skip first 4 lines of input file
for Nline = 1:4 % Moves input file ahead to line 5
   tline = fgets(fidIn);
end

%Reading in dimmer type from input file header
formatSpec = '%s';
C_text5 = textscan(fidIn,formatSpec,5, 'Delimiter', ',');
fclose(fidIn);
fidIn = fopen(fileIn);

% Skip first 5 lines of input file and read in lighting product information
for Nline = 1:5 % Moves input file ahead to line 5
   tline = fgets(fidIn);
end

C_text6 = textscan(fidIn,formatSpec,5, 'Delimiter', ',');

DimmingType = C_text5{1}{2}
Manufacturer = C_text6{1}{3}
Brand = C_text6{1}{4}
ModelNumber = C_text6{1}{5}

fclose(fidIn);
fidIn = fopen(fileIn);

% ***********Collect information about the test (number of readings, interval rate etc)**********
%  The row and column arguments are zero based, so that row = 0 and col = 0 specify the first value in the file
%  Variable = csvread(filename,row,col,csvRange) reads only the range specified by csvRange
%  Variable = csvread('csvlist.dat',1,0,[1,0,2,2]) once in M the index of the array starts with 1

Interval = csvread(fileIn,7,1,[7,1,7,1]) % Time period between each recorded measurement (8th row 2nd column)
Duration = csvread(fileIn,8,1,[8,1,8,1]) % Length of total measurement Duration (9th row 2nd column)
N = csvread(fileIn,9,1,[9,1,9,1]) % Number of data points (10th row 2nd column)

fS = (1/Interval) % sampling frequency of recorded data
Nz = floor(Duration/Interval)  % Nz should equal N
FracMeas = csvread(fileIn,11,1,[11,1,11,3])  % fraction of full light (12 th row 2-4 th columns)

% write to ModifiedJA10- file
% fopen - Open file and overwrite 'w' – only applies to output file
fidOut1 = fopen(fileOut1, 'w');

% Writing first 11 lines from source (input) file to destination (output) file
for Nline = 1:11
   tline = fgets(fidIn);
   fprintf(fidOut1, '%s', tline);
end

% Line 12 echo back Measured fraction from input file into output file
DimmingText = 'Measured fraction of max output' ;
myformat = '%s,%f, %f, %f\r\n';
fprintf(fidOut1, myformat, DimmingText, FracMeas);


% Vectors with 5 elements, CutOffHz - cut off frequencies, and
```

```
% FilterIndex - Fourier coefficient number that corresponds to Cut-off frequency

% Cut-off frequency*Duration = Fourier element number corresponding to cut-off frequency

CutOffHz = [1000 400 200 90 40]
FilterIndex = round(CutOffHz*Duration)
for Hz = 1:5    % 5 cut-off frequencies. See CutOffHz
   % filterindex - how many transform terms allowed before truncation
   % format of MATLAB transform frequency bins ( 0, 1, …N/2, -N/2+1, -N/2+2, …-2, -1)
   % filter array has 1's for low frequencies below cut-off frequency term,
% 0's in middle of array to cut-off high frequencies and
% 1's at end of end of array for low negative frequency terms
   FilterArray(:,Hz) = vertcat(ones(FilterIndex(Hz),1), zeros(N-2*FilterIndex(Hz),1), ones(FilterIndex(Hz),1));
end   % Hz loop

% PD - percent dimming 1 = 100% (full output), 2= 20%, 3 = minimum
% 3 columns of data corresponding to 3 increments of percent dimming

for PD = 1:3
   M=csvread(fileIn,21,PD,[21,PD,N+20,PD]);  % reading starting on line 22 (csvread uses 0 index for first value)
   F = fft(M);

% 5 cut-off frequencies. See CutOffHz **********
for Hz = 1:5
   FilteredFourier = FilterArray(:,Hz).*F;

% Store the filtered Fourier coefficients in a N x PD matrix
   FF(:,Hz) = FilteredFourier;

   InvFF = abs(ifft(FilteredFourier));

% Store filtered time domain data in a N x PD matrix
   FFI(:,Hz) = InvFF;
   AM(Hz,PD) = (max(InvFF) - min(InvFF)) /(max(InvFF) + min(InvFF));

% percent AM as a fraction,
% Note:  value between 0.000 and 1.000 (change from JA 10 which was between 0 and 100)

end     %Hz loop for each cut-off frequency**********

% Unfiltered Fourier evaluate M directly
   Hz = 6;
   AM(Hz,PD) = (max(M) - min(M)) /(max(M) + min(M));  % AM as a fraction < 1

end    % PD loop with data for each dimming level**************

% Display to screen
display(N)
display(FilterIndex)
display(CutOffHz)
display(FracMeas)
display(AM)



% print unfiltered amplitude modulation data to file
   UnfilText = 'Unfiltered Amplitude Modulation';
   myformat = '%s, %6.3f, %6.3f, %6.3f\r\n';  % note: only two decimal places for JA8 file
   newData = [AM(6,1), AM(6,2),AM(6,3)];
   fprintf(fidOut1, myformat, UnfilText, newData);

for Hz = 1:5    % Prints filtered amplitude modulation data to output file
```

```
myformat = '%s, %6.3f, %6.3f, %6.3f\r\n';  % note: only two decimal places for JA8 file
LabelHz = sprintf('Amplitude Mod  %d Hz cut-off', CutOffHz(Hz));
   newData = [AM(Hz,1), AM(Hz,2),AM(Hz,3)];
fprintf(fidOut1, myformat, LabelHz , newData);
end

% Placeholder for Normalized Modulation and Weighted Amplitude Modulation
myformat = '%s, %8.3f, %8.3f, %8.3f\r\n';  % note: can be much greater than 1.

NMText = 'Reserved for future use';
NM = [0, 0, 0]; % overwrite values with 0's while under development
NorMod = [NM(1), NM(2),NM(3)]
fprintf(fidOut1, myformat, NMText, NorMod);

AMwText = 'Reserved for future use';
AMw = [0, 0,0]; % overwrite values with 0's while under development
AMweighted = [AMw(1), AMw(2), AMw(3)]
fprintf(fidOut1, myformat, AMwText, AMweighted);


% Insert Raw data at end of ModifiedJ10 output file
for NIine = 12:20   % Moves input file ahead to line 21
   tline = fgets(fidIn);
end

NIine = 21;   % print header lines from row 21 of Input file to row 21 of output file
   tline = fgets(fidIn);
   fprintf(fidOut1, '%s', tline);

% read in high frequency photometric data (flicker data)
RawData=csvread(fileIn,21,0,[21,0,N+20,3]); % reading starting on line 22 (csvread uses 0 index for first value)

% transpose and write high frequency photometric data (flicker data) to output file
RawDataT = transpose(RawData);
myformat = '%f, %f, %f, %f\r\n';
   fprintf(fidOut1, myformat, RawDataT);

fclose(fidOut1);
fclose(fidIn);

% JA10 file finished and closed
%************************************************************

% write to FlickerJA8- file
fidOut2= fopen(fileOut2, 'w+');
% Column labels in first row of JA8-2016 file for MAEDBS database
A = {'Action';
'Manufacturer';
'Brand';
'ModelNumber';
'LightTech';
'ProductType';
'ConnectionType';
'LightSourceDimmingType';
'Efficacy';
'CCT';
'DUV';
'CRI';
'CRI9';
'StartTime';
'PowerFactor';
'TempTest';
'RatedLife';
```

```
'LumenMaint';
'SurvivalRate';
'ProjectedL70';
'DimmingLevel';
'NoiseFull';
'NoiseDimmed';
'FlickerFullUnfiltered';
'FlickerFull1000Hz';
'FlickerFull400Hz';
'FlickerFull200Hz';
'FlickerFull90Hz';
'FlickerFull40Hz';
'FlickerDimmedUnfiltered';
'FlickerDimmed1000Hz';
'FlickerDimmed400Hz';
'FlickerDimmed200Hz';
'FlickerDimmed90Hz';
'FlickerDimmed40Hz';
'FlickerMinUnfiltered';
'FlickerMin1000Hz';
'FlickerMin400Hz';
'FlickerMin200Hz';
'FlickerMin90Hz';
'FlickerMin40Hz';
'Marking';
'RegulatoryStatus'};

% Transpose labels and print to first row of JA8 file
C = A';
fprintf(fidOut2, '%s,', C{1,1:end-1}) ;
fprintf(fidOut2, '%s\n', C{1,end}) ;


%Fill second row with blanks, equipment tested and flicker (filtered amplitude modulation) data
DataStr = cell(1,23);
DataStr(1,2) = cellstr(Manufacturer);
DataStr(1,3) = cellstr(Brand);
DataStr(1,4) = cellstr(ModelNumber);
DataStr(1,8) = cellstr(DimmingType);

for PD = 1:3
FlickJA8(PD*6-5) =AM(6,PD);
for Hz = 1:5
FlickJA8((PD-1)*6+Hz+1) =AM(Hz,PD);
end  % Hz loop
end   % PD loop

fprintf(fidOut2, '%s,', DataStr {1,1:end}) ;
fprintf(fidOut2, '%6.2f,', FlickJA8);
fclose(fidOut2);
fclose('all');
case 'No'       % 'No' answer to disclaimer window
fclose('all');
case ''         % Closed disclaimer window without answering question
fclose('all');
end
```

For More Information

Primary Documents

- Energy Standards Section 100.1 – Definitions and Rules of Construction
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/section1001definitionsandrulesofconstruction.htm
- Energy Standards Sections 110.9 – Mandatory Requirements for Lighting Control Devices and Systems, Ballasts, and Luminaries
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/section1109mandatoryrequirementsforlightingcontroldevicesandsyst.htm
- Energy Standards Section 130.0 – Lighting Systems and Equipment and Electrical Power Distribution Systems
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/section1300lightingsystemsandequipmentandelectricalpowerdistribu.htm
- Energy Standards Section 150.0(k) – Mandatory Features and Devices
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/section1500mandatoryfeaturesanddevices.htm
- Energy Standards Joint Appendix JA1 – Glossary
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/appendixja1glossary.htm
- Energy Standards Joint Appendix JA8 – Qualification Requirements for High Efficacy Light Sources
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/appendixja8qualificationrequirementsforhighefficacylightsources.htm
- Energy Standards Joint Appendix JA10 – Test Method for Measuring Flicker of Lighting Systems and Reporting Requirements
  energycodeace.com/site/custom/public/reference-ace-2016/Documents/appendixja10testmethodformeasuringflickeroflightingsystemsandrep.htm
- 2016 Title 20 Appliance Efficiency Regulations:
  govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I8F8F3BC0D44E11DEA95CA4428EC25FA0&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default)
- Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification
  energy.ca.gov/appliances/led_lamp_spec/

California Energy Commission Information & Services

- Energy Standards Hotline: 1-800-772-3300 (Free) or
  Title24@energy.ca.gov
- Online Resource Center:
  energy.ca.gov/title24/orc/
  - The Energy Commission's main web portal for Energy Standards, including information, documents, and historical information
- JA8 Compliance for Test Laboratories Fact Sheet:
  energy.ca.gov/2016publications/CEC-400-2016-018/CEC-400-2016-018-FS.pdf
- Instructions for Submitting High-Efficacy Light Sources for Title 24 Appliance Data:
  energy.ca.gov/appliances/database/forms_instructions_cert/Lighting_Products/2016%20JA8%20High%20Efficacy%20Lighting%20(JEFF).zip
- Modernized Appliance Efficiency Database (MAEDBS):
  https://cacertappliances.energy.ca.gov/Login.aspx

Additional Resources

- California Lighting Technology Center (CLTC) Guides:
  - Residential Lighting: What's New in the 2016 Title 24, Part 6 Code?
    cltc.ucdavis.edu/publication/2016-title-24-code-changes-residential
  - Residential Lighting: A guide to meeting or exceeding California's 2016 Building Energy Efficiency Standards
    cltc.ucdavis.edu/publication/residential-lighting-design-guide-2016-standards
- Energy Code Ace:
  EnergyCodeAce.com
  - An online "one-stop-shop" providing free resources and training to help appliance and building industry professionals decode and comply with Title 24, Part 6 and Title 20. The site is administered by California's investor-owned utilities.
    Of special interest:
    - Sample MATLAB Files
      energycodeace.com/download/17579/file_path/fieldList/Report.BP.JA10%20Sample%20MATLAB%20Command.zip
      - Sample data header "sample-header.csv"
      - Sample data file "sample-datafile.csv"
      - Sample Fourier Filtering MATLAB script "JA10FourierFilter.m"
    - Fact Sheets
      energycodeace.com/content/resources-fact-sheets/
      - Residential Lighting 2016
      - Title 20 Certification Overview, Process and FAQs
      - Title 20 Lighting FAQs
      - Residential High Efficacy Lighting for Manufacturers
      - JA10 Flicker – Fourier Transform
    - Title 20 On-Demand Video Training:
      energycodeace.com/content/title-20-training/

    Please register with the site and select an industry role for your profile in order to receive messages about all our free offerings!