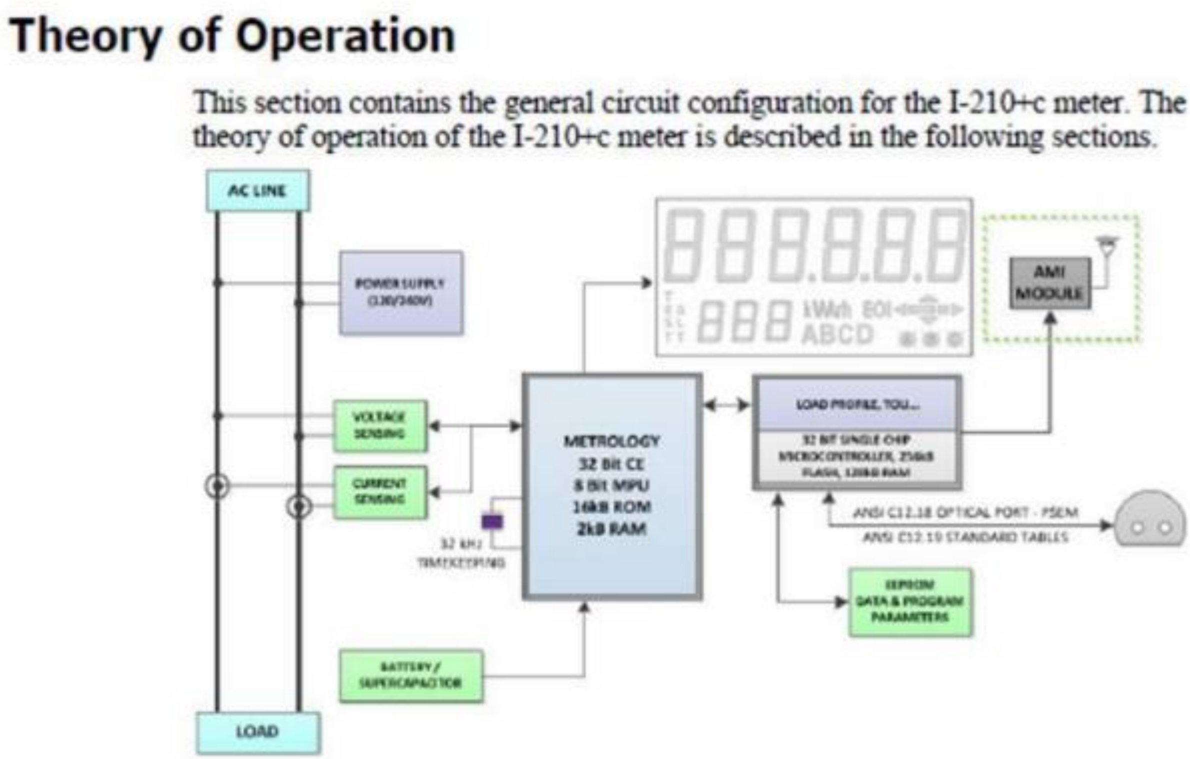
EXPERT REPORT OF William Bathgate

McKnight v PECO, C-2017-2621057

1. Introduction and qualifications

My name is William S. Bathgate, I am employed by TATA Consulting Services (TCS) as an assigned Program Manager for the FCA Automotive Group (Chrysler). My current assignment is for design of autonomous vehicles and the "Connected Vehicle" programs. This requires in-depth knowledge and experience in Radio Communication for WIFI, Cellular and electronic sensing systems for vehicle positioning accuracy. Prior to TATA I worked for Emerson Electric in high voltage / High Current power distribution system. I hold a Top Secret DoD Security Clearance and have been the lead on the design and manufacturing of the power and control systems for the THAD missile defense systems, seconded to Raytheon Corporation thru Emerson Electric. I have a degree in electrical engineering, with over 40 years of practical experience in commercial design and manufacturing of electrical power and computing systems such as the original IBM PC, S/370 Mainframe systems and intermediate platforms such as the AS/400, Unix and Linux systems. I may not have a PhD in electrical engineering, but no academic person has 40 years of practical experience in commercial endeavors in electrical and electronic systems.

In addition I have practical experience in High Voltage 115 KV to 138KV to Low Voltage <1000 Volts power conversion to enable power distribution in large industrial buildings such as the Sears Tower in Chicago, for example. I have been a leader of several design and manufacturing projects that use the same components as used in the AMI meters from several manufactures such as GE, ITRON, SENSUS, ACLARA and Landis+Gyr. I have disassembled each of these meters to understand the technology applied. My observations are that while there are differences in some of the circuit components and the board layouts are different as used by different manufacturers the basic block diagram of all the meters are very close to one another. Here is an example of the block diagram.



These products are basically a small tablet computer with one or two radio transceivers and some come with a relay mechanism to disconnect power remotely. So there are no unique circuit components that are not also used in many industrial control and power switching systems in the market today. In addition I have lead the efforts to obtain product safety certifications, such as UL CSA, CE, PSE and other countries safety certification bodies for many of products I was responsible for. I am highly familiar with the test regimen for Switching Mode Power Supply compliance to FCC Class A and Class B Conducted emissions compliance, in addition to FCC RF Radiated radio emissions. For an explanation of what is a Class A or Class B device see Exhibit mck.wb.ep03.FCCoet62rev.pdf. My resume is attached to this report as Exhibit mck.wb.cv.pdf.

2. My Testing and discovery of the PECO AMI Meter

In my preparation for this case I obtained a GE I-210+C AMI Meter and an Aclara I-210+ meter. Aclara purchased the GE line of AMI meters in November of 2015. The two meters internally are the same despite the model number differences. The I-210+C is the same as the I-210+ meter except the C designation indicates it is a "Demand" regulated meter via the internal software of the computer. The C type meter can have a prepaid billing functions and Time of Use features enabled via a software change. Otherwise the two I-210+ and the I-210+C meter are electrically identical.

I setup a test rig see Exhibit mck.wb.ev01a.Smart Meter Test Setup 1.jpeg and mck.wb.ev01b.Smart Meter Test Setup 1.jpeg to test each of these meters in a controlled environment. I have a second home under a complete teardown state. There are no electrical appliances or other electric circuits active, not even a light bulb. There is no heat of any kind. The power company circuit is fed by an Analog meter. There are no electronic circuits in the Analog meter so there are no supplemental electrical effects that can disrupt the electrical measurements made. Measurements were made with a Laptop PC (An HP Elite book 6930p) and an Oscilloscope (a 100 MHz bandwidth two channel OWON SDS7102V with a sample rate of 1 Giga-samples per second) both were running on internal batteries so there were no added mains power used to power this equipment that could corrupt the meter readings. This OWON oscilloscope in use for these measurement is a current product and on the market for the last several years and is verified for accuracy supported by a current calibration certificate by the National Institute of Standards Testing (NIST). The other common measurement devices on the market today such as the Stetzerwizer Micro surge meter is limited in its ability to provide an actual voltage result, and is expressed in non-standard GS (Graham-Stetzer) units not volts, is limited in that it can only measure frequency signals up to 100 KHz, has a very slow sample rate for measurements (as evidenced by the constant change with wide swings in indicated measurements) and is not calibrated with an actual certified test certificate from the NIST. Therefore it cannot be used as a precision instrument to make certified measurements testimony.

At the house that was used for this test the main power company power comes in to an isolated power transformer on a telephone pole with no other customers sharing the same transformer, into a meter housing with an Analog Meter then into a beaker panel and a 240 volts power connection plug, to the test rig, then to the Aclara I-210+ and/or the GE I-210+C meter. The 120 volts outlet of the A and B side alternately were connected to a special made 4 stage high pass filter that allowed channel 2 (in Yellow) to measure the voltage transients and frequencies beyond the dominant 60 Hz fundamental main power in Channel 1 (in Red). A high pass filter rejects (cuts off) the 60 Hz main power frequency and all frequencies below 60 Hz, but allows those above 60 Hz to pass on to the measurement oscilloscope. You have to have this high pass filter to conduct these types of measurements and is a common practice in electronic circuit design testing.

3. Test Results for Conducted Emissions of the PECO AMI Meter

In the chart file name Exhibit mck.ev02.Aclara I-210+ = no devices powered 3-25-2018 at 200mv scale for transients.jpeg and Exhibit mck.ev03.GE I-210+C = no devices powered 3-25-2018 at 200mv scale for transients.JPEG you see the 60 Hz mains power in red color (Channel 1) and the transients in yellow color (Channel 2). The red scale is 50 Volts per division for the mains power, and a division is a large square block on the chart, so while many people think the power outlets in their home are 120 volts, it is not the actual peak voltage. It is actually about 167 peak volts not 120. The common reference is to a 120 Volts RMS (Root Mean Square). The red waveform is called a sine wave and is a smooth in curvature and format. You can count the major division squares to see the peak of 167 volts above and below the centerline for a total peak to peak of about 334 volts. This is a normal condition.

In the yellow trace you will notice an erratic waveform that is at a 200 Millivolts scale per major division for an approximate peak to peak voltage of about 300 Millivolts. This voltage is called the conducted emissions and is created within the internal electronics of the meter in a circuit called a switched mode power supply (SMPS). This circuit converts the incoming 240 volts AC into the meter from the mains power transformer into much lower DC voltages that the electronics require to function. All electronic devices require DC volts to operate the electronic circuit chips in such devices. An AMI meter is both an AC and a DC device. As part of that conversion process there is a very fast switching circuit called a MOSFET transistor or similar electronic devices that can switch at very high frequencies anywhere from 16 KHz to 150 KHz depending on the design requirements. So the MOSFET or other circuit switching at 16 KHz or higher, unknown to many has numerous 1 thru 50 harmonic octaves of that 16 KHz, to 32 KHz, 64 KHz, 128 KHz and so forth. It can also go the other direction from 16 KHz, such as 8 KHz, 900 Hz and so forth. It is much like a tuning fork, where there are octaves above and below the first fundamental frequency that go on and on. Just like a piano tuner uses to tune all the keys of a piano. In the Analog meter there are no electronic components that create these kind of transients see Exhibit mck.wb.ev08.Baseline – Analog Meter Baseline 200mv scale – no devices powered 3-25-2018.jpeg. During the testing conducted there were no electrical circuits present other than the electric meter and a power disconnect. This Analog meter was in place between the Mains power feed from the utility and the test setup. As you can see from this Exhibit mck.wb.ev08.Baseline – Analog Meter Baseline 200mv scale – no devices powered 3-25-2018.jpeg there are no perceptible transients present.

4. Other harmonics

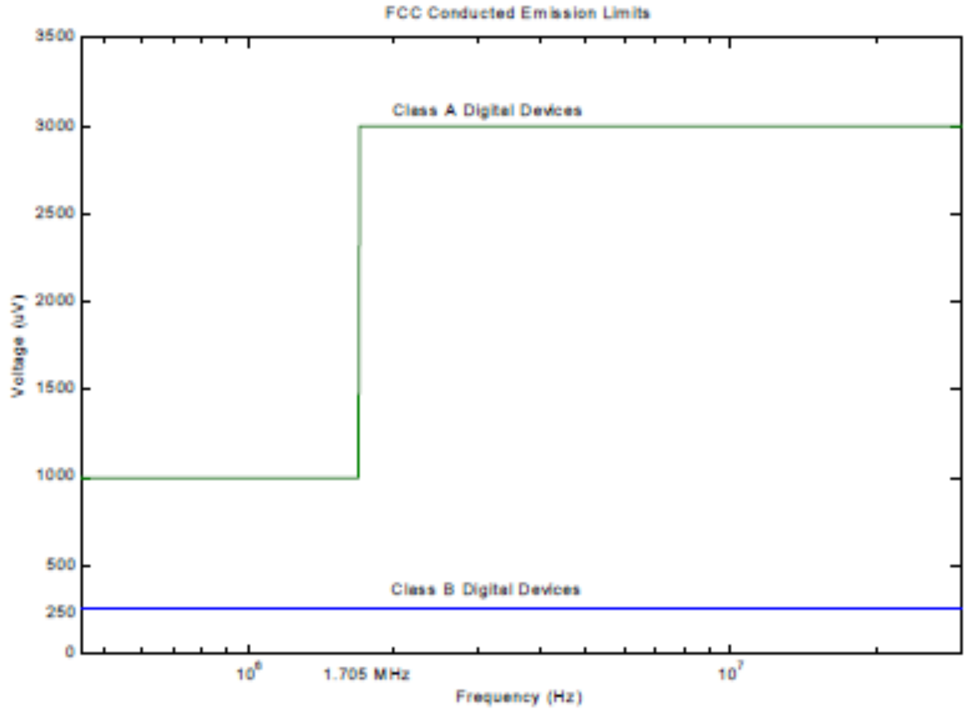
In the test conducted you will notice two other graphs with a Fast Fourier Transformation (FFT) representation. An FFT is an algorithm that samples a signal over a period of time and divides it into its frequency components. So, it is not necessary to overly analyze the FFT graph, but you can see the numerous frequencies present on the powerline and if I continued the graph it would go on thru at least 10 MHz or more. These are represented as Exhibit mck.wb.ev04.GE I-210+C = no devices powered 3-25-2018 at 200mv scale for transients FFT of Ch 2.JPG and as Exhibit mck.wb.ev05.Aclara I-210+ = no devices powered 3-25-2018 at 200mv scale for transients FFT of Ch 2.JPG. The pictures of the meters tested are in Exhibit mck.wb.ev06.aclara-meter.jpeg and Exhibit mck.wb.ev07.ge-I210+c.jpg.

5. Transients and the FCC Class B

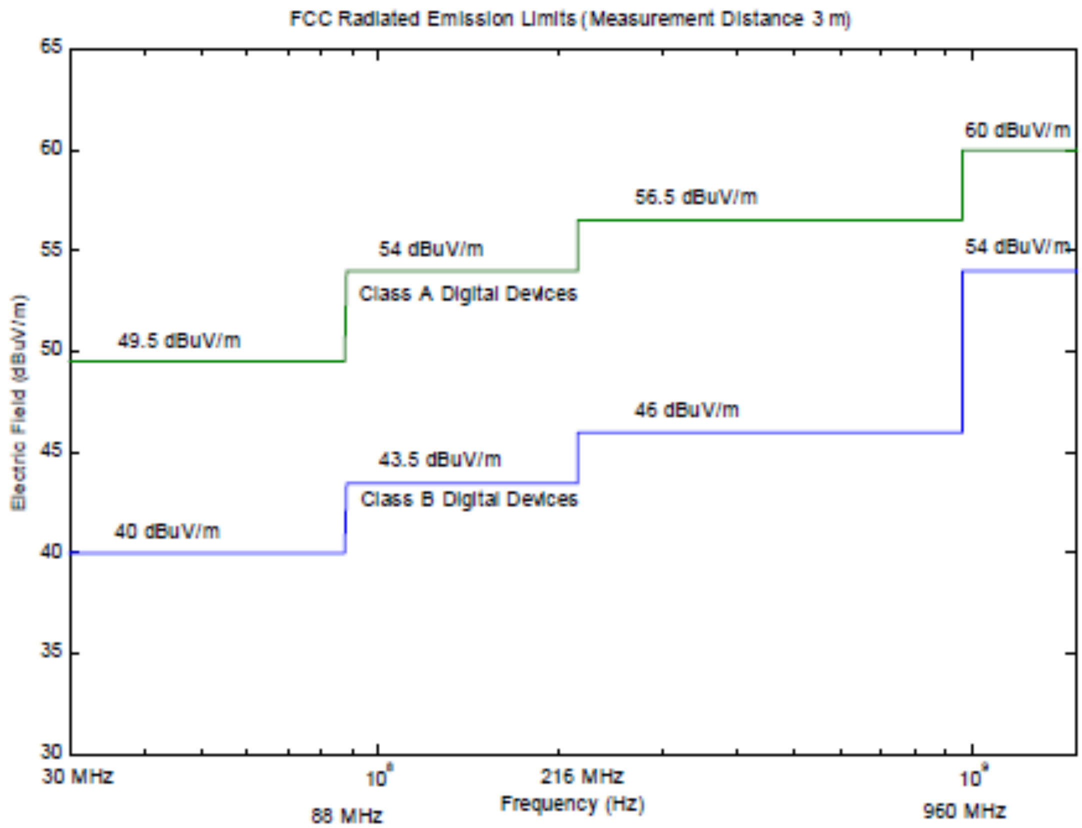
In the test conducted an observation made is the based on the comparison of the results to the FCC Class B specification which is for electronic based devices which the AMI certainly is, because it is not just a meter it is also a full-fledged computer too. So the FCC Class B

Specifications does apply. With the conducted emissions (not the RF emissions from the radio) there is a limit of 250 Microvolts (µV) (0.000250) across all frequencies, so with a measurement of about 300 Millivolts (mV) (.00300) the voltage transients exceed the specification by a multiple of 1200 times the maximum value and exceeds the FCC Class Specification as expressed in volts. These volts are injected onto the power lines of the home and could have been prevented by proper design of the AMI meter. This is not insignificant compared to other devices in the home. Other appliances, light bulbs etc. are not on 24/7 so a consumer can limit their exposure, unlike the AMI meter. In addition all other appliances and devices are compliant to the FCC Conducted Emissions specification, because they have the added circuit filtering to block the transients from being introduced back onto the mains power. There is also a frequency specification in the FCC Class B specification, but regardless of frequency spectrum limit, volts cannot exceed 250 Microvolts (250µV) at any frequency. Included here are two exhibits that summarize the FCC Conducted emissions. These exhibits came from Michigan State University as part of their Electrical Engineering curriculum and reference the appropriate FCC Specifications, but in an easier to read and understandable format. The first is called FCC Emissions module 8 regulations Exhibit mck.wb.ep01.FCC Module 8.pdf the second is FCC Emissions module 11 conducted Emissions Exhibit mck.wb.ep02.FCC Module 11.pdf.

In these two exhibits I will discuss two specific items, one the graph of Conducted Emissions for Class A and B devices and the second which discusses Radiated Emissions. We want to focus on the conducted emissions which are specified in volts across all frequencies.

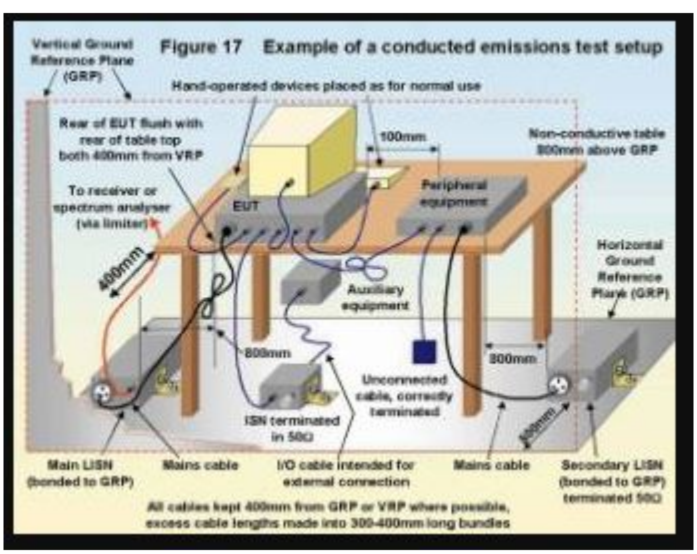


There is also radiated emissions in the form of RF emissions, as shown in the following chart, which is expressed in dbµv/m. But these radiated emissions are not easy to conduct in a field test such as we were able to perform. The Conducted emissions are relatively easy to test, and based on the results both meters we tested were not in compliance in terms of meeting 250 µV transients across all frequencies.

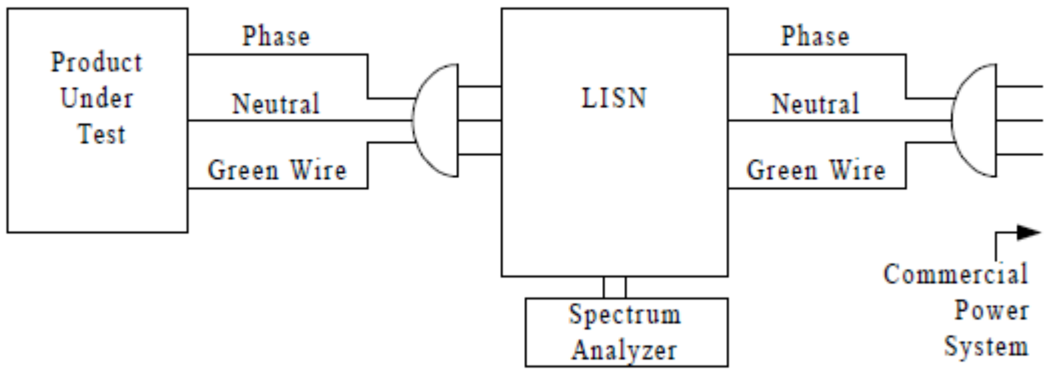


6. FCC Class B Test Regimen

In the FCC Class B test regimen for compliance there is a special set up required to conduct the frequency tests. The test setup looks like the following.

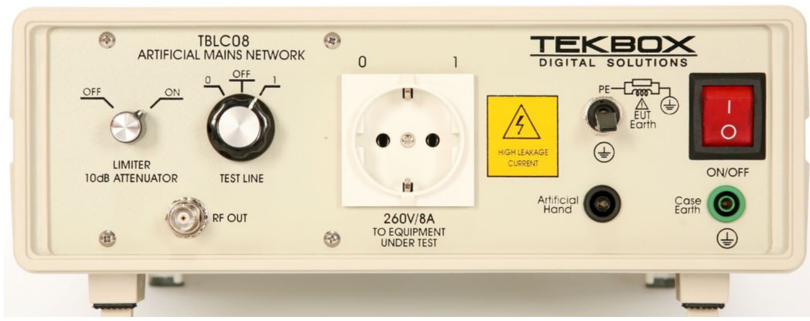


In addition the Product/Device under Test (DUT) requires a ground connection to conduct a valid frequency test as shown in the following diagram and in FCC Emissions module 11 conducted Emissions Exhibit mck.wb.ep02.FCC Module 11.pdf



The Line Impedance Stabilization Network (LISN) is a special device that provides “Unpolluted” power to the DUT. You will note that to conduct this test you must have a connection to ground and neutral for the DUT, there is no such connection in the AMI meter, therefore even if the meter manufactures conduct a test no valid test for conducted emissions could be properly performed or the test conducted did not reflect the in situ of normal meter operation which should include a connection to ground or even neutral. Given the test regimen required and the lack of a ground connection the electronics in the PECO AMI meter would never pass the FCC Class B specification and the manufactures product specification represented in the FCC ID does not express the meter passed the FCC Class B Conducted Emissions specification for either volts or frequencies. It does pass for radiated emissions for the radio transmitter’s portion of the product. But this means the PECO AMI meter only passed half the required specifications. There is no “Carve Out” for the FCC Conducted Emissions compliance in any device.

Here is an example of an LISN, this is for testing for a European mains connection but the same type of configuration can be used in North America.



In summary the FCC has concluded that the law makes it illegal to market digital devices that have not had their conducted and radiated emissions measured and verified to be within the limits set for by the FCC regulations. This means that digital devices that have not been measured to pass the requirements cannot be sold, marketed, shipped, or even be offered for sale. Although the penalties for violating these regulations include fines and or jail time, companies are more concerned with the negative publicity that would ensue once it became known that they had marketed a product that fails to meet all FCC regulations. Furthermore, if the product in question were already made available to the public, the company would be forced to recall the product. Thus it is important that every unit that a company produces is fully FCC compliant, including conducted emissions. Although the FCC does not test each and every module, they do perform random tests on products and if a single unit fails to comply, the entire product line can be recalled. Since PECO has decided on the use of the Aclara I-210+ product line and other AMI meters as their standard, these units should be recalled for non-compliance for exceeding conducted emissions regulations, PECO staff have neglected to fully consider all the safe meter options. There is a safe digital meter alternative with the ITRON C1S meter that has been widely deployed in North America and in my testing of that model unit there is no SMPS, and it instead uses a capacitive based power supply that does not exceed the 250µV limits. There is also no radio transceivers in this ITRON C1S unit. PECO should investigate this type of capacitive power supply design to be incorporated in the meters they use or switch suppliers. Alternatively PECO could make accommodations for customers that request a safer meter or be at risk for a class action by all PECO customers and action by the FCC for violation of specifications. Since Federal Law preempts State Law, PECO is in violation of Federal Law forcing customers to accept a non-compliant device onto the side of their homes.

PECO may make a stance that so many million meters have been deployed without issues, but how do they know this to be true? If PECO were to survey their entire customer base they will likely find most customers have a different view on the matter. So, when PECO expresses that they have no customer complaints about the AMI meters deployed, without a comprehensive customer survey of every customer this statement is misleading at best. To my knowledge no such survey has ever been conducted with regards to the new AMI meters deployed.

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3-26-2018