QUESTION BANK

PERIOD : JULY - NOV 2018　　　　　　　　　　**BATCH**: 2015 – 2019

BRANCH : ECE　　　　　　　　　　　　　　　**YEAR/SEM:** IV/VII

SUB CODE/NAME: EC6703- EMBEDDED AND REAL TIME SYSTEMS

UNIT – I - INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS

PART – A

1. Enumerate some embedded computers that are exists from origin of the embedded systems. **[ID][Nov/Dec-2016]**

2. In what way Interrupts differ from Exceptions? **[ID][Nov/Dec-2016]**

3. What is bus protocol? **[D][Apr/May-2017]**

4. Mention the various methods for reading from or writing to an I/O port? **[ID][Apr/May-2017]**

5. What is the role of Microprocessor in embedded computing? **[D][Nov/Dec-2017]**

6. How traps are handled in ARM processor? **[ID][Nov/Dec-2017]**

7. What are the basic sources of CMOS power consumption? **[ID][Apr/May-2018]**

8. List the functions of ARM processor in supervisory mode. **[D][Apr/May-2018]**

9. Give two features that differs a general purpose Micro controller from an embedded processor. **[D]**

10. What are the factors that govern the performance of CPU? **[D]**

11. What is the purpose of supervisor mode? **[D]**

12. State the functions of co-processors. **[D]**

13. Differentiate top-down and bottom-up design. **[D]**

14. List the functions of ARM processor in supervisor mode. **[D]**

15. Enumerate various issues in real time computing. **[D]**

16. Write short notes on ARM processor. **[D]**

17. What is the Instruction set features useful for embedded programming? **[D]**

18. What are the parameters used to evaluate the CPU performance? **[D]**

19. What is function of exceptions? **[D]**

20. How is ARM processor different from other processors? **[D]**

21. What is an embedded system? **[D]**

22. Distinguish between requirement and specification. **[D]**

23. Define embedded computer system. **[D]**

24. Name some processor in complex embedded system. **[D]**

25. What are the challenges in embedded computing system design? **[D]**

26. What are the factors that makes difficult in embedded computing system? **[ID]**

27. What is meant by deadline? **[D]**

28. What are the components that describe performance in embedded computing? **[D]**

29. What are the major goals of embedded system design? **[D]**

30. What are the steps in embedded system design process? **[D]**

31. Define UML? **[D]**

32. Define coprocessor. **[D]**

33. Define MMU? **[D]**

34. Define CPSR. **[D]**

35. What is meant by baud rate? **[D]**

36. What is meant by interrupt? **[D]**

37. What is meant by masking? **[D]**

38. What is meant by pipelining? **[D]**

39. Define cache memory. **[D]**

40. Define cache bit and cache miss. **[D]**

41. List out the instruction set of ARM processor. **[D]**

42. What is meant by Busy wait I/O. **[D]**

PART – B
[First Half]

[Complex systems and micro processors]

1. Explain in detail about characteristics, performance and challenges of a embedded computing system.(16) **[D]**

2. Explain in detail about microprocessors. (8) **[D]**

[Embedded system design process]

1. What are the several requirements of an embedded computing system design.(8) **[D][Apr/May-2017]**

2. Analyze the requirements for designing a GPS moving map in embedded system design process. (8) **[D][Nov/Dec-2016]**

3. Describe the different factors involved in embedded system design process. (16) **[ID][Apr/May-2018]**

[Design example: Model train controller]

1. How are the conceptual specifications and detailed specifications written in UML language to design the Model train controller? (8)**[D][Nov/Dec-2016]**

2. Explain model train controller with the frame format of DCC. (16) **[D][Apr/May-2018]**

3. Explain in detail the embedded system design process with an illustrative example of Model Train controller. (16) **[D][Nov/Dec-2017]**

[Instruction sets preliminaries -ARM Processor]

1. Explain the function of ARM processor instructions. (8) **[D][Nov/Dec-2017]**
2. How does branching and procedural has been performed in ARM processor? (8) **[D][Apr/May-2017]**
3. Write short note on Assembly language.(8) **[D]**
4. What is ARM? Also elaborate the memory and instructions of ARM. (10) **[D]**
5. Brief about Instruction sets preliminaries in embedded system environment.(8) **[D]**

[Second Half]

[CPU: programming input and output]

1. What are the ways of programming the input and output devices in an embedded system design? (8) **[D][Apr/May-2017]**

[Supervisor mode, exceptions and traps]

1. Explain about supervisor mode, exceptions and traps.(8) **[D]**

[Co-processors]

1. Discuss on the operation of Coprocessor used with ARM processor. (8) **[D][Nov/Dec-2017]**

[Memory system mechanisms]

1. How memory management is done for an embedded system processor in order to manage multiple programs in a single physical memory?(8) **[D][Nov/Dec-2016]**
2. Explain the memory system mechanisms to increase the performance in an embedded system.(16) **[D]**

[CPU performance]

1. How CPU performance is affected? Explain them with example instructions. (8) **[D][Nov/Dec-2016]**
2. Explain in detail about CPU performance.(8) **[D]**
3. What is co-processors? How it s used in embedded application? (4) **[D]**

[CPU power consumption]

1. Name three mechanism by which a CMOS microprocessor consumes power and also specify several power saving strategies are used in CMOS CPU's. (8) **[D][Apr/May-2017]**

UNIT-II - EMBEDDED COMPUTING PLATFORM DESIGN
PART A

1. Differentiate Harvard and Von Neumann architecture. **[D][Apr/May-2018]**

2. What is the basic building block of most bus control? **[D][Apr/May-2018]**

3. Compare Static and Dynamic RAM. **[D][Nov/Dec-2016]**

4. What are Data Flow Graph and Control/Data Flow Graph (CDFG)? **[D][Nov/Dec-2016]**

5. What is the disadvantage of nested loops in embedded programs? **[ID][Apr/May-2017]**

6. List the types of Co-verification techniques? **[D][Apr/May-2017]**

7. How power can be optimized at the program level? **[ID][Nov/Dec-2017]**

8. List the advantages and limitations of Priority based process scheduling. **[D][Nov/Dec-2017]**

9. What is 'memory map' input-output interface? **[D]**

10. What is need for Bus Arbitration? **[D]**

11. What do mean by control bus in CPU? **[D]**

12. Can latches be used to construct input ports? Justify. **[ID]**

13. What is the bus protocols especially, the four-cycle handshake? **[D]**

14. What is a data flow graph? **[D]**

15. What are CPU buses? **[D]**

16. List out the various compilation techniques. **[D]**

17. What are the different CPU buses? State the function of each one. **[D]**

18. State the principle of basic compilation technique. **[D]**

19. Name any two techniques used to optimize execution time of a program. **[D]**

20. What does a linker do? **[D]**

21. What are the parameters used in platform-level performance analysis? **[D]**

22. Write the Components used for embedded programming? **[D]**

23. What do you mean by "watchdog timer"? **[D]**

24. What is DMA? **[D]**

25. What are the two bus signals provided by DMA controller? Explain. **[D]**

26. Define: cross compiler. **[D]**

27. What do you mean by finite-state machine? **[D]**

28. What is the use of CDFG? **[D]**

29. Describe three different types of performance measures on programs. **[D]**

30. Write three important techniques in optimizing loops? Explain**[D]**

31. What are all the factors to be contributed on energy consumption of the program? **[ID]**

32. What do you mean by Cache? Explain. **[D]**

33. What are the optimizations used for improving energy consumption? **[D]**

34. Mention two major types of testing strategies? Explain. **[D]**

35. State Black-box testing strategy. **[D]**

36. Brief clear-box testing strategy? **[D]**

37. Explain Data flow testing. **[D]**

38. What are two boundary conditions used for Black-box Testing. **[D]**

39. What is In-Circuit Emulator. **[D]**

40. Define profiling. **[D]**

41. Mention the I/O devices used in embedded system? **[D]**

PART – B
[FIRST HALF]

[The CPU Bus-Memory devices and systems]
1. Explain about various CPU BUS configurations in embedded systems.(8) **[D]**

2. Describe the memory devices used in embedded system design. (8) **[D]**

3. Explain the different I/O devices used in embedded system. (16) **[D]**

4. Write short notes on component interfacing. (5) **[D]**

5. Describe about the basic types of memory components that are commonly used in embedded systems. (8) **[D][Apr/May-2018]**

[Designing with computing platforms]
1. Describe how embedded system is useful in competing with computing platform. (8) **[D][Nov/Dec-2016]**

2. Discus the steps involved while designing with computing platforms. (12) **[D]**

[Consumer electronics architecture]
1. Explain about consumer electronics architecture. (6) **[D]**

2. With an example in consumer electronics, explain the embedded system design with computing Platform. (8) **[D][Nov/Dec-2017]**

[Platform-level performance analysis]
1. Analyze the platform level performance in an embedded system. (8) **[D]**

[Components for embedded programs]
1. Explain the various components used in embedded programs. (8) **[D]**

2. Explain the various components and programming models used for developing embedded Programs.(8) **[D][Nov/Dec-2017]**

[Models of programs- Assembly, linking and loading]
1. Explain the following design tools used in embedded system design. Assembly, linking and loading. (10) **[D]**

2. Discuss in detail various programming models. (8) **[D] [Apr/May-2017]**

3. Explain models of the program with no conditionals.(8) **[D][Apr/May-2018]**

[SECOND HALF]

[Compilation techniques]
1. Outline the role of assemblers and linkers in the compilation process.(16) **[D][Apr/May-2018]**

2. Explain in detail about the compilation process in high level languages.(8) **[D][Apr/May-2017]**

3. Explain the principle of various compilation techniques.(8) **[D][Nov/Dec-2017]**

[Program level performance analysis]
1. What are the program level performance analysis of embedded system design.(8) **[D][Apr/May-2017]**

2. Explain the methods used to analyze the program-level performance. (16) **[D]**

[Software performance optimization]
1. What is optimization? Also explain software performance optimization. (6) **[D]**

2. Discuss about the embedded system software performance analysis and optimization.(8)**[D][Nov/Dec-2017]**

[Program level energy and power analysis and optimization]
1. Discuss in detail the optimization of energy and power of an embedded system.(8) **[D][Nov/Dec-2016]**

2. Explain the following. Analysis and optimization of execution time, power, energy, program size. (6) **[D]**

[Analysis and optimization of program size]
1. Explain in detail the testing process involved in developing an embedded system. (8) **[D][Nov/Dec-2016]**

2. Explain the various debugging techniques in the development of embedded system. (8) **[D][Nov/Dec-2016]**

[Program validation and testing]

3. Discuss in detail the optimization of program size of an embedded system.(8) **[D][Apr/May-2017]**

4. Discus in detail about program validation and testing. (16) **[D]**

UNIT-III - PROCESSES AND OPERATING SYSTEMS

PART A

1. Define context switching in RTOS. **[D][Apr/May-2018]**

2. Illustrate the interconnect network developed for distributed embedded systems. **[ID][Apr/May-2018]**

3. Define tasks and processes. **[D][Nov/Dec-2016]**

4. Write about scheduling states present in the embedded system design. **[D][Nov/Dec-2016]**

5. Define Semaphore. **[D][Apr/May-2017]**

6. What is Priority Inversion? **[D][Apr/May-2017]**

7. List the advantages and limitations of Priority based process scheduling. **[D][Nov/Dec-2017]**

8. State the major functions of POSIX RTOS. **[D][Nov/Dec-2017]**

9. How Real Time Operating Systems is uniquely different than a general purpose OS? **[ID]**

10. Define: Multitasking. **[D]**

11. Give any two properties of Operating Systems **[D]**

12. What the major styles are of inter process communication mechanisms. **[D]**

13. Define context switching. **[D]**

14. Define: processes. **[D]**

15. List the process scheduling policies. **[D]**

16. What is the power optimization strategies used for processes? **[ID]**

17. What does a scheduler do in operating system environment? **[ID]**

18. Define: Multithreading. **[D]**

19. What is mean by Multi-rate system? **[D]**

20. What are the two important requirements on processes? Explain. **[D]**

21. Define: Task Graph. **[D]**

22. What are the scheduling states used in operating system? **[D]**

23. Define: scheduling policy. **[D]**

24. What is mean by "cyclostatic scheduling"? **[D]**

25. What is "Kernel"? **[D]**

26. Describe two major ways to assign priorities with example. **[D]**

27. Distinguish between RMS & EDF. **[D]**

28. What do you mean by "predictive scheduling"? **[D]**

29. What if your set of processes is unschedulable and you need to guarantee that they complete their deadlines? **[ID]**

30. What is RMS? **[D]**

31. What is EDF? **[D]**

32. What is semaphore? **[D]**

33. What is mean by APCI? **[D]**

34. Brief the states present in APCI? **[D]**

35. What do you mean by POSIX? **[D]**

36. State advantages and uses of POSIX? **[D]**

37. Draw the architecture for Window CE? **[D]**

38. What is Window CE? **[D]**

39. Define threads. **[D]**

40. Define Kernel. **[D]**

41. What are the basic scheduling states? **[D]**

PART – B
[FIRST HALF]

[Multiple tasks and multiple processes]
1. Discuss in detail multitasking and multiprocessing. (8) **[D][Nov/Dec-2016]**

2. Summarize the services of operating system in handling multiple task and multiple processes. (8) **[D][Apr/May-2018]**

3. Explain the services of operating system in handling multiprocessor scheduling and communication. (16) **[ID]**

[Multirate systems]
1. Describe why automobile engines require a multi -rate control. (8) **[D][Nov/Dec-2016]**

[Preemptive real-time operating systems]
1. Explain how multiple processes are handled by Preemptive real time operating system.(6) **[D][Nov/Dec-2017]**

[Priority based scheduling]

1. Explain in detail rate monotonic scheduling with an example. (8) **[D][Nov/Dec-2016]**

2. Elucidate on scheduling policies with suitable examples. (8) **[D][Apr/May-2018]**

3. Describe in details about the scheduling policies and with suitable examples. (16) **[D]**

4. Explain the principle of priority based context switching mechanism. Discuss about the various priorities based scheduling algorithms. (16) **[D]**

5. Describe any two scheduling policies used in multiple process environments. (16) **[D]**

6. Explain in detail about Earliest-deadline-first scheduling. (8) **[D][Apr/May-2017]**

7. Write short notes on Co-operative Scheduling. (4) **[D]**

[SECOND HALF]

[Interprocess communication mechanisms]
1. Explain with a neat diagram inter process Communication.(8) **[D][Apr/May-2017]**

2. With neat sketch explain the interprocess communication mechanism. (16) **[D][Apr/May-2018]**

3. Compare the principle, merits and limitations of Inter-process communication mechanism. (10) **[D][Nov/Dec-2017]**

4. Describe in detail about the Inter Process Communication mechanisms. (12) **[D]**

5. Explain about inter process communication mechanism with neat sketch. (16) **[D]**

6. Explain in detail how shared memory and message passing mechanisms are used Inter Process Communication. (16) **[ID]**

7. Discuss about multiple processes and inter process communication mechanisms. (16) **[D]**

[Evaluating operating system performance]
[Power optimization strategies for processes]

1. Write short note on the power optimization strategies for processes in real time operating system environment. (6) **[D][Nov/Dec-2017]**

2. Explain in detail about power optimization strategies in embedded system. (8) **[D][Apr/May-2017]**

3. Discuss in detail about power optimization strategies for CPU operation. (16) **[D]**

4. Discuss the power management and optimization for processes. (8) **[D]**

[Example Real time operating systems-POSIX-Windows CE]

1. Explain the example real time operating system called windows CE in detail. (8) **[D][Nov/Dec-2016]**

2. Explain the example real time operating system called POSIX in detail. (8) **[D][Apr/May-2017]**

3. Discuss about the features and services of Windows CE real time operating system. (10) **[D][Nov/Dec-2017]**

4. How to evaluate operating system performance? Explain. (8) **[D]**

UNIT-IV - SYSTEM DESIGN TECHNIQUES AND NETWORKS

PART A

1. What do you mean by accelerators in embedded multiprocessor? **[D][Apr/May-2018]**

2. Mention the goals of design process in embedded computing systems. **[D][Apr/May-2018]**

3. What is the role of CRC bit in CAN Bus? **[D][Apr/May-2017]**

4. List out some of the verification requirements and specifications related to the design flow? **[D][Apr/May-2017]**

5. What do you mean by quality and quality assurance related to embedded systems? **[D][Nov/Dec-2016]**

6. Give examples of internet enabled system. **[D][Nov/Dec-2016]**

7. Draw the block diagram of Distributed embedded system. **[D][Nov/Dec-2017]**

8. Give the design flow used in embedded system design. **[D][Nov/Dec-2017]**

9. What do you mean by Network based design? **[D]**

10. State some of the networks dedicated for embedded systems. **[D]**

11. List the OSI layers from lowest to highest level of abstraction. **[D]**

12. What is a distributed embedded architecture? **[D]**

13. State the advantages of networks based design. **[D]**

14. State the important requirements to develop Network based embedded systems. **[D]**

15. What are the merits of embedded distributed architecture? **[D]**

16. State the major goals of design process. **[D]**

17. Define Spiral model. **[D]**

18. Define waterfall model **[D]**

19. State successive refinement design methodology. **[D]**

20. What do you mean by concurrent engineering? **[D]**

21. What are the elements used for concurrent engineering? **[D]**

22. What are two types of requirements used in designing? Brief each one. **[D]**

23. If you need to meet a good set of requirements, what are the tests we have to consider? **[ID]**

24. What do you mean by state chart? **[D]**

25. What are the two basic groupings of state chart? Brief each one. **[D]**

26. What do you mean by CRC card? Explain. **[D]**

27. What are the steps to be followed by a designer in CRC card methodology? **[D]**

28. Define: Quality Assurance. **[D]**

29. Justify the quality of products. **[D]**

30. What is CMM? **[D]**

31. State the levels used for judging an organization using CMM. **[D]**

32. What is prototype? **[D]**

33. What do you mean by Cyber-physical systems? **[D]**

34. Who are all the members present in design review process? **[D]**

35. Define internet protocol? **[D]**

36. What is meant by avionics? **[D]**

37. Define message passing. **[D]**

38. What is the use of attaching accelerator to CPU? **[D]**

39. What is the arbitration scheme types used in Distributed embedded systems? **[ID]**

40. What are the advantages and disadvantages of Linear or Water fall model? **[D]**

41. List the drawbacks of prototyping model. **[D]**

PART – B
[FIRST HALF]

[Design methodologies - Design flows -Requirement Analysis -Specifications]
1. Briefly discuss about the design methodologies for an embedded computing system. (16) **[D][Nov/Dec-2016]**

2. Discuss about the embedded system design methods and explain the importance of Requirement Analysis. (8) **[D][Nov/Dec-2017]**

3. Explain in detail about various Design flows in System Design Techniques.(16) **[D]**

[System analysis and architecture design]
1. Explain the type of Specifications in System Design Techniques.(16) **[D]**

2. With a neat diagram explain about CRC cards.(16) **[D]**

[Quality Assurance techniques]
1. Observe in detail about quality Assurance process using the following:

   i) Quality Assurance Techniques (8) **[D] [Apr/May-2018]**

   ii) Verifying the specifications. (8) **[D] [Apr/May-2018]**

2. Briefly explain the quality assurance process taken place in the embedded computing system design. (16) **[D][Apr/May-2017]**

3. Explain the principle of Quality Assurance techniques used in embedded system design. (8) **[D][Nov/Dec-2017]**
4. Explain about CMM's five levels of maturity.(8) **[D]**

[SECOND HALF]
[Distributed embedded systems]
1. Discuss about the distributed embedded architecture. (16) **[D][Apr/May-2018]**

2. Discuss in detail about the network based embedded system design. (8) **[D][Nov/Dec-2016]**

3. Explain in detail about The OSI model layers. (8) **[D]**

4. With neat diagram explain the working of CAN Bus. (8) **[D][Apr/May-2017]**

5. With neat diagram explain the working of I^2C. (8) **[D][Apr/May-2017]**

6. With neat diagram explain the working of Internet Protocol. (16) **[D]**

7. Write notes on internet enabled systems. (8) **[D][Nov/Dec-2016]**

8. Explain in detail about CAN architecture. (16) **[D]**

[MPSoCs - shared memory multiprocessors]

1. Explain how the concepts of Multiprocessor System-On-Chip MPSoC and shared memory multiprocessors are used in embedded application. (**16) [D][Nov/Dec-2017]**
2. Explain the accelerated system design and list its advantages. (16) **[D]**
3. Explain in detail about Verifying the specification & Design reviews of a multiprocessor.(16) **[D]**
4. List and explain in detail about various Categories of multiprocessors.(16) **[D]**

UNIT-V - CASE STUDY

PART A

1. Determine the requirements of block motion estimator. **[ID][Apr/May-2018]**

2. What are data compressors? **[D][Apr/May-2018]**

3. Write the requirement form for an alarm clock. **[D][Apr/May-2017]**

4. What is the advantage of video accelerator? **[D][Apr/May-2017]**

5. Specify the MPEG layer 1 data frame format set for the audio player application. **[ID][Nov/Dec-2016]**

6. What are the classes in data compressor? **[D][Nov/Dec-2016]**

7. Write the main functions performed by Video accelerator**[D][Nov/Dec-2017]**

8. What are the major components used in the design of Alarm clock? **[D][Nov/Dec-2017]**

9. Define: Data compressor. **[D]**

10. Justify the technique used in Data compressor. **[D]**

11. What are all the methods used in Data compressor to define a class? **[D]**

12. What is the code require to test the Data compressor internals? Justify it. **[D]**

13. Draw the class diagram for alarm clock. **[D]**

14. What is the software components required for alarm clock system architecture? **[D]**

15. Draw the architecture for Audio player. **[D]**

16. List the functions of Digital Still Cameras. **[D]**

17. Draw the hardware architecture for Digital Stills Camera. **[D]**

18. What do you mean by Block Motion Estimation? **[D]**

19. What is the goal of Block Motion Estimation? **[D]**

20. Define: Motion Vectors. **[D]**

21. Draw the sequence diagram for video accelerators. **[D]**

22. Define: Loop back testing. **[D]**

23. Justify the performance of Loop back testing. **[D]**

24. What is the compression scheme used in Telephone Answering Machine. **[D]**

25. Draw the architecture of ADPCM. **[D]**

26. List the software modules in Telephone Answering Machine. **[D]**

27. Draw the Hardware structure of Telephone Answering Machine. **[D]**

28. Draw the Hardware Structure of Engine control. **[D]**

29. Give the advantage of data compressor. **[D]**

30. What do you mean by co-design? **[D]**

31. List out the application of software modem. **[D]**

32. What are the types of data compression. **[D]**

33. Write the types of program design for data compressor. **[D]**

PART – B

[Data compressor]
1. Discuss about Data compressor in detail with suitable diagrams.(16) **[D]**

2. Explain the hardware and software design for data compressor. (16) **[D]**

3. Write in detail about the embedded concepts in the design of data compressor. (8) **[D][Nov/Dec-2016]**

[Alarm Clock]
1. Explain about Alarm Clock with neat sketch. (16) **[D]**

[Audio player]
1. Explain operation of Audio Player. (5) **[D][Nov/Dec-2017]**

2. Demonstrate the role of a audio player along with its Hardware and software design.(16) **[D]**

3. Demonstrate in detail about design example of audio player. (8) **[D][Apr/May-2018]**

[Software modem]
1. Explain the hardware and software design of software modem and telephone answering machine. (16)**[ID][Nov/Dec-2016]**

2. Summarize the principle and operation of software MODEM. (8) **[D][Apr/May-2018]**

3. Explain operation of Software modem (5) **[D][Nov/Dec-2017]**

[Digital still camera]
1. Explain the hardware and software design of digital still-camera designed with automation of camera functions. (16) **[D][Apr/May-2017]**

2. Describe in detail about the principle of operation of digital still camera and discuss the design of Digital still camera with the help of necessary diagrams? (16) **[D]**

3. Demonstrate the sequence diagram of taking a picture with digital still camera. (16) **[D][Apr/May-2018]**

4. Explain operation of Digital still camera. (6) **[D][Nov/Dec-2017]**

[Telephone answering machine]
1. Discuss about Telephone Answering Machine in detail with suitable diagrams.(16) **[D]**

[Engine control unit]
1. Justify that Engine Control Unit is an embedded system. Explain in detail the hardware and software components of Engine Control Unit. (16) **[D][Nov/Dec-2017]**

2. With neat diagram, explain the software and hardware design of engine control unit.(16) **[D]**

3. Write in detail about the embedded concepts in the design of engine control unit. **[D][Apr/May-2017]**

4. Discuss in detail about automotive engine control. (16) **[ID]**

[Video accelerator]
1. Illustrate the principles of video accelerator and its software and hardware design. (16) **[D]**

2. Write in detail about the embedded concepts in the design of video accelerator. (16) **[D][Nov/Dec-2016]**