# Case Study - III

**Working with Sensor Data**

For this data analysis, you can download the necessary dataset from this link. In the above link there are two datasets; building.csv contains the details of the top 20 buildings all over the world and HVAC.csv contains the target temperature and the actual temperature along with the building Id.

HVAC (heating, ventilating/ventilation, and air conditioning) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. Through the HVAC sensors, we will get the temperature of the buildings.

Here are the columns that are present in the datasets:

- Building.csv – BuildingID, BuildingMgr, BuildingAge, HVACproduct,Country
- HVAC.csv – Date, Time, TargetTemp, ActualTemp, System, SystemAge, BuildingID

**Objective – 1:**

1. Load HVAC.csv file into temporary table
2. Add a new column, tempchange - set to 1, if there is a change of greater than +/-5 between actual and target temperature

**Objective -2:** Load building.csv file into temporary table

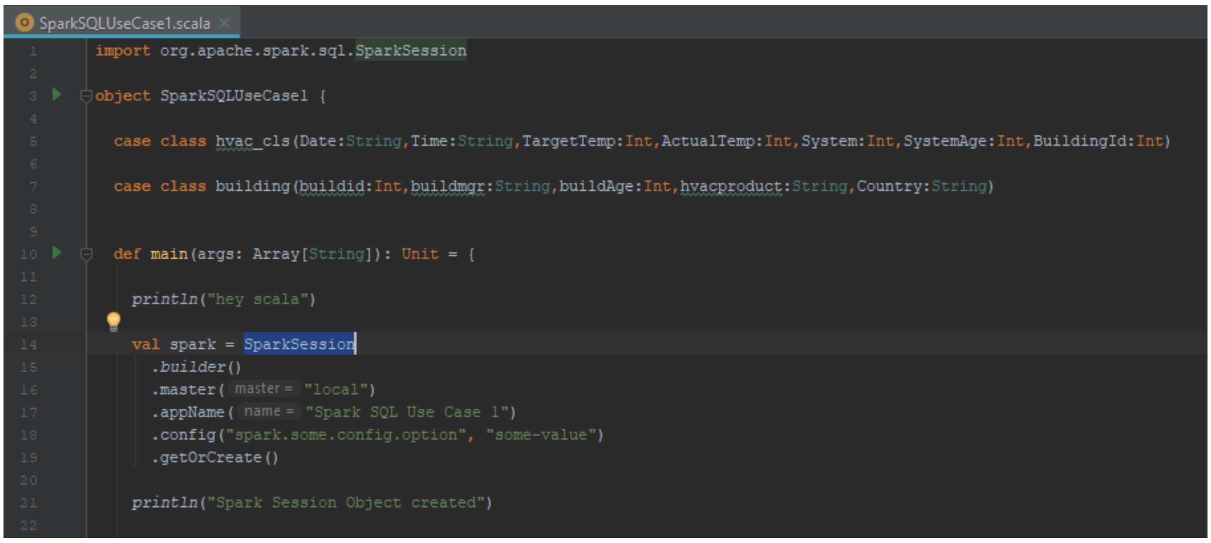
**Objective – 3:**

Figure out the number of times, temperature has changed by 5 degrees or more for each country:

1. Join both the tables.
2. Select tempchange and country column
3. Filter the rows where tempchange is 1 and count the number of occurrence for each country

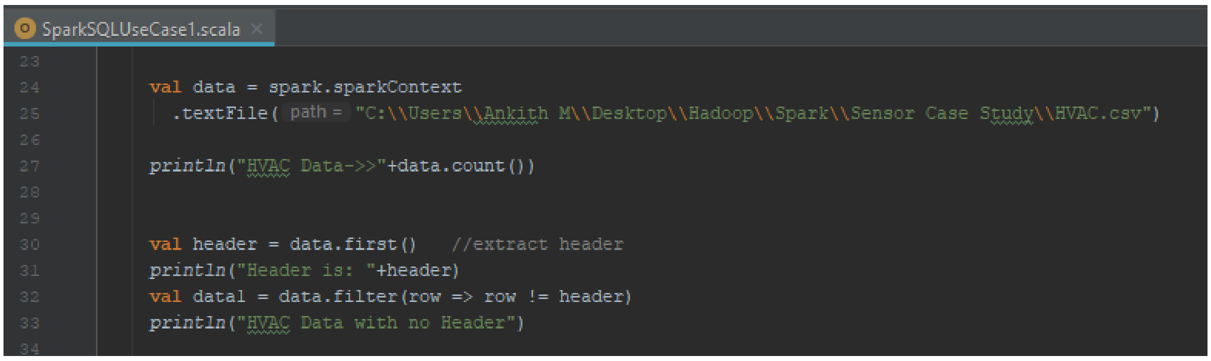
**Answer:** Now initially we are setting up the SaprkSession to continue for the given case study and then we proceed for data handling as per Objective1.

Below screenshot defines the Spark session parameter.



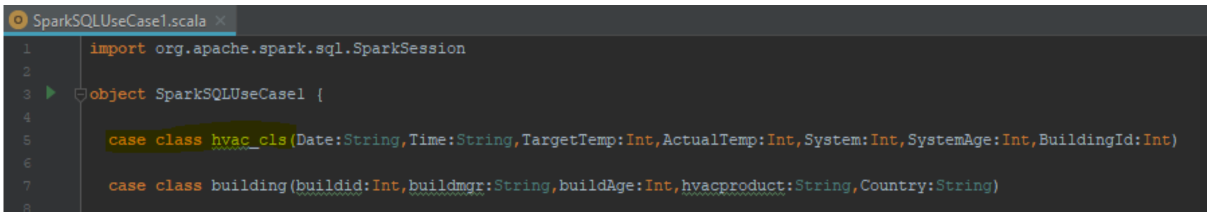
```scala
import org.apache.spark.sql.SparkSession

object SparkSQLUseCase1 {

  case class hvac_cls(Date:String,Time:String,TargetTemp:Int,ActualTemp:Int,System:Int,SystemAge:Int,BuildingId:Int)

  case class building(buildid:Int,buildmgr:String,buildAge:Int,hvacproduct:String,Country:String)


  def main(args: Array[String]): Unit = {

    println("hey scala")

    val spark = SparkSession
      .builder()
      .master( master = "local")
      .appName( name = "Spark SQL Use Case 1")
      .config("spark.some.config.option", "some-value")
      .getOrCreate()

    println("Spark Session Object created")

```

Now next step is to get HVAC.csv after removing the Header record.

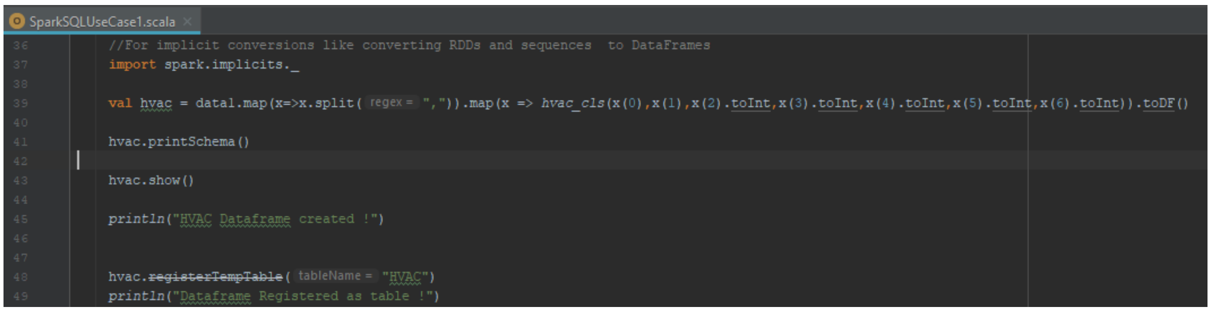


```scala

    val data = spark.sparkContext
      .textFile( path = "C:\\Users\\Ankith M\\Desktop\\Hadoop\\Spark\\Sensor Case Study\\HVAC.csv")

    println("HVAC Data->>"+data.count())


    val header = data.first()   //extract header
    println("Header is: "+header)
    val data1 = data.filter(row => row != header)
    println("HVAC Data with no Header")

```

**Objective 1.1:** Now we are going to define the Data Frame using the Case class and the define statements and load the data in temporary table.

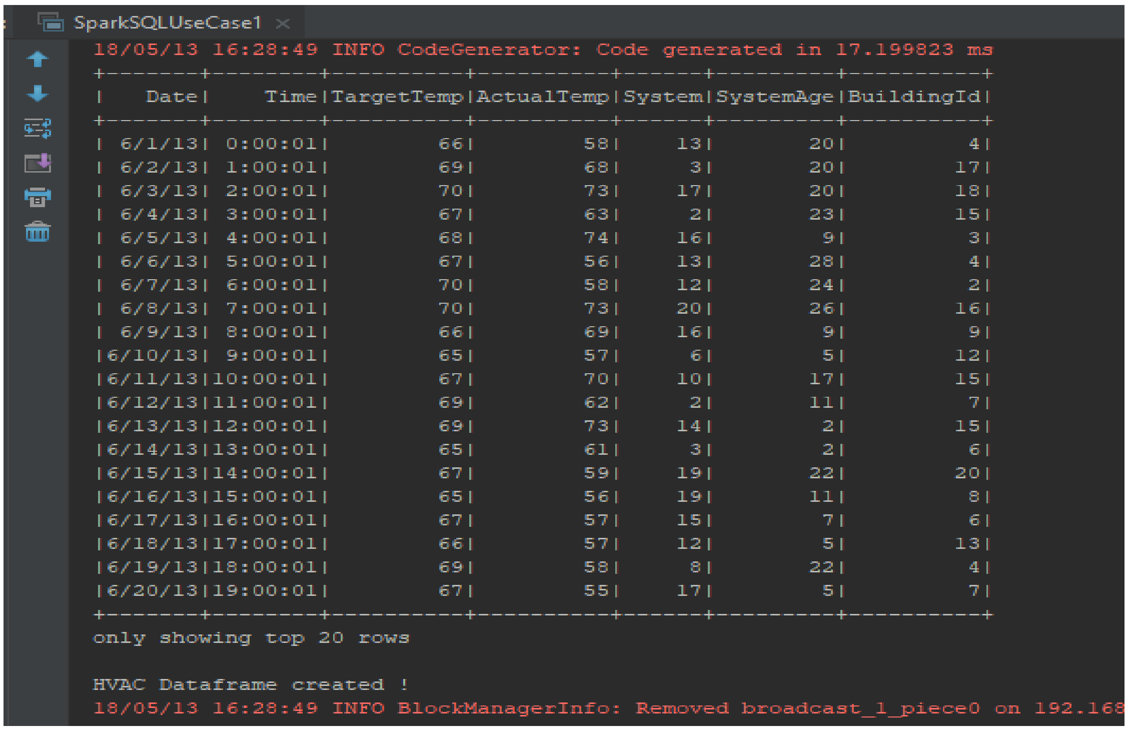


```scala
import org.apache.spark.sql.SparkSession

object SparkSQLUseCase1 {

  case class hvac_cls(Date:String,Time:String,TargetTemp:Int,ActualTemp:Int,System:Int,SystemAge:Int,BuildingId:Int)

  case class building(buildid:Int,buildmgr:String,buildAge:Int,hvacproduct:String,Country:String)

```



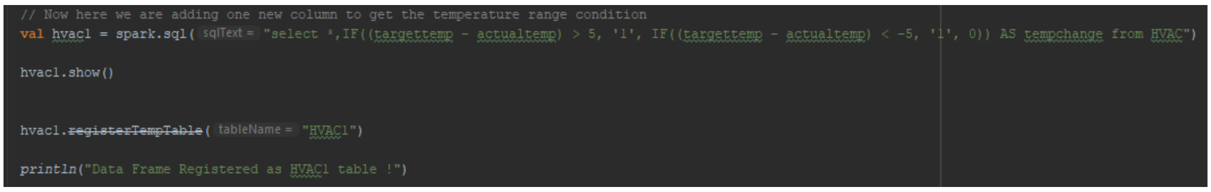
```scala
    //For implicit conversions like converting RDDs and sequences  to DataFrames
    import spark.implicits._

    val hvac = data1.map(x=>x.split( regex = ",")).map(x => hvac_cls(x(0),x(1),x(2).toInt,x(3).toInt,x(4).toInt,x(5).toInt,x(6).toInt)).toDF()

    hvac.printSchema()

    hvac.show()

    println("HVAC Dataframe created !")


    hvac.registerTempTable( tableName = "HVAC")
    println("Dataframe Registered as table !")
```

**Output:**



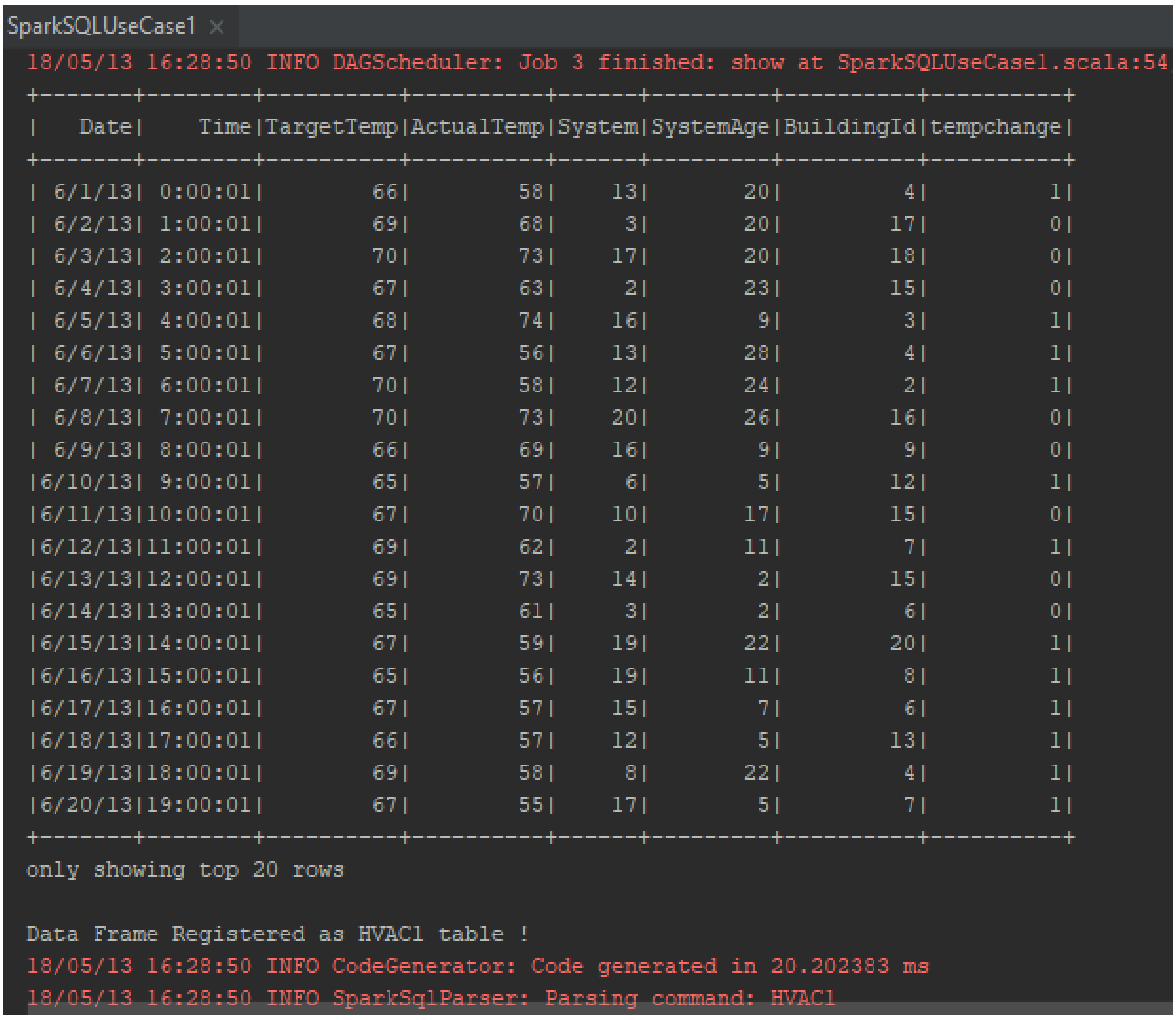
```
18/05/13 16:28:49 INFO CodeGenerator: Code generated in 17.199823 ms
+-------+--------+----------+----------+------+---------+----------+
|   Date|    Time|TargetTemp|ActualTemp|System|SystemAge|BuildingId|
+-------+--------+----------+----------+------+---------+----------+
| 6/1/13| 0:00:01|        66|        58|    13|       20|         4|
| 6/2/13| 1:00:01|        69|        68|     3|       20|        17|
| 6/3/13| 2:00:01|        70|        73|    17|       20|        18|
| 6/4/13| 3:00:01|        67|        63|     2|       23|        15|
| 6/5/13| 4:00:01|        68|        74|    16|        9|         3|
| 6/6/13| 5:00:01|        67|        56|    13|       28|         4|
| 6/7/13| 6:00:01|        70|        58|    12|       24|         2|
| 6/8/13| 7:00:01|        70|        73|    20|       26|        16|
| 6/9/13| 8:00:01|        66|        69|    16|        9|         9|
|6/10/13| 9:00:01|        65|        57|     6|        5|        12|
|6/11/13|10:00:01|        67|        70|    10|       17|        15|
|6/12/13|11:00:01|        69|        62|     2|       11|         7|
|6/13/13|12:00:01|        69|        73|    14|        2|        15|
|6/14/13|13:00:01|        65|        61|     3|        2|         6|
|6/15/13|14:00:01|        67|        59|    19|       22|        20|
|6/16/13|15:00:01|        65|        56|    19|       11|         8|
|6/17/13|16:00:01|        67|        57|    15|        7|         6|
|6/18/13|17:00:01|        66|        57|    12|        5|        13|
|6/19/13|18:00:01|        69|        58|     8|       22|         4|
|6/20/13|19:00:01|        67|        55|    17|        5|         7|
+-------+--------+----------+----------+------+---------+----------+
only showing top 20 rows

HVAC Dataframe created !
18/05/13 16:28:49 INFO BlockManagerInfo: Removed broadcast_1_piece0 on 192.168
```

**Objective 1.2:** Add a new column, tempchange - set to 1, if there is a change of greater than +/-5 between actual and target temperature



```
// Now here we are adding one new column to get the temperature range condition
val hvac1 = spark.sql( sqlText = "select *,IF((targettemp - actualtemp) > 5, '1', IF((targettemp - actualtemp) < -5, '1', 0)) AS tempchange from HVAC")

hvac1.show()


hvac1.registerTempTable( tableName = "HVAC1")

println("Data Frame Registered as HVAC1 table !")
```

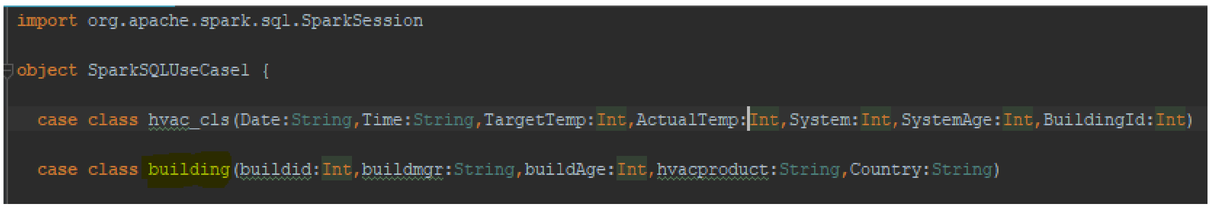
***Output:***



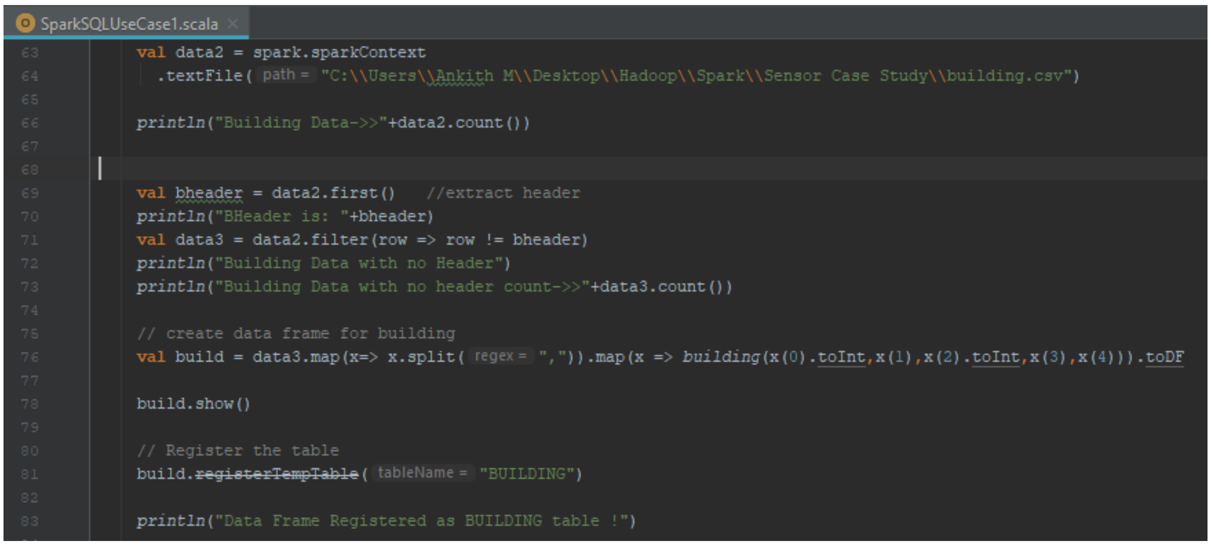
```
18/05/13 16:28:50 INFO DAGScheduler: Job 3 finished: show at SparkSQLUseCase1.scala:54
+-------+--------+----------+----------+------+---------+----------+----------+
|   Date|    Time|TargetTemp|ActualTemp|System|SystemAge|BuildingId|tempchange|
+-------+--------+----------+----------+------+---------+----------+----------+
| 6/1/13| 0:00:01|        66|        58|    13|       20|         4|         1|
| 6/2/13| 1:00:01|        69|        68|     3|       20|        17|         0|
| 6/3/13| 2:00:01|        70|        73|    17|       20|        18|         0|
| 6/4/13| 3:00:01|        67|        63|     2|       23|        15|         0|
| 6/5/13| 4:00:01|        68|        74|    16|        9|         3|         1|
| 6/6/13| 5:00:01|        67|        56|    13|       28|         4|         1|
| 6/7/13| 6:00:01|        70|        58|    12|       24|         2|         1|
| 6/8/13| 7:00:01|        70|        73|    20|       26|        16|         0|
| 6/9/13| 8:00:01|        66|        69|    16|        9|         9|         0|
|6/10/13| 9:00:01|        65|        57|     6|        5|        12|         1|
|6/11/13|10:00:01|        67|        70|    10|       17|        15|         0|
|6/12/13|11:00:01|        69|        62|     2|       11|         7|         1|
|6/13/13|12:00:01|        69|        73|    14|        2|        15|         0|
|6/14/13|13:00:01|        65|        61|     3|        2|         6|         0|
|6/15/13|14:00:01|        67|        59|    19|       22|        20|         1|
|6/16/13|15:00:01|        65|        56|    19|       11|         8|         1|
|6/17/13|16:00:01|        67|        57|    15|        7|         6|         1|
|6/18/13|17:00:01|        66|        57|    12|        5|        13|         1|
|6/19/13|18:00:01|        69|        58|     8|       22|         4|         1|
|6/20/13|19:00:01|        67|        55|    17|        5|         7|         1|
+-------+--------+----------+----------+------+---------+----------+----------+
only showing top 20 rows

Data Frame Registered as HVAC1 table !
18/05/13 16:28:50 INFO CodeGenerator: Code generated in 20.202383 ms
18/05/13 16:28:50 INFO SparkSqlParser: Parsing command: HVAC1
```

**Objective 2:** Load building.csv file into temporary table.

Define the case class for the Buuilding table structure as below.



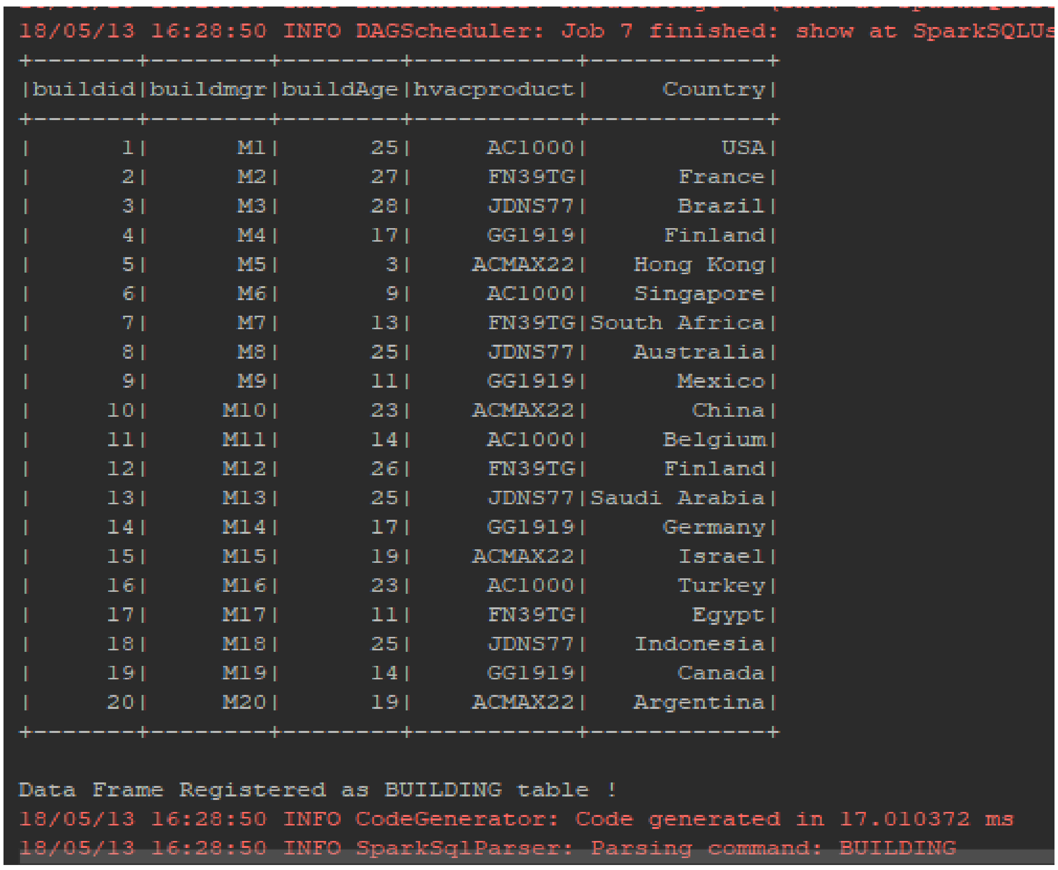
```
import org.apache.spark.sql.SparkSession

object SparkSQLUseCase1 {

  case class hvac_cls(Date:String,Time:String,TargetTemp:Int,ActualTemp:Int,System:Int,SystemAge:Int,BuildingId:Int)

  case class building(buildid:Int,buildmgr:String,buildAge:Int,hvacproduct:String,Country:String)
```



SparkSQLUseCase1.scala

```
    val data2 = spark.sparkContext
      .textFile( path = "C:\\Users\\Ankith M\\Desktop\\Hadoop\\Spark\\Sensor Case Study\\building.csv")

    println("Building Data->>"+data2.count())


    val bheader = data2.first()   //extract header
    println("BHeader is: "+bheader)
    val data3 = data2.filter(row => row != bheader)
    println("Building Data with no Header")
    println("Building Data with no header count->>"+data3.count())

    // create data frame for building
    val build = data3.map(x=> x.split( regex = ",")).map(x => building(x(0).toInt,x(1),x(2).toInt,x(3),x(4))).toDF

    build.show()

    // Register the table
    build.registerTempTable( tableName = "BUILDING")

    println("Data Frame Registered as BUILDING table !")
```

Output:

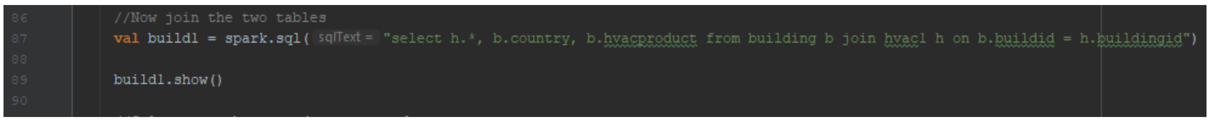


```
18/05/13 16:28:50 INFO DAGScheduler: Job 7 finished: show at SparkSQLUs
+-------+--------+--------+-----------+------------+
|buildid|buildmgr|buildAge|hvacproduct|     Country|
+-------+--------+--------+-----------+------------+
|      1|      M1|      25|     AC1000|         USA|
|      2|      M2|      27|     FN39TG|      France|
|      3|      M3|      28|     JDNS77|      Brazil|
|      4|      M4|      17|     GG1919|     Finland|
|      5|      M5|       3|    ACMAX22|   Hong Kong|
|      6|      M6|       9|     AC1000|   Singapore|
|      7|      M7|      13|     FN39TG|South Africa|
|      8|      M8|      25|     JDNS77|   Australia|
|      9|      M9|      11|     GG1919|      Mexico|
|     10|     M10|      23|    ACMAX22|       China|
|     11|     M11|      14|     AC1000|     Belgium|
|     12|     M12|      26|     FN39TG|     Finland|
|     13|     M13|      25|     JDNS77|Saudi Arabia|
|     14|     M14|      17|     GG1919|     Germany|
|     15|     M15|      19|    ACMAX22|      Israel|
|     16|     M16|      23|     AC1000|      Turkey|
|     17|     M17|      11|     FN39TG|       Egypt|
|     18|     M18|      25|     JDNS77|   Indonesia|
|     19|     M19|      14|     GG1919|      Canada|
|     20|     M20|      19|    ACMAX22|   Argentina|
+-------+--------+--------+-----------+------------+

Data Frame Registered as BUILDING table !
18/05/13 16:28:50 INFO CodeGenerator: Code generated in 17.010372 ms
18/05/13 16:28:50 INFO SparkSqlParser: Parsing command: BUILDING
```

**<u>Objective – 3:</u>** Figure out the number of times, temperature has changed by 5 degrees or more for each country:

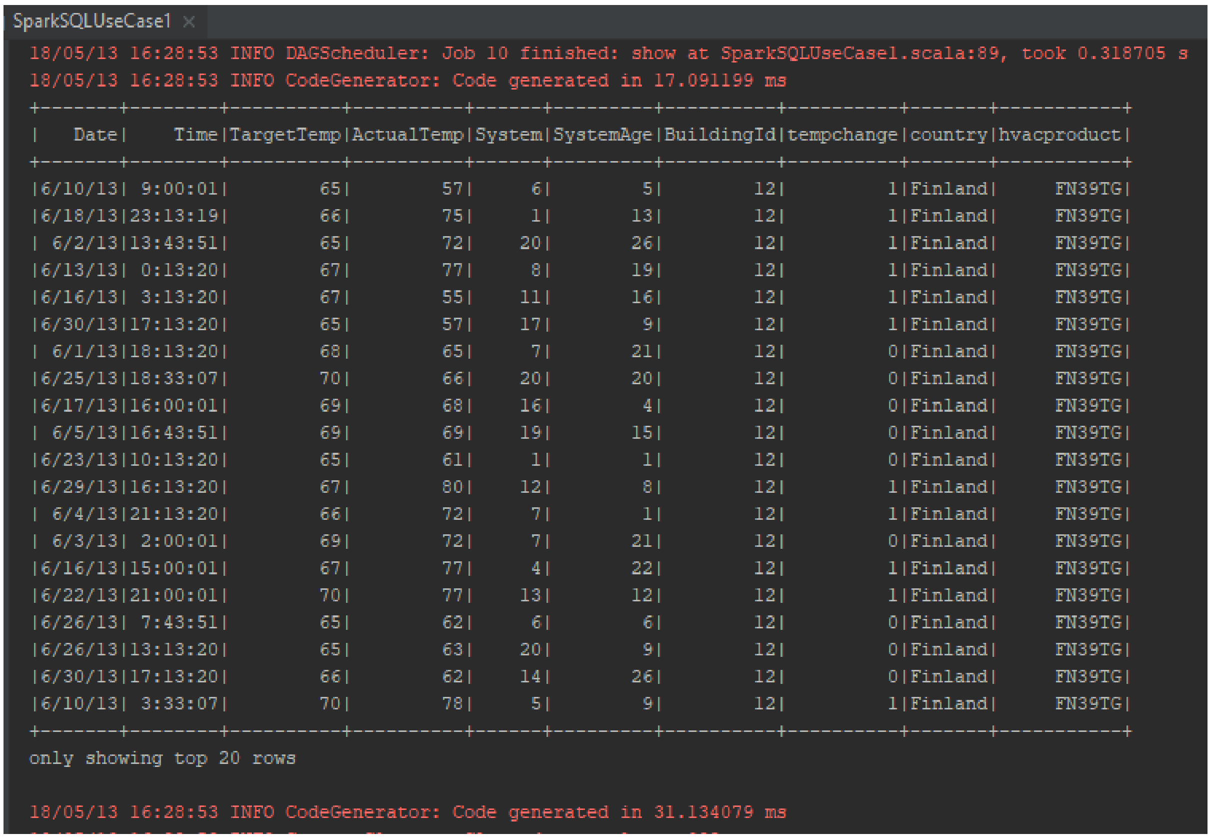
1. Join both the tables.
2. Select tempchange and country column
3. Filter the rows where tempchange is 1 and count the number of occurrence for each country

**<u>Objective 3.1:</u>** Join both the tables.



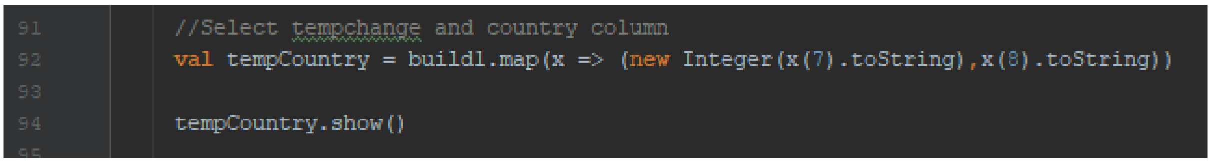
```
//Now join the two tables
val buildl = spark.sql( sqlText = "select h.*, b.country, b.hvacproduct from building b join hvacl h on b.buildid = h.buildingid")

buildl.show()
```

Output:



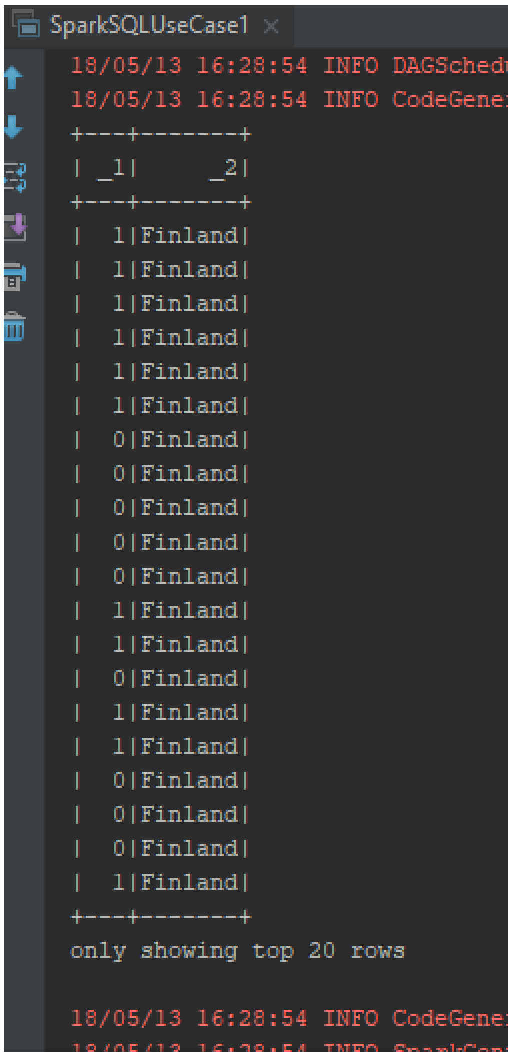
```
18/05/13 16:28:53 INFO DAGScheduler: Job 10 finished: show at SparkSQLUseCase1.scala:89, took 0.318705 s
18/05/13 16:28:53 INFO CodeGenerator: Code generated in 17.091199 ms
+-------+--------+----------+----------+------+---------+----------+----------+-------+-----------+
|   Date|    Time|TargetTemp|ActualTemp|System|SystemAge|BuildingId|tempchange|country|hvacproduct|
+-------+--------+----------+----------+------+---------+----------+----------+-------+-----------+
|6/10/13| 9:00:01|        65|        57|     6|        5|        12|         1|Finland|     FN39TG|
|6/18/13|23:13:19|        66|        75|     1|       13|        12|         1|Finland|     FN39TG|
| 6/2/13|13:43:51|        65|        72|    20|       26|        12|         1|Finland|     FN39TG|
|6/13/13| 0:13:20|        67|        77|     8|       19|        12|         1|Finland|     FN39TG|
|6/16/13| 3:13:20|        67|        55|    11|       16|        12|         1|Finland|     FN39TG|
|6/30/13|17:13:20|        65|        57|    17|        9|        12|         1|Finland|     FN39TG|
| 6/1/13|18:13:20|        68|        65|     7|       21|        12|         0|Finland|     FN39TG|
|6/25/13|18:33:07|        70|        66|    20|       20|        12|         0|Finland|     FN39TG|
|6/17/13|16:00:01|        69|        68|    16|        4|        12|         0|Finland|     FN39TG|
| 6/5/13|16:43:51|        69|        69|    19|       15|        12|         0|Finland|     FN39TG|
|6/23/13|10:13:20|        65|        61|     1|        1|        12|         0|Finland|     FN39TG|
|6/29/13|16:13:20|        67|        80|    12|        8|        12|         1|Finland|     FN39TG|
| 6/4/13|21:13:20|        66|        72|     7|        1|        12|         1|Finland|     FN39TG|
| 6/3/13| 2:00:01|        69|        72|     7|       21|        12|         0|Finland|     FN39TG|
|6/16/13|15:00:01|        67|        77|     4|       22|        12|         1|Finland|     FN39TG|
|6/22/13|21:00:01|        70|        77|    13|       12|        12|         1|Finland|     FN39TG|
|6/26/13| 7:43:51|        65|        62|     6|        6|        12|         0|Finland|     FN39TG|
|6/26/13|13:13:20|        65|        63|    20|        9|        12|         0|Finland|     FN39TG|
|6/30/13|17:13:20|        66|        62|    14|       26|        12|         0|Finland|     FN39TG|
|6/10/13| 3:33:07|        70|        78|     5|        9|        12|         1|Finland|     FN39TG|
+-------+--------+----------+----------+------+---------+----------+----------+-------+-----------+
only showing top 20 rows

18/05/13 16:28:53 INFO CodeGenerator: Code generated in 31.134079 ms
```

**<u>Objective 3.2:</u>** Select tempchange and country column



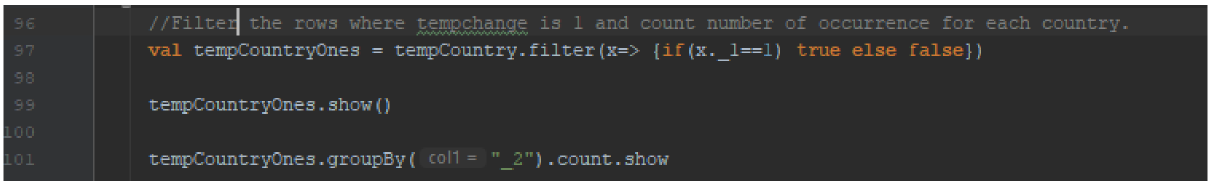
```
//Select tempchange and country column
val tempCountry = buildl.map(x => (new Integer(x(7).toString),x(8).toString))

tempCountry.show()
```

Output:



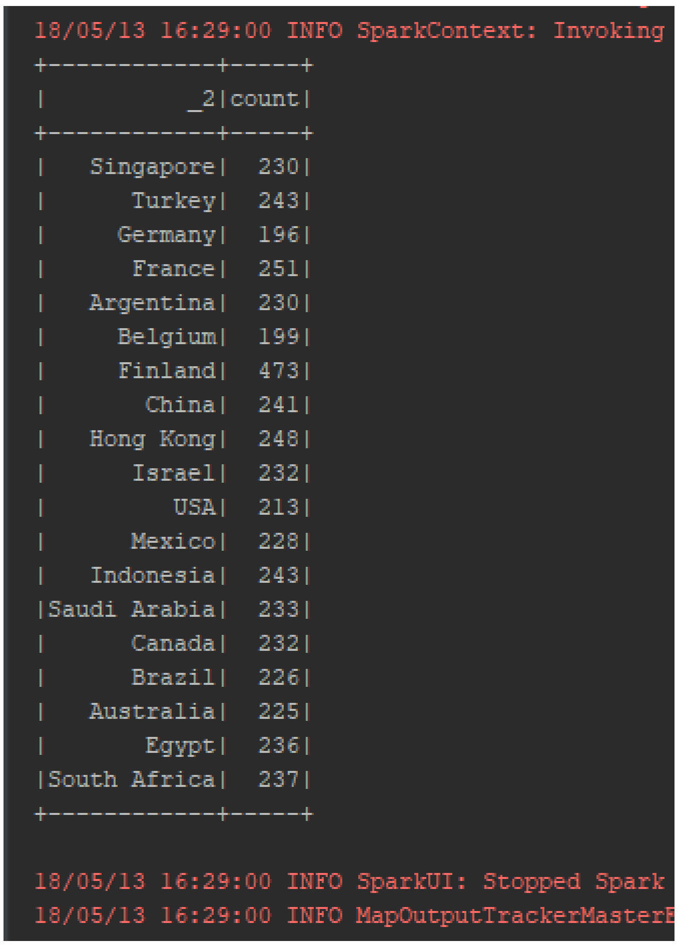
```
18/05/13 16:28:54 INFO DAGSched
18/05/13 16:28:54 INFO CodeGene
+---+-------+
| _1|     _2|
+---+-------+
|  1|Finland|
|  1|Finland|
|  1|Finland|
|  1|Finland|
|  1|Finland|
|  1|Finland|
|  0|Finland|
|  0|Finland|
|  0|Finland|
|  0|Finland|
|  0|Finland|
|  1|Finland|
|  1|Finland|
|  0|Finland|
|  1|Finland|
|  1|Finland|
|  0|Finland|
|  0|Finland|
|  0|Finland|
|  1|Finland|
+---+-------+
only showing top 20 rows

18/05/13 16:28:54 INFO CodeGene
```

**Objective 3.3:** Filter the rows where tempchange is 1 and count the number of occurrence for each country.



```
//Filter the rows where tempchange is 1 and count number of occurrence for each country.
val tempCountryOnes = tempCountry.filter(x=> {if(x._1==1) true else false})

tempCountryOnes.show()

tempCountryOnes.groupBy( col1 = "_2").count.show
```

Output: Please refer next page.



```
18/05/13 16:29:00 INFO SparkContext: Invoking
+------------+-----+
|          _2|count|
+------------+-----+
|   Singapore|  230|
|      Turkey|  243|
|     Germany|  196|
|      France|  251|
|   Argentina|  230|
|     Belgium|  199|
|     Finland|  473|
|       China|  241|
|   Hong Kong|  248|
|      Israel|  232|
|         USA|  213|
|      Mexico|  228|
|   Indonesia|  243|
|Saudi Arabia|  233|
|      Canada|  232|
|      Brazil|  226|
|   Australia|  225|
|       Egypt|  236|
|South Africa|  237|
+------------+-----+

18/05/13 16:29:00 INFO SparkUI: Stopped Spark
18/05/13 16:29:00 INFO MapOutputTrackerMaster
```

**<u>Complete Code Base for Case Study III:</u>**

```
import org.apache.spark.sql.SparkSession

object SparkSQLUseCase1 {

  case class
hvac_cls(Date:String,Time:String,TargetTemp:Int,ActualTemp:Int,System:Int,SystemAge
:Int,BuildingId:Int)

  case class
building(buildid:Int,buildmgr:String,buildAge:Int,hvacproduct:String,Country:String
)


  def main(args: Array[String]): Unit = {

    println("hey scala")

    val spark = SparkSession
      .builder()
      .master("local")
      .appName("Spark SQL Use Case 1")
      .config("spark.some.config.option", "some-value")
      .getOrCreate()

    println("Spark Session Object created")
```

```scala
    val data = spark.sparkContext
      .textFile("C:\\Users\\Ankith M\\Desktop\\Hadoop\\Spark\\Sensor Case 
Study\\HVAC.csv")

    println("HVAC Data->>"+data.count())


    val header = data.first()   //extract header
    println("Header is: "+header)
    val data1 = data.filter(row => row != header)
    println("HVAC Data with no Header")


    //For implicit conversions like converting RDDs and sequences  to DataFrames
    import spark.implicits._

    val hvac = data1.map(x=>x.split(",")).map(x => 
hvac_cls(x(0),x(1),x(2).toInt,x(3).toInt,x(4).toInt,x(5).toInt,x(6).toInt)).toDF()

    hvac.printSchema()

    hvac.show()

    println("HVAC Dataframe created !")


    hvac.registerTempTable("HVAC")
    println("Dataframe Registered as table !")

    // Now here we are adding one new column to get the temperature range condition
    val hvac1 = spark.sql("select *,IF((targettemp - actualtemp) > 5, '1', 
IF((targettemp - actualtemp) < -5, '1', 0)) AS tempchange from HVAC")

    hvac1.show()


    hvac1.registerTempTable("HVAC1")

    println("Data Frame Registered as HVAC1 table !")



    val data2 = spark.sparkContext
      .textFile("C:\\Users\\Ankith M\\Desktop\\Hadoop\\Spark\\Sensor Case 
Study\\building.csv")

    println("Building Data->>"+data2.count())


    val bheader = data2.first()   //extract header
    println("BHeader is: "+bheader)
    val data3 = data2.filter(row => row != bheader)
    println("Building Data with no Header")
    println("Building Data with no header count->>"+data3.count())

    // create data frame for building
    val build = data3.map(x=> x.split(",")).map(x => 
building(x(0).toInt,x(1),x(2).toInt,x(3),x(4))).toDF

    build.show()

    // Register the table
    build.registerTempTable("BUILDING")

    println("Data Frame Registered as BUILDING table !")


    //Now join the two tables
    val build1 = spark.sql("select h.*, b.country, b.hvacproduct from building b
join hvac1 h on b.buildid = h.buildingid")

    build1.show()

    //Select tempchange and country column
    val tempCountry = build1.map(x => (new Integer(x(7).toString),x(8).toString))

    tempCountry.show()

    //Filter the rows where tempchange is 1 and count number of occurrence for each
country.
    val tempCountryOnes = tempCountry.filter(x=> {if(x._1==1) true else false})

    tempCountryOnes.show()

    tempCountryOnes.groupBy("_2").count.show




  }
}
```