Conservatorio Superior de Música de Murcia
1-2 December 2021

2.2

an introduction to the WEB AUDIO API

Dot Drone Generator

Dot **Drone Generator** is a drone generator which allows you to create **synthetic textures** directly on your browser.

Click on the window to generate a **Dot**, a sinusoidal wave with tremolo.

The **y-axis** represents the amplitude range. The **amplitude** is modulated by a **triangular LFO** (Low Frequency Oscillator), with random frequency.

The **x-axis** represents the frequency range.

Press 'L' and then Click+Drag from an existing Dot to an other one, to link two sinusoids and create a **Frequency Modulation** between them. The first Dot becomes the modulator of the second one (the carrier).

It is possible to create a **chain of modulation:** each carrier can become a modulator. This allows you to create complex spectra, to the point of creating very noisy sounds!

Click on an existing circle to **delete** it or to delete the modulation chain of which it is part.

Alberto Barberis

7. JAVASCRIPT DEALING WITH INTERACTION _ 2

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In our list of variable we created a couple of variable (modulator and carrier) that we set to `null`.

These variables will contain the **modulator** (the Dot Object that is selected first when the user type click+Drag+L) and the **carrier** (the second Dot Object over which the mouse is passed while click+Drag+L).

We create a new function `deleteModulatorCarrier()` that we use to empty the modulator and the carrier variables after that a couple (modulator + carrier) has been found.

The goal is to store in these variables always a different pair of modulator/carrier, every time the user click+Drag+L oon a couple of Dots.

```
/** ////////////////////////////////////////////////////////////////
  * SUPPORT FUNCTIONS
    * definition
* ////////////////////////////////////////////////////////////////// */

function startAudio(){ // audio to start when the first dot is created
    audioContext = new AudioContext(); // create an audiocontext
    masterGain = audioContext.createGain(); // create a gian Node for the master gain
    masterGain.gain.value = MASTER_GAIN; // set the level of the master gain (gain adaptation)
    masterGain.connect(audioContext.destination); // connect the master gain to the destination
}

function deleteModulatorCarrier(){
    modulator = null; // remove the object from the variable modulator
    carrier = null; // remove the object from the variable carrier
}
```

We create the function `applyFM()` that we use for the FM synthesis between the modulator and the carrier (the two parameters of the function).

To implement the FM we have to connect the **FM oscillator Gain** to the **carrier main oscillator frequency.**

After that we have to start the FM oscillator Gain (that is set to zero initially) setting it to the MODULATION_INDEX constant (the value that controls the amount of sidebands and their amplitudes).

```
/** ////////////////////////////////////////////////////////////////////////////
  * SUPPORT FUNCTIONS
    * definition
* ////////////////////////////////////////////////////////////////////////////// */

function startAudio(){ // audio to start when the first dot is created
  audioContext = new AudioContext(); // create an audiocontext
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  masterGain.gain.value = MASTER_GAIN; // set the level of the master gain (gain adaptation)
  masterGain.connect(audioContext.destination); // connect the master gain to the destination
}

function deleteModulatorCarrier(){
  modulator = null; // remove the object from the variable modulator
  carrier = null; // remove the object from the variable carrier
}

function applyFM(modulator, carrier){ // function that activate the FM synthesis
  modulator.FMoscGain.connect(carrier.mainOsc.frequency); // connect the FMoscGain to the frequency of the carrier main Oscillator (this is the FM)
  modulator.FMoscGain.gain.setTargetAtTime(MODULATION_INDEX, audioContext.currentTime , ATTACK_TIME); // set the FMoscGain to the modulation index value
}
```
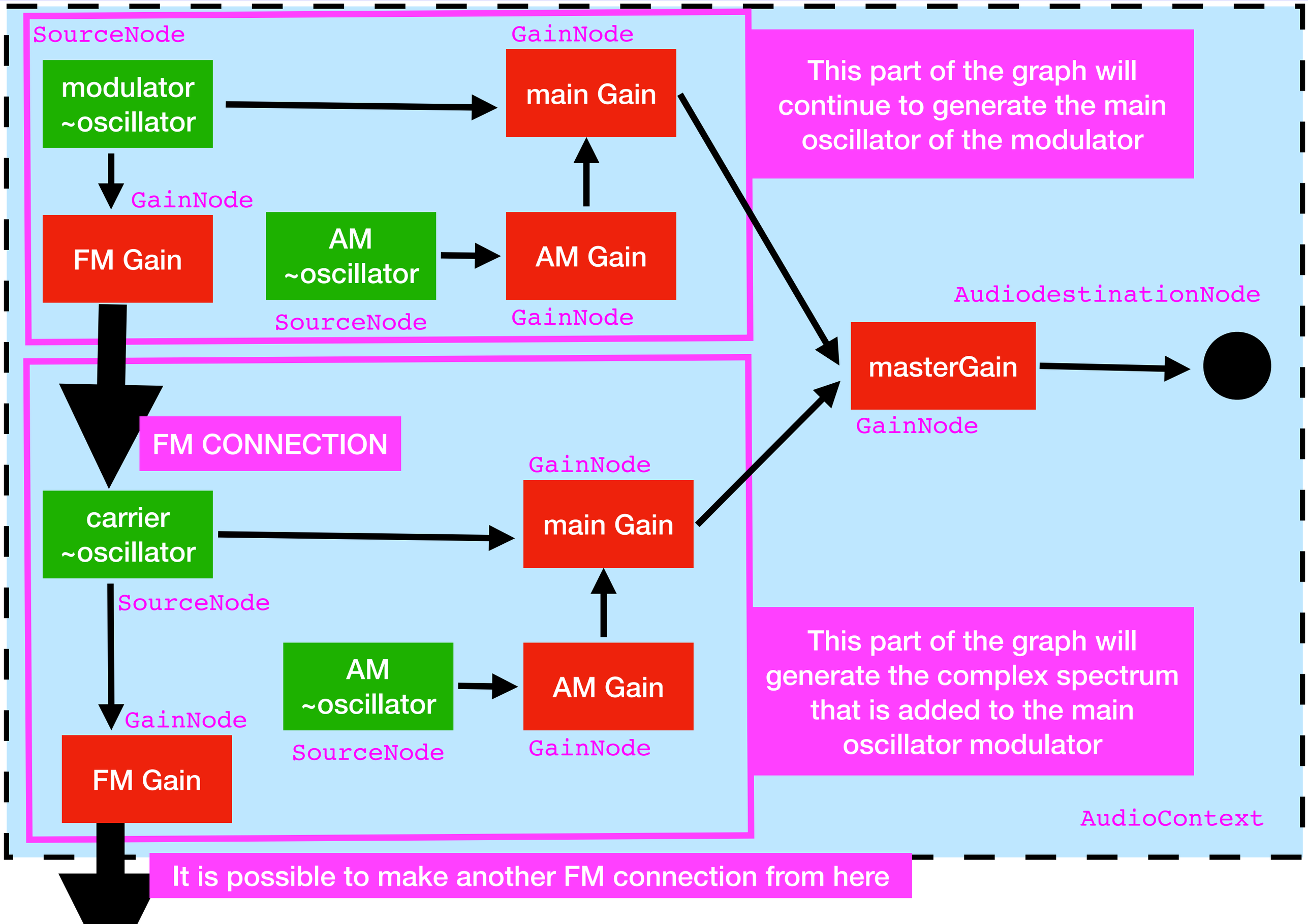


SourceNode
modulator ~oscillator
GainNode
main Gain
This part of the graph will continue to generate the main oscillator of the modulator
GainNode
FM Gain
AM ~oscillator
AM Gain
SourceNode
GainNode
AudiodestinationNode
masterGain
GainNode
FM CONNECTION
GainNode
carrier ~oscillator
main Gain
SourceNode
AM ~oscillator
AM Gain
GainNode
SourceNode
GainNode
FM Gain
This part of the graph will generate the complex spectrum that is added to the main oscillator modulator
AudioContext
It is possible to make another FM connection from here

Here we implement an other function of the p5.js library.

The `mouseDragged()` function is called every time the user click + drag the mouse.

In the first line of this function we use an other function of the p5.js the `keyIsDown()`.

`keyIsDown()` returns true if the user type a certain letter in the keyboard; the letter is passed as keyCode parameter (we use the “L” for “Link” that has 76 as keyCode).

If the keyboard letter is not the “L” we exit from the function. The “!” means NOT.

```
function mouseDragged() { // function called if the mouse is dragged (for the FM synthesis)
    if(!keyIsDown(76)) return; // exit from the function if is not pressed the key 'L'
```

https://www.cambiaresearch.com/articles/15/javascript-char-codes-key-codes

```
function mouseDragged() { // function called if the mouse i
  if(!keyIsDown(76)) return; // exit from the function if i

  for(let i=0; i<arrayOfDots.length; i++){
      let currentDot = arrayOfDots[i];
      let d = dist(currentDot.x, currentDot.y, mouseX, mouseY); // calculate the distance between the Dot center and the mouse
```

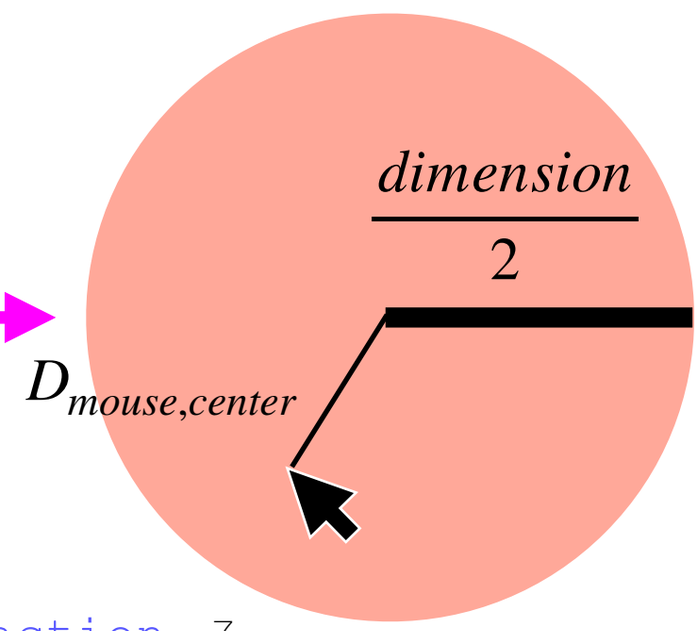
Here we fetch the current Dot from the Array of Dots using the syntax of the Array `arrayOfDots[i];` and we save it in a local variable

Here we calculate the distance between the current Dot center and the current mouse position and we save it in a local variable. `dist()` is a function of the p5.js library

Here we create a **for loop** that for each Dot in the **Array of Dots** calculate the distance between the current x and y positions of the mouse from the x and y positions of the Dot center.

If the distance is less than the dimension/2 of the Dot (i.e. the radius of the circle) we can say that the mouse position is inside a certain Dot.

We can say that the mouse is INSIDE the Dot because the distance between the mouse and the center is less than the radius (dimension / 2)



$$D_{mouse,center} < \frac{dimension}{2}$$

7.1 BOOLEAN EXPRESSIONS

A **Boolean expression** is an expression used in programming that produces a Boolean value when evaluated.

A Boolean value is **true** (1) or **false** (0).

The most common **Boolean operator** are:

- NOT (!)
- OR (||)
- AND (&&)

The Boolean algebra follows the **Truth Table**.

A	B	A AND B	A OR B	NOT A
False	False	False	False	True
False	True	False	True	True
True	False	False	True	False
True	True	True	True	False

```
function mouseDragged() { // function called if the mouse is dragged (for the FM synthesis)
  if(!keyIsDown(76)) return; // exit from the function if is not pressed the key 'L'

  for(let i=0; i<arrayOfDots.length; i++){
      let currentDot = arrayOfDots[i];
      let d = dist(currentDot.x, currentDot.y, mouseX, mouseY); // calculate the distance between the current Dot center and the mouse
position
      /**
       * if there is not a modulator and not a carrier
       * and the mouse is on a Dot
       * and that Dot does not already have a carrier;
       *      set the Dot as a modulator
       */
      if(!modulator && !carrier && d<currentDot.dimension/2 && !currentDot.connections[1] ) {
          modulator = currentDot;
          break; // exit from the for loop
      }
```

`break` is a way to exit from a for loop. In this case if we have found a modulator we can exit.

Here we check the following conditions with one boolean expression:

- the modulator does not exist (`null` is `false` in javascript)
- the carrier does not exist
- the distance is less than the radius
- and the current Dot does not already have a carrier (we fetch the second Object in the Array connections)

If these conditions are verified then: **we have found a modulator**! And we store it in the right variable. We exit also from the current loop cycle, because if the Dot is a modulator it can not be a carrier and it does not make sense to proceed.

```
function mouseDragged() { // function called if the mouse is dragged (for the FM synthesis)
  if(!keyIsD
  for(let i=
      let cu
      let d
position
      /**
       * if
       * and
       * and
       *
       */
      if(!mo
          mo
          br
      }
      /**
       * else if there is a modulator but not a carrier
       * and the mouse is on a Dot
       * and that Dot does not already have a modulator
       * and the current index of the loop is not the one of the modulator
       *      set the Dot as a carrier
       *      assign the carrier to the modulator
       *      assign the modulator to the carrier
       *      and apply the FM
       */
      else if(modulator && !carrier && d<currentDot.dimension/2 && !currentDot.connections[0] && arrayOfDots.indexOf(modulator)!=i){
          carrier = currentDot;
          modulator.connections[1] = carrier;
          carrier.connections[0] = modulator;
          applyFM(modulator, carrier);
          break; // exit from the for loop
      }
  }
}
```

Here we check the following conditions with one boolean expression:

- the modulator exists
- the carrier does not exist
- the distance is less than the radius
- and the current Dot does not already have a modulator (we fetch the first Object in the Array connections)
- and the index of the already found modulator in the arrayOfDots is not the index of the current iteration (otherwise we would find that the modulator is also the carrier)

```
function mouseDragged() { // function called if the mouse is dragged (for the FM synthesis)
  if(!keyIsDown(76)) return; // exit from the function if is not pressed the key 'L'

  for(let i=0; i<arrayOfDots.length; i++){
      let currentDot = arrayOfDots[i];
      let d = dist(currentDot.x, currentDot.y, mouseX, mouseY); // calculate the distance between the current Dot center and the mouse
position
      /**
       * if there is not a m
       * and the mouse is on
       * and that Dot does n
       *      set the Dot as
       */
      if(!modulator && !carr
          modulator = curren
          break; // exit fro
      }
      /**
       * else if there is a modulator but not a carrier
       * and the mouse is on a Dot
       * and that Dot does not already have a modulator
       * and the current index of the loop is not the one of the modulator
       *      set the Dot as a carrier
       *      assign the carrier to the modulator
       *      assign the modulator to the carrier
       *      and apply the FM
       */
      else if(modulator && !carrier && d<currentDot.dimension/2 && !currentDot.connections[0] && arrayOfDots.indexOf(modulator)!=i){
          carrier = currentDot;
          modulator.connections[1] = carrier;
          carrier.connections[0] = modulator;
          applyFM(modulator, carrier);
          break; // exit from the for loop
      }
  }
}
```

If the conditions are all verified, it means that **we have found a carrier!**

We store the Dot Object in the variable.

We say to the modulator what Dot Object is the carrier and viceversa.

Then we apply the FM calling the function we already defined and passing it, as parameters, the **modulator** and the **carrier** that we have found.

```
// when the mouse is released or a key is released delete the stored modulator and carrier
function mouseRealeased() {
    deleteModulatorCarrier();
}
function keyReleased(){
    deleteModulatorCarrier();
}
```

Now we implement other two functions of p5.js. Both of these functions call the function `deleteModulatorCarrier()` that we already implemented.

In this way every time the user releases the mouse, `mouseReleased()`, or releases the key “L” `keyReleased()`, the process of finding modulator and carrier will stop, emptying the variables and making them available for a new search process.

```
function draw(){ // this is the draw function of the p5.js called to draw on the canvas
    clear(); // clear the canvas
    fill('rgba(255,0,255,0.3)'); // the color of the Dot: red with alpha
    strokeWeight(2); // the weight of the border of the elements

    for(let i=0; i<arrayOfDots.length; i++){ // draw each Dot in the array
        let currentDot = arrayOfDots[i];

        ellipse(currentDot.x, currentDot.y, currentDot.dimension, currentDot.dimension); // draw a circle

        let carrier = currentDot.connections[1]; // the carrier of the current Dot
        if(carrier){ // if the carrier exists draw a line between the modulator (current Dot) and the carrier
            line(currentDot.x, currentDot.y, carrier.x, carrier.y);// draw the line
        }
    }
}
```

Now we go back to the `draw()` function.

Here we check if the current Dot in the loop cycle has a carrier, that means that the Object inside `connections[1]` is not `null`.

If so, we want to draw a line from the current Dot center to the carrier center. We do this with the p5.js function `line()`.

Now we can start to create some FM-paths in the 2D space of Dots.

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It is possible to create a **chain of modulation:** each carrier can become a modulator. This allows you to create complex spectra, to the point of creating very noisy sounds!

Click on an existing circle to **delete** it or to delete the modulation chain of which it is part.

Here we implement a function that delete a Dot and all the Dots possibly connected with it (FM chain)

```
function deleteDot(currentDot){ // this is a recursive function that delete a dot from the array
    let indexToDelete = arrayOfDots.indexOf(currentDot); // fetch the index of the Object
    if(indexToDelete == -1) return;

    currentDot.mainOscGain.gain.setTargetAtTime(0, audioContext.currentTime, RELEASE_TIME); // set to 0 the main osc Gain
    currentDot.AMoscGain.gain.setTargetAtTime(0, audioContext.currentTime, RELEASE_TIME); // set to 0 the AM osc Gain
```

This is a RECURSIVE FUNCTION, that means a function that can call itself.

The method `indexOf()` returns the index of the Current Dot. We need this later to delete the element from the Array.

Then we set to 0 the main oscillator Gain and the AM oscillator Gain. This action stops the sound of the Dot.

```
function deleteDot(currentDot){ // this is a recursive function that delete a dot from the array
    let indexToDelete = arrayOfDots.indexOf(currentDot); // fetch the index of the Object
    if(indexToDelete == -1) return;

    currentDot.mainOscGain.gain.setTargetAtTime(0, audioContext.currentTime, RELEASE_TIME); // set to 0 the main osc Gain
    currentDot.AMoscGain.gain.setTargetAtTime(0, audioContext.currentTime, RELEASE_TIME); // set to 0 the AM osc Gain

    let modulator = currentDot.connections[0]; // store in a variable the modulator associated to the Object
    let carrier = currentDot.connections[1]; // store in a variable the carrier associated to the Object

    arrayOfDots.splice(indexToDelete, 1); // remove the object from the array
```

We fetch the modulator and the carrier that are (possibly) connected to the current Dot.

The method `splice()` of the class `Array` can be used to delete an element from an `Array`.

The first parameter is the index of the Array from where delete and the second parameter specifies how many elements we want to delete. In our case we just want to delete one element, the current Dot itself.

```
splice(start, deleteCount)
```

```
function deleteDot(currentDot){ // this is a recursive function that delete a dot from the array
    let indexToDelete = arrayOfDots.indexOf(currentDot); // fetch the index of the Object
    if(indexToDelete == -1) return;

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    let modulator = currentDot.connections[0]; // store in a variable the modulator associated to the Object
    let carrier = currentDot.connections[1]; // store in a variable the carrier associated to the Object

    arrayOfDots.splice(indexToDelete, 1); // remove the Object from the array

  if(modulator){ // if the modulator exists
    deleteDot(modulator); // delete it with a recursion
  }

  if(carrier){ // if the carrier exists
    deleteDot(carrier); // delete it with a recursion
  }
}
```

We want to delete also all the Dots connected to the current Dot. We do the following using the RECURSION of the same deleteDot function:

- if the current Dot has a modulator, delete it;
- if the current Dot has a carrier, delete it;

```
function mousePressed() { // function called if the mouse is pressed
    if(!audioContext){ startAudio(); } // if the audio context still does not exists create it
    if(mouseY < 0 || keyIsDown(76)) return; // exit if the mouse is out of the canvas OR the user is pressing "L"

    for(let i=0; i < arrayOfDots.length; i++){ // check if the mouse is pressed in an existing Dot; if so delete it

        let currentDot = arrayOfDots[i];
        let d = dist(currentDot.x, currentDot.y, mouseX, mouseY); // calculate the distance between the Dot and the mouse

        if(d < currentDot.dimension/2){ // if pressing on an existing
            deleteDot(currentDot); // delete the Dot
            return;
        }
    }

    let newDot = new Dot(mouseX,mouseY); // create the Dot calling th
    arrayOfDots.push(newDot); // put the Dot in the array of Dots
}
```

Every time the user press the mouse, we check with a for loop if the mouse is inside a Dot that already exists. We do this calculating the distance between the Dot center and the mouse position.

We implement the code of the `mousePressed()` function.

We want to delete an existing Dot when it is pressed, and also to delete all the Dots connected to it, if there are any.

If the distance is less than the radius we delete the current Dot, calling our function `deleteDot()`.

If we delete a Dot we exit from the function with the keyword `return`. This means that the following lines are not executed, and so we do not create a new Dot.